J.W. Watts Sc

THE NEBULA IN ORION.

1859-1863.

MONOGRAPH

OF THE

CENTRAL PARTS OF THE NEBULA OF ORION

EDWARD S. HOLDEN

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CENTRAL PARTS OF THE NEBULA OF ORION.

[R. A. $5^h\ 28^m\ 24^s.0$; N. P. D. $95°\ 29'\ 10''.9$; 1860.0.]

BY

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NOTE.—The important results obtained by Dr. HUGGINS from his photographs of the spectrum of this nebula were known too late for insertion in the text.

MONOGRAPH

OF THE

CENTRAL PARTS OF THE NEBULA OF ORION.

The main object of this memoir is to leave such measures and descriptions of the brightest parts of the nebula of *Orion* as shall enable another person observing in after years with the same telescope, under like conditions, to say with certainty whether or no changes have occurred in these parts of this nebula. The brightest parts are chosen so as to avoid as far as possible any uncertainty in the conclusion then to be reached, and also because there is little to be added to the complete observations of Lord Rosse and of G. P. Bond on the fainter portions. A second and an important object is to make a thorough discussion of the vast mass of material now on hand.

The brilliant success attained by Dr. Henry Draper in his photographs of this nebula leads to the hope that photographs may in the near future largely take the place of eye-drawings for such objects as comets and nebulæ; the present is an appropriate time for a *résumé* of all observations made by the old methods.

A complete research on this nebula might treat of the following questions:

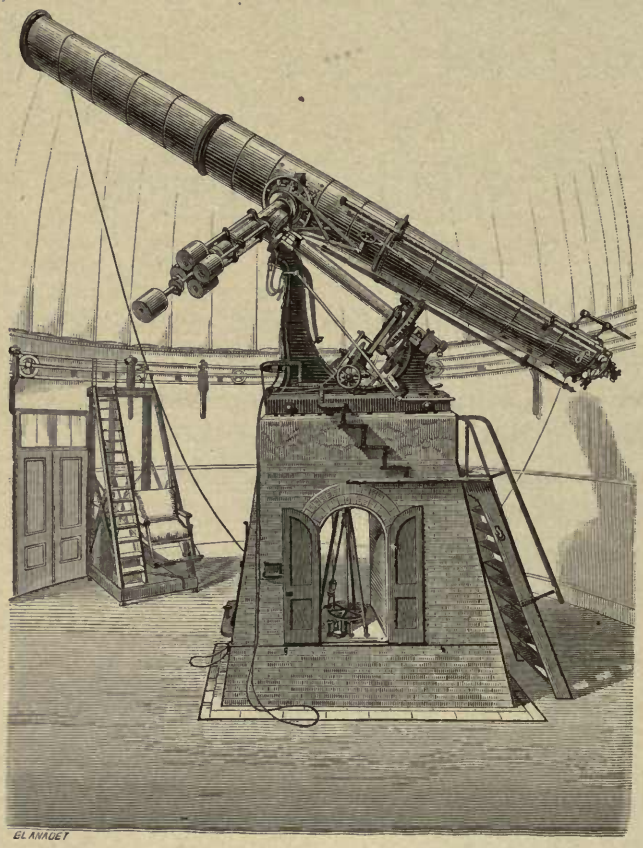
I. Its distance from the earth.
II. Its connection with the stars contained in it.
III. Its physical constitution.
IV. Its proper motion.
V. The variations in the shape of its parts.
VI. The variations in the brightness of its parts.
VII. Its possible rotation as one mass.
VIII. The possible rotation of one or more of its parts.
IX. The proper motion of one or more of its parts.

The present memoir affords evidence relating to II, IV, V, VI, VII, VIII, and IX.

II has also been treated in the Washington Observations for 1877, Appendix I, "On the Multiple Star Σ. 748," where I have discussed a most complete set of measures of the six stars of the trapezium made by Professor Hall.

The object to be attained could not have been reached by adding another drawing to the many excellent ones we now have, and my original plan of making micrometric and photometric measures of the various masses has been carried out without much change. All the observations at Washington have been made with the 26-inch Clark

refractor, with magnifying powers from 130 to 600 diameters. A full description (with plates) of this telescope is given in Washington Astronomical Observations, 1874, Appendix I. A view of it is given in the accompanying wood-cut from André and Rayet's *Astronomie Pratique*, kindly furnished by M. Gauthier-Villars.



Probably no object outside of the solar system has received more attention from the best observers than the nebula of *Orion*. Before discussing the observations of so many astronomers, each of whom has applied his own peculiar notation to the various parts of this nebula, it is necessary to fix upon one system of nomenclature which shall be used uniformly throughout the work. For the *stars* no doubt can arise as to the proper system to be adopted, as the *Catalogue of Stars in the Nebula of Orion*, published by G. P. Bond in vol. v of the *Annals of the Harvard College Observatory*, is by far the most full that we possess, and is likely to remain so for many years.

I have uniformly adopted the nomenclature of all stars in the nebula from that great work, and while, in quoting from other authorities, I have given in most cases the letter or number of the star from the original source, I have added the synonym from Bond in square brackets, thus: [G. P. B., No 685, etc.] or simply [685]. I give, immediately following, a catalogue of all the stars referred to in the subsequent pages reduced to 1877.0 from Bond's elements. This catalogue forms the basis of the present work.

Catalogue of Stars in the Central Part of the Nebula of Orion for 1877.0.

Bond.	Mag.	Herschel and Struve.	Bond's letter in his Zones.	Herschel.	W. C. Bond.	Lassell.	Liaponoff.	$\Delta\alpha$ 1877.0.	$\Delta\delta$ 1877.0.
479	10.0	35	F′	o	3	56	y	− 400″.8	+ 272″.5
523	10.1	45	P″	τ	5	40	l	− 243.1	− 116.2
558	10.7	50	Q″	.	9	39	v	− 159.7	− 119.0
*567	13.9	51	μ	.	10	.	.	− 103.4	− 8.7
570	9.4	53	R″	σ	13	33	n	− 96.0	− 273.6
573	13.9	54	r_2″	.	12	35	n_1	− 87.4	− 179.4
*575	11.9	57	r_1″	.	11	45	.	− 85.4	− 22.7
581	14.2	*ad* 54	r_3″	.	.	.	.	− 77.1	− 159.5
*589	12.7	57*	r_4″	.	15*	.	.	− 57.8	− 21.0
*595	13.9	.	ν	.	15	43, e	.	− 47.5	− 15.6
*601	15.6	.	.	.	.	.	.	− 37.0	− 32.0
602	14.3	.	ν'	.	.	.	.	− 33.6	− 68.1
*608	14.3	.	ν''	.	.	f	.	− 24.3	− 18.6
*612	13.5	.	ξ	.	16		.	− 17.0	+ 24.0
*617	. .	64	I′	γ'	—	.	bb_1	− 10.7	+ 12.9
*618	13.1	.	π	.	19	h	.	− 11.0	+ 24.0
*619	. .	65	K′	γ	17	.	b	− 10.0	+ 8.7
*621	15.6	*ad* II	.	.	.	.	.	− 9.0	− 37.0
*622	12.7	II	ρ	.	18	.	.	− 8.1	− 28.4
*624	. .	67	U″; L′	δ	21	.	d	− 5.0	+ 16.1
625	15.6	*ad* II	.	.	.	d	.	− 5.0	− 29.0
628	. .	69	M′	a	22	.	a	0.0	0.0
*631	14.3	.	τ	.	.	.	.	+ 2.0	− 43.0
*633	. .	71	N′	a'	.	.	.	+ 3.5	− 2.1
635	10.5	70	O′	.	23	2	i	+ 7.9	+ 97.7
*636	13.3	.	σ	.	24	.	.	+ 7.8	− 9.3
*640	. .	73	P′	ϑ	25	.	c	+ 11.5	+ 6.8
*641	14.8	III	o'	.	.	.	.	+ 11.5	+ 110.6
*642	15.6	.	ν'	.	.	.	.	+ 12.0	+ 47.0
*647	12.1	75	ϕ; p_1′	.	26	9; l	.	+ 22.0	+ 37.4
*648	14.3	.	χ	.	.	.	.	+ 23.6	− 9.3
*651	13.1	*ad* 75	ψ	.	27	.	.	+ 28.8	+ 47.0
*652	13.9	76	ζ	y'	32	.	f''	+ 30.0	+ 170.8
*654	12.3	78	ω	.	31	.	.	+ 32.6	+ 9.2
*657	13.1	80	ε	y''	33	4	f_1	+ 39.4	+ 164.4
*663	11.7	84	δ	w	37	.	g_1	+ 55.1	+ 146.3
*666	13.9	81	$\times_2$″	.	30	.	.	+ 58.7	− 196.6
669	9.8	87	Q′	ν	39	10	k	+ 62.9	+ 99.2
*671	11.5	88	β	.	41	18	e_{11}	+ 69.0	− 25.2
*675	15.2	.	.	.	.	a	K	+ 73.7	− 94.2
*676	13.1	*ad* 88	γ	.	43	k	.	+ 77.9	− 28.4
*677	14.8	*ad* 81	$\times_2$″	.	34	.	.	+ 77.6	− 202.2
*681	14.8	89	η	z	.	.	e_1	+ 90.1	+ 172.4
685	8.3	93	Y″	ε	45	26	e	+ 96.9	− 95.8
*686	15.6	91	.	.	44	.	.	+ 99.0	− 40.0
*688	15.6	.	.	.	.	.	.	+ 105.0	− 19.0
707	11.2	103	A″ A″	ψ	49	27	σ	+ 150.2	− 254.5
708	9.6	101	B″ B″	ζ	50	23	f	+ 150.6	− 99.5
*709	12.3	100	b'' b_1''	G	51	.	μ	+ 152.1	− 137.4
724	10.5	104	C″ C″	λ	55	25	h	+ 182.3	− 177.0
741	10.0	110	E″ E″	η	61	19	g	+ 225.1	− 111.7
746	10.8	111	Q‴, F″, F″	E	64	29	ζ_1	+ 231.3	− 585.0
784	10.8	123	H″ H″	K	78	24	γ_1	+ 387.2	− 287.4
889	11.3	142	K″ K″	(λ)	94	17	δ_{11}	+ 800.4	− 256.0

The magnitudes are from G. P. Bond's estimates. Those stars marked * are supposed to be variable by Struve.

It is equally necessary that a rather minute system of nomenclature should be adopted to distinguish the various bright masses, dark channels, spirals, etc., of the central portion, and the *Index-Map*, herewith, gives the nomenclature uniformly used throughout the present work, not only in referring to my own observations of 1874, '75, '76, '77, '78, '79, and 1880, but in the discussion of the work of others.

It is necessary to say a few words in regard to the nomenclature there adopted, as it is not all that could be wished. During a visit of M. TROUVELOT, formerly of the Harvard College Observatory, to Washington, he made, in connection with myself, the drawing of the central part of *nebula Orionis* which is reproduced in Appendix I, *Washington Astronomical Observations* for 1874. This was only a preliminary sketch, but it gave an idea of what could be seen with the 26-inch refractor. On his return to Cambridge I requested him to prepare a lithographed skeleton map of the central portions of the nebula, on which I proposed to insert letters, figures, etc., to designate the various bright masses, dark channels, etc. I intended to choose these symbols so as to preserve, not only the nomenclature proposed by Sir JOHN HERSCHEL in *Memoirs of the Royal Astronomical Society*, vol. ii, which has been adopted and added to by subsequent investigators, but also the nomenclature of the bright masses (α, β, γ, etc.) given in Lord ROSSE's memoir of 1868 (*Phil. Trans.*, 1868, p. 57), and in LIAPONOFF's Memoir published by STRUVE in *Mémoires de l'Académie Impériale des Sciences de St. Petersbourg*, vol. v, 7th series, 1862. The brilliant labors of Lord ROSSE, LIAPONOFF, and STRUVE in this field demanded that the nomenclature adopted by them should not be lightly changed.

On the return of the lithographed charts (which were executed by M. TROUVELOT at his own expense), however, I found on them a system of letters and numbers excellent in itself, but varying from the nomenclatures of ROSSE, LIAPONOFF, and STRUVE. These charts were put into immediate use in my own work, and copies of them were sent to Dr. DOBERCK, Mr. PRITCHETT, Lord ROSSE, M. OTTO v. STRUVE, Dr. SCHMIDT, M. TEMPEL, M. TISSERAND, Dr. VOGEL, Dr. WINNECKE, and others; and some of these were at once used in comparisons with the nebula by these astronomers. They were constantly used in my own work, and thus almost unavoidably a nomenclature was adopted which did not fulfill all the prerequisite conditions. Added to this was the fact that the nomenclatures adopted by former astronomers were not then as familiar to me as now, as it was my constant endeavor while the actual work was in progress to keep my mind as free from bias as possible, and to avoid too great familiarity with previous work. That this process, while advantageous from a purely scientific point of view, has also its disadvantages, the preceding remarks will show.

I have seriously considered the question of changing my nomenclature throughout on these accounts, but the fear of introducing error, and the chance that these charts may also be used by the astronomers to whom they were sent has deterred me, and the index-chart herewith remains substantially as it has been during the series of observations. I have, however, added the nomenclature of LIAPONOFF in many cases, distinguishing his letters by inclosing them in a right angle. Lord ROSSE's Greek letters are underscored in the index-map to distinguish them from M. TROUVELOT's.


Regio Gentiliana
Regio Fouchiana
Sinus Gentilii
Oceanus
Fons
Sinus Lamontii
Palus
Palus Bondii
dark
Regio subnebulosa
Brachium Messieri
Rostrum
Sinus Magnus
Pons Schröteri
Spitze
Regio Derhemiana
Regio Picardiana
Lacus Lasselii
α Rosse
A Liaponoff
E Trouvelot
· Bond's Stars
⊙ Struve's Variables
△ Lassell's Stars
·c Cooper's Stars

INDEX-CHART.

DESCRIPTION OF THE INDEX-CHART.

The stars are laid down from Bond's Catalogue, and the *numbers* are throughout those of Bond. The stars inclosed in circles are those suspected by Struve to be variable, and were so distinguished in order to attract the eye, except the star *h*. Those stars in triangles were stars laid down by Lassell, which my own early observations did not verified. The letters, numbers, etc., were laid down by M. Trouvelot, and are very convenient for the purpose for which they were intended. I have kept the nomenclature of Herschel, *Sinus magnus*, *regio Hugheniana*, etc., as it is now classic, and I have added but one such term, and this was done almost by inadvertence. The sharp *following* point of σ I have called "Spitze."

The dimensions of the various masses in the Index-Chart are not strictly accurate, although nearly so. For accurate dimensions recourse must be had to my measures in Part III. The index-chart is simply intended as a key to the system of nomenclature, and to make verbal descriptions intelligible.

The principal drawings referred to, with their dates, are given in the following list, in which the order is the same as that adopted in the subsequent discussion:

Observer.	Date.	In what published, etc.	Figure in this work.
Huyghens	1656	Systema Saturnium, p. 8	1
Picard	1673	Recueil d'Observations Inédits, p. 248, and Hist. de l'Acad. Roy. des Sciences, 1729, p. 432.	4
Huyghens	1694	Opp. Varior. Vol. Volume I, p. 7	2
Mairan	1731	Traité de l'Aurore Boréale, p. 249, and Lalande's Astronomie, p. 272	3
Long	1743	Astronomy in two books p. 321 and Fig. 96	5
Legentil	1758	Mém. de l'Acad. Roy. des Sciences, 1759, p. 453	6
Messier	1771	Mém. de l'Acad. Roy. des Sciences, 1771, p. 480	10
W. Herschel	1774 and later.	P. T. 1811, p. 310, and MSS. in possession of the Royal Society of London.	11
Lefebvre	1779	Obs. sur la Physique, 1783, p. 34 (Rouen)	13
Schroeter	1794	Aphrodographische Fragmente, p. 248	14
Schroeter	1797–'98	Beiträge z. d. neuesten Astron. Entdeck. III, p. 109	15, 16, 17
Bode	1800?	Anleit. z. Kenntniss d. Gest. Himmels, p. 168 and Plate I	18
Flaugergues	1802	Connais. des Temps An XI, 1802, p. 361	—
J. Herschel	1824	Mem. R. A. S. I. p. 487	19
Pond	1826	Mem. R. A. S. II. p. 93	—
J. Herschel	1837	Obs. Cape of Good Hope, pp. 25 *et seq.*	20
Lamont	1837	Ueber d. Nebelflecke, p. 23, and MS. drawing kindly communicated by Dr. Lamont.	21
Cooper	1851	MS. sketch communicated by Dr. Dowden	—
Dr. Vico	1859	Mem. Osc. C. R. Romano, 1859	22
Rondoni	1841	Mem. Osc. Coll. Romano, 1839	—
Kaiser	1841	Verhandelingen, vol. I	23
Lassell	1847	Nichol's Architecture of the Heavens, 1841, p. 24	24
W. C. Bond	1848	Mem. Amer. Acad., vol. iii, p. 67, and Annals H. Coll. Obs., vol. I	25
Lassell	1854	Mem. R. A. S. vol. [illegible] p. 21	27
Schmidt	1860–'75	Two MS. unpublished drawings, courteously communicated by Dr. Schmidt.	28
Schmidt	1861		


Regio
Gentiliana
Regio
subnebulosa
Sinus Magnus
Spitze
Trouvelot

INDEX-CHART.

DESCRIPTION OF THE INDEX-CHART.

The stars are laid down from BOND's Catalogue, and the *numbers* are throughout those of BOND. The stars inclosed in circles are those suspected by STRUVE to be variable, and were so distinguished in order to attract the eye, except the star *h*. Those stars in triangles were stars laid down by LASSELL, which my own early observations had not verified. The letters, numbers, etc., were laid down by M. TROUVELOT, and are very convenient for the purpose for which they were intended. I have kept the nomenclature of HERSCHEL, *Sinus magnus*, *regio Huygheniana*, etc., as it is now classic, and I have added but one such term, and this was done almost by inadvertence. The sharp *following* point of σ I have called "Spitze."

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Observer.	Date.	In what published, etc.	Figure in this work.
HUYGHENS	1656	Systema Saturnium, p. 8	1
PICARD	1673	Traité de l'Aurore Boréale, p. 248, and Hist. de l'Acad. Roy. des Sciences, 1759, p. 435.	4
HUYGHENS	1694	Tidj. v. Wis-en Nat. Wetens. i, p. 7	2
MAIRAN	1731	Traité de l'Aurore Boréale, p. 249, and LALANDE's Astronomie, p. 272	3
LONG	1742	Astronomy in five books, p. 321 and Fig. 96	5
LEGENTIL	1758	Hist. de l'Acad. Roy. des Sciences, 1759, p. 453	6
MESSIER	1771	Hist. de l'Acad. Roy. des Sciences, 1771, p. 460	10
W. HERSCHEL	1774 and later.	P. T., 1811, p. 320, and MSS. in possession of the Royal Society of London.	11
LEFEBVRE	1779	Obs. sur la Physique, 1783, p. 34 (ROZIER)	13
SCHROETER	1794	Aphroditographische Fragmente, p. 248	14
SCHROETER	1797–'98	Beiträge z. d. neuesten Astron. Entdeck, iii, p. 149	15, 16, 17
BODE	1800?	Anleit. z. Kenntniss d. Gest. Himmels, p. 166 and Plate I	18
FLAUGERGUES	1802	Connais. d. Tems An XI, 1802, p. 361	—
J. HERSCHEL	1824	Mem. R. A. S., ii, p. 487	19
POND	1826	Mem. R. A. S., ii, p. 93	—
J. HERSCHEL	1837	Obs. Cape of Good Hope, pp. 25 *et seq.*	21
LAMONT	1837	Ueber d. Nebelflecken, p. 23, and MS. drawing kindly communicated by Dr. DOBERCK.	20
COOPER	183?	MS. sketch communicated by Dr. DOBERCK	—
DE VICO	1839	Mem. Oss. Coll. Romano, 1839	22
RONDONI	1841	Mem. Oss. Coll. Romano, 1839	—
KAISER	1844	Sterrenhemel, vol. ii	23
LASSELL	1847	NICHOL's Architecture of the Heavens, 1841, p. 24	24
W. C. BOND	1848	Mem. Amer. Acad., vol. iii, p. 87, and Annals H. Coll. Obs'y, vol. 5	25
LASSELL	1854	Mem. R. A. S., vol. xxiii, p. 53	27
SCHMIDT	1860–'75	Two MS. unpublished drawings, courteously communicated by Dr. SCHMIDT.	28
SCHMIDT	1861		

The principal drawings referred to, with their dates, etc.—Continued.

Observer.	Date.	In what published, etc.	Figure in this work.
B. B. STONEY . .	1851	Unpublished drawing. A photograph of this has been kindly given me by Lord ROSSE.	—
LIAPONOFF . . .	1847	Mem. de l'Acad. Imp. de St. Petersbourg, tome v.	26
O. STRUVE . . .	1861		
SECCHI	1862	Ast. Nach., Bd. xlv, col. 60	29
TEMPEL	1862?	Ast. Nach., Bd. lviii, col. 240	30
LASSELL	1862	Unpublished drawing, on a large scale, made by Miss CAROLINE LASSELL, at Valetta, of which a full-sized *fac simile* has been most kindly communicated by the artist.	31
G. P. BOND . . .	1859–'65	Annals Harv. Coll. Obs'y, vol. v	Frontispiece and Fig. 32.
Lord ROSSE . .	1867	Phil. Trans., 1868, p. 57 *et seq.*	33
SECCHI	1868	Firenze Ital. Soc. Mem., vol. i, 3d ser., pt. 2	34
D'ARREST . . .	1872	Undersogelse over de nebulose Stjerner, etc.	35
WINLOCK . . .	1874	Ast. engravings from Harvard College Observatory, and Annals Harvard College Observatory, vol. viii.	36
TROUVELOT . . .			
WASHINGTON . .	1875	Wash. Ast. Obs., 1874, Appendix I	37
LANGLEY . . .	1879	MS. observations, kindly communicated by Professor LANGLEY, with the permission of the Superintendent of the U. S. Coast Survey.	38
DRAPER	1880	From photographs taken in 1880.	40

I add here a list of writings on the nebula of *Orion*, reprinted with additions from my *Index-Catalogue of Books and Memoirs relating to Nebulæ Clusters, etc.* Washington, 1877. (Smithsonian Miscellaneous Collections, No. 311.)

LIST OF THE MORE IMPORTANT BOOKS AND MEMOIRS RELATING TO THE NEBULA OF ORION.

ARAGO: C. R., xiii, p. 450. [Remarks on RONDONI's drawing.]

———: C. R., xxvi, p. 50. [BOND's drawing.]

BARNEBY: Mon. Not. R. A. S., vol. xxxiv, p. 248. [Variability of 6th star in trapezium.]

BESSEL: B. J., 1808, p. 122. [CYSAT knew of the nebula of Orion.]

BISHOP: [HIND]: BISHOP's Astron. Obs., 1839–'51, p. 12; 1852. [Small star near θ Orionis; mag. 13, $p =$ 126°.9 (3); $s = 2''.8$ (1).

BODE: Anleitung z. Kenntniss des Gestirnten Himmels, p. 166, Plate 1, p. 556. [Two drawings.]

———: Himmelskarten, Tafel 30. [Drawing.]

BOND, G. P.: Annals Harvard College Observatory, vol. v, 1867. [With two steel engravings and two charts.] 4°.

———: Mon. Not. R. A. S., xxi, p. 203. [Spiral structure.]

———: Mon. Not. R. A. S., xxiv, p. 177.

BOND, W. C.: Description of the nebula about θ Orionis, Mem. Am. Ac. Arts and Sciences, vol. iii (1848), p. 87. [With steel engraving.]

———: Proc. Am. Ac. Arts and Sciences, i, p. 325. [Observations.]

———: Same volume, p. 342. [Resolvability of nebula of Orion.] See also Am. Jour. Sci., 2d series, iv, p. 427.

CARPENTER and STONE: Mon. Not. R. A. S., xxiv, p. 92. [On G. P. BOND's drawing.]

CASSINI, J. D.: De Cometa Anni 1652–'53. [Discovery of the 4th star in Orion's trapezium, etc.]

———: Decouverte de la lumière céleste qui parait dans le Zodiaque. [Suspects nebula of Orion to be a star cluster.] See DELAMBRE. Hist. de l'Astr. Mod., vol. ii, pp. 700, 709, 744.

CYSAT: CYSAT, der erste Entdecker des Orions-Nebel. (1619.) [R. WOLF, 1853.]
———: Mathemata astronomica de loco cometæ qui sub finem anni 1618, etc.
D'ABBADIE: Mon. Not. R. A. S., xvii, p. 245. [PORRO's new star in trapezium.]
D'ARREST: Undersögelse over de nebulose Stjerner, etc. 1872. 4°. [With drawing of the nebula and detailed memoir.]
———: A. N., lvii, col. 341.
———: A. N., lxx, col. 337. [Notice of LEFEBVRE's drawing.]
———: Om den store Orionstage. Kjöbenhavn. Dansk. Vid. Selsk. Oversigt. (1867), pp. 236–241. [This paper relates to the connection between the ι, θ, and c Orionis nebulæ.]

I. ι and θ are connected by two nebulous streaks:

A. The co-ordinates of the middle of the first are—

$\Delta\alpha$ -65^s, -72^s, -80^s, -84^s, -85^s, -85^s, -83^s, -73^s, -46^s, -28^s;
$\Delta\delta$ $-630''$, $720''$, $810''$, $900''$, $990''$, $1170''$, $1260''$, $1350''$, $1530''$, $1620''$.

B, Those of the second are—

$\Delta\alpha$ -34^s, -16^s, $+3^s$, $+9^s$, $+16^s$, $+21^s$;
$\Delta\delta$ $-660''$, $-810''$, $-1180''$, $-1210''$, $-1360''$, $-1650''$.

Professor SAFFORD has proposed for the whole system the name *Corona Herschelii*; D'ARREST proposes for A the name *Semita Bondiorum*; the name *Paeninsula Othonis Struvii* is proposed for a region there described.

II. A threefold connection of θ and c Orionis is described—

1. $\Delta\alpha$ -49^s, -72^s, -79^s, -81^s, -68^s -46^s;
$\Delta\delta$ $+430''$, $+720''$, $+900''$, $+1130''$ $+1440''$, $+1780''$.
2. The middle and faintest band is described.
3. The 3d is also described. The name *Paeninsula Cysati* is proposed for the region the co-ordinates of whose middle point are $\Delta\alpha = -56^s$, $\Delta\delta = +490''$.

———: See DOBERCK.
DAWES: Mon. Not. R. A. S., viii, p. 31. [New star.]
DENNING: A. N., lxxx, col. 299. [Ten stars in and near trapezium.] See SALTER.
DE VICO: Mem. Oss. Coll. Romano, 1839, p. 31, Plates i and ii. [Drawing; new stars in trapezium.]
———: Same, 1840–'41, p. 22. [Plate by RONDONI.]
———: C. R., xiii, p. 449. [Note on RONDONI's drawing.]
DOBERCK: A. N., xci, col. 335. [Remarks on COOPER's drawing.]
———: Nature, vol. xvii, p. 311. [D'ARREST's work on nebulæ.]
DOPPELMAYER: Himmels-Karten, Blatt 26.
ENGELMANN, R.: Messungen 90 Doppelsternen, etc., p. 147. [Variability of stars.]
FAYE: C. R., vol. lx, 1865, i, p. 468. [Remarks on SECCHI's observation of the spectrum of the nebula in Orion.]
FLAUGERGUES: C. T., 1802 (An xi), p. 361. [Observations.]
———: Mem. de l'Institut, i (An vi), 1798, p. 106.
GILL: Mon. Not. R. A. S., xxvii, p. 315. [Stars within the trapezium of Orion.]
GLEDHILL: The variable (?) star *h* No. 78, near the trapezium of Orion. Observatory, 1880, p. 601.
GOLDSCHMIDT: A. N., lix, col. 31.
HAHN, VON: B. J., 1797, p. 157; B. J., 1799, p. 235
[HALL]: Wash. Ast. Obs., 1877, App. I. Observations, etc., of Σ. 748.
HERSCHEL, J.: Results of Astronomical Observations at the Cape of Good Hope, p. 25. [With a plate.]
———: Account, etc., of the nebula of Orion. Mem. R. A. S., vol. ii, p. 487. [With plates.]
———: Mem. R. A. S., vol. iii, p. 189. [Fifth star of the trapezium.] See also same vol., p. 187.
HERSCHEL, Capt. J.: Proc. R. S., vol. xvi (1867–'68), pp. 417, 451. [Observations of spectrum.]
HERSCHEL, W.: MSS. in possession of Royal Society, London. [Unpublished observations.] See Mem. R. A. S., vol. xxxv, p. 52. [There is an erratum in the Mem. R. A. S.: For 1780. 521 read 1780. 134 and for 22″.41 read 22″.521.]
———: refers to the nebula of Orion in P. T., 1782, p. 129; 1785, p. 258; 1789, p. 249; 1791, pp. 72, 75, 77; 1811, pp. 276, 320; 1814, p. 258.

HOLDEN: Mon. Not. R. A. S., vol. xxxvii, p. 231. [List of drawings.]
———: Washington Astronomical Obs., 1874, plate vi, fig. 4. [Drawing.]
———: Washington Astron. Obs., 1877, Appendix I. [Discussion of HALL's observations of Σ. 748.]
HOOKE: Micrographia, London, 1665, p. 242. [Discovery of the 4th and 5th? stars in trapezium.]
HUGGINS: On the spectrum of the great nebula in Orion. Proc. R. S., xiv, 1864, p. 39; also, 1865, Jan. 26.
———: Ditto, ditto. Proc. R. S., xx, 1872, p. 379.
———: Ditto, ditto. Proc. R. S., xxii, 1873, p. 251.
———: Mon. Not. R. A. S., xxvi, p. 71. [Nine stars in trapezium.]
———: Am. Jour. Sci., 3d series, v, p. 75.
———: P. T., 1868, p. 541. [Spectrum.]
HUYGHENS: Systema Saturnium. 4°. 1659. [Drawing.] See KAISER.
KAISER, F.: Amster. Tijdsch. v. Wiss. en Nat. Wetens, i, 1848, p. 7. [HUYGHENS' drawing, 1694.]
———: De Sterrenhemel, vol. ii, Plate 3, pp. 538, 542. [Original drawing.]
LALANDE: Astronomie, i, p. 272. [With a figure, MAIRAN's.]
LAMONT: Ueber die Nebelflecken. Munich, 1837. 4°. [With a plate.]
LAPLACE: Exposition de la Système du Monde, p. 452. [Opinion that nebulæ change.]
LASSELL, W.: Observations of the nebula of Orion, etc. Mem. R. A. S., xxiii (1854), p. 53. [Plate.]
———: Proc. R. S., xvi, p. 322. [Measures of stars.]
———: A. N., xxxv, col. 386.
———: Mon. Not. R. A. S., xiv, p. 74.
———: Mon. Not. R. A. S., xvii, p. 68. [Relative visibility of 5th and 6th star in trapezium.]
———: Mon. Not. R. A. S., xxii, p. 164. [New star in trapezium.]
———: Mon. Not. R. A. S., xxix, p. 165.
LEFEBVRE: ROZIER Obs. sur la Physique, xxii, 1783, p. 34. [With drawing.]
LEGENTIL: Remarques sur les Etoiles nébuleuses. Hist. de l'Ac. Roy. des Sciences, 1759, p. 453 [with several figures].
LESUEUR: Proc. R. S., xviii, pp. 1, 242. [Spectrum.]
———: Proc. R. S., xix, p. 18. [Spectrum.]
LE VERRIER: C. R., vol. xliv, 1859, pp. 1074, 1293–5. [PORRO's new star in nebula of Orion.]
LIAPONOFF: See STRUVE.
———: Mon. Not. R. A. S., vol. xxiii, p. 228. [Review of his memoir.]
LONG: Astronomy, vol. i, p. 321, Plate 67, Fig. 96. [Observations and drawing.]
MAIRAN: Traité de l'Aurore Borèale, [p. 249; nebula Orionis varies in shape; date of PICARD's drawing given as 1673, March 20. MAIRAN's drawing (Fig. xxvii), 1727–1733.]
MESSIER: Nébuleuse d'Orion. Hist. de l'Acad. R. des Sciences, 1771, pp. 435, 458. [Drawing.]
NICHOL: System of the world, 1846, p. 55. [Lord ROSSE's observations.]
NOBILE: Osservazione del systema 748 Σ. Rendiconte d. Ac. d. Sci., 1877, May, No. 5.
POND: On an appearance hitherto unnoticed in the nebula of Orion. Mem. R. A. S., iii, 1826, p. 93. [Recession of the nebula from the stars.] (See also same volume, p. 187, for an observation of J. HERSCHEL and RAMAGE on this point.)
PORRO: Mem. dell'Osserv. Coll. Romano, 1856–'57, p. 3. [Discovery of a new star in trapezium.]
———: A. N., xlvi, col. 171. [Same.]
———: C. R., xliv, p. 1031. [Same.]
ROBINSON: Nature, vol. xv, p. 292. [Note on the resolvability of the central part of nebula Orionis.]
RONDONI: See DE VICO.
ROSSE (Fourth Earl of): Account of observations on nebula of Orion, 1848–1867, P. T.; 1868, part i, p. 57 [Plates.] For a review of this, see O. STRUVE in V. J. S., 1870, p. 25.
———: Mon. Not. R. A. S., xxix, p. 165.
SALTER: A. N., lxxx, col. 299. [Ten stars in and near trapezium.]
SCHMIDT: A. N., vol. xciii, col. 78. [Places of G. P. B. Nos. 746, 784, 822. 822 is certainly variable; at least between 9.7 and 13 mag.]
SCHROETER: Aphroditographische Fragmente, p. 248. [Has a chart and memoir.]
———: Beyträge zu den neuesten astron. Entdeckungen, vol. iii, p. 429. [With figures.]
———: B. J., 1797, p. 198. [Observations.]

SCHROETER: B. J., 1801, p. 128. [Changes in nebula of Orion.]
SECCHI: Mem. dell'Oss. Coll. Romano, 1852–'56, p. 80, p. 92, and Plate v. [Drawing.]
———: Mem. dell'Oss. Coll. Romano, 1856–'57, p. 3. [New star in trapezium.]
———: Bull. Meteor. d. Coll. Romano, 1865, January.
———: Acc. d. Nuovo Cimento, serie 2ª, vol. v–vi, 1872, p. 20. [The solar Corona is brighter than the nebula of Orion.]
———: Atti dell'Ac. d. N. Lincei, Anno xxv, sess. iv, 1872, p. 226. [Spectrum.]
———: Sulla grande nebulosa di Theta Orione. 1868. 4°. Mem. Ital. Soc. Firenze, vol. i. [Memoir; drawing; spectrum.]
———: A. N., xlv, col. 60. [Sketch of nebula of Orion.]
———: Mon. Not. R. A. S., vol. xviii, p. 8.
———: Mon. Not. R. A. S., xxv, p. 153. [Spectrum.]
———: Mon. Not. R. A. S., vol. xxviii, p. 162; xxix, p. 165.
———: C. R., xliv, p. 1279, and xlv, p. 170. [PORRO's new star.]
———: C. R., lx, pp. 460, 543. [Spectrum.]
———: C. R., lxv, p. 63.
———: C. R., lxvi, p. 643. 1868. [Spectrum, etc.]
———: Sugli Spettri Prismatici. Mem., i, ii, iii.
SENARMONT: C. R., xliv, pp. 1075, 1294. [PORRO's new star.]
SMITH: Opticks. 4°. [HUYGHENS' drawing.]
STONE, E. J., and CARPENTER: Mon. Not. R. A. S., xxiv, p. 92. [On G. P. BOND's drawing of nebula of Orion.]
STRUVE, O.: Obs. de la grande nébuleuse d'Orion, avec 4 planches. Mem. de l'Acad. Imp. des Sciences de St. Petersbourg, tome v, No. 4, 1862. See M. M., ii, p. 517. [Abstract of above memoir.]
———: Bull. de la Classe Phys.-Math. de l'Acad. Imp. de St. Petersbourg, xvi, 1858, col. 113.
———: M. M., iii, p. 535. [Observations at Malta.]
———: M. M., iii, p. 550. [Variability of nebula of Orion.]
———: Mon. Not. R. A. S., xvii, p. 225. [Stars.]
———: Bestimmung d. Constante der Praecession, p. 40. [Proper motion of θ Orionis.]
———: V. J. S., 1870, p. 25. [Review of the memoir of Lord ROSSE.]
STRUVE, W.: Rapport sur les observations de LIAPONOFF sur la nébuleuse d'Orion. Bull. de la Classe Phys.-Math., vol. xii, p. 316, and Mélanges Math., ii, p. 45.
———: Catal. Nov. Stell. Duplic., 1827, p. xiv. [Discovery of 5th star in trapezium.] Also, p. 242. [System of θ Orionis.]
TEMPEL: A. N., lviii, col. 240. [Drawing.]
———: A. N., lxxx, col. 29. [Trapezium.]
———: Unpublished drawing, made in 1876.
TISSERAND: Bull. Inter. Obs. Paris, 1876, No. 119; also, C. R., lxxxi, April 17, p. 891.
TROUVELOT: Annals Harv. Coll. Obs'y, vol. viii. [Drawing.]
———: Wash. Ast. Obs., 1874, Appendix I, Plate vi, Fig. 4. [Drawing.]
VICO: See DE VICO.
VOGEL, H. C.: A. N., lxxviii, col. 245. [Spectrum.] Also, Bothkamp Observations, vol. i, p. 56.
VON HAHN: B. J., 1797, p. 157.
———: B. J., 1799, p. 235.
WEBB: Intellectual Observer, vol. xii, p. 258. [History.]
———: Mon. Not., R. A. S., xxvi, p. 208. [Account of his drawings and observations.]
WINLOCK: Astronomical Engravings from the Observatory of Harvard College, Plate 24. [Drawing of central part by TROUVELOT.] See Annals Harv. Coll. Obs., vol. viii.
WINNECKE: Mélanges Math., iii, p. 499, and Bull. de l'Ac. Imp., vii, p. 18.
———: Mon. Not. R. A. S., xxiv, p. 7. [New stars near θ Orionis.]
WOLF, C.: Sur la variabilité des nébuleuses. Association scientifique de France, No. 535, 1878, February 3, p. 277. [History of the nebula of Orion.]
WOLF, R.: J. B. CYSAT von Luzern, 1853.
———: A. N., xxxviii. col. 109.

List of Telescopes employed to observe the Nebula of Orion.

Observer.	Date.	Telescope.	Aperture, inches.	Focus, feet.	Maker.
Cysat . . .	1618	Refractor .	?	6, 10	?
Huyghens . .	1656–94	Refractor .	2.33	12 or 23	Huyghens.
Hooke . . .	1665	Refractor .	3.5	36	Hooke.
Picard . . .	1673	Refractor? .	?	?	?
Mairan . . .	1731	Refractor .	?	7, 18, 22	?
Long	1742	Refractor .	?	17	Long.?
Legentil . .	1758	Reflector .	?	6	?
Messier . . .	1771	Refractor .	3.33	3.5	Dollond.
W. Herschel .	1774 to 1811	Reflectors .	4½ to 48	5½, 7, 10, 20, 40	Herschel.
Lefebvre . .	1779	Reflector .	?	3½	?
Schroeter . .	1794–98	Reflectors .	6 to 19	7, 13, 27	Herschel, Schräder,
J. Herschel .	1824, 1837	Reflector .	18½	20	Herschel.
Pond	1826	Reflector .	.	26	Ramage.
Lamont . . .	1839	Refractor .	10.5	15	Frauenhofer.
De Vico . . .	1839	Refractor .	6½	7½	Frauenhofer.
Kaiser . . .	1844	Refractor .	6	?	?
Cooper . . .	1847	Refractor .	13.2	25	Cauchoix.
Lassell . . .	1847, 1854	Reflector .	24	20	Lassell.
W. Bond . . .	1848	Refractor .	15	23	Merz.
Liaponoff . .	1847	Refractor .	10	16	Merz.
O. Struve . .	1851	Refractor .	15	23	Merz.
Schmidt . . .	1861	Refractor .	6	6?	Dollond.
Lassell . . .	1862	Reflector .	48	37	Lassell.
Secchi . . .	1862–68	Refractor .	9.6	14	Merz.
Webb	1863	Refractor .	5	5	A. Clark.
G. P. Bond . .	1865	Refractor .	15	23	Merz.
Webb	1867	Reflector .	9.4	?	With.
Bird	1866	Reflector .	12	?	Bird.
Lord Rosse . .	1867	Reflector .	72	55	Rosse.
D'Arrest . .	1872	Refractor .	10.5	15	Merz.
Trouvelot . .	1874	Refractor .	15	23	Merz.
Trouvelot . .	1875	Refractor .	26	32	A. Clark & Sons.
Keeler . . .	1878	Refractor .	2.5	?	?
Holden . . .	1874–80	Refractor .	26	32	A. Clark & Sons.
Langley . . .	1879	Refractor .	13	?	Made by Fitz and re-figured by A. Clark.
Draper . . .	1880	Refractor .	11	?	A. Clark & Sons.
Holden . . .	1881	Refractor .	15.5	20	A. Clark & Sons.

I.—HISTORY OF THE VARIOUS RESEARCHES ON THE NEBULA OF ORION IN CHRONOLOGICAL ORDER.

The drawings and memoirs are here considered in chronological order. First a wood-cut of the original drawing is given, followed by extracts more or less copious relating to the observations. These wood-cuts were made in the following way: Good prints of the original drawings were selected and photographed on a scale of one English inch, equal to the distance between the stars G. P. B. 685 and 741; the scale

is thus about 1 inch = 129″ of arc. The copying-lens used produced no appreciable distortion. The wood cuts have, however, never been used as evidence. A set of photographic prints of the original drawings has been constantly used for comparison and for suggestions as to doubtful points. In every case reference has been made to the original drawing (when possible), or to the original engraving or wood-cut. The negatives so made were used to transfer the photograph on to wood, and the various revises of the cuts have been again compared with the original publication. They are therefore tolerably faithful representations of their originals, and will serve to recall them to those readers who have not these originals at hand.

As they are nearly all on the same scale, and as the drawings made by reflectors have been inverted so as to present the appearances as seen in a refractor, they are all immediately comparable (except a few of the figures which, for special reasons, are on other scales), and they are interesting on account of the enormous differences at once apparent even among the more modern drawings.

Everything relating to the Huyghenian region I have attempted to give fully, generally in the words of the author. Many of the memoirs contain, beside the records of original observations, a discussion of the results obtained by others, and these I have usually given in the words of the authors. Thus the discussion of the various drawings is partly completed in the progress of the work. I have resumed this discussion in the light of the Washington observations. By including these discussions, the admirable *résumés* of 'Liaponoff, Struve, D'Arrest, and others, are available for immediate reference.

It was first formally pointed out by Professor Wolf, of Zurich, that Huyghens was not, as commonly supposed, the first discoverer of the nebula of *Orion*,* but that this distinction must be assigned to Cysat of Luzern, who saw it in 1618, 38 years before Huyghens published his account of it. It is now just visible to the naked eye under good circumstances, but it does not appear to have been seen by any of the early astronomers, not excepting the acute Abdel Rahman al Sûfi, who was acquainted with the nebula of *Andromeda* before A. D. 950.

Cysat speaks of his discovery as follows:

"Caeterum huic phaenomeno similis stellarum congeries est in firmamento ad ultimam stellam gladii Orionis, ibi enim cernere est (per Tubum) congestas itidem aliquot stellas angustissimo spatio et circumcirca interque ipsas stellulas instar albæ nubis candidum lumen affusum."† This observation of Cysat's is mentioned by Bessel in the *Berliner Jahrbuch*, 1808, p. 122.

OBSERVATIONS OF HUYGHENS.

Although Huyghens was not the first observer of the nebula of *Orion*, yet his discovery was made independently. His account of it is given in the *Systema Sat-*

Astronomische Nachrichten, vol. xxxviii, col. 109, and "J. B. Cysat von Luzern." 4°. Bern, 1853.

† Cysat *Mathemeta Astronomica de Cometa Anni* 1618, p. 75.

urnium (1659, p. 8), with a figure which I have reproduced from the original work.* HUYGHENS says that in examining the stars of the sword of *Orion* in 1656 with a telescope† he perceived, instead of the three stars commonly known, twelve in all, of which three were close together, and four others which shone "as if through a cloud," so that the space around them appeared much brighter than the rest of the sky, which was serene and quite black, so that the appearance was produced of looking *through an opening*. All this he saw many times still unchanged in the same spot, and he concludes that this wonderful thing, whatever it may be, has there a place, apparently forever; the like of it he has never seen among the fixed stars. It will be observed that this figure, in the original, is uniformly shaded throughout, so as to appear to represent a uniform brilliancy in the nebula.

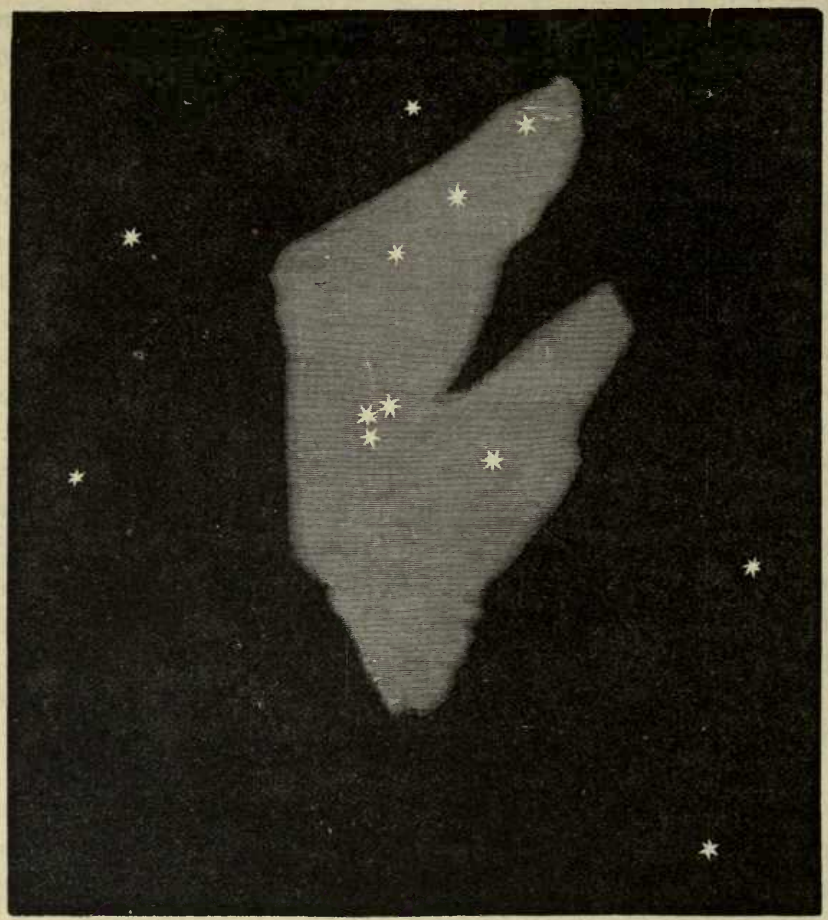

FIG. 1. HUYGHENS, 1656.

It appears that HUYGHENS' observation did not escape HOOKE, for we find the following reference to this object in his *Micrographia*. For this reference I am indebted to the courtesy of HENRY B. WHEATLEY, esq., assistant librarian of the Royal Society of London, to whom all matters relating to the activity of HOOKE are familiar through his long study of his life.

"In that notable asterism also of the sword of Orion, where the ingenious Monsieur HUGENS VAN ZULICHEM has discovered only three little stars in a cluster, I have, with a 36-foot glass, without any aperture [diaphragm] (the breadth of the glass being about some three inches and a half), discovered five, and the twinkling of divers others up and down in divers parts of that small milky cloud."‡

* For access to a fine copy of the original work I am indebted to Professor NEWCOMB.

† ARAGO in *Annuaire du Bureau des Longitudes*, 1842, p. 268, states that the telescopes of HUYGHENS of 12 and 23 feet had an aperture of 2⅓ inches (63 m. m.), and magnified 48, 50, and 92 diameters.

‡ *Micrographia*, by ROBERT HOOKE, folio, London, 1665, p. 242.

HOOKE's 12-foot telescope magnified 74 diameters, according to ARAGO (*op. cit.*, p. 269), and it is likely that even a higher power was used on the 36-foot.

Whether HOOKE really saw the fifth star of the trapezium, and the question as to how faint stars can be seen in the nebula with an aperture of 3 5 inches, I have discussed at length in Washington Astronomical Observations for 1877, Appendix I, "On the Multiple Star Σ 748," and the observations are given at length later in this work, The conclusions reached there are that from HOOKE's language in the *Micrographia*, as well as from an entry in the MS. journal of the Royal Society of London (which is discussed by Sir JOHN HERSCHEL in Mem. R. A. S., vol. III, p. 189), no other stars than the fourth and fifth stars could have been meant by HOOKE; and yet, that the observations made with the 26-inch refractor at Washington, with its aperture reduced to 3.5 inches, show that the 5th star cannot now be certainly seen with a telescope superior to HOOKE's. The obvious conclusion from these two facts, if accepted, is that the fifth star is now fainter than in HOOKE's day (1666). I am not prepared to assert this, although I know of no way of explaining HOOKE's early observation other than that which I have stated. HOOKE must have had the original of Fig. 1 before him, and "three little stars in a cluster" are only to be found in the trapezium. These three HOOKE declares to be five.

OBSERVATIONS OF HUYGHENS (1694).

In an account of HUYGHENS by KAISER* is a description of HUYGHENS' observations on this nebula, and a drawing found among his MS. is given, which we reproduce in Fig. 2.

"On the 8th of January, 1684, he first perceived that the group of stars in the nebula of *Orion* in which, up to this date, he had only been able to make out three stars with difficulty, was composed of four. Beside this note we find in HUYGHENS' journal another observation. This is the very last astronomical note made by HUYGHENS.

"HUYGHENS discovered, in the year 1656, the nebula in the constellation of *Orion*, which, in later times, has been productive of so much research and speculation. That nebula was represented by him in his *Systema Saturnium*, page 8, and is there exhibited as a spot of irregular shape over which the light is equally distributed. HUYGHENS certainly did not know of how much importance a correct representation of the nebula, made in his time, would be to astronomers in later years, and it is nearly certain that it could not have appeared so uniformly illuminated, or with such distinct edges as he has indicated.

"Not long after HUYGHENS had published his discovery, a new representation of the nebula was given to the world by PICARD† which coincides in many respects with that of HUYGHENS, but which ascribes to the nebula different external form. A century after HUYGHENS, LE GENTIL gave two illustrations which neither coincided with each other nor with the representations of HUYGHENS and PICARD, and differing widely from the beautiful illustration produced a few years after by MESSIER, in which the nebula

* *Tijdschrift voor de Wis-sen Naturkundige Wetenschappen*, vol. i, 1848, p. 7.

† I believe this was never published, but was communicated in MS. to GODIN.

was represented for the first time as flowing and spreading, and with the light unequally distributed. The differences between all these drawings, between themselves, as well as with the later efforts of SCHRŒTER and HERSCHEL seems to indicate that the nebula underwent great variations; from these one might even infer a doubt as to its very existence.

"The younger HERSCHEL, however, did not allow himself to be misled by this seeming contradiction. He knew the difficulty of producing a correct representation of such an object, and from the illustrations given by his predecessors, which were probably made with imperfect means, he came to the conclusion that the nebula of *Orion* had undergone no considerable change since its discovery. For our knowledge of the higher regions of the heavens is certainly not so definite as to assure the possibility of indicating undemonstrable variations in the nebulæ; and every contribution which can serve to confirm or oppose HERSCHEL'S ideas about the nebula of *Orion* may be considered as an important gain to science.

"Such a contribution HUYGHENS left us in his last astronomical note. This contains a representation of the nebula of *Orion*, until now entirely unknown, drawn with the pen in his journal of the 4th of February, 1694. There is certainly no more intractable instrument than a writing pen for giving an illustration of such an object, and yet the drawing of HUYGHENS expresses to us something of the form of its most illuminated portion and the play of its edges, with the relations of the surrounding stars. Of all the old drawings this approaches much more nearly the present appearance of the nebula in *Orion*, which is favorable to the younger HERSCHEL'S opinion. HUYGHENS did not indicate the telescope with which he made this observation; but it was most probably with that of 44 feet in length, which he had had constructed a short time before at his Hofwyk station at (or near) the Hague, which was a new and most suitable instrument.

"We can be very certain that the illustration was not made by measurements, and therefore, to make the matter clear, can allow ourselves a slight variation between the present relative position of the stars in the nebula and their position as given by HUYGHENS.

FIG. 2. HUYGHENS, 1694.

"The illustration, with a brief note, forms the contents of the last page of HUYGHENS' journal. We think we are subserving a not unimportant use in presenting a very exact reproduction of the page, in order to make this communication complete."

This drawing of HUYGHENS is very precious, since it is a fac-simile of the rough sketch in his note-book, untouched by the engraver. On it we find the trapezium correctly laid down. The *Sinus Gentilii* is plainly indicated; the *Sinus magnus* also, and the three stars [G. P. B. 685, 708, 741] are outside the light. Even the true *north* edge of the *Sinus magnus* is indicated, while the boundaries of the unshaded portions are similar to the appearances

seen to-day in small telescopes. The angle between the *frons* and *occiput* is 116°; in LE GENTIL'S drawing (1758), Fig. 6, it is 129°. Its value to-day is about 91°. The angle between the *occiput* and the *north* side of the *Huyghenian region* is according to HUYGHENS, Fig. 2, 110°; in LE GENTIL'S, Fig. 6, 118°; to-day it is about 120°.

OBSERVATIONS OF MAIRAN (1731).

In *Traité de l'Aurore Boréale* (1733), p. 248, MAIRAN notes that HUYGHENS used telescopes 22¼ Paris feet in length, and that HUYGHENS declares that it was only with such that the nebula of *Orion* was well seen. MAIRAN asserts, however, that he saw it in 1733 with a 7-foot telescope, from which fact he deduces the inference that it is denser [brighter] than in HUYGHENS' time. "Quant à sa figure, je crois aussi qu'elle varie; et c'est qui m'a été confirmé par deux astronomes [MM. GODIN et GRANDJEAN DE FOUCHY] que j'avais prié d'y regarder avec moi. . . . . M. GODIN m'a communiqué de plus un dessin et une observation manuscripte de M. PICART de 20me mars 1673, oú la forme extèrieure de cet espace lumineux diffère de celle de M. HUYGHENS." . . . . . After describing the position of the nebulous star n. f. θ Orionis [G. P. B. 757], MAIRAN proceeds (p. 249), "la figure xxvii représent ces objets renversés et tels qu'ils m'ont parus le plus souvent depuis cinq à six ans avec une lunette de 18 et de 22 pieds." PICARD'S (from Hist. del 'Acad., 1759, Plate 21, Fig. 5), and MAIRAN'S figures are given in Figs. 3 and 4. In 1733 the original MS. drawing of PICARD was in existence, and MAIRAN refers to it as a proof that the "*exterior form*" differs from that given by HUYGHENS. His own figure represents the "exterior form" uniformly filled with nebulosity.

FIG. 3. MAIRAN, 1731.

FIG. 4. PICARD, 1673.

OBSERVATIONS OF LONG (1742).

ROGER LONG, of Cambridge, author of "Astronomy, in five books" (1742), was also an observer. In vol. i, p. 321 *et seq.*, [Plate 67, Fig. 96], we find his account of the nebula of Orion: "HUYGHENS, who first discovered this wonderful appearance, as he justly calls it, has given us a draught of it, but the stars are all drawn nearly of equal magnitude, and the luminous space is more defined than it ought to be; which faults were, in all likelihood, owing to the mistakes of the engraver. I have, therefore, in figure 96, given another scheme of it, such as I have often seen it through a telescope of 17 feet, and have expressed therein the apparent magnitudes of the several stars."

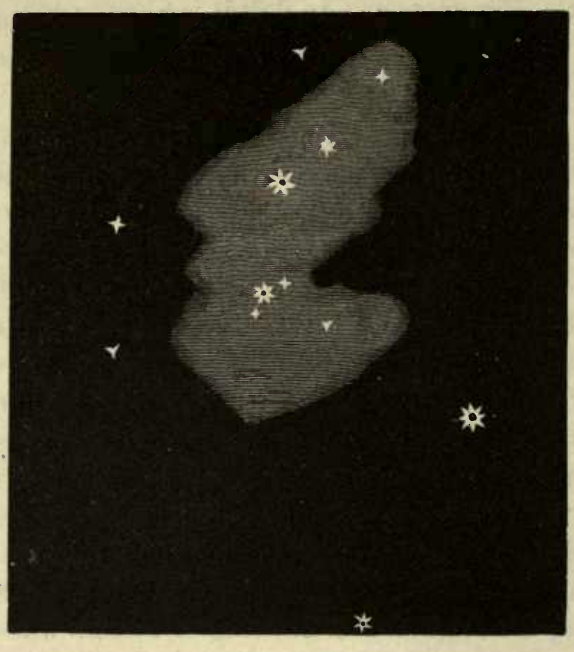

FIG. 5. LONG, 1742.

OBSERVATIONS OF LE GENTIL (1758).

A memoir read to the French Academy of Sciences July 26, 1758, by LE GENTIL, is the first in which a proper attention was paid to the observations of the details of a nebula, and it is indeed somewhat surprising to remark how carefully LE GENTIL's observations were made and how cautiously his conclusions were drawn. He had observed, in common with others, that the representations of the nebula of *Orion* by HUYGHENS and PICARD did not agree, and he adduces in this paper evidence to show that the nebula in *Andromeda* had also varied in brilliancy; so that he says, "Y seroit-il en effet arrivé quelque changement, ou ne pourroit-on pas attribuer cette grande différence . . . . aux différentes longueurs des lunettes dont on se sera servi. . . .?" "C'est ce qui m'a engagé à employer les plus courtes et les plus longues lunettes que j'ai pu avoir à ma disposition, pour comparer ensemble les différens effets que j'en pourrois tirer."

"Ainsi nous avons tout lieu de croire que la plus grande partie de la différence qu'on trouve entre la description de SIMON MARIUS et celle que j'ai faite de la nébuleuse d'Andromède, vient de la différente longueur des lunettes dont nous nous sommes servis."

LE GENTIL remarks that the nebula of *Orion*, as seen by him with various telescopes for several years, also varied considerably in form, and he gives his observations in detail. March 10, 1758, he observed, in company with M. JOLY and M. PINGRÉ, with a gregorian telescope of 6 feet, and this observation was repeated with the same telescope on the 3d of April. The drawing [Fig. 6] was made by LE GENTIL from observations with this telescope, and *afterwards compared with the heavens.*

The *Sinus Gentilii* is there laid down distinctly, and faint nebulosity is described extending towards the north. This is the *Regio Picardiana* of HERSCHEL. It is to be remarked that LE GENTIL'S figure is not equally bright throughout, but that it is brightest along the following side of the *Sinus Gentilii*, along the *frons* and along the north shore of *Sinus magnus*. An inspection of a good print of this engraving will show that in the meridian of the star [G. P. B. 708] the end of the brighter part of the *frons* is shown [the point B of LIAPONOFF, the following point of Q in the index-chart], and that the trapezium is situated on nebulosity of the same kind as that near the northern limit of his drawing round star [G. P. B. 479 ?], which nebulosity he expressly describes as "faint." So much is at once evident, on a careful inspection of all the prints I have been able to see. I was at first inclined to suppose with Sir JOHN HERSCHEL that "these older representations are mere curiosities and present no points of exact resemblance," and that, therefore, such a shading as I describe was merely an accidental impression. I have frequently recurred to this drawing, not being able to believe that when so careful an observer as LE GENTIL expressly set about discovering whether the changes in the older drawings of this nebula were not due to a difference in the telescopes employed, he should be content to leave so extraordinary a figure of it as his witness of its shape in his day

On examination of his figure with a magnifying glass, the explanation of the varied brightness of different parts of his drawing is at once manifest. He attempts to represent three grades of brilliancy, according to his own account: 1st, the brightest central portions; 2d, the fainter northern portions near the star [479?] and near the *Sinus Gentilii;* and 3d, the black background of the heavens. The copper-plate engraver working most probably under LE GENTIL'S own eye, has chosen to represent the brighter nebulosity by wavy parallel lines about a sixtieth of an inch apart; the lines run completely across the whole picture, over the black ground of the heavens as well as over the *Huyghenian region.* The nebulosity which LE GENTIL in his memoir explicitly declares to be "faint," the engraver represented by putting in a faint black line between each pair of the waved parallels, thus diminishing the brightness of the engraving. Various parts of the central portion not explicitly declared by LE GENTIL to be faint, are, however, shaded precisely the same way, and these parts are in general those which to-day are faint. I have submitted this drawing to experienced engravers, and I am informed that there is no manner of doubt but that the engraver of this drawing

FIG. 6. LE GENTIL, 1758.

intended that the portions in question should be fainter. I also can have no doubt but that the astronomer so drew them in his sketch, which was "verified at the telescope," and from which the engraver worked. This drawing, so considered, will give us important testimony, and it extends our knowledge of the central portion of the nebula back from MESSIER (1771), formerly considered the first trustworthy drawing, to 1758. It has been said that LE GENTIL gives PICARD'S figure also, and it will be found on a similar examination of PICARD'S drawing that a portion of the *Regio subnebulosa* is on that figure represented as fainter by the same conventional sign, and professional engravers assure me (as, indeed, any one can convince himself by the use of a magnifier), that this is not accidental, but designed. HUYGHENS' figure is likewise given by LE GENTIL, but this is represented of equal brilliancy throughout, as was done in HUYGHENS' original plate. It thus becomes necessary to examine the evidence with regard to the drawing of PICARD. I consider these points quite important. To see how conclusive the proof is an examination of these figures should be made with a magnifier. The original drawing of PICARD was made March 20, 1673, and was communicated with a manuscript observation by GODIN to MAIRAN in 1731, or about that time. No account is given of the "observation," but MAIRAN refers to this figure (but does not reproduce it), which he adduces to prove that "*la forme extérieure*" is different from his own. MAIRAN'S own drawing is uniformly shaded throughout. LE GENTIL speaks of MAIRAN'S copy of PICARD'S figure, as follows: "M. MAIRAN se fonde encore sur un dessin de M. PICARD, dans lequel *la forme extérieure* de cet espace lumineux diffère assez de celle que M. HUYGHENS nous a laissée du même espace." In the explanation of his various figures LE GENTIL says, Fig. 5: "Nébuleuse d'Orion suivant M. PICARD." There is nothing said of borrowing the figure or original drawing from MAIRAN. It is impossible, at this day, to decide whether LE GENTIL had access to the original drawing of PICARD or not. My own idea is that he had. I shall, however, treat the drawing of PICARD in both ways: 1st, as if MAIRAN'S figure was correct; 2d, as if LE GENTIL'S figure (including the fainter portions) was so. In this way we may arrive at some conclusion.

FIG. 7. Drawing made at Washington through tourmaline plates.

"Nébuleuse d'Orion telle que je l'ai vue le 10 mars et le 3 avril 1758, au soir avec un télescope de 6 pieds de longueur; l'ouverture A B *c* m'a paru de 65 degrés environ, et les trois étoiles inférieures paroissent faire, avec le côté *c*D, un angle de près de 40 degrés." The angle which LE GENTIL called about 40° is about 50° to-day. The stars of this drawing are [G. P. B., Nos. 741, 708, 685, θ, 969, and 479??].

During 1877 I made a number of sketches of the nebula through tourmaline plates, so as to reduce the light at will. One of these is given in Fig. 7 (see my observations of 1877, February 3). One made 1877, January 30 (not given here), strikingly resembles Fig. 6, with one exception, *viz*, Fig. 6 puts the trapezium on darker ground; my drawing puts it on brighter ground.

If we regard PICARD's, HUYGHENS', and LE GENTIL's drawings as simple evidences of the *exterior* shape of the nebula in their times (1656, 1673, and 1758), we can best examine MAIRAN's idea of a change in "la forme extérieure" by superposing these. Fig. 8 shows the result of a superposition of the three drawings. The true positions of the stars are denoted by a dot surrounded by circle; PICARD's positions by a dot and a square; HUYGHENS' by a dot and a circle of dots; LE GENTIL's by a dot and a triangle. HUYGHENS' outline is given by a dotted line; PICARD's by a broken, and LE GENTIL's by a full line.

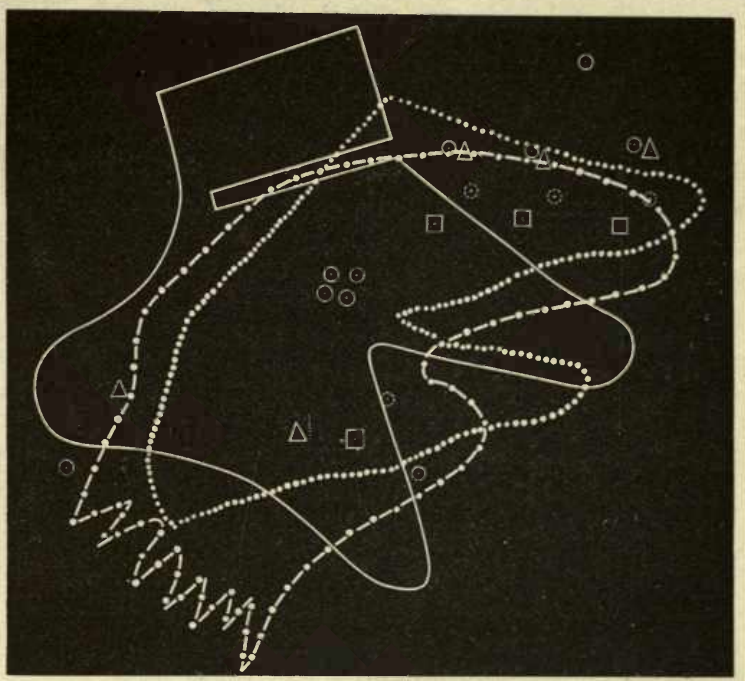

FIG. 8. Comparison of the drawings of HUYGHENS, PICARD, and LE GENTIL, (uncorrected).

If we correct the distortion of each drawing by means of the true positions of the stars; *i. e.*, if we suppose that those portions of the nebula near a star are correctly drawn, while portions distant from stars are distorted by the same proportional amounts as the star positions, then we shall have outlines like Fig. 9. In this figure it is seen that HUYGHENS* and PICARD agree as to "la forme extérieure," as we should expect, since their telescopes were, in all likelihood, sim-

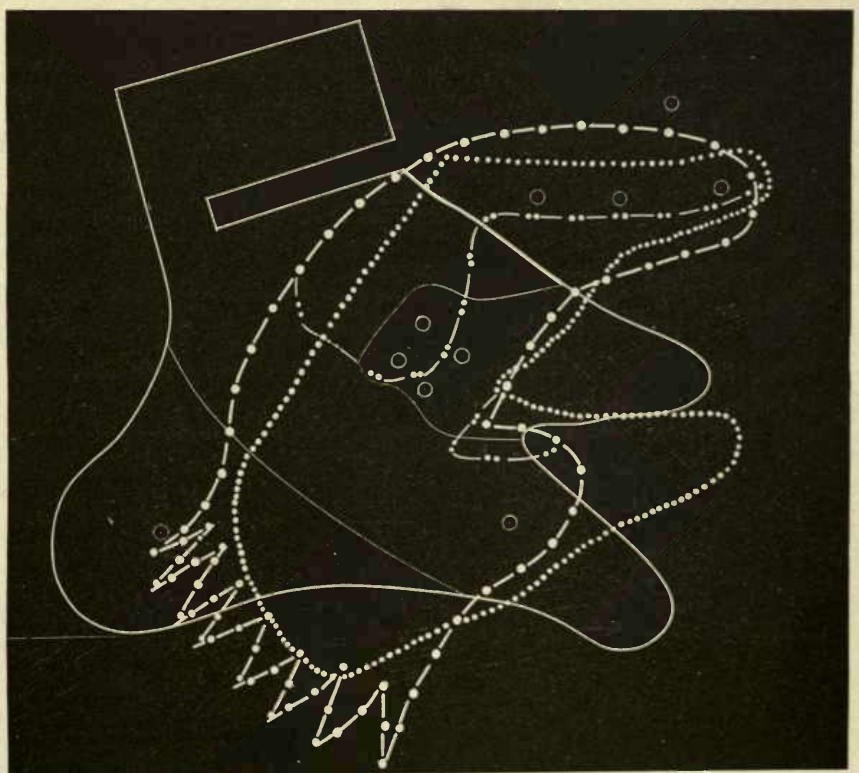

FIG. 9. Comparison of the drawings of HUYGHENS, PICARD, and LE GENTIL (corrected).

*A comparison of Fig. 1 and Fig. 9 shows that it is probable that HUYGHENS began his drawing of 1656 too near the right hand side of the paper he was using.

ilar. The bounding lines of LE GENTIL do not agree with the others. His telescope was quite different in power from that of HUYGHENS.

On Fig. 9 I have also put the bounding lines between the faint and bright portions of the nebula, as given by PICARD (broken line with two dots) and LE GENTIL (full lines, faint). There is no marked agreement, but it is to be noted that PICARD, thus corrected, agrees even more closely than before with both of HUYGHENS' figures.

I have not included HUYGHENS 1694 and MAIRAN 1731 in these comparisons, as they would yield no additional evidence, but simply confuse the drawing.

OBSERVATIONS OF MESSIER (1771).

The observations and drawing of MESSIER are thus described by himself:

"Le dessin de la nébuleuse d'Orion, que je présente à l'Académie a été tracé avec le plus de soin qu'il m'a été possible. La nébuleuse y est représentée telle que je l'ai vue plusieurs fois avec une excellente lunette achromatique de trois pieds et demi de foyer, à triple objective, portant 40 lignes d'ouverture [3.33 Paris inches] qui grossissoit 68 fois. Cette lunette [a été] faite à Londres par DOLLOND. J'ai examiné cette nébuleuse avec la plus grande attention par un ciel entièrement serein : savoir,

Les 25 et 26 février 1773; Orion au méridien.

Le 19 mars entre 8 and 9 heures du soir.

Le 23 entre 7 and 8 heures.

Les 25 et 26 du même mois, à la même heure.

Ces observations combinées et les dessins rapprochés les uns des autres, m'ont mis à même de rendre avec soin et précision sa forme et ses apparences.

Ce dessin servira à reconnoître, dans la suite des temps si cette nébuleuse est sujette à quelques changemens. Il y auroit déjà lieu de le présumer: car, si on compare ce dessin avec ceux donnés par messieurs HUYGHENS, PICARD, MAIRAN et avec LE GENTIL on y trouvera un changement tel qu'on auroit peine à se figurer que ce fût le même. * * * * *

Le jet de lumière, dirigé de l'étoile no. 8 à l'étoile no. 9 passant à côté d'une petite étoile de la dixième grandeur, étoit extrêmement *rare*, ainsi que la lumière dirigée vers l'étoile no. 10 et celle qui y est opposée où sont les huit étoiles contenues dans la nébuleuse: * * * * * *"**

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* *Mém. de l'Acad. des Sci.*, 1771, p. 458.

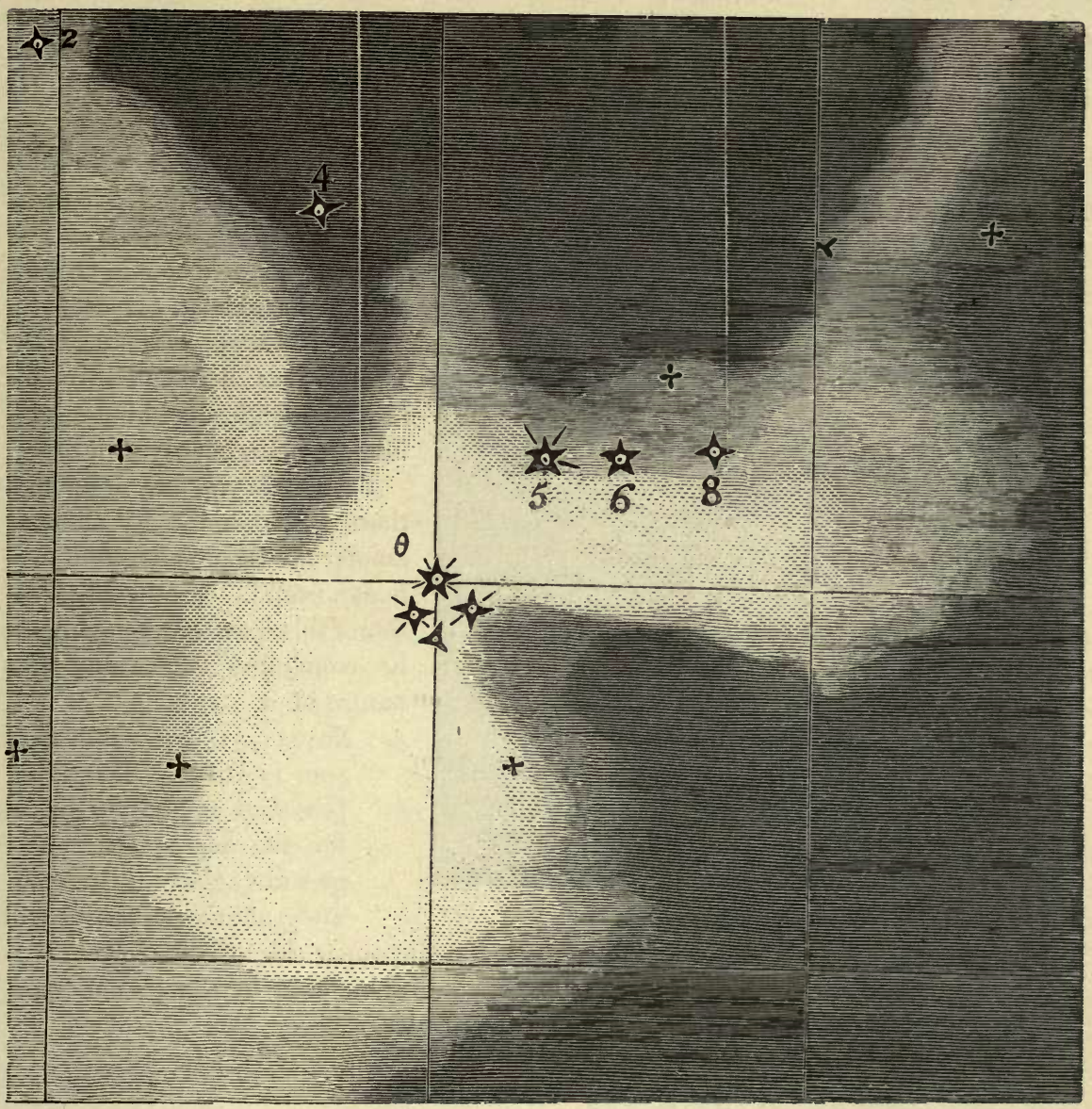


FIG. 10. MESSIER (1771).

It may be remarked of this figure that the star-positions are quite erroneous, and therefore the shape of the nebula as a whole is somewhat distorted. Unfortunately MESSIER'S erroneous star-positions not only affect his own drawing, but those of SCHROETER (1794) also, who took MESSIER'S stars as a basis for his own drawing.

The synonyms of some of MESSIER'S stars are given below:

MESSIER'S Number.	BOND'S Number.	Remarks.	MESSIER'S Number.	BOND'S Number.	Remarks.
1	467		6	708	
Star.	49⁻	Not numbered.	Star.	724	Not numbered.
2	505		7	734	
Star.	449	Out of place in R. A.	8	741	
Star.	479		Star.	784	Not numbered.
Star.	523		Star.	822	Not numbered.
4	570		9	843	
5	685		10	848	

OBSERVATIONS BY SIR WILLIAM HERSCHEL (1774 TO 1811).

(*From the original papers in possession of the Royal Society, referred to by Sir J. F. W. Herschel in vol.* 154 *of the Phil. Trans., p.* 6, *No.* 2.)

[These papers were kindly put at my disposition by Sir GEORGE AIRY and by Professor STOKES, secretaries of the Royal Society, during a visit to London in 1876.]

FIG. 11.* HERSCHEL (1774).

"1774, March 4. [*Journal No.* 1.] Saw the lucid spot in Orion's sword through a 5½ feet reflector; its shape was not as Dr. SMITH has delineated in his Optics, though something resembling it, being nearly as follows:

From this we may infer that there are undoubtedly changes among the fixed stars, and perhaps, from a careful observation of this spot, something might be concluded concerning the nature of it.

5. Nov. 11, [17]76 The lucid spot in Orion. The figure [see page 27] is only drawn for the description. The greatest glare is immediately about the four small stars. The 3 stars 1, 3, 4, were almost (on the upper side of this figure) free from any glare. There was a total darkness in the corner by the 4 small stars.

The stars 1, 2 [685, 628], were of one size,
those 3, 4 [708, 741], of the next,
the two 5, 6 [640, 619], considerably less,
7 [669], very small,
8 [624], rather smaller still.

Instrument, 10-feet reflector; power only 120, but very distinct.

6. Jan. 25th, [17]78. See figure, page 6. A tollerable (*sic*) exact delineation of the 10^h to 12^h lucid spot At the eastern side the rays seem to make an equilatteral (*sic*) triangle with the stars 1 and 3 [685, 708]. It goes on in the direction 1, 3, 4 [685, 708, 741], rather approaching to 4 [741]; at 4 [785] it bends round in an angle of about 110° or 120° towards the east.

From two [628] to 7 [669] the lucid part is concave; the concave part being turned towards 3 [708]. It goes to the northward about ¾ of the distance from 2 to 7 beyond 7. From thence it turns to the west in an angle of about 75 or 70 deg.

* This figure is not given in Journal No. 1, but a reference is there made to the *Phil. Trans.*, 1811, from which the cut is copied.

6. Jan. 26, [17]78 6, 2, 1 [619, 628, 685], make a straight line [*so in* 1879].
6, 8, 7 [619, 624, 669], make a straight line [*not so*, 1879].
4, 5, 8 [741, 640, 624], make a straight line [*so in* 1879].
The lines 2, 5 [628, 640], and 1, 3, 4 [685, 708, 741] diverge.
5 [640], a little larger than 6 [619] [*so in* 1879]

7. Feb. 7, [17]78. The situation of the 4 stars in the lucid spot agrees perfectly well with the observation of Jan. 25.

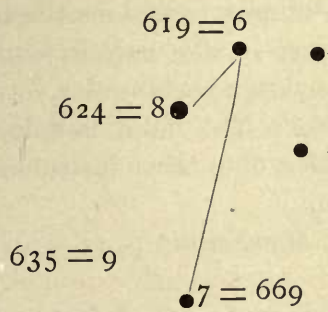
? —— 25, [17]78. No change in the situation of those 4 stars to be observed. [*Paper torn here so that the date is illegible*].

7 Dec. 15, [17]78, 6, 8, 7 [619, 624, 669], a straight line [*not so*, 1879]
6, 2, 1 [619, 628, 685], a straight line [*so in* 1879].
4, 5, 8 [741, 640, 624], a straight line [*so in* 1879].
The lines 2, 5 [628, 640] and 1, 3, 4 [685, 708, 741] diverge.

This agrees exactly with Jan. 26, but there is a visible alteration in the figure of the lucid part.

28. Oct'r 7, [17]79. θ Orionis see Fig., p. 6. The line 6, 2, 1 [619, 628, 685] is a little convex towards 5 [640], when that line is taken into the middle of the field; this I mention, as it is possible there might be a little curvature arising from the spherical figure of the eye-glass, tho' I believe there is not. If a line be drawn from 6 [619] to 7 [669], the star 8 [624] stands outwards, I suppose, no less than 15°, so that 6, 8, 7 [619, 624, 669] is concave towards the side 1, 3, 4 [685, 708, 741] [*so in* 1879].

The line 4, 5, 8 [741, 640, 624], I cannot very well compare, being rather too far distant by the power I now use, but I believe it is not far from a right line. I see a 9th star, which is marked in the annexed figure. [*This figure gives* 1 = 685; 2 = 628; 3 = 708; 4 = 741; 5 = 640; 6 = 619; 7 = 669; 8 = 624; 9 = 635. *The numbers of three figures are* BOND'S.]



where, however, not the least exactness is intended.

Altitude about 26 degrees, 14^h 10′. The figure of the lucid part is very much altered

43. Dec. 5, [17]79. 6, 2, 1 [619, 628, 685] concave, *vid.* page 6 and 28. The concave part turned to the south. 8, 6, 7 [624, 619, 669], still make an angle at 6 [619], tho' very small. I see the 9th star [635] mentioned page 29.

45. Jan. 22, 1780, 10^h 30′. The stars 6, 1, 2 [119, 628, 685] instead of seeming concave towards the north appear convex. This may, however, be a deception, as the star 2 [628] is the largest, and since there is a pretty strong aberration on account of a fog, its diameter is more encreased than that of 6 [619], and, consequently, may give the balance towards the north.

46. Feb. 19, 1780. Exactly as described, page 28.

46. Feb 28, 1780. The two stars 6, 2 [619, 628], page 6, measure $22 - 20\frac{1}{2} = 20\frac{1}{2}$ parts $= 12''.812$. The measure is pretty narrow, but I believe true enough. The two stars 2, 5 [628, 640] measure $24\frac{1}{3} - 1\frac{1}{2} = 15''.208 - .937 = 14''.271$. This is also a pretty narrow but just measure. The two stars 6, 8 [619, 624] measure about $16 - 1\frac{1}{2} = 14\frac{1}{2} = 9''.062$. But this is doubtful on account of the obscurity of the star 8 [614] which is hardly perceptible when the field of view is illuminated properly so as to make the parallel hair very distinct. The two stars 5, 8 [640, 624] measure $34\frac{1}{3} - 1\frac{1}{2} = 21.458 - .937 = 20''.521$. This is also doubtful on the same account. [*N. B. A new reduction of these measures, with the value* 1 *part* $= 0''.6251$, *shows no change to be required in the hundredths of seconds.*]

81. Oct. 10, 1780. The upper stars concave by the hair. The spot extremely fine. The 4 stars all full, round, and well defined.

84. Nov. 24, 1780. I view the nebula in the highest perfection. I perceive not the least change.

319. Jan. 31, 1783. The nebulous part is quite different from what it was last year. The 9th star [635] very strong, the nebula about it and the 7th (669) being much dispersed.

432. Sept. 20, 1783. Has evidently changed its shape since I saw it last, 20 ft., 200.

441. Sept. 28, 1783. Nebula in Orion is surprisingly changed.

457. 15 Sw. Nov. 3, 1783. The nebula is beautiful, and I see several circumstances which I never observed with other instruments. Just close to the 4 stars it is totally black for the short space of a few seconds. In the open black part of the nebula is a small distinct nebula of an extended shape [*o π of the Index-Map*]. The eastern branch of the great nebula extends very far; it passes between two very small stars, and runs on till it meets a very bright star. The nebulous star below the nebula is not equally surrounded, but most nebulous towards the south. On the north of this lesser nebula is another smaller nebula joining to it, which is much fainter than the other, and it makes a rectangular corner by its meeting with the nebula surrounding the star. This faint nebula, as well as that contained within the dark part of the great one, other instruments did never show, and I suppose is not visible by them.

296. Sw. Oct. 16, 1784. The beginning of the nebula. 5 *Monocerotis*, p. 41′ 6″ n 0° 43′. R. A. 5^h 23′ 7″, P. D. 95° 30′.

Sweeping Journal No. 2. Dec. 20, 1784. 20 ft. The nebula as described, but moonlight, and therefore seemed to take hardly ¾° in extent.

Sweeping Journal No. 3. Feb. 13, 1785. I examined the nebula in Orion with a new 10 ft. reflector, and with long attention could just perceive my small, faint nebula in the dark part of the great nebula.

458. Sw. Oct. 5, 1785. A wonderful phenomenon.

510. Sw. Jan. 18, 1786. The nebula observed. The place brought to the present from the Connoiss. des tems is R. A. 5^h 24′ 49″, P. D. 95° 33′ (var. from 1769 to 1786 in R. A. 49″.8, in P. D. 1′ 1″.4).

528. Sw. Feb. 23, 1786. The 4 stars in the great nebula Orionis. 36 (υ) Orionis f. 3′ 11″, n 1° 56′, R. A. 5^h 24′ 42″, P. D. 95° 32′.

640. Sw. Nov. 28, [17]86. The nebula which I saw by the front view was so glaring and beautiful that I could not think of taking any place of its extent.

Rev. Jan. 14, 1801. Large X-foot telescope, power 120. As before described.

Rev. Feb. 11, 1806. Large 10 feet. The 4 stars are completely in the nebulosity. The 3 stars are intirely [*sic*] out of it with 270. With the double glass appearances are very different.

Rev. Feb. 4, 1810. 10 feet. The nebulosity is intirely [*sic*] of the milky kind, and extends a great way.

Rev. Dec. 31, 1810. 10 feet, double eye-piece. The 4 stars are within the nebulosity. The star No. 7 [669] (see the figure of Oct. 7, 1779) is upon the borders of the dark vacancy. I see No. 9 [635] very well. The little star between 3 [708] and 4 [741] is still within very faint nebulosity. [*This refers to 724 possibly, but I do not understand it.*]

The nebulosity reaches beyond 4 [741] as far as from 1 [685] to 4 [741] nearly It touches a very small star [793?], and from that star goes on to two very bright ones [843, 905?] in the direction from the small star [793?] to the preceding one [843?] of the two. The black space near the 4 stars is much contracted. The nebulosity from 1 to 4 is concave, the concavity being to the following side. The parallel is nearly in the line of 1, 3, 4 [685, 708, 741]. I can see 8 different condensations, notwithstanding the moon is very bright. The nebulous star [734] is pretty equally involved. It has the appearance of a star shining through a very faint mist. The star is a little larger than 4 [741]. The concavity from 2 [628] to 7 [669] goes beyond 7 [669].

Rev. Jan. 19, 1811. 10 feet. 2 of the 4 stars are within the nebulosity. No. 7 [669] is very near the borders of the black. The little star [724] between and following 3 and 4 [708, 741] is still within very faint nebulosity. The nebulosity reaches beyond 4 [741] rather farther than from 1 to 4 [628 to 741].

X feet. I perceive 7 or 8 different condensations. The place near the 4 stars is much contracted. The nebulous star is exactly what we might expect to see if a star were to shine through whitish nebulosity.

40 feet. 5^h 16′, B affected.
17′, B much affected.
22′, the 4 stars are intirely involved in nebulosity.

The 7th [669] and 9th [635] stars are very bright.

In the brightest part are four places brighter than the rest. I see the small detached nebula; it is extremely faint. It is between the corner and a small star. The star called nebulous is within a nebulosity nearly detached; but the small stars marked nebulous in the figure of the 4th of March, 1774, are free from nebulosity. There is a very small, nearly detached nebulosity north of the nebulous star. The nebulous star has some resemblance to a star shining through a very thin mist.

[*What follows, I suppose to be in Sir Wm. Herschel's handwriting. I suppose what precedes to have been written by his sister.*]

Rev. Mar. 13, 1811. 7 feet; double eye-piece. The following or rather the southern branch (for I find the parallel nearly in the line 1, 2, 3 [685, 708, 741]) goes towards the preceding star *e* [843] of the two large stars *d e* [905, 843], or rather a little preceding it, but it partly includes the star *e* and makes it appear a little nebulous. The light about the nebulous star *b* [734] is a little denser nearer the star than at a distance. A line from 5 [640] through 7 [669] goes to *b* [734], or rather a little south of it, and 7 is about ¼ of the distance towards *b*.

The star [724] south of 3 [708] and 4 [741] makes an equilateral triangle with them. The two large stars *d* and *e* [905, 843] are parallel to 1, 3, 4 [685, 708, 741], nearly. A line from the 4 stars parallel to 1, 3, 4 passes a little south of the small, formerly nebulous, star *c* [848]. There are many other stars connected with the nebula which I do not notice.

Rev. Mar. 15, 1811. 7 feet; double eye-piece. The northern branch is parallel to the stars *a b* [543, 734]. The nebulosity reaches nearly up to the stars *g*, *h* [570, 523].

A very faint nebulosity still joins the star *b* [734] to the northern branch, but *b* is more nebulous than the intermediate nebulosity. The southern nebulosity goes towards the star *e* [843], and some part of the very faint nebulosity incloses the star.

Rev. Mar. 16, 1811. 10 feet reflector. Power, 100. The stars 1, 3 are in the parallel; 4 is a very little south of their parallel. The nebulosity about *b* [734] is brightest about the star.

In *Philosophical Transactions*, 1802, p. 499, Sir William Herschel alludes to changes in the nebula of *Orion*, as follows:

"IX. *Of Milky Nebulosity.*

"The phenomenon of milky nebulosity is certainly of a most interesting nature; it is probably of two different kinds; one of them being deceptive, namely, such as arises from widely-extended regions of closely connected clustering stars, contiguous to each other, like the collections that construct our milky-way. The other, on the contrary, being real and possibly at no very great distance from us. The changes I have observed in the great milky nebulosity of *Orion*, 23 years ago, and which have also been noticed by other astronomers, cannot permit us to look upon this phenomenon as arising from immensely distant regions of fixed stars. Even Huyghens, the discoverer of it, was already of opinion that, in viewing it, we saw, as it were, through an opening into a region of light. (See *Systema Saturnium*, pages 8 and 9.) Much more would he be convinced now, when changes in its shape and lustre have been seen, that its light is not like that of the milky-way, composed of stars. To attempt a guess at what this light may be, would be presumptuous.

"If it should be surmised, for instance, that this nebulosity is of the nature of the zodiacal light, we should then be obliged to admit the existence of an effect without its cause. An idea of its phosphorical condition, is not more philosophical, unless we could show from what source of phosphorical matter such immeasurable tracts of luminous phenomena could draw their existence and permanency; for, though minute

changes have been observed, yet a general resemblance, allowing for the difference of telescopes, is still to be perceived in the great nebulosity of Orion, even since the time of its first discovery."

Sir WILLIAM HERSCHEL, in his "Astronomical Observations relating to the Construction of the Heavens," in the *Philosophical Transactions* for 1811, has a detailed discussion of his observations on the nebula of Orion, which I quote almost in full:

"In the year 1774, the 4th of March, I observed the nebulous star which is the 43d of the *Connaissance des Temps* [G. P. B., 734], and is not many minutes north of the great nebula; but at the same time I also took notice of two similar, but much smaller, nebulous stars: one on each side of the large one and at nearly equal distances from it [G. P. B., 543 and 848]. Fig. 37 [of the Plates to the *Phil. Trans.*, 1811, Fig. 11 of this work], is a copy of a drawing which was made at the time of observation. In 1783 I examined the nebulous star [734], and found it to be faintly surrounded with a circular glory of whitish nebulosity, faintly joining to the great nebula. About the latter end of the same year I remarked that it was not equally surrounded, but most nebulous towards the south. In 1784 I began to entertain an opinion that the star was not connected with the nebulosity of the great nebula of Orion, but was one of those which are scattered over that part of the heavens. In 1801, 1806, and 1810 this opinion was fully confirmed by the gradual change which happened in the great nebula, to which the nebulosity surrounding this star belongs. For the intensity of the light about this nebulous star had by this time been considerably reduced by the attenuation or dissipation of the nebulous matter; and it seemed now to be pretty evident that the star is far behind the nebulous matter, and that, consequently, its light in passing through it is scattered and deflected so as to produce the appearance of a nebulous star. A similar phenomenon may be seen whenever a planet or a star of the 1st or 2d magnitude happens to be involved in haziness; for a diffused circular light will then be seen, to which, but in a much inferior degree, that which surrounds this nebulous star bears a great resemblance.

"When I reviewed this interesting object in December, 1810, I directed my attention particularly to the two small nebulous stars by the sides of the large one, and found that they were perfectly free from every nebulous appearance; which confirmed not only my former surmise of the great attenuation of the nebulosity, but also proved that their former nebulous appearance had been entirely the effect of the passage of their feeble light through the nebulous matter spread out before them. The 19th of January, 1811, I had another critical examination of the same object in a very clear view through the 40-feet telescope; but notwithstanding the superior light of this instrument, I could not perceive any remains of nebulosity about the two small stars which were perfectly clear, and in the same situation, where, about thirty-seven years before, I had seen them involved in nebulosity.

"If then the light of these three stars is thus proved to have undergone a visible modification in its passage through the nebulous matter, it follows that its situation among the stars is less distant from us than the largest of the three, which I suppose to be of the 8th or 9th magnitude. * * * * From the very considerable changes which I have observed in the arrangement of its nebulosity, as well as from its great

extent, this inference seems to have the support of observation; for in very distant objects we cannot so easily perceive changes as in near ones, on account of the smaller angles which both the object and its changes subtend at the eye. The following memorandum was made when I viewed it in 1774: 'Its shape is not like that which Dr. SMITH has delineated in his Optics, although somewhat resembling it, being nearly as in Fig. 37; from this we may infer that there are undoubtedly changes among the regions of the fixed stars; and, perhaps, from a careful observation of this lucid spot, something may be concluded concerning the nature of it.' In January, 1783, the nebulous appearance differed much from what it was in 1780, and in September it had again undergone a change in its shape since January.

"March 13, 1811. With a view to ascertain such obvious alterations in the disposition of the nebulous matter as may be depended on, I selected a telescope that had the same light and power, which thirty-seven years ago I used when I made the above mentioned drawing; and the relative situation of the stars remaining as before, I found that the arrangement of the nebulosity differs considerably. The northern branch N still remains nearly parallel to the direction of the stars *a b* [543, 734]; but the southern branch S is no longer extended towards the star *d* [905]; its direction is now towards the star *e* [843], which is very faintly involved in it. The figure of the branch is also different; the nebulosity in the parallel P F of the three stars being more advanced towards the following side than it was formerly."

DISCUSSION OF THE VARIATIONS IN FORM, ETC., ACCORDING TO HERSCHEL.

In his memoir of 1811, Sir WILLIAM HERSCHEL recites three ways in which the nebula of *Orion* has changed between 1774 and 1811. These are:

(*a*) The stars 543 and 848 which were nebulous in 1774, as seen through a 5½-foot reflector, were afterwards, 1811, found to be free from nebulosity with a telescope of the same power, and no nebulosity could be detected about them even with the 40-foot telescope.

(*b*) The *Messierian* branch which, in the drawing of 1774, was directed towards star 905, in 1811 was directed toward the star 843, and

(*c*) The figure of the lucid part had altered; in particular the nebulosity in the direction of the parallel having moved further towards the east.

These points could scarcely be intelligently considered as long as we possessed only the very rough drawing of 1774, Fig. 11, as a record of HERSCHEL's observations. The conclusions of HERSCHEL, which are never to be lightly doubted, were, in this case, not easily examined, since no knowledge was at hand as to the instrumental means, the manner of observation, or the amount of time spent upon the subject.

The preceding copy of the observations in detail made by HERSCHEL upon the nebula, enables us to examine with more care the data upon which these conclusions rest. It must not be supposed, however, that all the evidence considered by HERSCHEL is there reduced to writing, since it is plain, from the memoir of 1811, that these were the merest notes which served to remind him of former work done. We have from these notes, however, a much more certain clue to the data really available to HERSCHEL himself, and we may with more confidence, though still with circumspection,

examine his conclusions. It must not be forgotten that Sir JOHN HERSCHEL has purposely omitted all the figures which accompany the memoir (1811) of his illustrious father from his "List of figured Nebulæ," in the Introduction to his General Catalogue of Nebulæ, as he says "they do not profess to be resemblances." It is quite true that so much as this is stated by Sir WILLIAM HERSCHEL, on page 272 of this memoir, but it is evident that we must partially except from this rule Fig. 37 of the nebula of *Orion*, for Sir WILLIAM HERSCHEL expressly says that the nebula was, in 1774, "nearly as in Fig. 37," and he proceeds to predicate a change of shape on evidence derived from this drawing.

The figure of this drawing is like a Greek Ω, and I have been able to reproduce its general shape by viewing the nebula (1875) through the small finder of the 26-inch refractor of the Naval Observatory ($2\frac{1}{8}$ aperture, magnifying power about 15 diameters), and M. TROUVELOT has made a sketch of this appearance, which roughly agrees with Fig 11. As is stated by SECCHI in his memoir of 1868, it is the very dark, straight channel between *nebula Mairanni* and the main nebula that determines the shape of some of the older drawings to be similar to that of a Greek *omega* with an elongated base.

In HERSCHEL'S figure the north base of the *omega* is not sufficiently extended toward the west to agree with the present appearance.

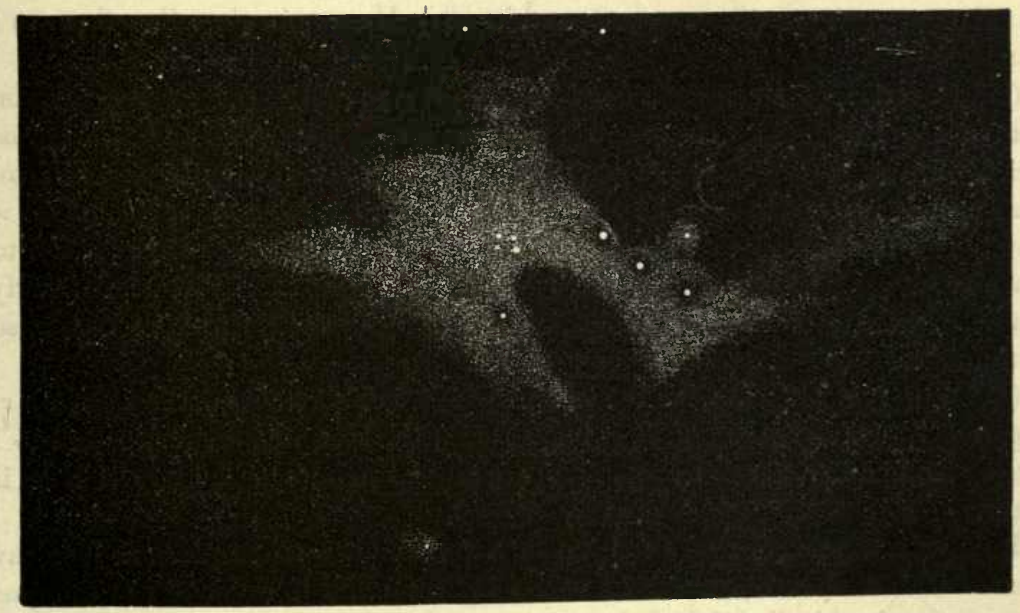


FIG. 12. KEELER, 1878.

The accompanying Fig. 12 (for comparison with HERSCHEL'S) was drawn by Mr. J. E. KEELER, instructor in physics at the Johns Hopkins University of Baltimore, January 23, 1878, with a telescope having an aperture of 2.5 inches; power, 75.

We may now consider the points (*a*), (*b*), (*c*) in detail. With regard to the first, which concerns the (formerly) nebulous stars 543 and 848, the MS. journal of observations enables us to see that, although the nebula was observed 33 times in all, in

no case is the nebulosity about these stars explicitly mentioned as observed, although its absence is remarked. Neither MAIRAN (1733), LONG (1742), LE GENTIL (1758), MESSIER (1771), LEFEBVRE (1779), nor SCHROETER (1794), mention this nebulosity, and however little negative evidence should in general avail, it would seem that here was sufficient to establish a strong probability, if not a certainty, that the observation of 1774 with the weak 5½-foot telescope was erroneous in ascribing a nebulous envelope to these two stars. It is to be noted that several of the above named authorities specially examined MAIRAN'S nebula (about the star 734), and the nebulosities about 543 and 848 could hardly have escaped them all. Moreover, the drawing bears the marks of being mainly a memorandum, as it is not possible to *certainly* identify all the stars without his description. The 5½-foot reflector was probably the first telescope that HERSCHEL himself made (in the winter of 1773–'74), and before this time he had not had extensive opportunities to familiarize himself with the appearance of nebulæ, so that, as STRUVE justly remarks (Obs. sur la nebuleuse d'Orion, page 97) this observation of 1774 is not of the same weight, as those made somewhat later.* The showing of nebulous halos to bright stars is a not uncommon defect of reflectors, and it seems quite possible, and in the light of contemporary work even probable, that some such accidental error is here recorded.

With regard to (*a*), then it seems probable, from a consideration of all the evidence, that no material change took place in the appearance of these stars from 1733 (MAIRAN) to 1794 (SCHROETER), and in 1811 HERSCHEL describes them to be as they now are.

(*b*). *Direction of the Messierian branch.*—In 1771 MESSIER figures this branch directed to (and including) the star 843, as does also SCHROETER in 1794. HERSCHEL describes it in 1774 as directed to 905, and as later he found it to be directed to 843, a change was supposed to have taken place. To admit HERSCHEL'S explanation would be to suppose the branch to have been in 1771 at the star 843, to have moved to 905 (distant about 4½′) by 1774 and back again to 843 by 1794. This is manifestly improbable, and the error arose in the defective drawing of 1774, which, as before, served only to mislead.

(*c*). With regard to the motion of the whole nebula toward the east, or rather that part of it in the parallel of θ', it is plain that the idea was first suggested to HERSCHEL by comparing his drawing of 1774 with the nebula as he saw it later in the heavens.

It may be at once declared that no such motion has taken place as his drawing, compared with modern observations, would indicate; but in order to test the question of any motion in this direction, I have excerpted from the various observations and drawings such details as bear on this and allied points, and they follow immediately after this paragraph.

* L'argument principal de W. HERSCHEL en faveur des changements, consiste dans son observation que la nébulosité qui entoure l'étoile de MAIRAN, lui a paru autrement disposée et beaucoup plus faible en 1810 qu'en 1774, et que deux petites étoiles situées dans le voisinage de l'étoile de MAIRAN avaient en 1810 entièrement perdu la nébulosité qu'il avait remarquée auteur d'elles en 1774. Évidemment de pareilles observations peuvent facilement avoir leur origine dans quelque défaut optique de l'instrument ou en d'autres déceptions; mais avec un observateur aussi consommé et circonspect que l'était W. HERSCHEL même cette remarque perdrait tout son poids, s'il n'y avait encore à considérer qu'en 1774 il ne possédait encore ni des instruments assez parfaits, ni l'expérience qu'il a gagnée plus tard.

SITUATION OF THE TRAPEZIUM WITH REGARD TO THE ADJACENT NEBULOSITY, ETC.

1656. HUYGHENS. The trapezium involved in nebula; the south ½ of *Sinus magnus* is filled with nebulosity. The north shore of *Sinus magnus* much as at present. 685, 708, 741 in bright nebulosity.

1673. PICARD. The trapezium much as in HUYGHENS as to *following* nebulosity. 628 and 619 are, however, in a dark space (V) surrounding them and extending toward the W. and S. The south ½ of *Sinus magnus* filled with *fainter* nebulosity: its *north* shore in the same general direction as at present. 685, 708, 741 in *fainter* nebula.

1742. LONG. The trapezium involved in nebulosity. The south part of *Sinus magnus* filled with nebulosity. The *north* shore much as at present. 685, 708, 741 in bright nebulosity: 724 free from nebulosity. The parallel of θ' is involved *east* of 708, but not so far as 741.

1758. LE GENTIL. The trapezium in a dark space (V). The western end of *Sinus magnus* filled with nebulosity; its *southern* ½ also nebulous. The line of its northern shore somewhat as a very small telescope shows it to-day; *i. e.*, with the s. f. corner of σ cut off. 685, 708, 741 are in darkness. The extreme northern star of the drawing is probably 479. The parallel of θ' is involved east of 708.

1771. MESSIER. The trapezium involved, the following star being just on the *preceding* edge of *Sinus magnus*. No darker space about trapezium. The parallel through θ' and following is involved in nebulosity from θ' to beyond 741; *i. e.*, the space called *Sinus magnus* at present has, according to MESSIER, its south part filled with nebulosity. The *north* shore is much as small telescopes show it to-day, the s. f. part of σ being cut off. 685, 708, 741 on the southern edge of the bright nebulosity, but in the darker part. The Messierian branch goes to 843.

1774. HERSCHEL (from the drawing). The trapezium is involved, but its two following stars are on the edge of the *Sinus*. The *north* shore of the *Sinus* is on the parallel of 619 and 640. The general *shape* of this gulf is much as it is to-day, but its situation is entirely different. 685, 708, 741 involved in bright nebulosity.

1776, Nov. 11. HERSCHEL (MS.). "The greatest glare is about" the trapezium. 685, 708, 741 "almost free from any glare." The *Sinus magnus* was totally dark.

1778, Jan. 25. HERSCHEL (MS.). "At the eastern side the rays seem to form an equilateral triangle" with 685, 708. ? At 741 "it bends towards the east at an angle of 110° to 120°", much as in MESSIER. The *north* shore of *Sinus magnus* is concave towards the *south*, different from MESSIER. The angle between the *south* and *east* shores of σ is about 75° to 70°. In MESSIER it is about 90°.

1783, Nov. 3. HERSCHEL (MS.). "Just close to the 'trapezium' it is totally black for the short space of a few seconds" (V). In the *Sinus magnus* "a small distinct nebula of an extended shape." (See observation of 1811, Jan. 19.)

1806, Feb. 11. HERSCHEL (MS.). Trapezium completely involved. 685, 708, 741 completely free.

1810, Dec. 31. HERSCHEL (MS.). 724 in "very faint nebulosity." "The black space near the four stars" (*Sinus magnus*) "is much contracted."

1811, Jan. 19. HERSCHEL (MS.). "2 of the 4 stars (of the trapezium) are within the nebulosity." The *Sinus magnus* "is much contracted."

I include the results of LEFEBVRE (1779) and SCHROETER (1797–'78) in this comparison.

1779. LEFEBVRE. The trapezium completely in the *Sinus magnus*. 685, 708, 741 free from nebulosity.

1794. SCHROETER. SCHROETER made his drawing of 1794 on a chart in which MESSIER'S positions of the stars were taken as a basis, and this at the outset will account for a considerable amount of distortion in the drawing. Thus SCHROETER'S drawing gives G. P. B. 523 about 50″ *west* of 479, while it is in fact *east* of 479 by over 150″. Hence, in a part of the nebula quite close to θ', we may expect misplacement of the various minor features by as much as 3′ in some cases. But when the features are important, and still more when two are to be compared which SCHROETER saw in the same field of view, we may rely with more confidence upon the drawing as it stands, and in nearly every case, though often only after much pains, I have succeeded in satisfying myself as to the portion intended to be represented.* From the drawing and text the following may be established:

The Messierian branch passes through 843; the three *following* stars of the trapezium are in a dark space (V). 685, 708, 741 are free from nebulosity.

The parallel through θ' and following it is entirely immersed in nebulosity; that is, the south ½ of what is now the *Sinus magnus* is nebulous.

The angle of 685–741, and the north shore of the *Sinus*, is 70°.

From all of this I conclude that HERSCHEL'S point (*c*) is not established.

OBSERVATIONS OF LEFEBVRE (1779).

ROZIER'S *Observations sur la Physique*, volume xxii (page 34 and Plate I, Fig. 3), for 1783, contains a letter to the Abbé ROZIER from M. LEFEBVRE, which I extract in full.

"OBSERVATIONS SUR LES NÉBULEUSES D'ORION; *par* M. LEFEBVRE, *Prêtre à l'Oratoire, Professeur de Physique du Collège de Lyon.*

"A l'occasion de la ressemblance que M. de MAIRAN soupçonne entre la matière de a lumière zodiacale, celle de l'aurore boréale et celle de ces nébulosités qui accompagnent quelques étoiles, j'ai eu la curiosité de revoir la nébuleuse de *l'épée d'Orion* dont la figure m'avoit toujours paru différente de celle qui lui ont donnée MM. HUYGHENS et de MAIRAN. La voici, telle que j'ai cru l'apperçevoir le 15 février 1779, par un ciel très-pur, à onze heures et demie du soir, ayant à-peu-près 17 degrés de hauteur. *Voyez Planc.* I, *fig.* 3 [our fig. 13].

"Les sept étoiles qui la composent m'ont paru entièrement hors du nuage, sur-

*If it were worth while a corrected drawing could have been made, as in the case of HUYGHENS, etc.

tout les trois inférieures qui laissoient entr'elles et le nuage un intervalle obscur bien tranché, à l'exception de celle qui en est la plus proche, qui peut me laisser quelque doute.

"M. de MAIRAN croyait déjà que, depuis 1756 [misprint for 1656] (temps de l'observation de M. HUYGHENS) cette nébulosité avoit éprouvé quelque changement. Il seroit aujourd'hui bien plus considérable, et surtout la position des étoiles, détachées du nuage, sembleroit indiquer qu'au moins la nébulosité n'est produite par aucune de ces étoiles. *Voyez les fig. de la Pl. I. La fig.* 1re *est celle de M. Huyghens, en* 1656. *La fig.* 2, *celle de M. Mairan en* 1725. (*Ces deux figures sont renversées.*) *La fig.* 3 *est droite, et représente la nébulosité, telle qu'elle a paru cette année* 1779, *observée avec un télescope de* 3½ *pieds.*"

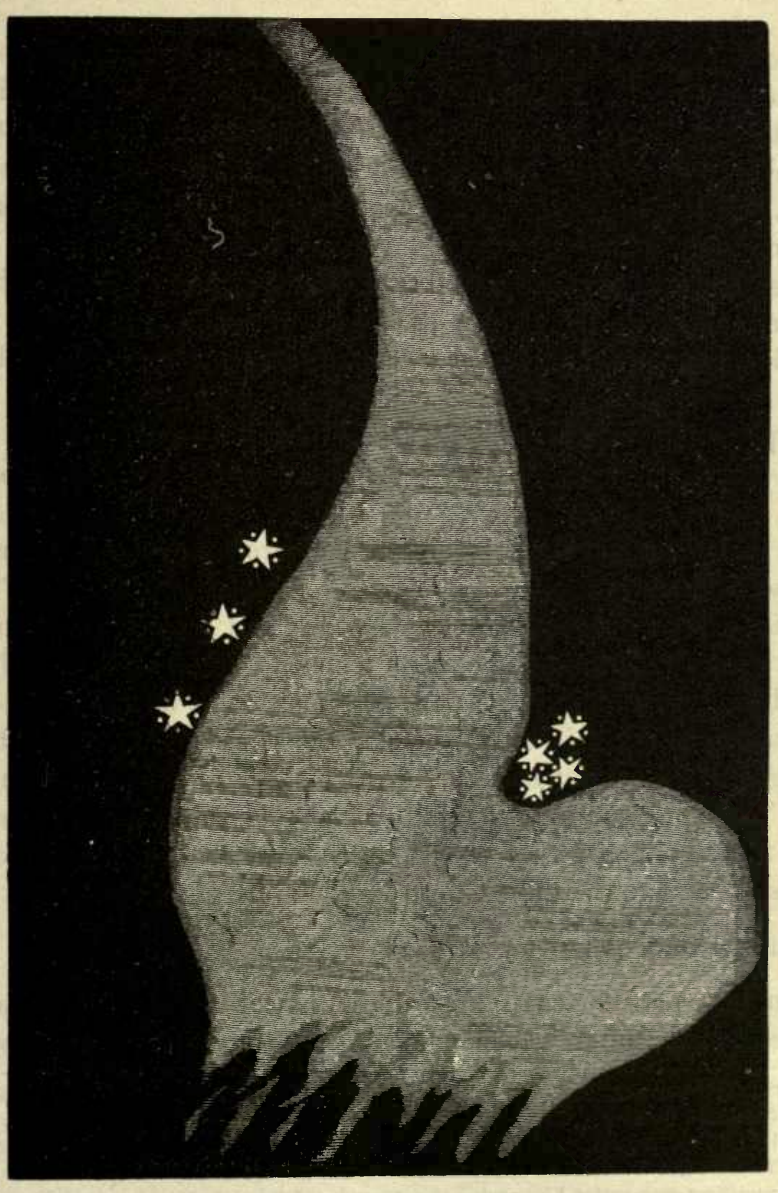


FIG. 13. LEFEBVRE, 1779.

This figure is but eight years later in date than MESSIER'S. and by no means so detailed. The principal differences and resemblances are as follows:

(*a*) Both have the *Messierian branch;* in LEFEBVRE the distance from *θ Orionis* to the end of this branch is 5 times the distance apart of stars 685 and 741 of G. P. BOND'S Catalogue [128″], while, according to MESSIER, the latter distance is 6 times the former;

(*b*) the stars 685, 708, and 741 are detached from the nebula in LEFEBVRE'S drawing, on the edge of it in MESSIER'S; the outline of LEFEBVRE'S drawing would nearly follow a line of equal light on MESSIER'S, except in the *Messierian branch;*

(*c*) the four stars of the trapezium are quite outside of all nebulosity in LEFEBVRE, quite inside according to MESSIER.

The angle of the opening ot the "jaws" is almost the same as given by LE GENTIL, namely, 75° in LEFEBVRE to 56° (LE GENTIL).

It is also noteworthy that LEFEBVRE uses the same conventional sign to represent a nebulosity gradually shading off to nothing, as does PICARD (see fig. 4), namely, the ragged and saw-shaped boundary. This drawing is hardly more detailed than HUYGHENS', although nearer the present shape of the nebula, as seen with very small telescopes.

OBSERVATIONS OF SCHROETER (1794–'98).

In BODE'S *Jahrbuch*, 1798, p. 198, SCHROETER has a few observations on the nebula in *Orion*, from which I quote. These observations are subsequently given in full, but the following notes will serve to settle one or two doubtful points in the subsequent accounts:

In "the central parts of MESSIER'S drawing" no less than 18 new stars were seen (Jan. 7, 1794), "und ausser diesen im Nebel nahë nord- und westlich bey den ein Trapezium bildenden 4 Sternen, Zwey kleine hellere Nebelflecken, in deren Mitte sich zwischendurch, ein hellerer doch sehr matten Nebelpunct zeigte. Auch haben Zwey gedachter 18 Sterne, gleich dem Huygenischen Nębelsterne, ihren eigenen vom übrigen getrennten Nebel um sich."

These "Zwey" *may* be *i* and *a* of his drawing of 1794 [Fig. 14], but of these only *a* answers to the description, and as no mention is subsequently made of a change it is quite likely that for *north* and *west* we should read *south* and *east* when *c* and *b* would be referred to.

I know of no other explanation. He also makes the following notes:

(1) 685, 708, 741 are in a dark space, different from MESSIER, 685 being just on the edge of the *Frons*.

(2) The *Sinus magnus* is darker than the surrounding background of the heavens.

(3) The *Proboscis minor* is described.

In the *Aphroditographische Fragmente* of SCHROETER (p. 243 and Plate II) may be found a *résumé* of his work upon the Orion-nebula, from which I quote largely, partly because this work is now difficult to obtain,* and partly because of its intrinsic value. As OTTO VON STRUVE has justly remarked in his memoir on the same nebula, no doubt can be entertained of the good faith of SCHROETER, nor of his general acuteness and accuracy as an observer. The apparent discredit into which his works have fallen seems to be largely due to the unwillingness of astronomers to follow him in his theoretical conclusions, and partly also to the diffuse form in which he gives them.†

"BEMERKUNGEN ÜBER ORIONS LICHTNEBEL.

"Verschiedene Augen mit verschiedenen Fernröhren bewaffnet, dürften zwar diesen merkwürdigen Lichtnebel unter verschiedenen Witterungs-und sonstigen

*I am indebted to the courtesy of President ELIOT, of Harvard University, and to the kindness of the authorities of Harvard College Observatory, for the use of the copy from which I quote.

†We find in Mem. R. A. S., vol. iii, p. 188, a foot-note to a paper of Sir JOHN HERSCHEL'S, in which his opinion of SCHROETER'S drawing of nebula Orionis is given, which we quote: "I have been guilty, I find, of a piece of involuntary injustice to M. SCHROETER in omitting to mention him among the observers of this nebula. I am indebted to my esteemed and admired correspondents, Dr. OLBERS and M. HARDING, for a reference to his *Aphroditographische Fragmente*, for his observations on this nebula; and the title of the work will plead my excuse for the omission. The representations of it there given are, however, so dreadfully bad as almost to convert the excuse into a justification * * * *"

Nebenumständen immer etwas verschieden sehen; bis jetzt sind wir aber in der Schöpfungskunde zu weit zurück, als dass es nützlich sein sollte, alle Bruchstücke von Beobachtungen solcher Art der Nachwelt zu umständlichern Vergleichungen, Prüfungen und Folgerungen aufzubewahren. In solcher Hinsicht können daher auch folgende Bemerkungen nützlich werden, die mit zwei vorzüglich lichtstarken Instrumenten, nämlich einem 13füssigen besonders aber mit dem 27füssigen Reflector angestellt sind.

"Bei der davon verfertigten Tab. II befindlichen Charte, die in der Gestalt und Begränzung des Lichtnebels von den bisherigen bekannten Zeichnungen merklich abweichet, habe ich die in des Herrn Prof. Bode Vorstellung der Gestirne Tab. XXX, fig. 6, mit enthaltene Zeichnung nach den Beobachtungen des Herrn Messier, in dem Unterschiede der Aufsteigung und Abweichung, jedoch nach einem grössern Maass-stabe zum Grunde gelegt, so dass diejenigen ältern, bisher darin bekannt gewesenen Sterne, bei welchen nichts zu bemerken vorgefallen, ohne Bezeichnung geblieben, die hinzugekommenen aber mit Buchstaben bezeichnet nachgetragen worden sind. Eine wirkliche mikrometrische Messung fand ich theils wegen der Feinheit und Dunkelheit der Gegenstände unsicher und fast unmöglich, theils aber auch für meinen Zweck überflüssig, weil ein im Schätzen geübtes Augenmaass in solchen Fällen oft sicherer ist. Um aber desto leichter die dunklern Sterne von den hellern zu unterscheiden und in der Folge wieder zu finden, ist die

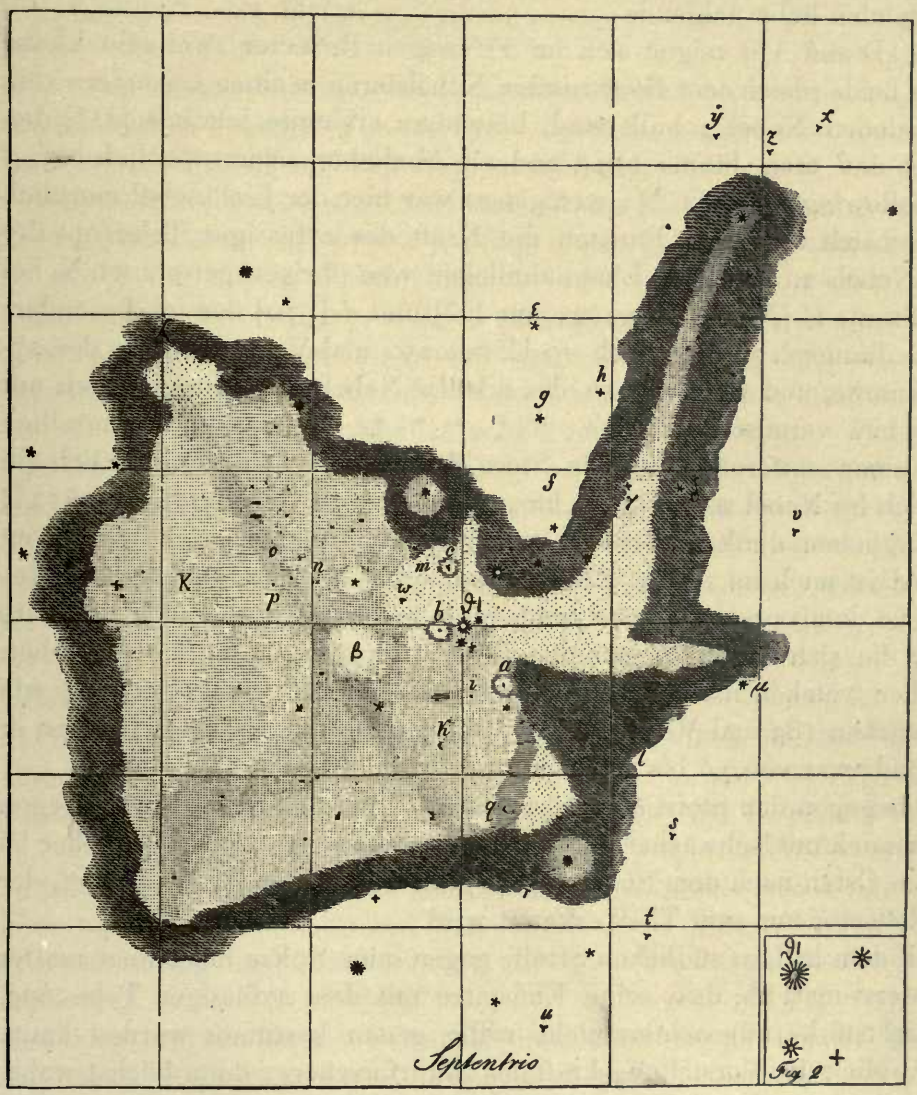


Fig. 14. Schroeter, 1794.

Characteristik der abnehmenden Lichtstärke, wenn sie auch gleich aus bekannten Gründen nur sehr beyläufig und einem veränderlichen Wechsel ausgesetzt sein dürfte, unter der Charte nach mehrern und wenigern Sternstrahlen ausgezeiget.

"Vornehmlich habe ich mich beflissen, die äusserst verschwachenen Gränzen und die Gestalt des hellern und schwächern Lichtnebels, die ich auch mit kleinern Telescopen und Vergrösserungen controliret und eben so gefunden haben, möglichst genau zu bestimmen.

"Nach diesen vorläufigen Bermerkungen sind die kleinen Sterne, welche ich bis jetzt ausser den von dem berühmten Astronomen Herrn MESSIER ausgezeichneten nach und nach gefunden habe, folgende:

"In *a* und *b* [D and A?] zeigen sich im 27füssigen Reflector zwei sehr kleine Kernpunctgen, die beide gleich dem *Huygenischen* Nebelsterne in einen besondern vom übrigen unterschiedenen Nebel gehüllt sind, besonders erkannte ich in *a* [D?] den hellern Nebelpunct den 6ten Jänner 1794, und ein ähnlicher schien westlich bey *β* durchzublicken [following part of C?]: wenigstens war hier der Lichtnebel merklich heller, und es schien sich in diesen Puncten die Kraft des 27füssiges Telescops der Auflösbarkeit des Nebels zu nähern. Einen ähnlichen vom übrigen getrennten Nebel haben die beiden Sterne C [Not in MESSIER; our E?] und *d* [570] den ich besonders deutlich den 7ten Jänner 1794, ab nach 10 U. mit 250 mal Vergrösserung des 27füss. Telescops erkannte, und von welchen des erstern Nebel sich blos nördlich mit dem übrigen Nebel zu vermischen schien. * * * * * Weiter fand ich nördlich zunächst unter θ_1 einen entfernten dunkeln Stern *i* [635] bei dem sich westlich ein etwas dunkler Strich im Nebel zeigte [W = lacus secchii] * * * * * *q* [650 + 653?] liegt in einem länglichen dunkeln Striche, welcher den östlichen Lichtnebel vom übrigen trennt und ist auch im 13füss. Refl. sichtbar. * * * * * Der Anblick des Lichtnebels selbst ist damit prachtvoll und erscheint in mehrere von einander getrennte Theile aufgelöset, die sich durch Zeichnung nicht ausdrücken, sondern nur sehen lassen, und zwischen welchen man die dunklere Himmelsluft unterscheidet. So wie er unter der lichtstärken 183 mal Vergröss. des 27füss Reflectors ins Auge fällt, ist er Zunächst bei θ_1, und zwar von $\gamma\delta$ bis nördlich unter *k* und *q* hin am hellesten.

Von *a* [D?] bis gegen den Stern *ζ* [843] sprosst von ihm ein langer Zweig gegen Süden ab, welcher auch mit schwächern Fernröhren sichtbar ist. Viel schwächer ist hingegen ein gegen Osten nach dem Stern *μ* [848] hin absprossender Lichtstrief, der mit dem 13füss. Reflector nur zum Theil erkannt wird.

Er fällt gleich dem hellern südlichen Streife gegen seine Spitze hin immer matter und zuletzt so äusserst matt ab, dass seine Endspitze mit dem 27füssigen Telescope, dessen grosser Lichtstärke ungeachtet, nicht völlig genau bestimmt werden kann. Reizend ist sein Anblick der Vorstellungskraft des Naturforschers: denn höchst wahrscheinlich hat er gleich dem südlichen Lichtstreife gegen unser Auge eine schräge Lage und erstreckt sich in einem unermesslich entfernten Himmelsraume bis zu einer Entfernung fort, die sich der Fasslichkeit des Beobachters entziehet. Eine ähnliche schräge Lage scheinet auch von θ_1 an bis zur Endspitze des lichtern Nebels *η* hin statt zu finden: denn auch heir wird ein gleicher matterer Abfall des Lichts merklich, und der Nebel fällt von *a* [D?] nach *η* hin eben so matt und unbegränzt, als nach *ζ*

[843] und μ [848] hin ab. Der westliche Nebel hingegen ist bei ι, χ, n, o, p, und β an sich sehr schwach jedoch von λ, χ, η an bis zur westlichen Gränze wieder etwas heller.

* * * * * * * * * *

Bemerkenswerth ist übrigens noch (I) dass θ_1 sammt die beiden östlichen folgenden Sternen, bei allen diesen Boebachtungen mit mancherlei stärken und schwächern Fernröhren gesehen, *nicht innerhalb, sondern ausserhalb des Nebels im dunkeln Raume* liegt, so dass der Lichtnebel nur durch den östlichsten streichet, da doch die ältern Zeichnungen diese Sterne innerhalb des Nebels setzen.

Unentschieden bleibt es freilich, ob der verdienstvolle MAIRAN, welcher damals schon urtheilte, dass Orions lichter Nebel seit HUYGHENS Zeiten einige Veränderung erlitten zu haben scheine [S. des Herrn DE LA LANDE Astronomie § 837], dieser Meinung ungeachtet nicht sorgfältig genug in der Zeichnung seiner Gestalt verfahren, oder auch zu schwache Fernrohre dabei angewandt habe: allein seine Zeichnung, welches die beiden hellesten solche 3 Sterne innerhalb des Lichtnebels setzt, weichet von der des Herrn MESSIER *zu auffallend* und selbst diese, welche gedachte drei Sterne ebenfalls innerhalb des lichten Nebels enthält, von der meinigen wieder, wenn gleich nicht auffallend, doch so viel ab, dass die unvergänglichen Namen eines MAIRAN und MESSIER die Zukunft zu einer desto sorgfältigern Vergleichung der bis herigen und künftgen Beobachtungen auffordern. Zumal da auch meine mit 7- und 4füssigen Telescopen und einem 10füssigen DOLLOND geschehenen Vergleichungen mit dieser Bemerkung übereinstimmen. Immer wird indess eine solche Vergleichung mit vieler Behutsamkeit blos auf das Wesentlichste zu richten sein, weil bei der verwachsenen Unbegränztheit dieses Lichtnebels wohl eben nicht zu erwarten ist, dass selbst gleichzeitige, mit gleichen Instrumenten versehene Beobachter seine Gestalt durchgehends *pünctlichst gleich* entwerfen würden."

SCHROETER, in a letter to BODE, dated December 10, 1797, published in BODE's *Jahrbuch* for 1801, p. 126, in referring to his observations of the nebula of *Orion* of 1797, says: "Eine gewiss merkwürdige Beobachtung ist, dass ich in Theilen fixer Nebel, nämlich des Nebels im Orion * * * wirklich zufällige Veränderungen wahrgenommen habe." The observations to which he refers, follow here.

In the iii volume of SCHROETER's "Beyträge zu den Neuesten Astronomische Entdeckungen," p. 149, there is found a long account of his "Beobachtungen über zufällige Veränderungen fixer Lichtnebel," from which I give the following synopsis setting forth his *observations* nearly in full, but in some cases abbreviating the account of *conclusions* reached.*

After a preliminary reference to the known variation in the light of some of the fixed stars, SCHROETER says: "For several years I believe I have made out similar variations in the remarkable nebula of *Orion*, and these variations I have seen not alone in its contained stars, but also in the nebulous matter itself." He remarks that deception in such things may easily arise, and that in order to be sure of variation it is

* In the copy of this work belonging to the Naval Observatory (1st ed., Göttingen, 1800), the paging is wrong *after* page 160 to the end of the book. The page after page 160 is numbered 149, so that the pages 149–160 occur twice. The references are to the pages *as printed.*

necessary to confine the attention to some of the smaller and well known parts—the parts being taken so small that they are equally bright all over—and to compare such parts not only among themselves, but also to the light of the neighboring small fixed stars, in order to discriminate the truth from delusion by frequent comparisons under all circumstances of observation and all atmospheric conditions. The result of such an examination is given in the figure in *Aphroditographische Fragmente* (our Fig. 14) from the comparison of which with earlier figures, SCHROETER came to the conclusion that some change had taken place. In reference to such conclusions further observations were made, which are given in great detail. The italics are SCHROETER'S own.

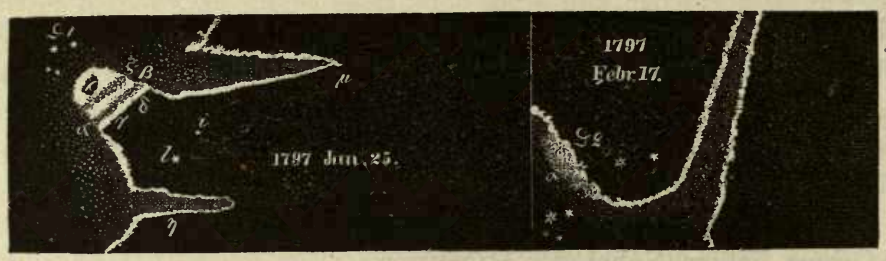


FIG. 15. SCHROETER, 1797.

January 25, 1797. The dark space (*Sinus magnus*) appeared to SCHROETER "uncommonly black, and darker than ever before," and "und es fiel mir als eine ganz neue, für die Folge wahrscheinlich sehr instructive Bemerkung höchst merkwürdig auf, *dass mir dieses Mal sofort mit dem ersten Blicke in diesem schwarzdunkeln eingreifenden Raume, ein neuer heller, aber äusserst matter Lichtstreifen ins Gesicht fiel. Er gieng nach Fig.* 1 (our Fig. 15) *von α bis β südlich zum Osten quer durch solchen ganzen dunkeln Raum*, und westlich von ε nach ζ schien ihm parallel, ebenfalls etwas Helles hinzustreifen." This observation was confirmed by HARDING, who saw it somewhat brighter than SCHROETER, who describes it as very faint, and seen only at intervals. "Gleich merkwürdig war es, *dass wir beide übereinstimmend in dem deutlichen östlichen Lichtstreifen α, β, und zwar in γ, δ, zwey äusserst matte, aber doch merklich hellere* Lichtpunctchen fanden, die uns als äusserst entfernte kleine dunkle Sternchen ins Auge fielen, und von welchen γ [ξ*o* of Index-Chart] das augenfälligste war. Aber auch das war nicht alles: denn eben so merkwürdig und lehrreich war es mir, *das ich etwas nördlicher, einen zweyten neuen eben so matten Lichtstreifen η entdeckte*, [*o π* of the Index-Chart??] *welcher östlich in solchen dunkeln Raum strich, auch* l *und* i *zwei feine matte Lichtpünctchen fand*, wovon *l* das augenfälligere, mein in der den Aphroditographischen Fragmenten angehängten Charte mit *l* bezeichnetes ist [781?].

Wer es bedenkt, mit welcher sorgfalt ich nicht nur Orions Nebel nach seinen kleinern Theilen überhaupt, sondern auch besonders den in ihn eingreifenden, *mir immer vorzüglich merkwürdig gewesenen*, so ausgezeichnet schwarzdunkeln Raum, Jahre hindurch, sowohl mit dem 27 als 13füssigen Reflector, bey der heitersten Luft gemustert hatte, der wird es selbst fühlen, dass ich gedachte drei Lichtstreifen sammt den Lichtpuncten γ, δ, und *i*, mit allem Grunde für *ganz neue Erscheinungen* halten musste, *weil ich bey allen jenen ältern Beobachtungen*, da ich zum Theil viel feinere weniger augenfällige Theile von Orions Nebel bemerkte, und seinen hineintretenden schwarzdunkeln Raum näher zu erforschen suchte, von diesen Erscheinungen *nicht*

die geringste Spur wahrgenommen hatte, die mir nun auf einmal und zwar sämmtlich in solchem kunkeln Raume zum Theil mit der erster Blicke ins Gesicht fielen."

* * * * * * * * *

1797, Feb. 17. The atmospheric and other conditions being as good as on the 25th of January, the nebula was not seen as on that date, but different in the following respects: both the streaks of faint light $\varepsilon\zeta$ and $\alpha\beta$ were seen, the first much better than on January 25, but in the eastern one, $\alpha\beta$, only the brighter northern point γ [ξo] was seen, while δ was invisible. Whatever the condition of the atmosphere, as SCHROETER justly remarks, either the western streak $\varepsilon\zeta$ had increased in light, or the small nucleus δ had diminished. Furthermore, the *Sinus magnus* had encroached upon the nebulous portions so that the distance from the Trapezium was no more than the distance between its two southern stars. In the spot χ (SCHROETER'S Fig. 1) the space was perfectly black. As noted in his large chart (see our Fig. 14), it is quite different from the appearance in his Fig. 1 (our Fig. 15).

For several years SCHROETER had seen the three bright stars *south following* θ_1 (BOND'S 685, 708, 741) in a completely dark space, according to his own account, and, indeed, he founded an argument for a change between HUYGHENS' time and his own on this very circumstance. The former appearance and the one now observed he describes thus: "*der Lichtnebel dicht an dem östlichen dieser drey Sterne* [685, 708, 741] *hinstrich. Jetzt hingegen stand der Lichtnebel von solchem östlichen Stern* * * * *nach Fig.* 2 *beträchtlich ab. Dagegen trat aber von dem Lichten um* θ_1 *befindlichen hellern Lichtnebel ab, ein etwas matterer aber doch sehr deutlicher Lichtnebel von* α *Fig.* 2 *bis an* θ_2. (See Fig. 16). *Abermahls ein Umstand, den ich mit aller Gewissheit nicht so gefunden hatte,* weil ich deisen Umstand vor dem Druck meiner Charte nochmals, und zwar unter andern auch mit dem 10füssigen DOLLOND nachsahe, und von dem mattern Lichtnebel α, gleich als vorhin, überall nichts fand." Such repeated revisions do not allow us to think of a deception in this matter, and in this detail again SCHROETER thinks there can be no doubt of a change.

1797, Dec. 27. On this date SCHROETER observed in the *Sinus magnus* "*eine blasse äusserst matte Lichtschicht wieder an eben derselben Stelle, wo wir vorhin die Lichtschicht* $\alpha\beta$, *Fig.* 1, *beobachtet hatten, jetzt gieng sie aber nicht ganz, sondern nur bis auf* ⅓ *durch den finstern Raume* nämlich von α bis gegen γ, Fig. 1 (our Fig. 15) *und von den beyden Lichtpuncten* γ, δ, *fand ich überall nichts wieder.*" At the same time the *Sinus magnus* was not so black as common, but notably brighter. The state of the atmosphere was so good that SCHROETER cannot ascribe this change to its influence.

1798, Jan. 25. In bright moonlight, the *Sinus magnus* was again found to be black as compared to the surrounding sky, but no trace was seen of $\alpha\beta$ and $\varepsilon\zeta$. In the place of the streak $\alpha\beta$, which at the last observation had extended ⅓ of the distance from the edges of the *Sinus* nothing was seen, while the nucleus γ had reappeared, and in spite of the bright moonlight, was as bright as the first of the five outer satellites of Saturn (*Tethys*). This remarkable

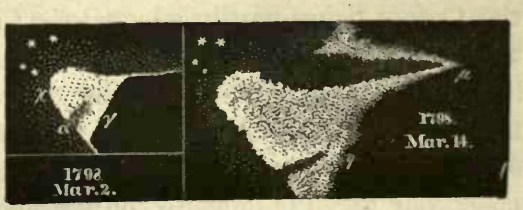


FIG. 16. SCHROETER, 1798.

observation was confirmed on the 29th of January, when, in spite of the moon, which was not far from the nebula and ¾ full, this point was again seen: "*von dem in eben solchen dunkeln Raume befindlichen, weit hellern Fixsterne* l *Fig.* 1 (Fig. 15) *hingegen fand ich so wie von* i *und von den beyden Lichtstreifen überall keine Spur. Offenbar hatte also der Punct γ neues und zwar viel stärkeres Licht, als vorhin erhalten.*"

1798, March 2. * * * "denn jetzt sahe ich *so gar bey vollem hellen Mondlichte nicht nur solchen intermittirend durchblinkenden Lichtpunct, sondern auch wieder etwas Streifiges vom Lichtstreifen αβ Fig.* 1." This streak SCHROETER maintains must have an entirely new one since none had been seen there on several previous occasions, and since it was seen so plainly in full moonlight. He has represented this in his Fig. 3 (our Fig. 16) and, as we see, it only extends to the nucleus γ. On this occasion, too, the *Sinus magnus* was three or four times as dark as the surrounding sky. Near χ (Fig. 16) the entire space, which had previously been seen intermixed with light, was now wholly black. 1798, March 13 [misprinted 1788], not the least trace was found of $\alpha\beta$ and $\varepsilon\zeta$, although on March 2 $\alpha\beta$ had been seen as far as γ. Of γ itself SCHROETER saw no *certain* sign, although both he and HARDING had glimpses of one or two brighter spots in the dark space of the *Sinus magnus*. SCHROETER gives a proof of the goodness of the atmosphere in that the small star *f* [707] of his large chart was plainly seen. This is about 11.2 magnitude. "Without any doubt this streak $\alpha\beta$ had in eleven days lost the greater part of its light." On the following evening, March 14, "bey ausserordentlich reiner Luft" absolutely nothing was seen of the two streaks of light, and no *certain* trace of γ, although it was suspected.

Again, the three stars [BOND 685, 708, 741], were now *all* in a completely dark space, while, according to SCHROETER's large chart the nebulosity passed through 741, the easternmost of these three, and on February 17, 1797, the western one [685] was likewise involved. On this date also a new appearance was observed "at the first glance," which is shown in our Fig. 16. The projection η was in about the same position as the projection η of Fig. 15, but in an entirely different *direction* and of a different magnitude.

1798, March 19. The star *f south following* the trapezium was seen, and also the small round nebula *a* [*D* of the Index-Chart]. (See SCHROETER's large chart, our Fig. 14). The atmosphere was good, but no trace was seen of the dark space *q*, which formerly had been so plain. * * * * "*Genug der dunklere in meiner Charte mit* q [*lacus Lassellii*] *bezeichnete Zwischenstrich, den ich vor etlichen Jahren so deutlich gesehen hatte, war verschwunden und an seiner Stelle Lichtnebel entstanden.*"

The *Messierian branch* or *proboscis major* had been correctly figured by SCHROETER in his large chart, but the *proboscis minor* was only well seen with his 27-foot reflector, the 13-foot being hardly adequate. This was in 1793 and 1794. Five years later, 1798, March 19, the *proboscis minor* was seen so bright with the 13-foot reflector that it was for a time supposed to be veritably the *Messierian branch;* this latter was so faint as to make deception easy, much fainter than the former. If this had been so in MESSIER's time (1771) it would not have been seen; from γ (of SCHROETER's large chart, our Fig. 14) onwards, only a faint trace of it was seen.

1798, Dec. 10. Under very favorable conditions γ and δ of (Fig. 15) were seen

as *one* "sehr matten schwachen und kaum erkennbaren Lichtpunct," while no trace of $\varepsilon\zeta$ was seen.

1799, Dec. 10. The state of the sky was particularly fine, and there was seen a faint trace of the streak $\alpha\beta$ extending from *north* to *south* half of the distance across the *Sinus magnus*. The nucleus γ was again seen, not as formerly, but as "*eine verwaschene gedrängtere Helligkeit*, die einem verwaschenen Kerne eines kleinen entfernten Cometen sehr ähnlich war." This would be the appearance ξo in a telescope like SCHROETER'S at the present time. Nothing was seen of δ nor of $\varepsilon\zeta$, and the *Sinus* east of $\alpha\beta$ was extraordinarily black, more so than it had before been seen.

In the *Nachtrag* to the *Zweite Abtheilung* of SCHROETER'S work (Beyträge, p. 222) reference is made to his figure 39 [our Fig. 17], and descriptions of observations given, of which a summary follows.

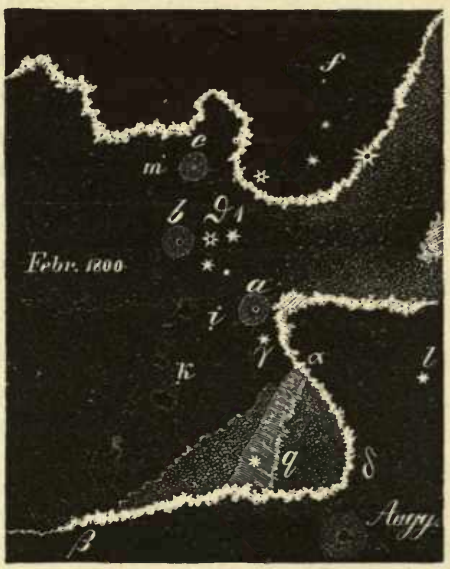


FIG. 17. SCHROETER, 1799.

a of his large chart [Fig. 14] was first discovered in 1793, and the central nucleus of *a* 1794, Jan. 6. His figure 39 shows plainly that *a* is our D, and the central nucleus is probably 647 and 651 seen as one star. This object had always been "ein sehr feiner, schwer zu unterscheidener Gegenstand." On Feb. 2, 1800, while examining "*other*" parts of the nebula, SCHROETER was astonished to see "dass mir dieser kleine, schwer zu erkennende ründliche Nebel, von selbst *in ausserordentlich starken Lichtglanze* ins Gesicht fiel," much brighter than ever before. It was at least three times as bright as the brightest parts of the nebula about it. On Feb. 5 the same appearance was observed, and *a* was again estimated to be three times brighter than the brightest parts about it. On Feb. 11 it had lost its brightness and become as before. On Feb. 12, under good circumstances, the observation of Feb. 11 was confirmed. The "spherical" mass *a* was compared with the dimensions of the trapezium, and its diameter was ¾ of the distance between the two brightest stars; that is, its diameter was in the neighborhood of 10″.

On Feb. 21 *a* was hardly so bright as the surrounding parts of the nebula. * * * * On pages 231 *et seq.*, is found a description of what must be the *lacus Lassellii*, though the scale of the figure is grossly wrong. It contains a star, SCHROETER'S *q*, which may be 663, or, as I at first supposed, 650 + 653. This dark stripe was first seen in 1795. In 1797–'98–'99 it was not seen In Feb., 1800, the part of σ of the Index-Chart containing *lacus Lassellii* and all east of it was invisible. On Feb. 21 and 23 the distance of the eastern limits of σ from 635 (SCHROETER'S γ), measured on the line 635 to 734, was only ¼ of the distance 635–734, while formerly it had been ¾.

On G. P. BOND'S engraving of 1865 the distance from 635 to 734 is 21 parts, and the distance from 635 to the brighter following edge of σ is 6 of the same parts, or a little more than ¼, so that the last observations of SCHROETER represent the present

appearances most nearly. If on BOND'S drawing we lay off ¾ of the distance 635–734 on this line, the point so fixed falls within the *nebula Mairanni*, and thus a suspicion is created that the channel $\alpha\ q$ of Fig. 17 was at first used by SCHROETER to represent the dark space *following* σ, and latterly used as *lacus Lassellii*.

I think, however, that there can be no doubt but that the small drawings after 1794 refer to the *lacus Lassellii*, and to the parts near the trapezium, and I believe the following list of identifications to be in the main correct. A reference to the original manuscript drawings of SCHROETER would be required to satisfy all doubts. This I have not been able to make.

SCHROETER'S Number.	G. P. BOND'S Number.	Remarks.	SCHROETER'S Number.	G. P. BOND'S Number.	Remarks.
Star.	467	Not numbered.	Star.	734	
Star.	497	Not numbered.	*l*	781	
o	427??		μ	848	
p	435??		γ	784	
Star.	449	Not numbered.	δ	822	
	505		*h*	793?	
n	490		ζ	843	
Star.	479		*y*	823	
Star.	554		*z*	855	
Star.	551		a	881	
Star.	506		Star.	905	
ω	524??		*v*	889	
m	558??		*b*	567? 575?	Bright part of A? *c*?
d	570		*c*	573???	Nucleus in E??
k	580		Dark space	*Lacus Secchii*	
i	635		*i*	635	
q	650–653?		Star.	669	Not numbered.
r	700		*a*	647??	Bright part of D?

In the preceding extracts I have omitted reference to several circumstances connected with the nebulous star discovered by HUYGHENS *north following* the trapezium, since this star is outside the limits which I have proposed to examine, and since the evidence adduced is not so striking as what has been given. I have also omitted many of the conclusions drawn by SCHROETER from his observations, but have endeavored scrupulously to give the essence of the observations themselves, as well as references to the state of the atmosphere, a most important datum. It is impossible to read the account of these observations without giving to them a certain faith and credence, and it must be remembered that in most of these observations SCHROETER had the assistance of HARDING, which is an additional argument for their acceptance.

From a consideration of all his own and some previous observations, the conclusion finally reached by SCHROETER is as follows, (Beyträge, p. 172): "*Fixe Lichtnebel sind zum Theil eben so gut einem bald stärkern, bald schwächern Zuflusse oder Modification des Lichts, einem wahren zufälligen Lichtwechsel unterworfen, als es gedrängtere Lichtphasen der Fixsterne oder Sonnen sind.*"

This was his own conclusion from the sum total of his six years' (1794–1800) observations. I find it impossible to follow him in all details which made up his judgment, as I believe that the grossly erroneous drawing of 1794, distorted by the errors of MESSIER's star positions, was accountable for some of the greatest variations.

The following seem to me the points established by his series of drawings and observations:

Drawing of 1794. (FIG. 14.)

The southern apex of the *Huyghenian region* (E) was prolonged to the south farther than it now is. This is represented in the same manner by MESSIER (1771) by the drawing of 1794 and by Fig. 17. The three *independent* drawings (for SCHROETER tells us that after 1794 he made another large chart) agree in giving a bright curved southern horn to E, which certainly does not exist at present.

His nucleus *c* must be near E [or 602], and was bright in 1794–1800.

His nucleus *b* must be the bright mass A or part of *c*, or possibly the star 575.

The *lacus Secchii* is laid down.

i must be 635, and the star *following* it 669. From the relation of *a* to these it follows that *a* is either D or the star 647.

The dark channel containing *q* has its *south* end where *lacus Lassellii* ought to be. The relations of his stars *k* [580], *r* [700], and 734 prove that on the drawing of 1794 *q* is 650. In the later sketches [Figs. 15, 16, 17] this is in doubt, and I believe that *lacus Lassellii* may have been correctly located at its south end, and the existence of a dark channel about *q* established, and on the final chart the two dark spaces connected. I am aware that this conclusion is doubtful; but after more study than the subject perhaps deserves, it seems to me correct, particularly if we remember that any limited region containing stars is likely to be correctly drawn, and that if we can correctly identify the stars the original facts of observation may be thus recovered, provided that the drawing is not assumed to be without distortion over too great an area.

Minor sketches in 1797–1800. (FIGS. 15, 16, 17.)

In the first of these (1797, Jan. 25), Fig. 15, SCHROETER's bridge is correctly laid down ($\alpha\beta$). The two nuclei [$\gamma\delta$] I do not understand. The interior bridge [in τ of the Index-Map] is also plainly laid down. The luminous space, χ, is inexplicable.

On Feb. 17, 1797 [Fig. 15], the position of 685 relative to the *Frons* is correctly shown. The abnormal appearance at the apex of E is also indicated. In Fig. 16 (1798, Mar. 2), SCHROETER's bridge is shown, as it might easily be seen in his reflector, and as HERSCHEL (1824) shows it.

In his Figs. 1 and 4 (our Figs. 15 and 16), the point η is inexplicable, unless it be the *following* point of σ in the Index-Map.

In his Fig. 39 (our Fig. 17), the nuclei *a*, *b*, *c* are shown, which I have before identified either as D, A, E, or I, or else, as is perhaps more probable, as 647, 575, and 602??

In this figure the abnormal shape of the apex of E is shown, and perhaps *lacus Lassellii*.

OBSERVATIONS OF BODE (*circa* 1800).

The following cut is a reproduction of a drawing by BODE, given in his *Anleitung zur Kenntniss d. Gestirnten Himmels*, p. 166, and Plate 1.

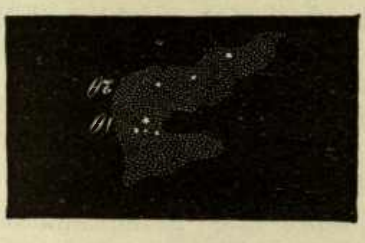


FIG. 18. BODE, 1800.

OBSERVATIONS OF FLAUGERGUES (1802).

In the *Connaissance des Tems* for 1802–'03 (An XI), p. 361, HONORÉ DES FLAUGERGUES has a note entitled "*Observations de la nébuleuse d'Orion*," from which the following extracts are taken:

"J'observe aussi depuis plusieurs années cette nébuleuse et j'y ai vu des changemens bien considérables: un grand espace carré d'une lumière faible qui était à l'occident de cette nébuleuse ovale, située au sud de cette nébuleuse qui en était séparée paraît actuellement être réunie à cette dernière sous la forme d'une gerbe lumineuse; enfin la partie inférieure de la nébuleuse s'est beaucoup rétrécie dans la partie occidentale, puisque les trois étoiles en droite ligne [685, 708, 741] qui dans les figures données par HUYGHENS et MAIRAN, sont dans le milieu de cette partie, se trouvent actuellement tout-à-fait au bord et même souvent hors de la nébulosité.

"Enfin je n'avais vu encore que trois étoiles dans le groupe marqué θ par HAMSTEED lorsque, le 18 vendémiaire au 7 de matin, j'en découvris une quatrième au sud de ces trois étoiles. MAIRAN remarque qui suivant un dessin de PICARD du 20 mars, 1673, qui lui avait été communiqué par GODIN il y avait quatre étoiles dans ce groupe.

"J'ai dessiné une figure de cette nébuleuse le plus exactement qu'il m'a été possible, afin qu'on puisse reconnaître les changemens qui pourront y arriver dans la suite et je l'ai adressée au Bureau des Longitudes pour qu'on puisse la consulter quand on aura fait d'autres observations analogues."

This figure has been sought for by M. M. YVON VILLARCEAN, MOUCHEZ, and ANGOT at the Bureau of Longitudes and at the Observatory of Paris, but without success. It is probably now lost.

I have to express my thanks to these gentlemen for the pains they have taken in this respect.

OBSERVATIONS OF SIR JOHN HERSCHEL (1824).

OF THE GREAT NEBULA IN ORION.*

"Before proceeding to comment on former drawings, it will be well to have before us a careful and correct representation of its present state. Such a one is that in the annexed drawing, which has been made from a set of drawings and notes taken

* *Mem.* R. A. S., vol. ii, p. 487.

in several nights' observations in the 20-feet reflector with its full aperture in favorable nights, and in the absence of the moon, but principally on that of Feb. 1, 1824, and compared afterwards with the real object, noting and correcting what stood in need of alteration. The last of these observations was made at Slough on the 3d of March, 1826, with the advantage of Mr. RAMAGE'S judgment as well as my own, when all the essential features represented in the drawing, from which this has been finally and very carefully copied, were distinctly seen by us both, and allowed to be truly depicted.

FIG. 19. J. HERSCHEL, 1826.

"I now come to describe the different parts of the nebula, in order to supply in some measure the unavoidable imperfections of every drawing, and to notice the discrepancies between this and former accounts.

"1. *Trapezium.*—These four stars I shall designate by α, β, γ, δ. They form the quadruple star θ *Orionis*. Their relative position is unaltered apparently. Mr. SOUTH has given measures of their angles of position and distance in his paper (*Phil Trans.*, 1826, part 1).

"The nebula, which is very bright in the parts surrounding the trapezium, seems (whether by the effect of contrast with the dazzling light of these stars, or from a real deficiency in nebulous matter) to have retreated from immediate contact with them, so that they appear in some degree insulated, and with a darkness about them. This would agree with the idea of a subsidence of the nebula into the stars by gravitation. But it is probably only a deception. Mr. POND has made the same remark of the apparent insulation of the trapezium, as seen with Mr. RAMAGE'S 25-feet telescope now at Greenwich.

"2. *The Huyghenian Region.*—The figure of this portion is nearly a right-angled triangle. The forehead and occiput form *exactly a right angle*, and the confine between bright light and comparative darkness on these sides is extremely well defined. The line of the forehead is continued across the insertion of the trunk, offering an appearance as if one well-defined nebula were laid upon another, which graduates away insensibly into what may be called the subnebulous region.

"The *Huyghenian region* is represented in MESSIER'S engraving as of a uniform brightness; but this is very far from being the case, as its illumination is extremely unequal and irregular. I know not how to describe it better than by comparing it to a curdling liquid, or a surface strewed over with flecks of wool, or to the breaking up of a *mackerel sky* when the clouds of which it consists begin to assume a cirrous

appearance. It is not very unlike the mottling of the sun's disc, only (if I may so express myself) the grain is much coarser and the intervals darker; and the flocculi, instead of being generally round, are drawn out into little wisps. They present, however, no appearance of being composed of small stars, and their aspect is altogether different from that of *resolvable nebulæ*. In the latter we fancy by glimpses that we see stars, or that, could we strain our sight a little more, we should see them. But the former suggests no idea of stars, but rather of something quite distinct from them I do not find it noticed or described in any former account, but this must be attributed to the want of light in the telescopes used, for it is not to be seen in a seven-foot Newtonian of six inches aperture. In MESSIER'S figure the frontal line is very indistinctly marked; and instead of preserving its direction all along, is made to form an obtuse angle or curve, following the course of the three stars ε [G. P. B. 685], ζ [G. P. B. 708], η [G. P. B. 741], which are there represented as situated exactly on the edge of the brightest part. This leads us to

"*The Subnebulous Region*, in which are situated the stars ε, ζ, η, λ [G. P. B. 724] and ψ [G. P. B. 707]. It is occupied by a faint nebulosity, insensibly and very gradually fading away into darkness. If we compare the figures of HUYGHENS, PICARD, MESSIER, and that here presented, it would seem as if the brighter portions of the nebula had formerly extended over this space, and were now contracting and receding towards the trapezium; for in the figures of HUYGHENS and PICARD the three stars are represented as deeply immersed within the nebula, and the division which contains them is by far the most considerable portion of the whole; but as in these there is no variation of shade, it is impossible now to say where they fixed the limit of what is to be considered as nebula. In MESSIER'S figure they are placed precisely on the edge of the most luminous portions, as above mentioned, while at present they are completely detached from it, and the line which they form makes an angle of at least 45° or 50° with the frontal line. This *appears* conclusive, as the withdrawing of the nebula would seem to have gone on progressively. Unluckily, however, the observations of LE GENTIL will not allow of this conclusion. This figure, drawn on March 10, 1758, and therefore sixteen years before MESSIER'S, represents it in this respect just as it stands at present, the line of the three stars forming the same angle with the frontal line; and to take away all doubt on the subject, he says expressly: "Les trois étoiles que Messieurs HUYGHENS et PICARD, et après eux GODIN et DE FOUCHY, ont vues en ligne droite dans ce que j'appelle la mâchoire inférieure, nous ont paru totale ment détachés de la nébuleuse—elles étaient sur une même ligne droite, et elles faisaient un angle considérable avec la mâchoire inférieure." On another night: "Je trouvai," he says, "* * * que les trois étoiles qui dans les figures de Messieurs HUYGHENS et PICARD sont dans la mâchoire inférieure faisaient avec elle un angle d'environ 40°;" the meaning of which he further explains by a reference to letters in his figure. The observation was made with a 6-feet Gregorian telescope, which of course would only permit the brightest part to be distinguished; but on turning on it telescopes of 8 and 16 feet, he assures us that the three stars then appeared exactly as HUYGHENS and PICARD represented them—*i. e.*, quite within the nebula, and of this appearance he gives a separate figure.

"These observations completely destroy the weight of any conclusion as to a change, drawn from the comparison of HUYGHENS' figure with MESSIER'S or my own. But how MESSIER could have overlooked the very remarkable and striking effect of the frontal line and its oblique position with respect to the three stars, with LE GENTIL'S figure and description before him, and his attention specially turned to the point, and with a telescope capable of showing the other peculiarities so well, is certainly surprising, and may lead to a suspicion that this line has really since become more definite, and that the nebula has retreated. The star ψ [G. P. B. 707] is not in this figure.

"*Sinus Gentilii.*—The totally dark recess designated by this name is represented by LE GENTIL as a very long, narrow exactly rectangular cut, commencing, not as at present, at a considerable distance to the southwest of the star ε [685], but nearly opposite it, so that the line joining ζ [708] and ε [685] produced actually enters the *Sinus*, and makes an angle with its general direction much less than at present—hardly more than 15° or 20° in his figure. The angle, too, between the frontal and occipital line, which at present is just a right angle, is represented by him as very obtuse—about 135°. MESSIER makes this *Sinus* dim and indistinct, but an approach to the rectangular form of this part (the vertex) of the nebula is perceivable.

"*Crista* seu *Regio Gentiliana.*—Represented by LE GENTIL as an exact well-defined rectangle, whose length is nearly twice its breadth, and bounded on the north following side by the *Sinus* which runs in the direction of its length. This figure presents no resemblance in this part to MESSIER'S. The rectangle is made to adhere to the nebula by a thin neck of less breadth than the *Sinus*.

"In MESSIER'S figure, a very much greater extension is to be remarked in the crest. In his figure it includes the star marked 2, and its boundary passes off to the south preceding, a little below the star marked 1 (which stars he has been at the pains of laying down by actual micrometrical measure, and which are inserted in my drawing from his measures), and considerable strength and boldness is given to its outline in this part. The portion next to 1 is represented as even brighter than the great branch (*Brachium Messieri*). At present, if nebulosity exist in that region (and, perhaps, hardly any part of the sky for some degrees round can be regarded as quite free from it), it is certainly very faint; and if MESSIER'S figure is to be trusted, a material alteration here must have taken place. With respect to this latter point he must be allowed to speak for himself. "Le dessin de la nébuleuse d'Orion que je présente à l'Académie a été tracé avec le plus de soin qui m'a été possible. La nébuleuse y est représentée telle que je l'ai vue plusieurs fois, etc." And the engraving is inscribed "Présenté au Roi le 27 mars 1774." It has consequently all the authenticity which can be desired; and the habit of viewing such objects as its author had acquired in his very successful researches on nebulæ, would seem to render it little probable that his eye would be deceived in such a point. Yet, of the two, it must be confessed that this part of LE GENTIL'S approaches much the nearest to the present appearance, and there is even an approximation to the rectangular form still perceptible. This will serve to show how great is the difficulty of representing such objects, and with what caution evidence of changes in them ought to be received.

"*Regio Messieriana.—Brachium Messieri* seu *Probiscis Major.*—This arm was first

seen, and is very imperfectly represented by MESSIER; the fainter arm or proboscis has escaped his observation altogether, as also has the elongated nebula between the stars $\varkappa$ [848] and μ [734], which is of the last degree of faintness. In favorable moments it exhibits a suspicion of a star in its middle.

"*Mairanni Nebula et Constellatio.*—The curious form of this nebula which throws out a sort of projection or tail just reaching to a small star *a*, is not depicted by MESSIER, who indicates merely a faint round nebulosity encircling the star μ [734] equally on all sides like an atmosphere. It consists of two principal parts: the body, which is the part formerly seen, and the tail, which extends between the stars *a* and *e*, leaving a pretty perceptible division or space of fainter light, as if it were about to break into two. The other small stars *b*, *c*, *d*, *f*, *g*, *h* are unaffected by nebulosity; *i* is one of MESSIER'S stars micrometrically laid down.

"*Regio Picardiana.*—Only the star ν is noticed by MESSIER. The very curious filaments which extend across or nearly across *the great Sinus* are here noticed for the first time. They require distinctness as well as light. The small island *nebula minima*, just at the entrance of the fauces, appears as if drawing together into a star. It is barely if quite detached from the point of the lower jaw, which is pretty bright and of a ragged appearance. The portion in which the stars ν [G. P. B. 669], w [G. P. B. 663], y [G. P. B. 652] are situated is on the other hand darkish, and the nebula appears as if about to separate in this place and leave the extremity of the lower jaw detached. Between δ [624] and φ [647], close along the borders of the *Sinus* at its bottom, is a part much brighter than the rest, of a small breadth.

"*Regio Derhamiana, etc*—From the trapezium there run out branches or tails like those of comets, in the direction of the star τ [523] along the confines of this and the *Huyghenian region*, and across all that space between τ [523] and o [479] and ξ [449], which lose themselves imperceptibly in the very faint, diluted nebulosity which fills the *Fouchian region* and adheres more or less in the form of wisps to all the stars in the latter, especially the stars π [335] and ρ. The stars o [479] and ξ [449], on the contrary, are rather free of nebulosity, being situated in a darker portion, which forms a natural separation between the *Fouchian* and *Godinian region*. In the latter, the nebula dies away imperceptibly into total darkness."

HERSCHEL'S remarks have been quoted from largely, as his memoir served to settle a nomenclature which has been since adhered to, and as they give a good general description of the different parts. In his first figure (Fig. 19) it is only necessary to call attention in passing to the nebulous filaments which he has represented on the north border of *Sinus magnus* near SCHROETER'S bridge. I conceive them to be, in fact, representations of the two bridges of SCHROETER imperfectly seen.

OBSERVATIONS OF POND. (1826.)

The recession of the nebula from the brighter stars is remarked upon by HERSCHEL in what immediately precedes The earliest notice of a recession of the light of the nebula from the neighborhood of the brighter stars in it is, however, due to POND, who, in 1826, communicated to the Royal Astronomical Society the results of his observations with RAMAGE'S reflecting telescope.*

* *Mem.* R. A. S., vol. 2, p. 93.

After describing the situation of stars 685, 708, 741 of BOND's Catalogue, he proceeds as follows: "Now these three stars are neither situated on the edge of the nebula as represented in M. MESSIER's plate, * * * nor are they parallel to the edge; but they seem to be insulated from the nebula, the light of which retires from them in a semicircular form, as if they had, in some incomprehensible way, either absorbed or repelled the light from their immediate vicinity. The same appearance is observable in the trapezium, round the four stars of which the light has also receded in a very analogous manner, leaving them on a comparatively dark ground. In both these cases the impression on my mind is that the stars have been the immediate cause of the disappearance of the light. * * * * *" Another similar case is noticed a few minutes distant from the trapezium, and the Astronomer Royal concludes with an expression of his intention to communicate a drawing of this appearance to the society. I have not been able to learn anything regarding this drawing. Through the kindness of Sir GEORGE AIRY an unsuccessful search has been made for it at Greenwich and in the archives of the Royal Astronomical Society.

OBSERVATIONS OF LAMONT (1837).

LAMONT speaks of his own drawing (Fig. 20) as follows: "Meine Zeichnung bezieht sich nur auf den glänzendsten Theil des Nebels, der das Trapez umgiebt. Vergleicht man sie mit der HERSCHEL'schen Darstellung [in *Mem.* R. A. S., vol. 2 (1826)] so ergeben sich nicht unbedeutende Unterschiede; dass merkwürdigste aber ist, dass der Refractor bestimmte und begrenzte Abtheilungen erkennen lässt, wo Sir JOHN HERSCHEL nur im Allgemeinen ein ungleiches Licht gesehen hat.

FIG. 20. LAMONT, 1837.

"Ubrigens bemerke ich, dass meine Absicht bei Beobachtung des Orion-Nebels dahin ging, die einzelnen Abtheilungen, so weit es möglich war, micrometrisch zu messen, um über künftige Aenderung *bestimmt* entscheiden zu können: dass aber auch eben desshalb in der Zeichnung vorzugsweise nur die messbaren Theile mit Sorgfalt dargestellt, die schwächeren und unmessbaren Abtheilungen dagegen mit wenigerm Fleisse berücksichtiget sind."*

The Fig. 20 here given of the nebula according to LAMONT, is copied from his engraving published in the work just cited. Through the kindness of Dr. DOBERCK, astronomer of Colonel COOPER's private observatory at Markree Castle, I have had

*(*Über die Nebelflecken*, München, 1837, p. 23.) It is unnecessary to go into an examination of LAMONT's observations here, as they have been fully discussed by LIAPONOFF in his elaborate memoir. We may, however, repeat LAMONT's remark that the divisions of the *Huyghenian region* (E, F, G, H, etc., of the Index-Chart) are here first laid down with precision.

access to an original pencil drawing by LAMONT'S own hand, dated February, 1839, sent by him to Markree Castle for comparison with a sketch by EDWARD G. COOPER, esq. The engraving is a very faithful reproducing of the original, but it is to the latter sketch that I have referred in all comparisons throughout this work, and in general I have always referred to the original engravings and not to the wood-cuts herewith, which are inserted principally for the purpose of making text intelligible.

OBSERVATIONS OF SIR JOHN HERSCHEL (1837).

FIG. 21. J. HERSCHEL, 1837.

The central part of Sir JOHN HERSCHEL'S second and very elaborate drawing, made at the Cape of Good Hope in 1837, is given in Fig. 21 From his work, *Astronomical Observations at the Cape of Good Hope* (p. 25, *et seq.*), I extract the following: "I am aware of but four representations of this nebula which have appeared since 1824—one by Dr. LAMONT, published with his thesis "Ueber die Nebelflecken," read at the anniversary sitting of the Bavarian Academy of Sciences, August 25, 1837, and two by Sig. RONDONI, a Roman artist. The former, though rather a coarsely-executed figure, and confined solely to the denser part of the nebula, or those regions which I have termed the *frons*, *occiput*, and *fauces*, yet contains some valuable particulars respecting the apparent breaking-up of the nebula (especially about the *frons* and *occiput*) into patches and knots; particulars very unsatisfactorily expressed in my figure of 1824, but in which my observations of 1834 and 1837 fully confirm Dr. LAMONT'S remarks. In his figure he has (perhaps intentionally) omitted to express the remarkable effusion of the nebula from the "*frons*" and "*proboscis*" into what I have termed the "*Subnebulous region*," and he has filled the interior of the trapezium with nebula, a particular in which we disagree decidedly. The two figures of Sig. RONDONI, which are given in the Report of Observations made at the Collegio Romano, by the associated astronomers of the Gregorian University, for the years 1840 and 1841, are perhaps rather to be regarded as curious specimens of lithography than as accurate representations of the nebula (such, at least, as I have ever seen it), which they resemble in fact hardly more than they do one another. * * * * * *

I purposely avoid all comment on the remarks which accompany these two representations, leaving astronomers to form their own judgment on them. The other representation above alluded to is that of Sig. DEVICO himself, in the year 1839, printed in the Annals of the Collegio Romano for 1838, which, though much less inaccurate in many respects than Sig. RONDONI's, is by no means free from objection on that score."

On pp. 31 *et seq.* of the same work we find Sir JOHN's discussion "*Of evidences of change in the nebula.*"—"To the reader who has never viewed this object through powerful telescopes, but who is familiar with the various representations which have from time to time been made of it (including my own of 1824), the number and complexity of the various branches and convolutions now first exhibited, and the different aspects under which even the portions best known are now presented, will no doubt tend to convey a strong impression of great and rapid changes undergone by the nebula itself. I am far from participating in any such impression. Comparing only my own drawings made at epochs (1824 and 1837) differing by thirteen years, the disagreements, though confessedly great, are not more so than I am disposed to attribute to inexperience in such delineations (which are really difficult) at an early period—to the far greater care, pains, and time bestowed upon the later drawings—and above all to the advantage of local situation and the very great superiority in respect both of light and defining power in the telescope at the latter over what it possessed at the former epoch, the reasons of which I have already mentioned. These circumstances render it impossible to bring the figures into comparison except in points which could not be influenced by such causes. Now, there is only one such particular on which I am at all inclined to insist as evidence of change, viz, in respect of the situation and form of the "*nebula oblongata*," which my figure of 1824 represents as a tolerably regular oval extended very nearly in a right line, or at most but a very little curved upwards between the two stars $\chi =$ No. 120 [G. P. B. 781], and $\varkappa =$ No. 136 [G. P. B. 848] of the Catalogue. Comparing this with its present appearance, as exhibited in Plate VIII, it seems hardly possible to avoid the conclusion of some sensible alteration having taken place. No observer now, I think, looking ever so cursorily at this point of detail, would represent the broken, curved, and unsymmetrical nebula in question (lying, as it does, in its whole extent, clearly out of the line of junction of the two stars above mentioned), as it is represented in the earlier of the two figures; and to suppose it *seen* as in 1837, and yet *drawn* as in 1824, would argue more negligence than I can believe myself fairly chargeable with.

"There is another point on which considerable stress might be laid were I satisfied that the earlier diagrams on which it turns were done with sufficient care. In 1837, the nebulous spur towards the end of the great proboscis, which terminates at E (No. 111) [G. P. B. 746], certainly was neither joined to the proboscis itself nor directed towards the star A (No. 135) [G. P B. 843], but rather towards a point about one-third of the distance from A (No. 135), to C (No. 126), near to where there is a small star 16 *m* (No. 131). Now I find two diagrams, one of December 25, 1832, the other of November 25, 1834, in which this spur is represented as running directly from A to E, and forming a complete hook, no way disjoined from the proboscis. But the chief attention on the first of these occasions was

directed to the magnitudes and situations of the stars, and the hook seems to have been only roughly sketched in as a novelty to be further noticed in future, while on the last it was only very faintly indicated in a diagram of the stars adjacent to *θ Orionis* on all sides, preparatory to the formation of chart intended to take in both *ι Orionis*, on the one side, and *C Orionis* on the other, which was subsequently discontinued

FIG. 22. DE VICO AND RONDONI (1839–1841).

(69) "Still less can we insist, as evidences of change, on such particulars as the curiously notched outline of the "*nebula Mairanni*" about the star *μ* (No. 108) [G. P. B. 734], now for the first time represented; or on the intricately rifted and broken state of the frontal and occipital region of the principal nebula. I ought to mention here that (owing, no doubt, to the difficulty of properly representing on paper and by lamp-light an object of the kind) I find a good deal of disagreement in respect

of the number, size, and distribution of the portions into which it may be considered as broken up, not only between my present figure and Dr. LAMONT's, but between my own drawings of this part on several nights. But the most material difference between Dr. LAMONT's figure and mine consists in the characteristic forms of these portions, which he represents as rounded masses more or less detached from or running into each other and into a general nebulous ground; while in all my later drawings the effect is rather that of a tolerably uniform surface marked with branching rifts or channels like roads. There is one peculiarity in Dr. LAMONT's figure which I can no way reconcile to my own impressions, viz, the strangely different form and magnitude which he assigns to the "*Sinus Gentilii*," from what I have always found it. This is a point which I trust he will be induced to re-examine."

A full discussion of HERSCHEL's drawing is given by LIAPONOFF and STRUVE, and will be best understood in connection with their observations.

OBSERVATIONS OF DE VICO AND RONDONI (1839–1841).

These are detailed in the Memoirs of the Roman College in the volumes for 1839 and 1841. Fig. 20 gives the best one of the three drawings. It was made by M. ROVERE and probably revised by P. DE VICO. Attention may be called to the comparative faintness of the region E (Index-Chart), the *south* point of the *Huyghenian region.*

FIG. 23. KAISER, 1844.

OBSERVATIONS OF KAISER (1844).

These are detailed in *Die Sterrenhemel*, vol. ii, Plate iii, Fig. 1, and p. 538. I have not been able to see this work, but I owe to Dr. V. DER SANDE BAKHUYSEN a copy of the plate which is given in Fig. 23.

OBSERVATIONS OF COOPER (1847).

Through the kindness of Dr. DOBERCK I have received an exact copy made by him of an outline sketch of the nebula made by COOPER about 1847. It is not reproduced here, as the only points of note are:

1st. E, of the Index-Chart, has at its *s. p.* corner a curved continuation like MESSIER's E, and similar in outline to LASSELL's drawing of 1862.

2d. Three small projections are shown on the *north* shore of τ (of the Index-Chart) similar to those shown in HERSCHEL, 1824 (Fig. 19). The *east* one of these is the longer, the *west* one the shorter. They undoubtedly refer to the bridges of SCHROETER.

3d. At the *spitz* (*s. f.* point of σ in Index-Chart) COOPER has a small star marked No. 11.

4th. An oval space near where star 602 would be (it is not laid down) marks some special region. It is in all probability intended to discriminate the blank channel *following* I.

OBSERVATIONS OF LASSELL (1847).

In February, 1847, Mr. LASSELL made some studies of the nebula at his observatory, Starfield, near Liverpool. An oil-painting of this date was presented to the

Royal Astronomical Society, and a copy also is preserved at Ray Lodge, his residence in later years. These paintings were poorly copied in an engraving privately distributed, a portion of which is given in Fig. 24.

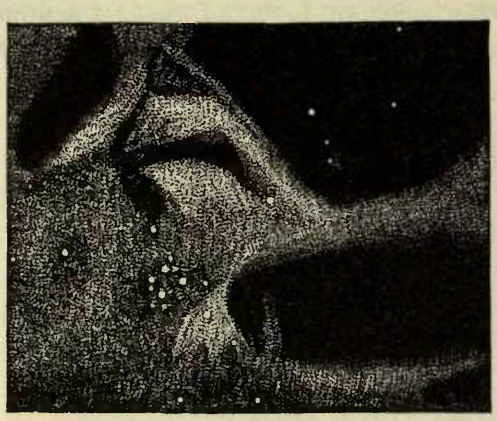


FIG. 24. LASSELL, 1847.

The full title of the oil-painting which was made at Burlington House from LASSELL's observations is, "The Great Nebula of Orion, with its Stars, as seen in February, 1847, with the Starfield Equatorial Reflector of 24 inches aperture and 242 inches focus. LASSELL."

This was also reproduced in NICHOL's Architecture of the Heavens, p. 106, Fig. x.

Little need be said of this in this place, except to call attention to the peculiarities of light and dark within the *Huyghenian region* itself, and particularly near A (Index-Chart). As a drawing, it does not compare with the later and admirable one made (1862) in Malta. See Fig. 31.

OBSERVATIONS OF W. C. BOND (1848).

The essential parts of W. C. BOND's description of his observations with the Harvard College Refractor in 1848 are extracted below:

"All such parts of the nebula in the vicinity of the trapezium as presented definite outlines susceptible of being measured were referred to θ'." . . . . "The stars Nos. 10, 12, 26, and 27 [G. P. B., Nos. 567, 573, 647, 651] mark the present boundaries of the *Huyghenian region* . . . very accurately. . . . . No. 10 [567] is situated close on the preceding edge of this bright region, and is closely followed almost in the same parallel [*meridian?*] by No. 12 [573], a star of the 17th magnitude, the latter being *within* the boundary. [I must believe that No. 11 = G. P. B. 575, marked 18th magnitude, is here meant, in spite of the evidence from the letter of the text to the contrary.] No. 27 [651] is as nearly as is possible to determine with our telescope on the very edge of the following side . . . . and is pretty closely preceded by No. 26 [647] of the 17th magnitude within the bright part.* . . . . There is a great diminution of the light in the interior of the trapezium but no suspicion of a star. Sir JOHN HERSCHEL's drawing shows the southern termination of the *Huyghenian region* (E) strongly *preceding* [θ'], whereas I have repeatedly laid the micrometer wire upon it, and have found it to be of the same right ascension as [θ']. The difference of declination is . . . . 161″." "The bright portion of the *Huyghenian region* terminates abruptly and roughly at No. 50 [708]." [That is, the following point of Q is in the same R. A. as 708, or $\Delta\alpha = 150''.5$.] "The preceding side of the *Huyghenian region* in [Sir JOHN HERSCHEL's figure] has the light gradually softened away into the *Regio*

* In *Proc. Amer. Acad.*, i, p. 326, W. C. BOND says that a star which he calls *h* 91, but which really is G. P. B. 651 + 647 = ad 75, "has hitherto been taken for a single star of the 17th magnitude. This is double, and the direction is towards θ' of the trapezium. The following one of this pair [651] is as precisely as possible on the following edge of the bright part of the nebula at the bottom of the *Sinus magnus*." The last phrase identifies the stars as 647 and 651. The position of 651 is now practically the same as in 1848.

Gentiliana. I here see a strong irregular outline extending from the *Sinus Gentilii* to a little beyond No. 10 [567]." [This is quite different from to-day, when J is a strongly marked mass, nearly all of which is dark in BOND's description, and it accounts for the angle of position of the *occiput* in his drawing $p = 147°.5$ against $p = 136°$ for G. P. BOND's drawing of 1865.] A further discussion of these observations occurs in connection with LIAPONOFF's and STRUVE's measures.

Fig. 25 is a copy of the steel engraving published by BOND.

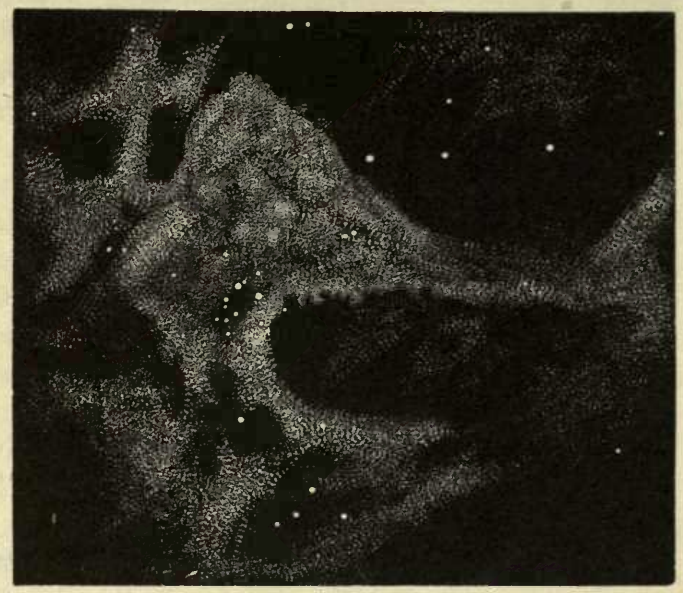


FIG. 25. BOND, 1848.

I would call attention to the convex outline of the *frons* which BOND first correctly laid down. The mass A just preceding the trapezium is also faint. The other masses are well terminated, and appear differently disposed from their present arrangement.

Through the kindness of Professor PICKERING, director of Harvard College Observatory, I have had BOND's original drawings and observations in my possession for some months; and although I have not the sketch from which this engraving was made, I have another nearly completed one. On this A is considerably brighter than in Fig. 25. E is quite bright, and there is a suspicion that the masses within the *Huyghenian region* were not laid down one by one and accurately, but dotted in to represent the general effect simply.

From other original sketches, also unpublished, I find:

1847, Dec. 13. [Order of brightness appears to be D, B, A, and the regions round G, H, E; region round F, I. These estimates are rather uncertain.]

1848, Jan. 17 [Order of brightness appears to be D; part of J?, I; G?, H?, or F?; Q, N, A; north parts of E. These estimates are again rather uncertain.] Large completed drawing (no date). [Order of brightness D, E, A. These masses are plain, and others are indicated, but not sufficiently to deduce the order of brightness intended by the author.]

OBSERVATIONS OF LIAPONOFF AND STRUVE (1847–1851).

§ 20 [p. 68]. *Observations sur différentes régions de la nébuleuse.*—La nature et la constitution physique de la nébuleuse ne pouvaient devenir, à cause de sa position australe et sous les conditions peu favorables de ma station, un objet d'observations détaillées et régulières. L'extrême difficulté des recherches de ce genre se fait déjà sentir en comparant superficiellement les résultats obtenus par les travaux de Sir J. HERSCHEL [1837], M. LAMONT [1839], et M. BOND [1848]. En examinant ces résultats,

on est le plus frappé par la grand différence qui existe dans les dessins de MM. Herschel et Bond, par rapport aux formes et à la constitution de la région centrale, la plus lumineuse et la plus définie de toutes les parties de la nébuleuse. Il est presque impossible de concilier sous ce rapport les deux dessins sans admettre la supposition d'un changement considérable qu'aurait subi cette région dans l'intervalle écoulé entre les époques des deux observations. L'éclaircissement de ces discordances appartient certainement à un travail futur à entreprendre dans ce but spécial à l'aide d'un télescope de force suffisante et sous des conditions favorables dans un degré proportionné Sans pouvoir affirmer rien de positif sur ce sujet, je vais cependant exposer les résultats des études comparatives, que j'ai eu l'occasion d'exécuter dans le courant de mes observations sur les dessins des trois astronomes nommés.

Fig. 26. O. Struve, 1862.

§ 21 [p. 69]. *Études relatives à la région centrale de Huyghens.*—Cette région m'a constamment paru offrir sur ces limites des formes prononcées, qui se laissent définir par des lignes à peu près droites. La planche II donne une représentation graphique de sa figure générale, qui est définie selon mes observations par une ligne rompue A, B, C, F, E, G, D. Les pointes A, B, C, etc., se présentaient dans ma lunette si bien terminées, que j'ai trouvé possible de fixer leur position par des mesures micrométriques avec une exactitude assez considérable.

Les résultats définitifs de mes mesures sur la position des pointes observées s'établissent maintenant:

	A.	D.	A_w	D_w
	"	"		
a [628] et D	− 91.3	− 39.9	. .	. .
a [628] et E	− 87.6	+ 44.3	. .	. .
a [628] et G	− 81.3	+ 18.4	. .	. .
a [628] et A	− 4.4	− 138.0	+ 0″ to + 1″	− 145″
a [628] et F	+ 26.5	+ 69.6	. .	+ 94″?
a [628] et C	+ 32.8	+ 3.1	. .	. .
a [628] et K	+ 143.6	+ 71.5	+ 166″	+ 79″
a [628] et B	+ 146.5	− 22.0	+ 150″	− 28″

The approximate positions of these points from Washington observations are given for comparison in the columns A_w and D_w.

En comparant la figure que mes observations assignent à la région de Huyghens,

avec le dessin de Sir J. HERSCHEL, je retrouve ici les pointes A, C, F et la direction A D, la position de la pointe A dans ce dessin paraît convenir très exactement aux résultats de mes mesures. D'un autre côté les pointes B, D, G, E manquent dans la figure que donne à cette région Sir J. HERSCHEL. Cependant selon mes observations la pointe B [Q] est la plus prononcée par une condensation particulière de la matière nébuleuse dans son voisinage, nommément dans un espace triangulaire, qui s'étend à l'ouest à partir de cette pointe. Cet espace lumineux se retrouve dans le dessin de HERSCHEL, mais au lieu de se terminer par une pointe il se prolonge à l'est jusqu'à la région de MESSIER. La comparaison avec le dessin de M. BOND [1848] donne à peu près les mêmes résultats, on n'y trouve que les pointes A, C, F, la pointe B [Q] y manque comme les autres, et la région près de B y est plutôt faible, que lumineuse. La forme de la région se montre plus conforme à mes observations dans le dessin de M. LAMONT. Je retrouve ici mes pointes A, B, C, F et G. Parmi les mesures, qu'avait instituées M. LAMONT, voy. *Obs. Astr. in Spec. Reg. Monach. Inst., vol. XI seu VI, p.* 21 *et* 22, les suivantes se laissent comparer avec les miennes:

	P.		*d.*	*d'.*
	° ′			
a et A	180 27		R.	″
A et D	321 53	*a* et A D	7.027	[96.3]
A et B	50 52	*a* et A B	8.310	[113.9]
B et C	282 4			

Ayant comparé les distances observées par M. LAMONT entre plusieurs étoiles, avec les miennes, j'ai trouvé la valeur angulaire de sa vis micrométrique R = 13″.745.* Il en résulte que les distances des directions A D, A B (*occiput, frons*) à l'étoile θ' Orionis, observées par M. LAMONT, sont: 96″.6 [96″.3] et 114″.2 [113″.9]. Par un calcul je déduis de mes mesures les mêmes distances = 96″.4 et 106″.6. Ainsi les différences de nos résultats sont:

Liapounov–Lamont.

	*d*P.	*ad.*
	′	
a et A	+ 82	″
A et D	− 255	[+ 0.1]
A et B	+ 87	[− 7.3]
B et C	+ 26	

[Washington observations of the distance of *occiput* from θ' (1877, January 5) give s = 106″.5(3) LIAPONOFF–HOLDEN = − 10″.1.

[p. 74]. Quant à la constitution physique de la région de HUYGHENS, mes observations indiquent d'une manière certaine l'existence réelle de plusieurs centres de con-

* This value was really 13″.7036 according to a letter from Dr. LAMONT to Professor HUBBARD, U. S. N., and hence LAMONT's measures, as here given, are too large in the ratio of 1,000 to 997. I have corrected the more important of these.

densation dans les limites de cette région. La planche II représente en α_0, a_0, b_0, c_0, d_0, A_0 six centres d'une forte accumulation de la lumière diffuse, dont je puis affirmer l'existence réelle et dont je suis parvenu à fixer la position par des mesures micrométriques. Le centre α_0 [in F] fut remarqué dès le commencement de mes observations en 1848 et je le regardais à cette époque comme une petite étoile entourée d'une atmosphère nébuleuse. En 1849 j'avais remarqué une condensation analogue autour des centres a_0 et b_0 [in D and G]. Cependant, des connaissances plus positives sur la distribution de la matière nébuleuse dans la région de HUYGHENS ne furent acquises qu'à l'époque de la dernière série de mes observations, en 1851. Avant que je fus parvenu à reconnaître la vraie nature de cette distribution, toute la région me présentait ordinairement des apparences qui variaient d'un jour à l'autre selon les circonstances atmosphériques. Même à l'époque de la dernière série, la plus favorisée par l'état atmosphérique, j'étais encore longtemps indécis par rapport à ce sujet Ainsi je trouve dans mon journal la note suivante, inscrite le 24 février 1851: "J'ai cherché en vain dans la région de HUYGHENS la répartition régulière de la nébulosité en masses globulaires, indiquée par MM. HERSCHEL et LAMONT, bien que je crois avoir remarqué quelque chose d'analogue antérieurement. Toute la région me paraît offrir aujourd'hui les apparences d'une surface liquide qui se trouve en mouvement ondulatoire rapide." Quelques jours après j'ai reconnu d'une manière certaine les masses de HERSCHEL et ce résultat est inscrit dans mon journal dans les termes suivants: "Le 2 mars 1851. Aujourd'hui je vois distinctement dans la région de HUYGHENS les masses globulaires de HERSCHEL, trois dans la partie australe, A_0, a_0, d_0 [E?, F, I], et deux un peu plus au nord, b_0, c_0 [G, H]. En a_0 [F] je supposais auparavant une petite étoile nébuleuse, probablement c'est une masse analogue, qui présente une condensation très forte près du centre." Depuis ce jour ont commencé les observations positives sur la région de HUYGHENS et jusqu'à la fin de la série, en mois d'avril, je voyais constamment et sans difficulté la distribution mentionnée de la matière nébuleuse en masses globulaires condensées.

Les mesures micrométriques, exécutées par moi pour fixer la position des centres reconnus de condensation par rapport à θ' Orionis, sont: [Omitted].

Ayant corrigé ces mesures pour l'effet de la réfraction, j'en tire les coordonnées suivantes:

Centre.	A	A_w	D	D_w	
	″	″	″	″	
d_0	− 34.5	[− 33.0]	− 81.9	[− 67.5]	These are G. P. BOND's co-ord. of 602 for 1857.0.
b_0	+ 18.5	+ 16	− 63.3	− 65	
a_0	+ 26.1	[+ 29.4]	+ 55.5	[+ 47.8]	G. P. B.'s 651.
a_0	+ 28.6	+ 27	− 97.4	− 10.2	
c_0	+ 51.8	. .	− 66.3	. .	

[A_w and D_w give approximate positions from Washington observations.]

Quant à la masse A_0 (E), sa position est donnée par celle de la pointe A (apex) qui en forme le sommet austral.

Au sujet de la nature des masses nébuleuses condensées autour de centres, je trouve dans les notes de mes journaux d'observation, les informations suivantes:

L'intensité de lumière dans les masses α_0, a_0, b_0, et c_0 [D, F, G, H] est si grande qu'elles furent encore visibles par une illumination très-forte des fils micrométriques sans l'usage des modérateurs. Ces masses m'avaient présenté à plusieurs occasions des ressemblances frappantes avec des amas d'étoiles. Le caractère stellaire s'est prononcé d'abord dans la masse la plus lumineuse α_0 [D], dont l'apparence me conduisait depuis constamment à l'idée d'une agglomération de petites étoiles condensées. L'intensité de la masse a_0 [F] me parut quelquefois presque égale à celle de la masse α_0 [D], et son apparence porte les caractères de constitution stellaire à peu près avec la même évidence. Dans la masse b_0 [G] j'ai cru pouvoir remarquer, à côté des indices d'un état stellaire, la présence d'une matière nébuleuse irrésoluble; du moins il est sûr que la condensation de lumière y est plus faible que dans les autres masses. Le caractère des amas stellaires est plus difficile à reconnaître dans la masse c_0 [H], dont l'intensité me parut encore plus faible que celle de b_0 [G]. Quant à la masse A_0 [E] située au sommet austral de la région, elle est beaucoup plus grande que les autres, mais elle ne montre ni le caractère des amas stellaires, ni une condensation assez forte, et sa lumière est d'une intensité considérablement plus faible. Enfin dans la nébulosité du centre d_0 [I] plus intense que celle de A_0 [E], je reconnaissais les indices de constitution stellaire à peu près dans le même degré de développement que dans la masse c_0 [H].

En rapprochant ces résultats de mes études à ceux des travaux antérieurs, je trouve d'abord que mes centres de condensations A_0, a_0, b_0, c_0 [E, D . . . .] sont identiques avec les agglomérations globulaires, indiquées dans le dessin de Sir J. Herschel. Cependant il existe une différence importante entre les résultats de nos observations par rapport à ces masses. Dans le dessin de Sir J. Herschel les différentes masses sont toutes de la même intensité, et en outre les masses isolées ne présentent que des indices très-faibles de condensation vers le centre et ressemblent plutôt aux disques arrondis d'un éclat uniforme des nébuleuses planétaires. La forme de la masse d_0 [I] est beaucoup plus irrégulière que d'après mes observations et on y voit le même caractère d'un éclat uniforme dans toute son étendue. Quant à la position des masses a_0, b_0, c_0 [F, G, H], elle ne s'accorde pas assez avec les résultats de mes mesures micrométriques. Enfin la masse α_0 [D] n'existe pas du tout dans le dessin de Herschel, on n'y remarque qu'une faible condensation de lumière à peu près à l'endroit, où j'ai vu cette masse brillante. D'un autre côté les journaux de mes observations ne font aucune mention de la masse arrondie, qui est représentée dans le dessin de Sir J. Herschel en connexion immédiate avec la nébulosité située entre ma pointe C [in T near 654] et la masse c_0 [H].

Il est plus difficile de concilier mes observations sur la constitution de la région de Huyghens, dans sa partie australe, avec le dessin de M. Bond. Le nombre, la position et les formes des masses, qui se trouvent dans son dessin, ne conviennent pas à la répartition régulière de la nébulosité, que j'avais observée. Cependant dans la partie boréale de la région je trouve chez M. Bond la masse α_0 [in D], qui manque au dessin de Herschel. Il est vrai que M. Bond lui donne l'apparence d'un disque d'un éclat uniforme, mais il déclare dans son mémoire qu'il a remarqué dans toutes les

masses de la région *Huyghenienne* le caractère stellaire et qu'il croyait même pouvoir distinguer dans des circonstances favorables les étoiles qui les constituent.

Comparées aux observations de M. LAMONT, les nôtres offrent une ressemblance frappante. On retrouve dans son dessin les masses A_0, a_0, b_0, c_0, et d_0, leur position s'accorde de très près avec celle que leur assignent mes mesures et le caractère de condensation y est exprimé d'une manière analogue. Il n'existe qu'une seule discordance entre nos résultats, nommément dans l'intensité relative des masses observées. Selon M. LAMONT, les masses A_0 et d_0 [E and I] sont considérablement plus lumineuses que les autres, ce qui semble indiquer un développement plus rapide dans les masses a_0, b_0, c_0 [F, G, H], qui sont à l'époque actuelle d'une intensité supérieure d'après mes observations. En considérant que d'ailleurs nos résultats s'accordent très bien par rapport à la distribution de la matière nébuleuse dans la partie australe de la région, il paraît très remarquable que la masse α_0 [D] est représentée dans le dessin de M. LAMONT comme une masse oblongue, qui ne montre pas de condensation vers un centre. Ce centre se serait donc développé considérablement entre les époques de nos observations, ce qui paraît confirmé par les dessins de Sir J. HERSCHEL et de M. BOND, dont les époques s'accordent respectivement avec celles des observations de M. LAMONT et les miennes.

Les mesures, exécutées par M. LAMONT sur la position des masses condensées, sont:

		P.	*d.*	*d.*
		° ′	″	′
a et a_0	[628 et F]	165 42.0	105.70	[105.4]
a et b_0	[628 et G]	163 54.3	. .	. .
a et c_0	[628 et H]	140 46.5	86.46	[86.2]

En supposant que ces mesures se rapportent également aux centres des masses observées, nous trouvons les différences suivantes avec nos résultats:

Liaponoff–Lamont.

	*d*P.	*dd.*	
	′	″	″
a et a_0	− 118.0	− 4.20	[− 3.9]
a et b_0	− 10.3	. .	. .
c et c_0	+ 79.5	− 2.42	[− 2.2]

[p. 77.] Outre les centres mentionnés de condensation évidente j'ai remarqué encore, qu'aux pointes boréales G, E [B, C], il y a lieu de supposer un développement récent, encore peu prononcé, de deux centres pareils. La matière nébuleuse autour de ces pointes m'avait présenté quelquefois des indices d'un état stellaire; cependant j'ai trouvé une difficulté extrême de parvenir à un jugement définitif sur sa nature et mes observations ne donnent à ce sujet aucun résultat positif. J'ai déjà mentionné plus haut que ces pointes manquent dans les dessins de MM. HERSCHEL et BOND; dans

celui de M. LAMONT je trouve autour de la pointe G [north end of B] une masse condensée d'une étendue considérable, mais la pointe E [in C] y manque aussi.

A côté des masses arrondies qui présentent des centres marqués, j'ai observé dans la région de HUYGHENS encore deux masses, qui montrent un genre particulier de condensation suivant certaines directions. La première est située à l'ouest de la pointe B [in Q] dans un grand espace triangulaire entre B [Q], C [in T] et c_0 [H]. A partir de B [Q] jusqu'à l'étoile $e_{,,}$ [671] on remarque une condensation très considérable entre les directions BA et BC *frons*, QPR. Plus loin à l'ouest vers C [in T] et c_0 [H] cette condensation s'affaiblit successivement. L'éclat de la masse dans le voisinage immédiat de B [Q] me parut quelquefois égal à celui du centre brillant α_0 [D]. La seconde masse se trouve à l'ouest de l'espace noir, qui entoure les étoiles du trapèze [V]. Elle présente la forme d'un demi-anneau circulaire, qui se termine du côté austral à peu près au parallèle de la masse b_0 [G] et du côté boréal entre les pointes D et G. Dans toute l'étendue de cet anneau on voit une condensation prononcée au milieu de son épaisseur, et sa région moyenne entre l'étoile *'θ' Orionis* et le point R [near 608] possède un éclat très intense. Pendant mes études sur ces masses brillantes j'ai cru aussi remarquer dans leurs parties condensées des indices de constitution stellaire. [The *Hemicyclium Liaponovii* is here described; it is made up of parts of I, of L, and of A.]

Dans le dessin de Sir J. HERSCHEL je ne retrouve que la première de ces deux masses lumineuses. Elle y montre une condensation assez forte et présente la même forme triangulaire, cependant au lieu de se terminer par une pointe, comme je l'avais observée, elle se prolonge à l'est dans la région de MESSIER. Quant à la masse annulaire, située à l'ouest du trapèze, elle ne se retrouve que dans le dessin de M. LAMONT, et l'accord de nos résultats par rapport à la forme, la position et l'intensité de cette masse est à peu près parfait. D'après les observations de M. LAMONT la masse triangulaire est plus faible et moins étendue dans le sens du cercle de déclinaison; cependant elle possède dans son dessin un éclat égal avec la masse α_0 [D].

Les intervalles entre les masses globulaires A_0, a_0, b_0, c_0, d_0 [E, F, G, H, I, etc.], de même que les régions situées immédiatement au sud et au nord de l'espace noir, qui entoure les étoiles du trapèze [V] sont d'après mes observations d'une intensité beaucoup plus faible en comparaison avec les régions lumineuses environnantes. Dans ce pointe je suis d'accord avec les observations de Sir J. HERSCHEL et de M. LAMONT, à cette exception près, que la condensation au nord de l'espace noir [V] est encore assez considérable dans les dessins de ces astronomes, tandis qu'elle m'a paru extrêmement faible.

Pendant mes études sur la région de HUYGHENS j'ai reconnu l'existence certaine d'un espace très sombre dans sa partie occidentale [*Sinus Lamontii*]. Cet espace est entouré par la masse brillante annulaire, dont j'ai parlé plus haut, et se trouve en communication avec la baie noire de LE GENTIL, qui semble pénétrer en dedans de

la région de HUYGHENS, en interrompant la limite AD (*occiput*) entre les pointes A et D. Les positions des pointes A et R comme elles résultent de mes mesures corrigées, sont:

Point.	A.	D.	P.	∕.	Err. prob.
	"	"	° "	"	' "
A	− 61.5	− 76.4	218 41	97.9	18 0.6
R	− 29.5	− 28.6	225 46	41.0	60 0.7

[R is then not far from G. P. B. 601, A = − 36″; D = − 31″, 1857.0.]

Le fond de l'espace A, RD (*Sinus Lamontii*) m'a paru quelquefois tout-à-fait noir; cependant en résumant les notes qui se trouve dans mes journaux au sujet de sa nature, je tire la conclusion, qu'il doit être plus lumineux que la baie de LE GENTIL.

En revenant aux travaux antérieurs, je ne trouve cet espace sombre que dans le dessin de M. LAMONT. La région qui correspond à sa position dans le dessin de Sir J. HERSCHEL offre au contraire une condensation considérable de matière nébuleuse. De même la ligne AD se distingue d'après M. BOND par une forte condensation dans toute son étendue. Il paraît très difficile de donner une explication satisfaisante, comment cet espace si sombre, aperçu par M. LAMONT, ne fut pas remarqué, dans les conditions atmosphériques plus avantageuses où se trouvait Sir J. HERSCHEL à la même époque. [The continuation of the line of the *occiput* across the space A D received the particular attention of G. P. BOND, and he also declares that it certainly exists. It is so in Washington observations.]

Enfin, l'espace qui environne les étoiles du trapèze m'a paru parfaitement noir et dépourvu de tout indice de matière nébuleuse. Il est très possible cependant que l'éclat des étoiles brillantes du trapèze efface les faibles lueurs d'une nébulosité raréfiée, qui se trouve dans leur voisinage immédiat. Sous ce point de vue je serais à peu près d'accord avec les résultats de Sir J. HERSCHEL et de M. BOND. Mais il existe entre nos observations une différence essentielle, en ce que d'après mes observations l'espace sombre s'étend considérablement en dehors des étoiles du trapèze. La discordance sous ce rapport est encore plus grande, si on compare mes observations avec celles de M. LAMONT. Pour fixer la position et l'étendue de l'espace U, T, V, X, Y, W [bounding line of V], que je voyais sombre, autour des étoiles du trapèze, j'ai exécuté la mesure des angles et des distances entre θ' *Orionis* et les pointes qui limitent cet espace. Après les réductions nécessaires j'en tire les différences suivantes en ascension droite et en déclinaison par rapport à θ' *Orionis:*

Point.	A.	D.
	"	"
T	− 35.2	+ 22.0
U	− 1.7	− 10.1
V	+ 3.1	+ 34.7
X	+ 15.2	+ 13.0
W	+ 26.2	+ 0.1

[In the Washington observations the various points and angles do not appear, but rather rounded contours, and any measures made upon them would be illusory. The $\Delta\delta$ of the north boundary can, however, be accurately fixed. It is + 24″.0, which agrees tolerably with the measures of T above.]

[p. 79.] On voit que l'espace en dehors de la ligne qui joint les étoiles les plus brillantes *a*, *c* [628, 640] fut observé moins étendu, que du côté des étoiles plus faibles *b*, *d* [619, 624]. Il est donc probable, que le phénomène n'est pas produit par le seul effet du contraste. [This observation agrees with Washington observations, and with conclusions drawn from them, and it is an important point in regard to the question of the connection of the nebula with the stars. I believe it has been remarked by no one except LIAPONOFF.]

Le résultat le plus certain de mes observations sur la région de PICARD est celui de l'existence dans la grande baie noire B, C, F, K [*Sinus magnus*] d'une masse pyramidale [*pons Schroeteri*] très faible, située dans la direction des étoiles *k* et *e* [669 and 685], et qui se trouve en connexion avec la limite boréale F, K [south edge of σ]. J'ai vu cette masse en tout conforme au dessin de Sir J. HERSCHEL, à l'exception près que j'avais observé encore à son extrémité australe une petite masse condensée, qui présente des indices d'un état stellaire. La position de ce petit et faible amas par rapport à θ' *Orionis* suit de mes mesures corrigées :

	A.	D.	
g_0	+ 71″.9	+ 42″.3	
[g_0	+ 77″.6	+ 40″.8	Washington observations.]

A l'exception de la masse pyramidale, l'espace B, C, F, K [*Sinus magnus*] me parut en général sombre et dépourvu de matière nébuleuse. Une seule fois, le 4 mars 1851, j'ai cru reconnaître le long de sa limite australe C, B, Q, P, R, la série de dents observées par HERSCHEL. Cependant il m'a été impossible de compter le nombre et de fixer la position de ces dents, que j'ai indiquées dans mon dessin d'après les observations de HERSCHEL.

[p. 80.] J'ai déjà mentionné plus haut, que la limite AB [*frons*] est prolongée dans le dessin de Sir J. HERSCHEL au delà de la pointe B [Q] dans la région de MESSIER. Selon mes observations, la nébulosité située entre les pointes B et L est d'une nature très différente de celle qui est propre aux masses nébuleuses condensées dans la région de HUYGHENS. C'est une masse confuse d'une formation peu avancée, qui ne présente pas de formes définies et se confond avec la région subnébuleuse. Sous ce rapport je suis parfaitement d'accord avec les observations de M. BOND. Les deux branches lumineuses de la région de MESSIER commencent selon moi au pointe L, dont la position par rapport à θ' *Orionis* est d'après mes mesures micrométriques :

	A.	D.
L	+ 357″.8	− 59″.2

Quant à la nature de la lumière dans les deux branches de MESSIER, je l'ai trouvé analogue à celle des nuages nommés cyrrus.

Dans la région subnébuleuse j'avais reconnu les caractères de radiation observée par M. BOND; cependant j'ai trouvé une difficulté extrême de fixer le nombre et la

direction des raies sombres dont elle est traversée, à cause de la faiblesse que la lumière de cette région présentait dans ma lunette. J'ai indiqué ce caractère dans mon dessin d'après les observations de M. BOND.

La région de LE GENTIL consiste d'un espace sombre, qui communique en A, D avec un espace pareil de la région de HUYGHENS, et d'une masse régulière d'un éclat assez prononcé, qui se réunit en D, D E (K and β) avec la région de HUYGHENS. La limite intérieure de cette masse régulière est un arc D, Sh_0 [border of β and $\varkappa$]. La lumière s'affaiblit peu à peu à partir de cet arc vers l'occident. Du côté boréal en e_0 j'ai observé une pètite masse condensée de nature stellaire. Un amas analogue, mais plus petit, fut reconnu à l'extrémité australe en L_0. La lumière qui étend de cet amas à l'ouest, présente la forme d'une queue, à peu près comme dans le dessin de Sir J. HERSCHEL. La limite occidentale de toute la région se trouve un peu à l'ouest de l'étoile ν [558], où sa lumière affaiblie se confond avec les lueurs de la nébulosité environnante Malgré tous mes efforts je n'ai pas retrouvé l'espace sombre qui fut observé par M. BOND entre le point S [not marked in figure] et l'étoile ν [558]; au contraire j'ai vu un affaiblissement graduel de la masse nébuleuse à partir de la limite orientale vers l'occident, sans aucun changement brusque d'intensité, qui aurait pu expliquer l'espace noir de M. BOND.

Il me reste à dire que la distribution de la matière nébuleuse dans les régions de FOUCHY et de GODIN s'accorde en général avec les observations de Sir J. HERSCHEL.

EXTRACTS FROM THE MEMOIR OF DIRECTOR OTTO VON STRUVE.

[p. 97.] Il paraît que les observations de SCHROETER, faites à Lilienthal dans les années 1774 à 1779, n'ont pas attirées toute l'attention qu'elles méritent. Elles sont publiées dans un appendice aux "Aphroditographische Fragmente" et dans la 1re section des "Neueste Beiträge zur Erweiterung der Sternkunde," Göttingen, 1800. On y lira avec intérêt que des changements dans la distribution et l'éclat de la matière nébuleuse, dont on verra plus bas qu'ils sont notés par moi, ont été aperçus tout à fait de la même manière par SCHROETER et son aide HARDING. Cet accord est d'autant plus surprenant que je n'ai pris connaissance des observations de Lilienthal, que quatre ans après avoir remarqué les dits changements. De différents côtés on a reproché à SCHROETER que dans ses écrits il s'est laissé quelquefois entraîner par l'imagination; mais ces reproches concernent surtout les conclusions qu'il tire de ses observations, pas les observations elles-mêmes, qui sans doute ont été faites toujours de bonne foi. Personne n'oserait attaquer sa sincérité, si même on voulait admettre que ses observations ont été en partie le produit de déceptions optiques ou d'illusions. Heureusement dans notre cas les observations sont de nature que la supposition d'une déception optique est tout à fait hors de question. * * * * *

1856, Nov. 8. Le *Sinus Gentilii* avec la baie qui s'étend de lui dans la région *Huyghenienne* vers le trapèze [*Sinus Lamontii*] est le mieux représenté dans le dessin de M. LIAPONOFF. Cette baie ne cède pas en noirceur au *Sinus Gentilii*.

Dans les dessins de HERSCHEL cette baie n'est pas indiquée, et non plus dans celui de BOND, mais elle se trouve aussi dans le dessin de M. LAMONT. * * * *

1857, March 18. La baie LAMONT, aux bords de laquelle se trouvent les deux

étoiles 51 et 57 [567, 575], est aujourd'hui remplie de matière nébuleuse, de sorte qu'elle ne contraste que très peu avec les autres parties de la région *Huyghenienne*, tandis que le *Sinus Gentilii* lui-même est parfaitement sombre. Le pont SCHROETER présente aujourd'hui un éclat uniforme, sans lumière concentrée vers le milieu. Les étoiles 76, 80 et 84 [652, 657, 663] se trouvent dans un lac noir de forme oblongue [*lacus Lasselii*], 89 [681] est déjà entourée de matière nébuleuse assez dense [in σ].

1857, March 20. Au sud du trapèze deux masses globulaires se présentent aujourd'hui très distinctement dans la région *Huyghenienne*. Des mesures micrométriques donnent les positions suivantes de ces masses par rapport à c [628]:

$e =$	68.0	$P = 171.7$ $(b_0 = G)$
	106.5	164.2 $(a_0 = F)$

Évidemment la première de ces masses est identique avec celle que M. LIAPONOFF a désignée par b_0 [G], la seconde avec a_0 [F]. Cependant les différences de 8° dans l'angle de position du premier objet et de 5″.4 dans la distance de l'autre, sont assez surprenantes. Mais ce qui me frappe encore plus, c'est que dans mon journal j'ai désigné le premier objet comme la masse la plus précise et la plus luisante de toute la région, et que son intensité surpasse considérablement celle de l'autre objet qui, de son côté, est plus étendu que le premier—tandis que M. LIAPONOFF dit exactement le contraire par rapport à l'intensité des deux masses b_0 et a_0 [G, F].

1857, March 24. Dans les environs de 75 [647] il y a aujourd'hui une condensation très forte de matière nébuleuse. Aussi le pont SCHROETER présente aujourd'hui un point de lumière très concentrée dans son milieu [g_0]. Près de l'endroit où ce pont touche le bord boréal du *Sinus*, mais un peu suivant, on voit distinctement une baie étroite qui s'étend dans la direction du lac LASSELL. Ce lac, de forme oblongue, s'étend encore considérablement au delà de 84 [663] dans la direction de la baie indiquée. Par moments il m'a paru comme si la baie indiquée et le lac soient réunis entre eux par un canal étroit qui passe près de l'étoile luisante 87 [669], cependant je n'ai pas obtenu la conviction qu'il n'y existe une interruption dans ce canal.

1857, Sept. 24. La baie LAMONT peut être discernée, mais elle est remplie de matière nébuleuse.

1857, Oct. 24. Une tache noire circulaire [$W^1 = lacus\ Secchii$] de 15″ de diamètre précède 70 [635] un peu vers le sud. Je ne me rappelle pas l'avoir noté auparavant La baie LAMONT paraît aujourd'hui bien sombre; cependant on y remarque encore des traces de matière nébuleuse.

1857, Oct. 27. Le lac SECCHI a les bords très-peu définis, mais on peut le reconnaître encore sans difficulté. Du canal entre le lac LASSELL et le *Sinus magnus* je crois apercevoir par moments l'extrémité australe, mais pas bien distinctement. La baie LAMONT est remplie de matière nébuleuse. Un canal étroit joint le *Sinus Gentilii* avec l'espace obscur boréal [*palus Bondii*]. Hier je ne l'ai pu reconnaître, mais aujourd'hui je le vois très distinctement.

1859, Feb. 28. Le lac SECCHI me paraît aujourd'hui beaucoup moins sombre qu'autrefois. En revanche il y a une tache très noire près du trapèze, que je n'ai pas

remarquée précédemment. Elle suit le trapèze un peu vers le sud à une distance de peu de secondes de la ligne D C. [This is the space bounded nearly by 636, 648, 628, 640, which joins the canal between M and S.]

1861, March 9. Les environs du trapèze sont remplis de matière nébuleuse très condensée, de sorte qu'ils ne cèdent que très peu aux plus luisantes parties de la région *Huyghenienne*. [I presume this to refer particularly to the east side of A. In this way it agrees best with present appearances.]

L'étoile 126 [793], que nous voyons placée chez HERSCHEL un peu vers le sud de la pointe du promontoire de *Proboscis major* (*Promontorium Herschelii*), et que BOND a dessinée sur le parallèle de ce promontoire, à la distance d'une dizaine de secondes, se trouve aujourd'hui décidément sur la pente boréale du promontoire, exactement sur la limite de la nébulosité. Elle suit la pointe extrême de plusieurs secondes.

1861, March 27. Le pont SCHROETER joint les deux bords du *Sinus magnus*, sans lumière plus condensée au milieu. Le canal entre le lac LASSELL et le *Sinus magnus* peut être poursuivi dans toute son étendue; il me paraît maintenant plus large que précédemment. En revanche le canal entre le *Sinus Gentilii* et le *palus Bondii* est interrompu par des masses nébuleuses assez luisantes. La baie LAMONT peut être reconnue, mais elle est remplie de matière nébuleuse, et le demi-cercle luisant qui l'entoure ordinairement [*Hemicyclium-Liapunovii*] ne se voit qu'à peine. Le trapèze se trouve au milieu d'une masse nébuleuse très luisante; une tache presque noire touche de très près la ligne C D en s'étendant jusque dans le voisinage de 88 [671].

1861, Sept. 27. La baie LAMONT est aujourd'hui remplie de matière nébuleuse très forte, de sorte qu'on la reconnaît à peine. *L'hémicycle-Liaponoff* a presque entièrement disparu. Le pont SCHROETER joint en apparence les deux bords du *Sinus magnus;* à l'intérieur du pont tout l'espace est couvert d'une masse nébuleuse assez intense, de manière que M. WINNECKE, qui pour la première fois regardait la nébuleuse par le grand réfracteur, croyait d'abord que le *Sinus magnus* ne s'étendait que jusqu'au pont. L'étoile 110 [741] touche aujourd'hui le bord du *Proboscis major*, et 126 [793] est décidément sur la pente boréale du *promontoire Herschel.*

1861, Dec. 2. Le *palus Bondii* est aujourd'hui très sombre, mais je ne puis pas reconnaître le canal qui se joint avec le *Sinus Gentilii.* Au contraire le canal entre le lac LASSELL et le *Sinus magnus* paraît aujourd'hui très large, mais en même temps moins sombre que d'ordinaire. Le *lac Secchi* a les contours très-mal définis. La *baie Lamont* est aujourd'hui moins étendue, mais d'une noirceur assez intense. Le sommet du *promontoire Herschel* précède l'étoile 126 [793] de plusieurs secondes, ayant en même temps une déclinaison plus australe de 20″. [This is so in Washington observations, January 10, 1877, for example.] Aussi dans les parties boréales les apparences du *Proboscis major* diffèrent aujourd'hui essentiellement de celles que nous offre le dessin de Sir J. HERSCHEL. Tout le *Proboscis* paraît avoir fait un mouvement vers l'ouest, et le promontoire près de l'étoile 117 (778) a presqu'entièrement disparu. En tirant une ligne droite par les deux étoiles θ'' et 110, je trouve que la distance de θ'' à la limite suivante de la région *Huyghenienne* (ligne A B de M. LIAPONOFF) se rapporte à la distance de 110 au Proboscis, comme 1 à 1.5, tandis que le dessin de HERSCHEL fait ce rapport au moins 1 : 4.

Le *pont Schroeter* est, dans toute son étendue, d'un éclat uniforme, plutôt faible; mais il traverse tout le *Sinus magnus*. Le trapèze est plongé dans une masse nébuleuse bien intense; la tache sombre observée en d'autres occasions du côté suivant du trapèze ne peut guère être reconnu aujourd'hui.

1861, Dec. 29. L'existence de 75 [647] fut soupçonnée par moments, les autres étoiles ne sont pas distinctement reconnues. Le *pont Schroeter* joint les deux bords du *Sinus magnus*, sa lumière est considérablement plus condensée vers le milieu. A l'intérieur du pont [τ] le *Sinus* est parfaitement noir du côté nord; du côté sud, au contraire, il y a beaucoup de matière nébuleuse. [This is precisely contrary to present appearances.] La *baie Lamont* se voit avec facilité, mais elle est remplie d'une legère matière nébuleuse; à son embouchure dans le *Sinus Gentilii*, il y a aujourd'hui un fil de lumière plus intense, qui, en forme de pont, sépare les deux baies. Ce pont n'a jamais été aperçu par moi auparavant, malgré toute l'attention que j'ai vouée en toute occasion à cette partie de la nébuleuse. Le trapèze est plongé dans une masse nébuleuse très intense.

1862, March 6. La *baie Lamont* est très sombre. Le *pont Schroeter* a de la lumière fortement concentrée au milieu, mais il n'atteint pas le bord sud du *Sinus*.

1862, March 21. La *baie Lamont* s'est rétrécie en apparence; au centre elle est bien noire, mais les bords sont couverts de matière nébuleuse; son embouchure dans le *Sinus Gentilii* est en partie fermée par un fil lumineux. La tache noire qui suit le trapèze se voit très distinctement, son étendue me paraît plus petite qu'autrefois.

CONSIDÉRATIONS SUR LES OBSERVATIONS PRÉCÉDENTES.

Les extraits précédents de mon journal d'observations contient sans doute des indications très fortes de changements dans l'état de la nébuleuse. Néanmoins je suis bien loin de prétendre que tous les changements notés soient élevé au dessus de tout doute. Au contraire, en exerçant une critique sévere il n'y reste que très peu qui, à mes propres yeux, soit bien prouvé, je dirai même il n'y a rien de prouvé par rapport à des changements dans la nébuleuse elle-même. Les déceptions dans ce genre d'observations sont tellement nombreuses qu'on ne peut pas être assez sûr ses gardes dans ce qu'on avance comme des faits établis. Malgré la bonne volonté de se tenir libre de toute préoccupation, l'imagination, supportée dans ces cas par l'insuffisance de nos moyens d'observation et par l'effet de l'état variable de l'atmosphère nous entraîne facilement à voir ce que nous voulons voir ou plutôt à ce qui s'accorde le mieux avec nos pensées intimes et d'un autre côté à négliger de noter ce qui paraît s'opposer à nos vues.

[p. 115.] Passons maintenant aux observations concernant la distribution et l'éclat de la matière nébuleuse elle-même. Évidemment elles n'accusent presque aucun changement de forme, mais bien des fluctuations dans l'éclat des différentes parties. L'impression générale que j'ai gagnée par ces observations est que la partie centrale de la nébuleuse se trouve dans un état d'agitation continuelle, comme la surface d'une mer. Ici je me bornerai à diriger l'attention des astronomes sur les particularités suivantes:

(*a*) Sir J. Herschel a placé le trapèze dans un espace presque vide de matière

nébuleuse. En général je suis d'accord avec lui sur ce point, mais il y a eu des nuits, surtout en printemps 1861, où la nébulosité en dedans du trapèze et dans son voisinage immédiat m'a paru tout aussi forte, que dans les autres parties les plus brillantes de la région *Huyghenienne.* Cela me paraît prouver que l'observé vacuum n'est pas uniquement produit par l'effet du contraste. Dans des nuits où il y avait plus de masse nébuleuse en dedans du trapèze, j'ai vu à différentes reprises une tache considérablement plus sombre qui s'étendait à l'est du trapèze quelquefois jusque dans les environs de l'étoile 88 (671). [This is the canal between M and S.] Cette tache n'est indiquée chez aucun des autres observateurs. HERSCHEL et BOND indiquent au contraire à l'endroit de cette tache une condensation plus forte de la matière nébuleuse.

(*b*) *Sinus Lamontii.* Sur cette baie l'attention a été dirigée déjà par Sir J. HERSCHEL qui en conteste l'existence. (Cape obs., p. 32.) Elle n'est représentée, ni dans son dessin, ni dans celui de BOND [1848]. Mais M. LIAPONOFF l'a vu de très près comme elle est représentée par M. LAMONT. Mes observations indiquent que tantôt cette baie est à peu près aussi noire que le *Sinus Gentilii,* tantôt qu'elle est remplie de matière nébuleuse presque aussi lumineuse que le reste de la région *Huyghenienne.*

(*d*) Le pont du *Sinus magnus.* Le dessin de HERSCHEL indique à l'endroit de ce point un promontoire assez faible. Plus tard M. LIAPONOFF orne ce promontoire d'une pointe brillante [g_0] mais aussi cet astronome ne le fait s'étendre que jusqu'au milieu du *Sinus.* Les dessins de BOND et de M. LASSELL n'offrent pas de traces de cette formation. Au contraire il y a même chez BOND une tache plus sombre à l'endroit où M. LIAPONOFF place la pointe.

Mes propres observations étendent le promontoire presque toujours jusque dans le voisinage du bord sud du *Sinus* et quelquefois même il m'a paru qu'il n'y avait plus aucun intervalle, circonstance qui lui a valu la désignation de pont. Au milieu de ce pont j'ai remarqué presque toujours un point plus lumineux, qui s'accorderait avec la pointe indiquée par M. LIAPONOFF, mais il y en aussi des jours où le pont m'a paru de lumière uniforme dans toute son étendue. [g_0 was first plainly seen by SCHROETER. Since 1800 it has been seen on many occasions, and again under equally good conditions its absence has been noted. The Washington observations are remarkable in this respect, and agree in general with the conclusions of STRUVE.]

(*f*) La masse nébuleuse située au nord de l'étoile 75 (647) [D]. Il m'a paru que cette masse fût sujette à de variations bien considérables tant en dimensions qu'en intensité. [The same appearances have been remarked at Washington.]

(*g*) Le *promontoire Herschel* sur le *Proboscis major.* Dans son dessin de 1837, Sir JOHN HERSCHEL place l'étoile 126 (793) sur la pente australe du promontoire, en contact apparent avec la matière nébuleuse. En 1847 elle s'est trouvée, d'après BOND, au dessus de la cime, mais séparée d'elle par un espace obscur. A l'époque actuelle il n'y a pas de doute qu'elle se trouve de nouveau en contact avec la matière nébuleuse, mais déjà considérablement sur la pente boréale. N'y aurait il pas ici un indice d'un changement progressif dans la configuration de la nébuleuse? Au moins il est prouvé que l'étoile n'a pas changé sensiblement sa position dans l'intervalle de 1837 à 1850, et il paraît inadmissible de supposer que HERSCHEL ait pu se tromper d'autant dès les positions respectives de la cime et de l'étoile, qu'il ait placé cette dernière sur la pente

australe, si, comme aujourd'hui, elle s'était déjà trouvée en 1837 du côté boréal. [The position given by STRUVE for this star agrees with my own.]

(*h*) Le coin boréal du *Proboscis major*. Dans la dernière année toute cette partie paraît avoir fait un mouvement vers le sud-ouest. Sans la supposition d'un changement il serait impossible de concilier, sur ce point, mes dernières observations, avec les dessins des autres astronomes et même avec mes propres observations de 1857."

The preceding observations and remarks have been given at some length both on account of their importance and because they contain a careful and detailed comparison of the works of LAMONT and HERSCHEL. LIAPONOFF was the first to carry out the idea suggested by SCHROETER of making a minute study of single parts of a nebula, and it appears to me that the faithful and accurate manner in which this critique was done has not received all the commendation it deserves. In this way, also, we may secure the advantage of the minute criticism which Dr. OTTO V. STRUVE has given to preceding memoirs.

OBSERVATIONS OF LASSELL (1854).

I extract from LASSELL'S account of his observations on the nebula of *Orion*, *Mem.* R. A. S., xxiii, p. 53, *et seq.*, such notes as appear to throw the most light upon his views concerning it. These observations were taken with his admirable reflector of 2 feet aperture, at Malta. "Wednesday, Dec. 15, [1852]. * * * With 1018, the wool-like masses appear as I have previously described them, and there is no disposition whatever in them to turn into stars."

"7th Jan., 1853. The nebula of *Orion* was surveyed under better circumstances than yesterday, without my seeing anything remarkably different from former observations. The pea-green color of the nebula is very remarkable—different in this respect from all others—as, indeed, it is, I think, the brightest of all the nebulæ I have seen. * * * I tried several higher powers * * * on the brightest parts of the nebula, but they only strengthen my former impressions of my inability to resolve it with my utmost means."

FIG. 27. LASSELL, 1854.

"In order to perpetuate as far as possible the results of these observations, I send, herewith, a painting, in oil, of this nebula on the same scale as my original drawings. * * * It is the work of my friend, Mr. HIPPISLEY, executed under my own superintendence and carefully compared with my

original sketches. I consider it a very faithful picture of what I saw, when placed in a proper light and well illuminated. Without attention to these conditions the nebula will appear too faint. * * * I send also, herewith, a similar drawing on a smaller scale. * * * I have endeavored in these drawings to represent the original as closely as possible, comparing and improving my original sketches night after night with the nebula itself." [This second drawing is given as Plate I of the volume already cited, and is reproduced as figure 27 of this text]. In the same volume of the Memoirs a portion of a private letter of LASSELL's is quoted (p. 108), in which he says: "A comparison of Sir JOHN HERSCHEL's, Mr. BOND's, and my own drawings of [the nebula of *Orion*] must, I think, suggest the idea of change in the nebula or variability of the stars, or otherwise a less uniformity of delineation of the same thing than might have been hoped for."

In this figure attention should be directed to the brightness, or want of brightness, of the parts just *preceding* the trapezium and of the n. f. parts of the *Huyghenian region.*

I add (from MS. by G. P. BOND put at my disposition by the Harvard College Observatory) a list of identifications of the small stars of LASSELL's chart.

Small stars in LASSELL's *chart* (Mem. R. A. S., xxiii). [The stars on this chart are G. P. B. 567, 575, 589, 595 (*e*), 608 (*f*), 612 (*i*), 618 (*h*), 621 (*c*), 622, 625 (*d*), 636, 647 (*l*), 648, 651, 671, and 676 (*k*), *g*??, 675 (*a*), 685, *b*??, 708, 741, besides the 6 stars of the trapezium. BOND has no stars corresponding to *g* and *b;* 601, 602, 642, 654, 686, 688 of BOND's list are within the limits of LASSELL's chart and not mapped by him.

OBSERVATIONS OF SCHMIDT (1860–75).

FIG. 28. SCHMIDT, 1861.

The observations made by Dr. J. F. W. SCHMIDT, director of the Observatory of Athens, have been embodied in two drawings by him which he has most kindly communicated to me and put at my disposition. The first and most elaborate of these is given herewith (Fig. 28) The other relates to the nebula as a whole, and is preserved for reference. This work has not yet been published and no description has yet been given. Fortunately the drawing is complete in itself.

The different masses are well shown, and the amount of detail is quite striking for the 6-inch refractor used by Dr. SCHMIDT.

OBSERVATIONS OF SECCHI (1862).

The drawing of SECCHI, 1862, given in the *Astronomische Nachrichten*, Band xlv, col. 60, refers more particularly to the nebula as a whole, and is reproduced in Fig. 29.

FIG. 29. SECCHI, 1862.

It is used here simply to give the general form of the whole nebula. It has been severely criticized by D'ARREST. The drawing is inverted.

OBSERVATIONS OF TEMPEL (1862).

The early drawing by TEMPEL,* given in Fig. 30, is also introduced for a comparison with the drawings of the early observers, and being about contemporaneous with that of SECCHI may also be compared with it.

FIG. 30. TEMPEL, 1862.

OBSERVATIONS OF LASSELL (1862).

LASSELL'S drawing of 1862 was made by Miss CAROLINE LASSELL, an accomplished artist, and one familiar with astronomical work of this kind, by means of the 4-foot equatorial of Mr. LASSELL'S construction during his celebrated astronomical expedition to Valetta. It was not published with the admirable collection of drawings made at the same time† on account of its large size. The scale was $100'' = 1.194$ inches.

* From *Astronomische Nachrichten*, vol. lviii, col. 240. † *Memoirs Royal Astronomical Society*, vol. 36.

FIG. 31. LASSELL, 1862.

OBSERVATIONS OF TEMPEL (1862).

The early drawing by TEMPEL,* given in Fig. 30, is also introduced for a comparison with the drawings of the early observers, and being about contemporaneous with that of SECCHI may also be compared with it.

FIG. 30. TEMPEL, 1862.

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* From *Astronomische Nachrichten*, vol. lviii., col. 240. † *Memoirs Royal Astronomical Society*, vol. 36.

FIG. 21.—LASSELL, 1862.

A tracing of this was made by Mr. LASSELL himself in 1876, and after I had had an opportunity of inspecting the original at Ray Lodge, Maidenhead, the artist kindly offered to make a *fac-simile* of it, which is now in my possession. A photograph of the central portions only is reproduced in Fig. 31, and I cannot but regret that the drawing, as a whole, is not generally accessible, embodying as it does the results of great labor and skill employed under most favorable circumstances.

It is to be remarked, that in this drawing there re-appears for the first time since SCHROETER'S 1798 drawings (with the possible exception of HERSCHEL, 1826), the *second bridge* of SCHROETER. It is there plainly laid down, as it was subsequently seen by Lord ROSSE and by myself, and much as described by SCHROETER. In the subsequent discussion (Part III) I shall recur to this feature. A strong suspicion of its variability in brightness is excited as it was seen by SCHROETER with a reflecting telescope of 19 inches aperture, and remained unseen until LASSELL'S work, and was always unknown even to the indefatigable BOND, who observed the nebula under most favorable circumstances.

OBSERVATIONS OF STRUVE (1863).

OTTO STRUVE in *Mélanges Mathematiques et Astronomiques*, iii, p. 539, thus describes his examination of the *Orion*-nebula with the 4-foot telescope of LASSELL, which was at this time (1863) mounted at Malta. Comparison observations were made at the same time by Dr. WINNECKE at Pulkova. It will be remembered that the joint work of STRUVE and LIAPONOFF on this nebula was published in 1862, and that, therefore, all the details must have been fresh in STRUVE'S memory. His report is, therefore, of high importance: "Es ging jedoch meine Erwartung, hier an demselben allerhand neue Formen und Details zu sehen, die ich in Pulkowa nicht erkennt hätte, nicht in Erfüllung: wie denn überhaupt der gesammt Eindruck des Bildes, der Charakter der Erscheinung, hier genau derjenige war, mit dem ich durch die vielfachen Beobachtungen an unserem Refraktor vertraut geworden bin, nur etwa mit dem Unterschiede, dass hier einzelne Theile etwas heller erschienen und dadurch bestimmter hervortraten als wie bei uns." Neither STRUVE nor LASSELL under favorable circumstances saw any indications of the resolvability of this nebula, and in the *Huyghenian region* STRUVE found only five stars which he had not seen there in Pulkova.

"In Bezug auf Veränderungen in der Nebelmaterie boten die beiden Nachten in Malta nur eine einzige aber sehr entschieden dastehende Thatsache. Am 8. Oct. erstreckte sich nämlich *pons Schoeteri* kaum bis auf die Hälfte des *Sinus magnus* und zeigte nirgends mehr concentrirtes Lichte, während er am 10. Oct. bis nahe an die südliche Begränzung der Bucht reichte und die gewöhnliche Verdichtung von Nebelmaterie nahezu auf der mitte deutlich hervortrat. In dieser Wahrnehmung stimmte Herrn MARTH'S Urtheil vollkommen mit dem meinigen überein." STRUVE remarks that if either of the nights (8th and 10th October, 1863), which he elsewhere speaks of as "herrlichen" was better than the other, that of the 8th was to be preferred.

The description indicates a difference in position of the bridge of about thirty seconds of arc, and it is not at all probable that any *real* variation in shape could be remarked in 48 hours; so that the difference in aspect must be ascribed to something inside the earth's atmosphere.

"Der Stern 126, über dessen successiv veränderter Stellung zum *Promentorium Herschelianum* mein Mémoire Andeutungen enthält, stand jetzt erheblich auf dem nördlichen Abhange jenes Vorgebirges, und war um mehrere Secunden von dichter Nebelmaterie überragt. Hierin scheint sich ein continuirliches Fortschreiten der angedeuteten Veränderungen in diesem Theile der *Proboscis major* auszusprechen."

With regard to the spiral nature of this nebula, which was pointed out by G. P. Bond, both Lassell and Struve agree in certifying to the reality of the curved lines which Bond described. Their attention was particularly directed to the curve of light which starting from the *preceding* side of the *regio Huygheniana* stretches far into the *regio Gentiliana.* Struve is certain that this was not quite continuous throughout its length, and that it is broken in the narrow canal which joins the *palus Bondii* with the *Sinus Gentilii.*

OBSERVATIONS OF WEBB (1863–1876).

By the kindness of the Rev. T. W. Webb, I have access to two original pencil-drawings by himself, as well as MS. notes of his observations. Such of the notes as refer to the central parts I give below, exactly as they were communicated, and beside these I have given in Part III inferences derived from the original drawings.

The first drawing was begun 1863, Dec. 29, and was continued on the following dates: 1864, Jan. 1, 4; Feb. 9, 12; March 4, Dec. 27, and Dec. 30. On the last two dates the following notes are written on the drawing: "Dec. 27. I think there is a dark channel," [connecting *Sinus Gentilii* with dark spaces toward the *n p*] "The light *n. p.* the trapezium" is connected by a line which indicates the *p.* edges of J and B as they are at present. On Dec. 30 this dark channel was again seen.

The drawing of 1866 was made Feb. 17, and has this note: "The three cumuli [F, G, H] nearest 93, [685 G. P. B.] form an equilateral triangle." H is marked "very feeble."

The following observations on the great nebula in *Orion* were made by T. W. Webb with a 5-in. objective, by Alvan Clark:

1863, Oct. 5^{d}. Rather flaring definition. I did not know exactly where to look for D'Arrest's "bridging over" of the *Sinus magnus*, and definition was fluttering, and with considerable moonlight; yet 164 showed a nebulous bridge very feeble, but quite certain, in the line between 2 stars marked in the diagram [669 and 685]; now and then I fancied that a minute star peeped through about the middle of the bridge [g_0]; the space inside it [τ] (in Bond's drawing, the darkest in the *Sinus*) was less dark, as though veiled over; 216 showed the same, but without the star; 64 did not make it out well; 460 showed it faintly, but not the interior veil. With 64 and 164 it could not be doubted. [The *pons Schroeteri* of O. Struve.]

1863, Nov. 14^{d}. Very low, and definition frightful; no hope of dividing ζ. Yet *pons Schroeteri* visible with 164 and 205 $\pm$, and inner space [τ] considerably brighter, especially by averted vision. With 164, I fancy something like a bifurcation of the end of the N. side of the *Sinus magnus.*

1863, Dec. 29^{d}. Fine, but a little fluttering. *Pons Schroeteri* plain; no star in it; (power seems to have been 204 $\pm$ and 440). 5th star in trapezio difficult; 6th not seen.

1865, Jan. 20^{d}. Very transparent night, but much flare. Nebulosity within *pons Schroeteri* [τ] very evident, 65. Later this was less plain, but the whole *Sinus magnus* seemed slightly nebulous. [ξ and τ'].

1865, Jan. 21^{d}. Very cold night; very fine definition. No. 6 certainly seen at times with 204$\pm$, but not with 451 or a microscopic triplet. But I never yet saw the trapezium so beautifully.

1866, Jan. 5^{d}. Bad and fluttering definition. About 8^{h}, when not more than half way to the meridian, I saw with 111 very evident traces of the *neb. oblongata*, which, as far as my recollection will serve, I have in former seasons several times looked for in vain, under better circumstances. It was now faint, but quite certain The *pons Schroeteri* was very evident. At a later hour a dark irregular rift was noticed with 111 and 212 between the 2 stars 87 [635] and 70 [669] and the trapezium, but nearer to the former. It probably communicated with the *Sin. mag.* at the E. end, and extended a considerable distance *p*, forming a dark spot [W^{3}] which stood nearly equilaterally with 67 and 70 This was the darkest portion of it. Hence it stretched to the E. in nearly a straight line of irregular breadth, being wider W. of 87 than W. of 70 [135]. Half way between 65 [619] and 87 [669], but a very little P. the line is a bright knob, at times seeming to inclose a star. [S. point of D ? with 647 ?]

[The "dark spot" is probably part of *lacus Lassellii* with W_1, W_3, and W_5. I judge this is so from a diagram.]

1866, Jan. 11^{d}. Rather fuzzy definition. 111 (power). Though near the meridian, I did not see my dark rift so well as on Jan. 5^{d}. I could, however, distinctly make out the dark opening on lake to which it leads [W_2], and noticed that in the triangle it forms with 65 [619] and 70 [635] the side from the lake to 70 seemed rather shorter than the other two The N. edge of the cleft passing 87 and 70 seems a continuation of the N. edge of the *Sinus magnus*, the rift extends probably right through the more luminous region of the nebula. I do not think the projecting end of the *reg. Huyg* [E]? quite so conspicuous, as compared with the S P and S F masses as when I sketched it in 1863 and 1864. The *neb. obl.* is faintly but decidedly visible.

1866, Jan. 25^{d}. Small disks behind a great undulating flutter. The rift may still be detected, especially by averted vision, with 111, notwithstanding a moon 2 days past 1st qu. It seems to be feebly traceable beyond the lake, as a N P border to the brightest part of the *reg. Huyg.* running in fact from the *S. mag.* straight across to a large and conspicuous dark opening, not distinctly shown in any drawing which I have, except that by Bird, but forming a continuation of the direction of the *Sin. Gent.* with which it is connected by a long, narrow channel, discovered by me, 1864, Dec. 27, and confirmed on Dec. 30. Under these dates I have no marginal memorandum on my sketch as to the great lake into which this channel leads, but it was rather beyond my sketch at that time. I have of late noticed it more than once as a conspicuous long dark opening, which now seems to me, with the *Sin. Gent.*, the connecting channel, and my new rift to insulate the brightest part of the nebula on two sides from the adjacent nebulosity. In the triangle 67, 70, lake (see Jan. 5^{d}), 70 lake was certainly shorter than the other sides. With 450 the rift is still pretty distinct, the triangle is neither equilateral nor isosceles, the F side being longest, P next, and N shortest. The space included by the 4 lobes of light S. of the trapez. [E, F, G, I] is comparatively, I fancy, darker than formerly.

1866, Feb. 17d. Very small disks, but twirling too much, 212, 450. 5th star very plain; no 6th. 76, 84, 89 visible. I cannot see 80; *pons Schröt.* and included nebulosity very evident. I do not see *neb. oblong.* N. end of *Sin. mag.* projects about as far as end of W. edge of S. side. It is clearly bifid. I do not see the canal very plainly, but the lake is pretty visible; beyond it is a stretched out mass of nebulosity. 450 shows 5 masses in *frons* and *occiput;* the 3d [H] reckoned along the *frons* does not reach 93 [685] which is surrounded with strong nebulosity. The end of S. side [qu. N.?] of *Sin. mag.* has a finger, and a rounded projection N. of it. I doubt the continuation of my canal through the lake. Later, I see *neb. obl.* and my rift better with 450, the *frons* appears to consist of 6 cumuli, of which the first 3 are more distinct and less run together than the last. The bottom of the *Sin. Gent.* seems to fall just against the opening between the last great cumulus of the occip., and a large, less distinct round mass NP [between I and J]. Cumuli 2 and 3 of *frons* form an equilateral triangle with one in the interior. [F, H, and G.]

The following observations were made with a silver-on-glass speculum by WITH., 9.38-in. aperture:

1867, Feb. 2d. Blotty air; power, 212. No. 5, reddish; 6 not distinct in bad air. Blackness of *Sin. mag.* very striking just outside [following ?] the *pons Schröteri.*

1867, Mar. 2d. Bad definition. 111 ±. The dark rift and lake of last spring are pretty well seen.

1869, Nov. 9d. A fine night. 65. 4 in trap. very obvious, though so low; and spiral character of wisp round 108 [734].

1869, Dec. 1d. Definition especially bad, the focus showing the disturbance-plane to lie very near the earth. There is not only a strong nebulosity round *t*, with 65, notwithstanding the state of the air, but two considerable stars further S. are evidently involved in a similar, but separate, mass of it. With 450 I thought there were strong indications of my rift and lake.

1869, Dec. 11d. Good definition, but *Orion* too low. 450, 5th in trap., which had been feebly traced with 110, could be well made out, but would hardly have been discovered. The knob of haze at the end of the *Sin. mag.* is very conspicuous. In the direction of the longest diagonal in trapez. is a luminous ray, at 3 or 4 times the distance of the 2 stars, between which and the trapez. the nebulous films in a transverse direction. The nebula in this region is strikingly pulled out, as it were, into lengthened streaks, lying in various directions. [A?]

1869, Dec. 28d. Definition not good. With 450 I make out pretty fairly the dark rift and lake formerly observed. See 1866, Jan 5d.

1870, Jan. 25d. Unusually good definition (no powers specified). 5th distinct, but not bright or even obvious; it might easily have passed unnoticed. 6th I could not see. The interior of the trapezium, though fainter than the *regio Huyg.*, is decidedly and strongly nebulous, as compared with the *Sin. magnus.*

1874, Feb. 19d. Fluttering definition, but clear air. 5th in trapez. examined for HUGGINS with BROWNING'S E eye-piece = ± 357. I glimpsed it occasionally with difficulty, but for the most part it was invisible. I have remarked the same with 450 on more than one occasion during the present season.

1874, Mar. 18^{d}. Thin haze. 5th in trap; occasionally seen with $\pm$ 357, but never would have been discovered.

OBSERVATIONS OF BIRD (1866).

A drawing by FREDERICK BIRD, Esq., of England, bearing the date of 1866, January, has been also courteously communicated by the Rev. T. W. WEBB. It was made by means of a 12-inch silvered glass reflector. No notes accompany the original. The masses A, B, etc., are not separately laid down, and the following notes which I have deduced from the drawing are somewhat uncertain from this cause.

Decidedly the brightest portion of the *Huyghenian region* is that including the masses F and G. This portion is brighter than A or D. The apex of this region (E) is fainter than G, H, etc., and appears to be about equal to B.

The peculiarities of *figure* I have not specially examined, as we have contemporary drawings with larger telescopes.

OBSERVATIONS OF G. P. BOND (1859–1865).

Through the kindness of Prof. E. C. PICKERING, director of Harvard College Observatory, I was, in August, 1877, allowed access to the original papers of my cousin,

FIG. 32. G. P. BOND, 1865.

GEORGE BOND, at the Observatory in Cambridge, which I visited for the purpose. The following notes referring to the central regions of the nebula of *Orion* are given in addition to those selected for publication in the Annals of this Observatory, vol. v, p. 155 *et seq*, and these are given in the words of the writer with such explanations as seem to be required.

The exquisite steel engraving made under BOND's direction is reproduced in the frontispiece by the kind permission of the director of the Harvard College Observatory, who has lent the original steel plate. Fig. 32 gives its central parts on an enlarged scale. The frontispiece is, to my eye, the most satisfactory representation of any celestial object which has yet been produced. It was corrected and revised many times, and the artist (J. W. WATTS, Esq.) had the use of the Harvard College refractor for several years in order to study the pictorial effect. The MS. drawings of BOND abundantly show, however, that the forms of the masses, etc., are due to him.

EXTRACTS FROM OBSERVING-BOOKS OF HARVARD COLLEGE OBSERVATORY.

[Also, see BOND's Memoir, pp. 155 *et seq.*]

G. P. BOND, observer. Notes in square brackets are by myself.

Frons.

1859, Feb. 23. The edge [*frons* and *south* shore of *Sinus magnus*] seems to be just perceptibly brighter than the [*Huyghenian*] region within it. [A sketch, omitted here, gives a strip "as wide as the trapezium" along the *frons*, which is presumably the brighter strip.]

A.

[A] is the brightest part of the nebula. [Its *following* outline laid down.] This is verified 1859, March 4.

Sinus Gentilii

is very black.

D.

[D] is bright.

1859, March 23. [As twilight came on the relative brightness of the various masses was noticed by observing the order of their appearance. The first mass to appear was A, and the second was H = c_0 of LIAPONOFF.]

1862. March 27. The smallest stars in the bright masses of nebulosity about the trapezium are easily seen in strong twilight and before others in darker regions come in sight, although when the sky becomes dark the latter are much more easily seen.

This shows that the *small* stars near the trapezium are really much brighter than they appear to be, their light being commonly overpowered by that of the nebula. This fact is important as evidence of a clustering of stars about the brighter nebulous regions.

1863, Jan. 18. [The direction of the *following* side of *pons Schroeteri* is as in figure (omitted).] The line limiting it passes through 669 and a point ⅓ of the distance from 685 to 708 measured from 685.

1863, Jan. 19. [*Following* edge of *pons Schroeteri* is along a line joining 685 with No. 669?; g_0 seen.]

1863, Jan. 30. [F] is equilateral.

1863, Feb. 23. "The drawing of 1859 in detail was compared with nebula in the end of February, 1863, and no change of any prominent feature could be recognized."

[From sketches it appears that the dark channel between F and G is in the prolongation of 685, 708. A is plainly laid down. 647 and 651 both *inside* the border.]

1863, Dec. 7. I always look at *Sinus magnus*, etc., for change of feature, but was never satisfied of any not accounted for by change of atmospheric conditions.

1864, March 19. "In very early twilight the bright [*Huyghenian*] region is defined so as to extend the borders of *Sinus magnus* to the *preceding* side of θ'."

[This is of importance in connection with the same appearances laid down by PICARD and LE GENTIL and in my own drawings made through tourmaline plates.]

Note error of HERSCHEL'S engraving in placing the "cape" on the *n. f.* side of the *Sinus magnus;* edge of cape, 17″ *n.* of [669], whereas it is south as much as this. [HERSCHEL'S drawing certainly differs in this respect from all drawings since 1865.]

1864, March 28. [Memoir, p. 1864.] [The nebula was observed in the twilight for the purpose of noting the order of brightness of the various parts.]

$7^h\cdot17^m$, sid. time. [A] and surrounding parts visible.

$7^h\ 19^m$. Outline of *Huyghenian* region is readily distinguished, especially near 685. [D] is a little but not much fainter than [A].

$7^h\ 25^m$. The [*occiput*] is evidently less clearly defined than the [*frons*]. *Sinus Lamontii* is not darker than the dark channel between [I and (F and G)]. I was confident of tracing the continuation of [*occiput*] across the *Sinus Lamontii.*

1864, April 7. *R. Picardiana* immediately north of trapezium is far brighter than the *Messierian* branch. [This is different from LIAPONOFF, p. 79.]

1864, April 9. The [*north*] terminus of D is quite sharp.

1864, April 14. The limit of the *Huyghenian* region falls short of the R. A. of [708].

1864, April 15. $\Delta\delta$ of *north* point of D is measured 69″.8. [*Following* edge of [D] $\Delta\delta = 25''.6$ measured. 646 is far within the nebulosity.]

COMETIC TAILS TO 685, 708, 741.

[These were always seen under good circumstances, and, I believe, with various eye-pieces. I give below a few of the dates (from *Annals Harv. Coll. Obs.*, vol. v, pp. 155 *et seq.*) on which mention is made of them.]

1859, March 10.

1861, February 6. A tail to 570 noted.

1864, January 26. A tail to 746 noted.

1864, February 3.

MEMORANDA FROM A SKETCH OF GEO. P. BOND'S, DATED APRIL 16, 1864.

Sinus magnus.

A rough sketch is given showing τ' and τ'' [of index-chart], etc., and various notes are made, as follows:

τ.

From 640 a line is drawn *n. f.* in $p = 45°$, and BOND says "*n. p.* this line the *Sinus magnus* is filled with diffuse light, and edges are ill defined."

"Limit of dim outline of bay on *south* shore of *Sinus magnus* [*i. e.*, *south* shore of τ] reaches to declination of θ'."

"General direction of irregular [*southern*] outline of *Sinus magnus* (brighter light) * * * * is inclined 25° to parallel [$p = 115°$]. This cuts off part of decided promontory meeting bridge" [(*Pons Schroeteri;*) this refers to R.]

"Limit of dim outline of bay [τ'] in *south* shore of *Sinus magnus* reaches to 10″ or 12″ *south* of θ', terminates with second bridge" [by "second bridge" is meant the *preceding* edge of ξ and *not* "SCHROETER's second bridge"]. "South limits estimated with care."

"Outlines of two bays dimly suggested on the *north* shore of *Sinus magnus* [these are τ and τ']. Evidently the bay [τ'] has to do with the impression by the channel coming *southward*, or rather *s. f.* from [652, 657, 663, *lacus Lassellii*], and the separation into two bays is as evidently suggested by the bridge '*pons Schroeteri.*'"

North "outline of bay [τ] dimly suggested." * * * * * * "The above sketch appears to me to suggest a more correct outline of *Sinus magnus* than the lines of my engraving, although in that it is the effect mainly which should be corrected. The suggestion of two *ovals* forming *Sinus magnus* is stronger when vision is bad, and no doubt HERSCHEL's drawing [1837] aims at representing this."

Lacus Secchii.

"This prominent dark spot is the sudden limit of light of *Huyghenian region*, and from thence to [D] the limit, though indented, is precisely on the parallel."

The parallel of 1′ *north* of θ' is nearly the limit of bright light from the trapezium *northward* between the R. A. of [647] and the R. A. of the *preceding* edge of [*lacus Secchii*].

D.

The *following* side of D "is well defined and straight, forming nearly a straight line in the meridian with edges of masses *south* of it [*i. e.*, of T], but the latter incline more to the *south following*." 647 is immersed in D, and 651 is on its edge.

Preceding edges of J. and B.

"This edge of nebula in meridian precisely through [575]."

A.

The *south* point of A runs up to 608 pretty exactly. 621–622–625 appear to be in darkness according to this sketch.

From memoranda of features to be re-examined. BOND remarks that the outline of the *occiput* is continuous across the mouth of *Sinus Lamontii*, although less bright.

In the Memoir "On the Spiral Structure of the Great Nebula of Orion," presented by G. P. BOND to the Royal Astronomical Society (*Mon. Not., R. A. S.*, xxi, p. 203), BOND speaks of the small wisps or tails of light which are shown most plainly in his engraving in the Annals of Harvard College Observatory, vol. v, near the stars 685, 708, 741 of his Catalogue. That this was really seen by BOND we learn from his accurate description of them; he speaks of "the large number of instances in which collections of nebulous matter are found associated with stars, frequently in the

form of little wisps, shooting off in a southerly or south preceding direction." Other things are mentioned which point to a connection between the stars and the nebula, as *e. g.*, "the predominance of small stars in the nebulous regions," the "two remarkable instances where there is a deficiency of nebulous matter in close proximity to bright stars, which are yet closely encircled by it These are the bright groups of the *trapezium*, the central comparative darkness of which has been noticed by many observers, and *ι Orionis*. Lord ROSSE's figure of the latter is decisive on this point. These features seem to favor the idea of a physical association of the stars with the nebula. The existence of a spiral arrangement of its component parts falls in with the suggestion of a stellar constitution, since, among the objects exhibiting this peculiarity are included, not only resolvable nebulæ, but actual star-clusters, such, for instance, as the great cluster in *Hercules*, which has an unquestionable curvilinear sweep in the disposition of its exterior stars.

In the *Monthly Notices* of the Royal Astronomical Society, vol. 24, p. 179, G. P. BOND replies with definiteness and with perfect justness to strictures which had been made upon his published engraving (same work and vol, p. 92), and institutes a comparison between his drawing and HERSCHEL's (1837), which had been quoted as evidence against his own. I quote certain portions of this as supplementary to what has already been given:

"The only areas quite destitute of light which I have found in this part of the nebula, are: 1st. An irregular opening with its center in the position $\Delta\alpha + 108''$, $\Delta\delta + 50''$ [*i. e.*, our τ'], and 2d, a narrow channel having its axis nearly in the parallel, and a declination of $\Delta\delta = +72''$ at the right ascension $\Delta\alpha = +160''$" [our τ'']. * * * * * * * * * "We have a first well defined point of departure at the position $\Delta\alpha = +145''$, $\Delta\delta = -20''$ [our point Q; LIAPONOFF's B]. Of this there is no trace in HERSCHEL's drawing. LIAPONOFF gives $\Delta\alpha = 146''.5$, $\Delta\delta$ $22''.0$. HERSCHEL makes the breadth of the bright light here still 40″ to 50″, and continues the curve * * * 180″ beyond its actual limit." "We find, then, the following instances of discrepancy between HERSCHEL's delineations of the region in question and the actual appearance of the nebula:

"1st. The absence of a definite limit to the bright light of the *Huyghenian region* on its eastern side, etc.

"2d. The bright light on the southern shore is carried 10″ to 15″ too far north."

* * * * * * *

"4th. In its best defined part the western shore is placed 12″ too far to the west.

"5th. [g_0] is 15″ to 20″ too far north, etc.

"6th. All the features of the northern shore [of *Sinus magnus*] to the east of *pons Schroeteri* are represented in positions 30″ or 40″ north of their true locality at the same time that the direction of the principal lines is largely in error."

OBSERVATIONS OF LORD ROSSE (1867).

(These observations are extracted from *Phil. Trans.*, 1868, p. 57, *et seq.*)

"The observations upon this nebula, recorded in the journal of the observatory at Parsonstown, date from 1849. From that time till February, 1858, there are entries of 54 observations.

In the year 1852 Mr. BINDON STONEY made a drawing of the *Huyghenian region*, which is a very interesting record.* Mr. BINDON STONEY was a highly educated civil engineer, well accustomed to use his pencil.

His drawing was made with great care, and he was engaged upon it the whole season. It was compared by several persons with the nebula, and was considered exact. When we compare this drawing with the nebula as it is (Figure 33) at present, there are strong indications of change.

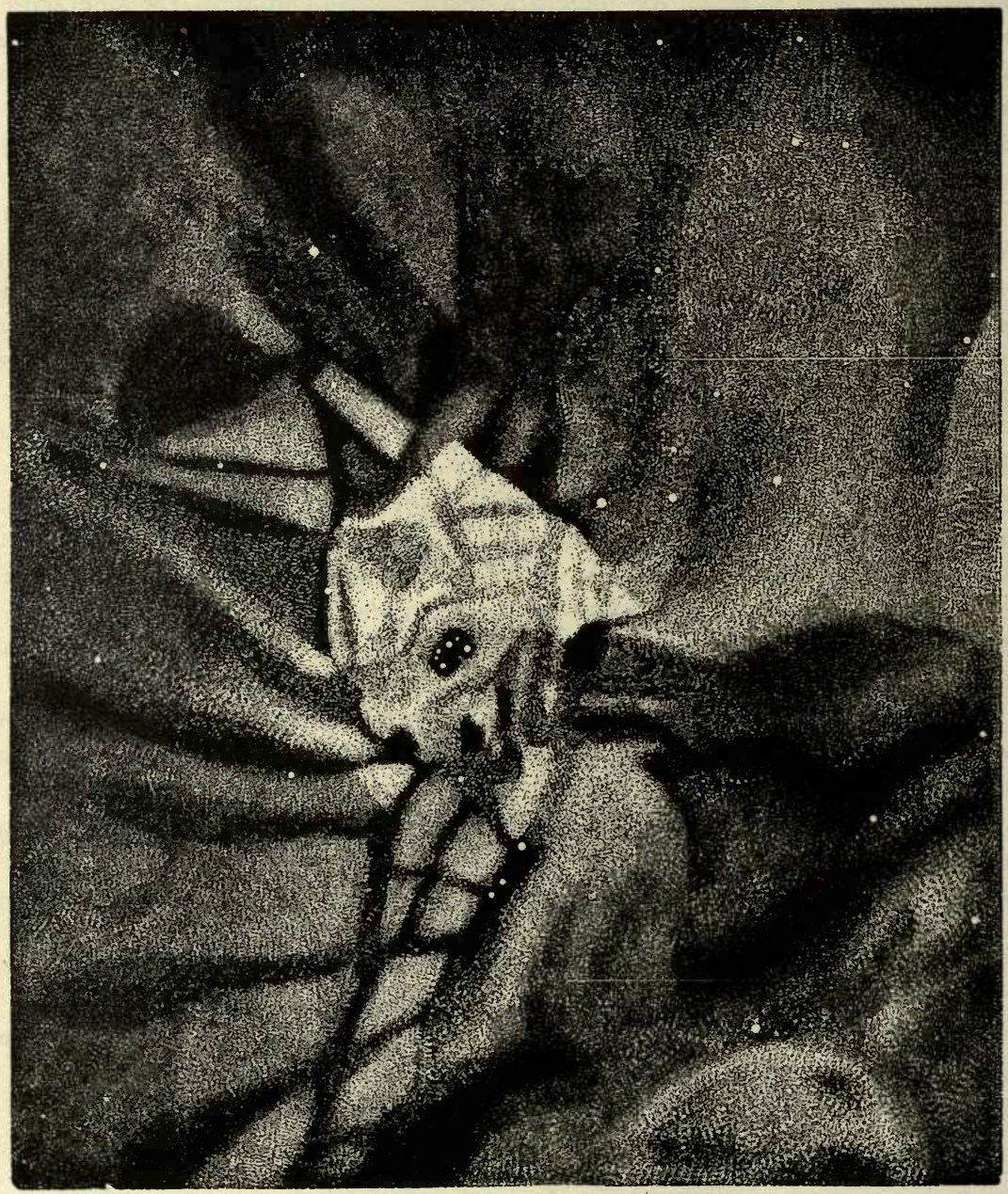

FIG. 33. ROSSE, 1865-'67.

Between February, 1860, and February, 1864, there are 74 entries of observa-

* A photograph of this interesting drawing has been kindly sent me by Lord ROSSE, to whom my thanks are due for this and other similar kindness.

tions. In February, 1860, Mr. HUNTER, who was then the assistant, being an accomplished artist, commenced a new drawing, and was engaged upon it till February, 1864

As a groundwork for his drawing, Mr. HUNTER laid down all the stars given in "Observations de la grande nebuleuse d'Orion faites à Cazan et à Pulkova, par O. STRUVE, St. Pétersbourg, 1862," in the positions given at page 118 of that treatise; the nebulosity was gradually filled in by eye as correctly as possible with reference to the stars given in that memoir, and twenty-eight additional stars from the 9th to the 15th magnitude were inserted by eye-estimation

During the season 1864–'65 the nebula was often examined with the view of verifying the drawing made by Mr. HUNTER, and in 1865–'66 some additions were made to it.

During the season 1866–'67 these measures were completed, the additions of the previous season verified, and the drawing extended. [The Figure 33 is copied from the drawing black on white published in sections, and not from the large engraving.]

Very little need be said on this subject, as the drawing will speak for itself; it may, however, be well to call attention to the apparent connection between some of the stars and the nebulosity near them.

In some places the stars appear to have either repelled or absorbed the nebulosity, for instance at the trapezium, at 32* and 35, and so on; and in other places the nebulosity is denser, as if the star had attracted it, for instance at 2_{I}, 4, 34, and 108. Around the star 108 [734] the nebulosity seems to have a spiral character, and the same appearance, though much less decided, may be seen round 4. Round the stars 46_{I}, 46_{II}, and 99_{I}, the nebulosity seems to have been concentrated, but close to them there appears to be an absence of nebulosity; and in the case of 99_{I}, the dark hole is situated eccentrically with respect to the principal star, its nearer companion being close to the opposite side of the hole; but in the case of the double star 46_{I}, 46_{II}, the hole is nearly symmetrically situated, but the nebulosity is brightest at the north preceding side. We can hardly, therefore, account for these numerous coincidences, except by supposing some at least of the stars to be situated nearly at the same distance from us as the nebula; in fact immersed in the nebulous matter.

[This point, as brought out by Lord ROSSE, and confirmed as it is by a telescopic examination, appears to be a conclusive proof that we have, at least, some of the stars associated with the nebula.]

Variability of form and intensity of the nebulosity.—On this subject it is impossible to speak decidedly. On comparing the following six drawings—

Sir J. HERSCHEL's of about the year 1825,
Sir J. HERSCHEL's " " 1837,
Mr. BOND's " " 1848,
M. LIAPONOFF's " " 1850,
Mr. LASSELL's " " 1854,
Mr. HUNTER's " " 1863,

great discrepancies exist in almost every part, but these are probably to be attributed in a great measure to the difference of power in the instruments used and

* Only those stars within the limits $\Delta\alpha = \pm 300''$ and $\Delta\delta = \pm 200''$ have been marked with BOND's number.—E. S. H.

the amount of labor expended on the drawings, as no continuous change seems to be shown by them. In the case of the spiral nebula round 108 [734], BOND'S, LASSELL'S, and HUNTER'S drawings appear to agree tolerably well, allowance being made for the difference of size of the instruments, but when we go back to HERSCHEL'S drawing of 1837, we find a considerable discrepancy. HERSCHEL'S drawing of 1825, however, as far as it goes, is in this place more like the latter drawings. With regard to the following extremity of the *Huyghenian region*, all the former drawings, with the exception of LIAPONOFF'S, represent the *frons* as curving round to meet the *Proboscis major*, which latter also curves round to meet the former, whereas Mr. HUNTER represents both these parts as curving slightly in the opposite direction. This I am satisfied is their present appearance. If, however, the night is not good, they acquire very much the appearance of the other drawings, the light of the brighter portions being scattered, to a certain extent, over the intervening space. In the case of the *Huyghenian region*, HERSCHEL'S drawing (1837) agrees much more nearly with Mr. HUNTER'S than any of the others, although the interval (30 years) is so much longer than in the case of Mr. BOND'S and Mr. LASSELL'S drawings (15 and 9 years, respectively).

With reference to the relative brightness of the various parts, I find recorded by Mr. HUNTER, February 22, 1861:

"In bright moonlight the degrees of brightness are—

"1. The *Huyghenian region.*

"2. The nebulosity immediately south preceding it.

"3. The *Mairanian region.*

"4. The subnebulous region.

"5. The south *Messierian* branch, and the nebulosity immediately north of the *Huyghenian region.*"

And again: "The observation of February 22, 1861, gives very different degrees of brightness for the various regions from what they had this season (1863–'64).

"1. The *Huyghenian region.*

"2. The nebulosity immediately south preceding it.

"3. The nebulosity immediately north of it.

"4. Subnebulous region.

"5 The south *Messierian* branch and the *Mairanian region* nearly equal."

Mr. HUNTER on two occasions estimated, as nearly as he could, the relative brightness of the various masses of nebulosity of the *Huyghenion region.* The following are his estimations. (See diagram.)*

FEBRUARY 13, 1864.	MARCH 1, 1864.
σ [A], τ [L], ν [Q], γ [F] nearly equal; brighest of these is perhaps σ.	σ [A], brightest.
	ν [Q], τ [L].
	γ [F], ε [H], δ [G].
π [C].	
ω [in A], ε [H], δ [G], β [I]; β is the faintest of these four.	θ [N], μ [R].
	π [C], very faint.
α [E], i [in Q], ψ [2], λ [in Q].	
ζ [in M], φ [between J and A] faintest.	

* To these estimates we may attach much importance, as Mr. HUNTER had the advantage of a considerable amount of training as an artist.

"There are several places where we have reason to suspect that a change of form may have taken place in the nebulosity since our observations commenced:

1st. In Mr. BINDON STONEY'S drawing, of which an outline is given at the upper right-hand corner of the skeleton map, a dark line exists running from 88 [671] in a direction parallel to the *frons*, whereas at present the only break in the nebulosity at all in the same direction runs from 88 [671] in a south following direction. [It is thus at present.]

2d. The projection of the nebulosity below 88 [671] into the *Sinus magnus* does not exist in Mr STONEY'S drawing. [μ of ROSSE = R?]

3d. The following outline of the nebulosity immediately below 75 [647] is concave towards the following side in Mr. STONEY'S drawing, but convex in Mr. HUNTER'S [also in Washington Observations]. In all these points I believe that Mr. HUNTER gives as nearly as possible the present appearance.

4th. Mr. HUNTER represents the outline of the nebulosity surrounding the dark region or lake round the stars 32 [449], 35 [479], as very marked. I often examined this part during the seasons 1864–'65 and 1865–'66, but never saw it quite as distinctly as it is represented on the following side, nor did I see the elbow just following 35; the nebulosity appeared to be more of the shape represented by the coarsely dotted line in the skeleton map.

5th. I was never able to see more than two of the three rays below this lake, and except on two or three occasions I could only make out one. Mr. HUNTER has since told me that in the last season during which he was working, these rays were much fainter than they had been previously, and that they are represented too bright for their appearance during the season 1863–'64.

In connection with this subject, it may not be uninteresting to compare the observations of former observers with each other and with our own.

Sir J. HERSCHEL in his paper of 1825 discusses the differences between his own drawings and those of HUYGHENS, PICARD, MESSIER, and LE GENTIL, and thinks that the first three, when compared with his, tend to show a gradual diminution or condensation of the nebulosity; but LE GENTIL'S, which was older than MESSIER'S, represents it just as he himself saw it.

We next come to Sir J. HERSCHEL'S paper of 1837, in which he says that although to any one who has not viewed this object through powerful telescopes the differences between the various drawings, including his own of 1824 and 1837, may seem great, and tend to convey an impression of great and rapid changes undergone by the nebula itself, yet, after carefully comparing his own two drawings, he comes to the conclusion that the differences are not greater than he is disposed to attribute to his own inexperience in such delineations in 1824, to the greater care bestowed on the later drawing, and especially to the advantage of better local situation and superior defining power, etc., of the telescope at the latter date (Cape Observations, page 31). There are three points, however, to which he directs attention, but in the case of two only of them is he inclined to conclude that there is any evidence of change; these points are—

1. The form and position of the nebula oblongata between 127 and 129.

2. The position of the nebulous spur between 111 and 122.

3. The form of the nebula round 108.

In 1824, Sir J. HERSCHEL saw the nebula oblongata as a "tolerably regular oval," nearly in a line between the stars 120 [781] and 136 [848], whereas in his drawing of 1837 it is irregular in outline, and decidedly above the line through 120 and 136

With respect to the form of the nebula oblongata, the brighter part forms a "tolerably regular oval," but when the fainter parts are included, it seems to be more of the form given in HERSCHEL'S drawing of 1837. It is, therefore, quite possible, even probable, that HERSCHEL would have seen it oval in 1825, but long and slightly curved upwards, with the superior means at his disposal, in 1837, without any change of form having taken place in the interval; but as regards its position, it appears to be now entirely above the line 120—136.

With regard to the nebulous spur between 111 [746] and 122 [783], diagrams which he made in 1832 and 1834 represent it as "running directly from 135 to 111 and forming a complete hook no way disjoined from the proboscis." In 1837 he saw it "neither joined to the proboscis nor directed towards 135, but rather towards a point one-third the distance from 135 to 126," near the position of 131. HERSCHEL'S second drawing appears to agree very fairly with the accompanying one in this respect; perhaps the superior definition of HERSCHEL'S instrument in 1837, a better atmosphere, and the greater* meridian altitude of the object enabled HERSCHEL to perceive the interval between this spur and the proboscis which had escaped his notice in 1832 and 1834.

With regard to the nebula round 108, the amount of detail in HERSCHEL'S drawing of 1837 is so much greater than in that of 1824, and the detail in the accompanying drawing is so much greater than in HERSCHEL'S of 1837, that it seems hardly possible to arrive at any conclusion by comparing them.

The engraving is upon the whole very accurate; a little more softening off in the faint outlying parts would have been desirable, but Mr. BASIRE did not think that it would be practicable, consistent with the reasonable durability of the plate; the forms, however, are correct. The sharpness of outline and the hard and marked character of the principal features are the result of the great light of the instrument; with a diminishing aperture, these characteristics gradually fade away. The engraving faithfully represents the object as it may be seen on any clear night, and the details are so well marked that no material change can take place hereafter which will not at once be recognized with an instrument of similar power. The interior of the trapezium has not been examined recently with the view to the question whether it is absolutely dark. With the 6-foot instrument the eye is so dazzled by the light of the four stars that it is difficult to form an accurate opinion; and any nebulosity which may exist is probably too faint to affect the spectroscope.† I am not certain that any part of the nebula is absolutely free from nebulosity, but the contrast is so great between the dark spaces alluded to by Sir JOHN HERSCHEL and the contiguous portions of the nebula, that even in the drawing it was scarcely possible to indicate nebulosity so

* This last applies to the diagram of 1832 only.

† See Memoirs by HUYGHENS, LE SUEUR, D'ARREST, and others.

slightly as not to interfere with the proper gradation of light; in fact it was scarcely possible to represent the bright parts sufficiently bright.

OBSERVATIONS OF SECCHI (1868).

Following I give a translation of portions of SECCHI's memoir:

"*Sinus magnus.*—The bottom of this gulf is separated from the region of the trapezium by two opposite promontories of moderate brightness and almost triangular form which close it by their juncture. We have already spoken of the inferior one F [the α_0 of LIAPONOFF D]; the other opposite is much less luminous. The bottom of the gulf is separated from the rest by the *bridge of Schroeter*, the variability of which is, it seems to me, indubitable. In HERSCHEL this *bridge* is indicated as a simple promontory, and on slightly cloudy evenings this has been its appearance, but when it has been clearer, it has always been visible as a true bridge formed by light veils of mist that traverse the gulf. And in a former year I find that, in this connection, a correction was made by hand to a drawing of HERSCHEL's with an express reference of this nature in the journal of observation. Prior to that we noted, by hand, upon the drawing of HERSCHEL a bright point, not stellar, in the middle of the bridge, which was not visible when our drawing was finally made (g_0).

FIG. 34. SECCHI, 1868.

Afterwards from the bridge down to the bottom of the gulf there was to be seen in 1857 a continuous nebulosity, not so thin, a drawing of which was made with much diligence, precisely because it was not to be seen in the drawing of BOND,* on which it was drawn by hand; it terminated, however, in an arc, convex toward the bottom of the gulf itself. In 1867, on the other hand, the mist, if not vanished altogether, had at least diminished very considerably; and the *bridge* seems curved inversely and

* All references by SECCHI to "BOND" are to W. C. BOND, 1848.

almost uninterruptedly, tracing a rudimental spiral arc. In the drawing of 1857, I find but a very faint trace of the other branches that may be seen as promontories in the gulf following the principal *bridge*, and that now have become brighter. But a little mist in the atmosphere causes all these minute details to disappear. The bottom of the gulf being free from stars, its luminous appearance cannot be attributed to the influence of the atmospheric air. LIAPONOFF has drawn a more brilliant luminous mass in g_0, near the middle of the *bridge*, which would seen to confirm the one seen by us.

On the 28th February, 1865, we observed the nebula together with STRUVE, and we were surprised to find the mouth of the *Sinus magnus* shut in by nebulosity in such a way that the anterior part of it appeared like a great closed (oval) ellipse, whence uniting to this the part *following* the *bridge*, all the gulf had the appearance of the figure 8 or of a *Lemniscata*. This form had already been seen by us, likewise, in 1858, on the 15th January, and noted as extraordinary, and as discrepant from another drawing of this part made previously. I read in the journal: *The nebula is well drawn; it only lacks a little nebulosity in the opening. The internal area* (*as far as the bridge*) *is black, and almost exactly round. The comma* (nebula of MAIRAN) *is composed of two pieces.* Here there is no mention made of the second rudimentary bridge, which is found not only in the drawing of Father FERRARI, but likewise in my sketch in 1867. [SCHROETER'S second bridge in τ is *not* here referred to.—E. S. H.] This nebulosity in the mouth (opening) is not to be confused with the *nubecula minor*, which stands in front of it, but at some distance, of which a trace is found in HERSCHEL, but which, according to him proceeds to unite with the peninsula of the region of PICARD, though I find no correspondence with these convolutions in our work.

The great gulf, which gives to the nebula the form of a monstrous head with wide open jaws, is reproduced in all (the old) drawings. By reason of the weakness of the instruments used, those drawings do not merit discussion, but it is curious to note in them the difference in the aperture of the gulf and the length of the jaws. Probably by imitating the old instruments in various conditions of the air one might succeed in obtaining the same appearances, and certainly nothing could justify the enormous variations that those configurations suppose, judging from what we saw here forty years ago.

Regio Picardina—Its extremity, K, forms a peninsula which has the form of a point of an arrow directed obliquely downward, and by moonlight is seen separated from the rest by the *lacus Lassellii*, which communicates with the *Sinus magnus* by means of a dark canal. But on a dark night no true interruption exists. This peninsula has three well-defined points on the side of the gulf, the middle one of which is the brightest. Only on one occasion the *lacus Lassellii* failed to be marked upon one of our drawings, but the fact that the necessity for correction was felt immediately after, proves that the omission was accidental. There is a trace in HERSCHEL of the *lacus*, but the ingress to it is barred by a nebulous zone without, which is certainly not seen now.

Lacus Secchii was discovered by O. STRUVE, and is perfectly visible but always difficult to recognize in the splendor of this region. Sometimes I have seen it very

clearly, again quite indistinctly, and it is difficult to indicate the reason of this. The bottom is nebulous and the margins poorly defined, and its contour is rudely cruciform. In Σ there is a similar spot, analogous, previously seen by STRUVE, which might be called *lacus Struvii*, but it is less clearly defined than the preceding one. Near its following margin it has the little star 70 [635] of HERSCHEL, and another, similar stands near the other small star, though eccentrically to it.

Going towards the left, in the direct line of the two lakes S and Σ, one comes to the *palus Bondii*, which is terminated by two circular arches The most southern of these arches is far more brilliant than the northern. These two hemicycles are separated by a narrow canal seen by STRUVE, from which the *palus* communicates with the *Sinus Lamontii*, and by it with the region of LE GENTIL.

Regio Gentiliana.—LE GENTIL was the first who saw above the region of HUYGHENS a black *oblique* canal, which was afterwards better traced by LAMONT. The figure of LE GENTIL presents it drawn with hard [border] lines, altogether unlikely in so nebulous an object. The *Sinus Gentilii*, which forms a bay beyond the canal of LAMONT, ordinarily is entirely free from nebulosity. Through this vestibule one enters the canal of LAMONT, which is distinct in two successive almost semi-circular spaces.

There is a trace in HERSCHEL of the vestibule and also of the first semi-circle, but none of the second. On certain evenings this canal is so black that it is surprising it should not have been seen by every one, and that explains the hard and strange contour of LE GENTIL. On the evening of the 23d of January, 1859, I find a drawing made by Father CAPPELLIETTI, and retouched by me, in which the *Sinus Lamontii* is quite free of nebulosity. In the same drawing the *palus Bondii* is fully illuminated, and the *Sinus magnus*, on the contrary, has the bottom shrouded from the *bridge of Schroeter*, upward. In another quite large drawing, done by myself in white on a dark blue surface, I find that the canal of LAMONT is quite well defined, but it lacks the point in the middle so that the two hemicycles form but one of larger size, with a brilliant mass in their midst, which is what now forms the midmost promontory. Whether these divers forms be one and all attributable to accidental causes, or to real mutations, I am not able to decide, but I find that STRUVE does not believe this to be the condition of this canal. In BOND there are traces of it, but not well defined. The gulf and the canal are quite easily recognizable in the drawing of DE VICO, though, owing to the weakness of his instrument (6 inches), it lacks many details. All this part has an illumination inferior to the region of HUYGHENS, and in feeble moonlight it seems almost as limited as in DE VICO, while by the full moon it approaches the figure of LASSELL. This proves the enormous influence of the strength of the instruments upon these contours. However, the canal of LAMONT is indirectly indicated in all those figures which cause the region of HUYGHENS to terminate brusquely in a triangle. I said that there is not a trace of the second semi-circle in the canal of LAMONT in HERSCHEL; but this gentleman kindly showed me an unpublished drawing, in which there is some indication of it, and if he did not publish it, it was, perhaps, because he did not see it confirmed. But to have drawn it is a proof of having seen it, and in short, all goes here to prove that we have to do with a region which is either variable or that merits further ulterior study.

Regio Derhamiana.—This is situated above the canal of LAMONT. It has a tolerably brilliant light, but is inferior to the region of HUYGHENS It exhibits quite a curious network of masses to us, among which is a semi-circle or arc T. U. in the polygon, page 14, which appears to be the *hemicyclium Liapanouvii* of STRUVE [?]. I find the two bright masses without this arc quite well indicated in a drawing of 1857. This region is somewhat difficult to examine with our instrument, and the gradation of light is not so sensible as in the other portions. The disagreements with the other drawings are notable. Probably because in the stronger instruments the augmented light brings the less clearly-defined lower regions into prominence, and thus causes the more brilliant portions to disappear, in such a way that the aperture and strength of the instruments would perform, up to a certain point, a contrary office to that of the moon, and further studies are therefore rendered necessary. Perhaps this circumstance explains certain hard contours given by several observers.

Regio Messieriana.—Returning now to the side toward the right, and most distant from the region of HUYGHENS, we have to consider here the great *proboscis* which does not enter entirely into the square of our drawing. On this proboscis two well-defined promontories are projected. The principal of these, called the *promontorium Herschelii* up to the year 1857, has its vertex below the neighboring small star, as in the actual drawing. It is placed differently by BOND, who puts the point against the little star, and by HERSCHEL, who makes the point more obtuse. In the cavity of the arc is the second minor promontory, which is not found at all in BOND, and is differently outlined in HERSCHEL. The form of this second promontory traced in the drawing of 1857 approaches more nearly to that of HERSCHEL.

The *proboscis major* is not joined immediately to the region of HUYGHENS, but is detached from the root of it, and the direct prolongation of the above-named region is more properly in the *proboscis minor.* The three parallel stars, *e*, *f*, *g* (685, 708, 741) of STRUVE are all outside of the denser nebula above the root of the proboscis, but are shrouded in a thin mist. Thence the uncertainty of their positions with instruments of small size and little strength, which are liable to show them wrapped in the principal nebula, which explains the figures of HUYGHENS and of PICARD. That of LE GENTIL, which places them entirely outside (whilst in another drawing he places them within), merits little faith for other qualities. M. D'ARREST has found a figure of LEFEBVRE which places them outside. To my mind all these differences lead to the conclusion that they proceed from differences in strength of instrument or in atmospheric clearness. Only a little power being employed the subdued luminous mist that enwraps the stars is not visible, and they appear to be without. With good vision, and an instrument which brings the light of the nebula in this part into prominence, one would judge them to be within.

In this great gulf, among the probosces and the region of HUYGHENS, there are really three gradations of light, and a little above the three stars before mentioned the feeblest light begins and extends to a very great distance, with an almost uniform density, but it has not been studied sufficiently by us, on account of its dimness.

Nebula Mairanii.—The little star marked μ by HERSCHEL, situated in N½, 2½, which MAIRAN saw surrounded by mist, has certainly a pretty decided outline in the

form of an inverted *comma*. On March 31, 1856, I find noted *that this mist has an undoubted spiral aspect*, notwithstanding the tail is separated by a thinner veil, which makes it at times appear detached and double. The convolutions indicated by HERSCHEL and by BOND are different from ours, and do not agree among themselves.

Between this nebula and the region of PICARD of the principal nebula is the *nubecola oblongata* of HERSCHEL, which almost touches the other small star, itself also surrounded by mist The most singular thing is that the space which separates this nebula has been found perfectly black by us, so that it was absolutely necessary, on those evenings when we noted the fundamental forms, to cancel utterly from the map every trace of thin mist which had previously been drawn upon it. I was surprised by so much darkness, and took note of it. This canal, so straight and black, was certainly the one which at the end of the last century determined the giving to the nebula a figure of a capital, elongated omega (see fig. of 1774), and thus it really does present itself in a small instrument which does not separate the details.

However, this is so much the more singular since O. STRUVE says positively that he saw some nebulosity between the region of PICARD and the *nebula oblongata*, and to us as well it would have appeared nebulous had we not traced that mist which subsequently we were obliged to cancel. Here, then, is one of those points to be re-examined in the future."

SECCHI sums up his results as follows:

"1st. From the comparison of our observations with those of preceding astronomers, it appears that the nebula is sufficiently known in its general structure. The coincidence of the principal points is now assured, and their relative variability remains only to be fixed by more exact measurements. The labors of LIAPONOFF, STRUVE, BOND, and HERSCHEL, confronted with ours, put the latter beyond controversy as to the points of greatest brightness and of the first order.

2d. The differences which are met with occur principally in the parts of the second order, where the weakness of the light, the power of the instruments, the sensitiveness of the observer's eye, and the state of the heavens exercise an immense influence. The nebula being green, all eyes have not the same sensitiveness for this color, and considerable diversities in the drawings must follow. Taking all these circumstances into account, the divergencies will be seen to sensibly diminish

3d. It is not yet proved, however, that in these parts all the differences are effected by the extrinsic causes mentioned above, and that some real variation may not take place. Worthy of principal consideration are the *Sinus Lamontii* and the *pons Schroeteri*, where it is difficult to attribute everything to accidental and extrinsic variations.

4th. The resolution into little stars of the bright masses does not at all prove that they are agglomerations of true stars The spectral diversity is fundamental, and that assures us that the physical constitution of nebulous bodies is gaseous. The form with distinct points may occur in a mass even of this nature and give rise to a similar appearance, but from this alone a true stellar constitution cannot be concluded. A similar concentration occurring in any less dense part may have given origin to some of

the bright points observed as stars by more than one. The very absence of continuance in these appearances proves the justice of this explanation.

5th. The mass being recognized as gaseous, it is impossible that it should be in constant equilibrium, hence nothing is more easy to explain by real movements, not only the aforesaid agglomerations, but also a large part of the variations presented in its aspect.

6th. The confusion which is felt on first observing the nebula is only an ordinary case of what happens at the first sight of an irregular object before one has become accustomed to it and has made of it a certain order of regular figures. This happens even when looking at the starry heavens before knowing the constellations; and in the (stellar groups) clusters, before studying them, all appears confusion, and not until after a certain time does order and regularity seem to enter. Then, however, the number of the objects seems to decrease, but this diminution is only apparent. Artists know in practice this effect, and it is not to be feared as a defect that a drawing made after much study should seem to decrease in parts because a certain order is gained.

7th. The nebula of *Orion* is not the only mass of cosmic matter, gaseous and irregular, which occupies space; it is only one of the more dense agglomerations of cosmic matter which extend in some parts of the heavens, specially in *Sagittarius* and in *Orion*. If the general clearness of the heaven prevents the discernment of the presence of this matter, it can, however, be shown by various devices, and by the help of certain spaces in which its presence is wanting. The great zone which extends over these regions seems to protract itself even to the northern hemisphere in which the black space or *coal-sack* in *Cygnus* may easily be carried out between the Milky Way and a luminous zone in continuation of those of *Orion*, to the pole in form of a very elongated M. Hence, the splendor of the heavens is due in these regions not only to the stars, but to an immense stratum of nebula in which our solar and stellar system is immersed.

8th. This matter interposing itself between us and the stars may give origin to the aureoles which surround them in some portions and influence their spectrum. Probably the green color of the stars in the neighborhood of *Orion*, and the extreme fineness of their black lines, depends upon this stratum whose action tends to paralyze the effect of the absorption of the atmosphere proper of the stars *Sirius*, which does not share this influence, would be outside of this mass.

9th. Yet if these masses are destined some day to form stars, there is very little hope that we can ever calculate the successive phenomena to be developed in such concentration. If the relations of time and space are in equal proportions, the movements here must be of the slowest, and the variation imperceptible beyond our imagination. The supposed enormous mutations in other objects is less believed in proportion to the more powerful means and more diligent care used in computing the forms, and what remains of uncertainty is more due to the imperfection of the study given than to the well-proved reality of changes."

After this was published, Secchi received a proof of the engraving of G. P. Bond (frontispiece), and he compared this critically with his own work.

Notes on Bond's Engraving.

"First of all Bond recurs, in the *region Huygheniana*, to the system of superposed cumuli as in Herschel, the different series of which form a pyramidal and almost *imbricated* figure. The three orders of cumuli essentially agree with our series, except in the special details obtained by us during moonlight; and as he retains the too small scale used in the other drawing, what we said of the cumuli of Herschel is applicable here.

Their flat forms and the narrow canals which divide them are due certainly to the great power of his instrument (16 inches), which by increasing the light very much in the fainter parts, causes the half shades of the globular forms, which come out better in the moonlight, to disappear. It is singular that Bond, who had often observed in the twilight, should not have noted this difference of intensity. But he, also, was a victim to the common prejudice of observing nebulæ in complete darkness in order to see it better.

The figure being positive, that is, the ground of the plate being black and exquisitely cut, is eminently suitable for an exact comparison with the sky. We have given the reasons why we could not use this system.

The *Sinus magnus* is barred towards the bottom by the *pons Schroeteri* that has a luminous mass in the middle, exactly as we said in our Memoria, at page 20, it was seen by us in 1857, but which we have not succeeded in seeing again since. The epoch of Bond's drawing being given as 1859 to 1863, would be a strong confirmation of the variability of this bridge and of the precision of our former observations. Hence, it is clear that this portion of the nebula should be watched. The bottom of the gulf from the bridge up is nebulous, as we also found formerly. It has a little nebulosity at the mouth, but is not barred as at present.

The *Sinus Lamontii* is quite black and has a double curvature on the left side, but is wider at the mouth than we found it to be; it, however, approaches more nearly to our figure than other drawings. This, also, is a region to be watched.

In the region *palus Bondii* long, continuous, spiral filaments are found, which, however, occupy the whole region *Picardiana* and *Derhamiana*. They have a pronounced spiral inclination, and start from side 57 of our polygon from below the principal of left base of the large triangle *Huygheniana* near the trapezium. The author states that it cost him much labor to trace these spiral convolutions in the midst of the labyrinth of the nebulous mass. If we should sincerely express our opinion, however, we believe that this preconceived idea of reducing the nebula of *Orion* to nebulous spirals, applying to it the principle of Lord Rosse, may have slightly forced the observer's judgment, inducing him to give prominence to certain traits which, perhaps, have not all the strength that they show in the drawing. The reticulation in the region H, G, F, K, of our polygon, is certainly very confused, and a preconceived idea can easily distort the fancy; but we do not remember ever to have seen lines so continuous and easy to trace as those drawn by the illustrious deceased, and they cannot be imagined from our drawing.

In Bond's drawing the large arc (H, 7) of the *region Fonchiana* is well traced, and

continues in a large oval that has in the middle the brighter mass represented by us in (D, 3 *a* 7). As our drawing in this part of the nebula is more limited than his, we cannot make a comparison throughout the whole extent. This confirms, however, the exactness of our figure in these parts."

OBSERVATIONS OF D'ARREST (1872).

"On the Nebula in Orion and its Spectrum.

"By Professor D'Arrest, 1872.

"[Translated from the Danish by Dr. William Doberck.]

What follows was kindly communicated to me by Dr. Doberek, and it has been slightly condensed through the care of Miss Elizabeth Harris, who is familiar with this nebula from the assistance rendered by her to George Bond during his directorship of the Harvard College Observatory. It is given here almost in full, as in its original form it is not generally accessible to English-speaking astronomers.

"Chapter II.

"The brightest and most interesting part of the nebula, Huyghens' region, with its environs, is represented on the plate at the end of the work, and may be consid-

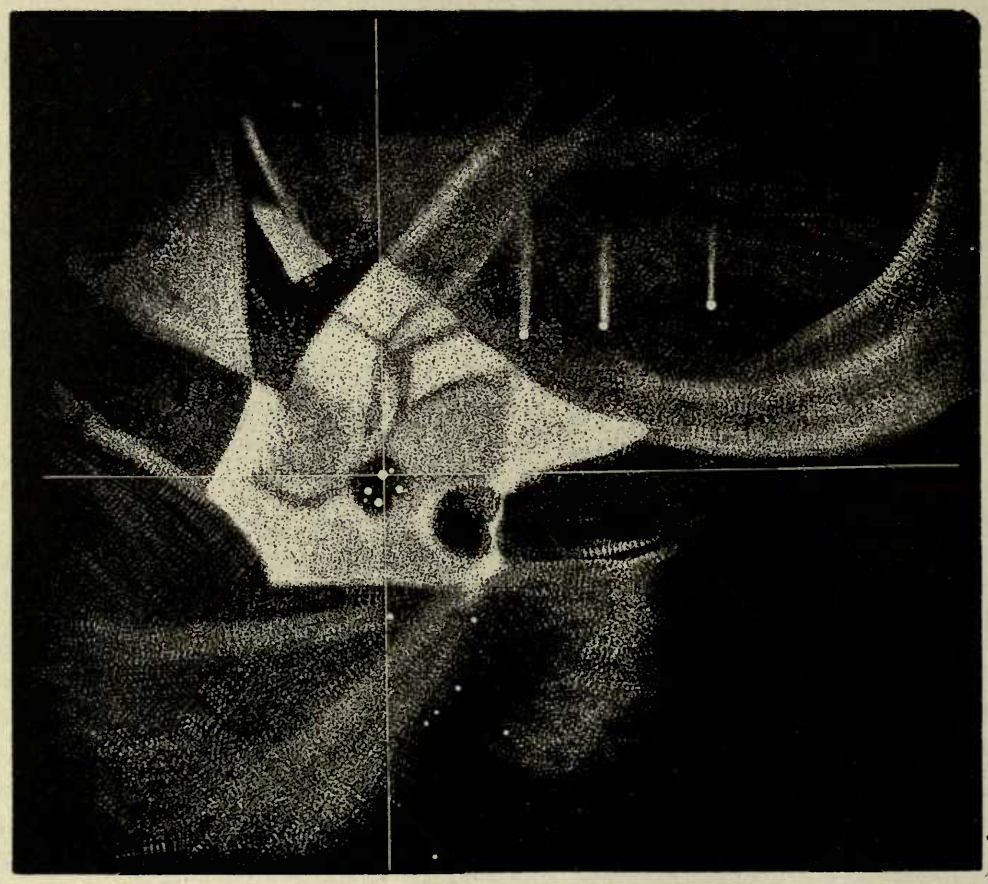

Fig. 35. D'Arrest, 1872.

ered as the result of my observations in the winters from 1865 to 1871. It may

especially be compared to the representation given thirty-five years ago by M. LAMONT,* as the large refractors in the observatories of Munich and Copenhagen may be considered as perfectly identical in optical respects; and we have not, to my knowledge, hitherto possessed two drawings of the *theta*-nebula made with exactly similar instruments after a considerable interval, although not a few valuable drawings have been made within this interval. While plates published by LASSELL and Lord ROSSE represent the details of the nebula as seen about 1853 and 1864 in the three largest reflectors which have ever been directed to the heavens, SECCHI's drawing of 1865 was made with a 9-inch refractor, and GEORGE BOND's, from 1857 to 1865, with a 12-inch object-glass [14 Paris inches.—E. S. H.]. The appearance of the nebula is known to depend in a considerable degree upon the optical power of the instrument. The first two named telescopes, especially that of Lord ROSSE, surpass surprisingly in their effects on this field all existing refractors; older contemporary ones are consequently strictly comparable with LASSELL's and ROSSE's only when it is certain what alterations have occurred in the *theta*-nebula, and in what regions they have occurred.†

"To my graphical representation I have added a general view, which gives the necessary information on the nomenclature and designations used at present. There was no occasion to introduce new names in the region referred to; those now used arise all from Sir JOHN HERSCHEL,‡ O. STRUVE, and ROSSE. We shall anon speak about certain parts previously discussed, for instance, *Hemicyclium Liapunovii*, which we are no longer able to recognize under the slow variations of light which doubtless take place in the nebula.

"A comparison between the two perfectly adequate representations of the central part (LAMONT's and my own) shows that HUYGHENS' region, in conformity with what else is known for certain, has, on the whole, not materially altered its form and appearance. The separation, however, in the southwestern part between the forms α, β, χ [E, I, F], which is but feebly and indistinctly indicated, appears so much more distinct that it is hardly possible that the divisions can have presented thirty-five years ago the same sharp and certain outline for which they are at present remarkable. This suspicion is indeed confirmed by HERSCHEL's first drawing of 1824; but in the Cape observations, where certainly the nebula was seen under favorable circumstances, there appear such definite traces of the existing main separations that we, on the other hand, dare not assign their first origin to so late an epoch. The attention of astronomers will therefore be directed to this point in the [immediate future].

"In LAMONT's figure there is no trace of the strong condensation in the *northwestern* corner of the great body, about the place where STRUVE put his *lacus Secchii*; an object which, however, I have not been able to identify from the description.§ I have

"* LAMONT.—*Ueber die Nebelflecken* (*Academische Schrift*) München, 1837. *Regio Hugeniana*, Fig. XI.

"† This opinion is shared by O. STRUVE, the most competent authority in this respect; compare: *Viert. Jahr. d. astr. Gesellsch.* V, page 26. Jan., 1870.

"‡ *Memoirs* R. A. S., II, page 490, *et seq.*, and plate VIII. STRUVE and Lord ROSSE, in the works mentioned in the first section. The star-numbers on my general view are given from O. STRUVE's catalogue in the paper on the nebula in *Orion* (1862).

"§ I have repeatedly, after STRUVE's description, and according to his measured positions and distances from * 70 and * c, sought for this black circular spot of 15″ diameter. I never succeeded in finding this little dark opening, although *lacus Secchii* no doubt was to be found in October, 1857. Everything here points to a permanent alteration in the distribution of luminous matter. I do not know that any other astronomer has ever seen this *Secchian Lake*.

every reason to consider my own representation as trustworthy. As I am on this point in relatively good agreement with G. BOND, no doubt can prevail that a substantial alteration has occurred here; so much the less, as the present sharply appearing and precise bounding is also altogether wanting on HERSCHEL's drawings of 1824 and 1835.

"Among the most extraordinary differences between LAMONT's and my representation, I further class '*pons Schroeteri*' in *Sinus magnus*, which is often found mentioned in older reports. LAMONT has nothing of this bridge across the gulf but the small [base], which, like a promontory, is attached to the north side of the gulf, while on my drawing is to be seen a perfect communication, with two brighter points about midway. This remarkable difference is in this instance but a corroboration of a partial transformation, or rather of local alterations in brightness, which were pointed out as certain by STRUVE as early as 1862.*

"LAMONT has hardly a recognizable trace of the two perfectly sure and thereby very characteristic configurations on the west side of *Sinus Gentilii*, round the stars 50 and 54 [558, 573] in my drawing, which are almost identical with those of BOND, and almost perfectly identical with those on ROSSE's splendid map. Sir J. HERSCHEL† remarked long ago, and no doubt justly, that the outline of LE GENTIL's gulf was not, on the whole, correctly given in LAMONT's diagram. I suppose that it was not at all LAMONT's intention to give the outer parts of the nebula.

"*Huyghens' region* of the nebula in *Orion*, apart from the mentioned, most prominent differences, is, on the whole, seen far more finished and with far finer particularities in my refractor, at Copenhagen, than might be presumed from the drawing made in Munich. LAMONT, I suppose, did not at that time make the large nebula an object of special study. We, therefore, need not attribute great weight to the really great difference existing between these two drawings, which, with an interval of so many years, have been made with equally excellent instruments. It is moreover to be remarked, that LAMONT fills the inner space of the trapezium with as dense a luminous matter as surrounds it on all sides. I see, on the contrary, the six trapezium stars always on a far feebler and almost dark background. HIERONYMUS SCHROETER‡ saw it in his time as LAMONT has shown it. The empty space, in reality, is but apparent; of this part, however, I will speak at length in § 14.

"CHAPTER 12.

"I shall in this chapter compare, in certain points, my own drawing of *Huyghens' region* with other lately published representations. From such a comparison of contemporary drawings made by the aid of different instruments, elements are obtained which will in future ages be of great value. However great the difference in the whole appearance of so complicated and difficult an object which climatical circumstances may produce, the artistic representations over which the observers have but little power, may very easily happen to exercise a far greater and sometimes disastrous influence on the representation. Remarks in a *negative direction* may, from these reasons, be not without importance.

"* *Observations de la grande nebuleuse, etc.*, page 116.

"† *Results of Astron. Observations*, 1847, § 69.

"‡ *Aphroditographische Fragmente*, Helmstedt, 1796. Pl. II.

"A. The drawings which depict the nebula in its whole extent give occasion to the ollowing remarks: According to my general knowledge of the nebula in *Orion*, LASSELL'S steel engraving,* compared with the image in a ten and a half inch refractor, represents the single parts of the nebala much too loosely, and the portions around the trapezium are in particular anything but successful.

"The considerable nebulosity, for instance, which closes *Sinus magnus* to the west, and whose brightest part (according to ROSSE it is traversed by a curvilinear, narrow, and dark channel) extends toward the trapezium, is almost entirely wanting. Therefrom arises round the trapezium a vacuum of an extent which surely is not to be found in the sky. Neither is the north side of the 'large gulf' at all naturally given. Further, it is decidedly wrong that '*nebula Mairanni*' should, as LASSELL represents, surpass all other parts in brightness; it has, and in reality never had, more than the third or fourth position in brightness. We may expect that these wants and disagreements in the engraving have been removed in the later drawing, which, after the return of the distinguished astronomer from his second sojourn in Malta, has been presented to the Astronomical Society in London.

"B. In GEORGE BOND'S posthumous work on the great nebula is to be found that representation which in every respect reproduces both its general appearance and its finest particularities. It might seem desirable that the central part had been given apart; but although the longest diameter of *Huyghens' region* now is not longer than eleven lines in the picture, still all details are presented sufficiently distinctly; while the characteristic appearance of the object, and especially the singular serenity which there reigns, is in perfect accordance with nature. My drawing of the main mass does not, in any important respect, deviate from BOND'S. I have, with our somewhat inferior refactor in point of light, found, after all, only the *northern* outline a little different. Less and separate masses in the pointed *southeastern* corner appear, too, more distinctly by BOND than I have ever been able to discern them. I consider, for instance, after repeated inspection and comparison, my own representation of the separate mass to the east of *palus Bondii*† more conformable to the true form. ROSSE also finds it very nearly as I have.

"C. I do not find ANGELO SECCHI'S large copper-plate of 1868 quite successful. Of the disagreements, I shall only mention the following: The parts α and β [E and I], of the main mass, whose real figures are, of course, for the present placed altogether beyond doubt, are hardly to be recognized. α [E] has really four sides and is almost a square; β [I] has decidedly the form of a lengthened triangle; but in the Roman representation they are both shown as round, almost circular. In the net of channels which traverse this region the courses are too broad. To the west of *Sinus Gentilii* all agreement with the sky is wanting. I find it is also difficult to understand how the

"* *Memoirs* R. A. S., vol. xxiii, pl. i.

"† I have, during a long time, used this Struvian denomination (*Observations*, etc, page 106) for the narrow, dark channel (or, according to ROSSE, the deep inlet), which separates the luminous isles around stars 50 and 54 S. F. (558, 573). But it was perhaps STRUVE'S design to use the denomination '*palus Bondii*' for the eastern isle alone; in this case the words 'a narrow bridge' does not well correspond to existing relations. In my general view I have followed the latter supposition."

very remarkable radiations, especially those which emanate from the south side of the central part, can have escaped the notice of this experienced astronomer.*

"No doubt much time, assiduity, and care have been spent in the Collegio Romano in the study of the nebula in *Orion;* the whole paper and some single observations of fine particularities testify this. The cause of the disturbance which apparently prevails in the drawing, and of the disagreement which exists on several points, I attribute to the circumstance that SECCHI made use of moonlight nights. The brighter and brightest parts have in consequence too much ascendancy over the fainter, and the general impression has thereby become somewhat different from that to which perfectly dark nights have accustomed us.

"D. As far as I, after all, can be in possession of a well-founded opinion on the importance of the large and splendid drawing which is the main result of the work of several astronomers during many years, with Lord ROSSE's transcendant reflector, I shall express that I have, by degrees, arrived at the conviction that his representation approaches in every important respect most nearly to the true state of the nebula as it was about 1862.†

"I have generally, allowing for the very inferior instrument (in point of light) of this observatory, at least found the representation by Lord ROSSE to agree with the truth. This verification is not without considerable importance for, to be brief, the refractor surpasses HERSCHEL'S 20-foot telescopes. Only in feebler extensions, in the very faint connections, and in the singularly intertwined bands which continue the nebula, especially to the west, I sometimes found it impossible to follow traces in ROSSE'S drawing. Furthermore, I share the opinion that the outlines, particularly in the separate plate of *Huyghens' region* (Plate I) are sharper, and the dark furrows somewhat broader than they ought to be; that the contrast between the brighter and fainter parts are very strongly marked, at least when we judge according to the image in the refractor of Copenhagen.

"I shall add in particular, with respect to *regio Huygheniana* and parts surrounding it, the following remarks, after a comparison of the different drawings *inter se*, and with my own observations.

"On the *north side*, I never saw the two large dark bays just below the trapezium [W^1 and W^3 of Index-Chart] appear as sharply and distinctly as on ROSSE'S drawing. In LIAPONOFF'S they are totally wanting, and in BOND'S and SECCHI'S but barely visible. They are, in reality, but darker intervals between two long, bent, tail-like areas, which, trailing off to the west and northwest, are lost far away between *regio Derhamiana* and *regio Picardiana.*

"The east corner of the main mass [B in SECCHI'S diagram, Plate II, λ in ROSSE'S = Q] is certainly bent somewhat upwards, and does not smoothly pass into the origin of

"* I had some years ago occasion to lay stress upon certain disagreements of a similar nature (*Astr. Nachr.*, vol. lxx, No 1678, page 342), which were afterwards explained by 'che la figura litografica publicata henchè esatto in generale, ha alcune inesattesse non trasciorabili.' (*Sulla grande nebulosa*, page 27.) The possibility of such an explanation is not open in this instance, as he remarks about the nebula in Orion, 'cosi siamo sicuri che l'incisione rappresenta la nebulosa come vedesi da noi nel nostro strumento.'

"† I refer to the privately distributed plate which represents the object on a black ground, and which, no doubt, is also, in technical respects, one of the most excellent productions of art. This plate is not annexed to the paper in *Phil. Trans.*, but, on the contrary, another one, executed in the common way. Volume for 1868.

proboscis major; ROSSE's words, 'curving slightly in opposite directions', convey the best idea of the way in which the transition takes place.

"I have remarked above that I unconditionally adhere to my own conception of the parts beyond the west side of *Sinus Gentilii*, which approaches essentially to ROSSE's image, and is not contrary to BOND's. But with this conception, the traces to which LIAPONOFF's diagram on this point confines itself do not well agree. The bright and rather shapeless luminous masses which, according to SECCHI, between K. L. 12 [*i. e.*, between μ and δ of Index-Chart], on the Roman plate, seem to rival in brightness the most apparent parts of HUYGHENS' region, did not exist during the time I observed. [These are probably the masses attached to the north shore of μ.]

"*Sinus Lamontii* I almost invariably found filled with rather dense nebulosity; here, however, the relative brightnesses seem so very inconstant that single objects are sometimes with difficulty recognized. In the adjacent *Hemicyclium Liapunovii* greater changes in brightness have doubtless occurred since O. STRUVE's investigations in 1861; but on this point even later contemporary representations agree but badly. I should like to know if the luminous heap which, according to SECCHI, extends in m. 5/8 n. from 9½ to 10½, may be considered as part of the *Hemicyclium.*

"An agreement in this domain seldom to be found occurs with respect to the large, very deeply indented bay which O. STRUVE has called '*Lacus Lassellii.*' Its outline is still exactly as it was given for 1857: stars 76, 80, and 84 (652, 657, and 663), a little outside star 89 (669) somewhat inside the nebula.* SCHROETER observed this remarkable indentation, or rather intersection, as early as 1795 and 1799. Notwithstanding possible variations in brightness, it can be proved that here during the last seventy years no variation whatever in form has taken place.†

"It is on the whole this *constancy of form* which I consider the most important result of the whole study which has been spent on the nebula in *Orion.* The observed variations in this extensive, gaseous mass seem solely and exclusively to end in temporary, luminous fluctuations, particularly in certain regions. Generally, perhaps always, the old forms reappear after a shorter or longer time. I have, during a lapse of years, seen instances of this in *pons Schroeteri*, *Sinus Lamontii*, and *Sinus Lassellii.* Fluctuations of light, which, taken apart, are seemingly inconsiderable, produce here sometimes remarkable alterations. Several years ago, when examining a representation dated 1779, in the 22d volume of ROZIER's '*Observations de la physique*,' I found the following, which leads to the same result: 'That we in the outline of the *theta*-nebula are able to point out an invariability in *form* which, the nature of the object considered, is plainly surprising.' At that time, spectroscopical investigations which have assured us in regard to the physical constitution, were yet unknown to me."

"* STRUVE: Observations, etc., page 103.

"† Beiträge z. den neuesten Astr. Entdeck., III vol., Göttingen 1800, page 231, and figure 39, Table V, to compare with *Aphroditographische* Fragmente, page 247. SCHROETER'S star near (9) must be either 76 or 80 of STRUVE'S catalogue. The passage in vol. II of *Melanges Math. et Astr.*, St. Petersburgh, 1854, page 531, where it is said about this channel that "it never was represented by any other astronomer" is hardly correct.

OBSERVATIONS OF WINLOCK AND TROUVELOT (1874).

Fig. 37 is a copy of a pastel drawing made in 1875. It was published in NEWCOMB's Popular Astronomy, page 446, Fig. 104. The electrotype kindly given me by the publishers of this work has been mislaid at the Naval Observatory, and, owing to my absence from Washington, it cannot now (1882, January 31) be found. I refer the reader to the cut in Professor NEWCOMB's work.

FIG. 36. WINLOCK AND TROUVELOT, 1874. FIG. 37. TROUVELOT, 1875.

The drawing of the central portion of the nebula of *Orion* given in Fig. 36 was made by M. L. TROUVELOT at the observatory of Harvard College in 1874, under the direction of the late Prof. JOSEPH WINLOCK.

The Fig. 37 represents the sketch of the nebula of *Orion* made by M. TROUVELOT with the 26-inch refractor of the Naval Observatory of Washington. It is avowedly but a sketch, but is of value for comparison. A poor representation was published by the heliotype process in the Washington Observations for 1874, Appendix I. Fig. 37 is copied from Fig. 104, p. 446 of NEWCOMB's Popular Astronomy.

OBSERVATIONS OF DOBERCK (1877–'78).

In the *Astronomische Nachrichten*, vol. 91, col. 335, Dr. DOBERCK, in an article entitled "Remarks on Nebulæ," refers to the nebula of *Orion*, as follows:

"Mr. COOPER made also a drawing of the *Orion*-nebula [this drawing has been previously described], and by comparing that with the image of the nebula seen last year (1877) in the indentical refractor, I had a rare opportunity of corroborating the changes which D'ARREST has pointed out." * * * * * Then follows the order of brightness of the various parts. The brightest part of the *Orion*-nebula is the *northwest* corner of the central part [D], then [A], then Q, then I and E.

V as about as bright as μ.

This is all that immediately relates to the *Huyghenian region*, but the complete article should be consulted, as it is a record of the order of brightness of the *whole* nebula.

OBSERVATIONS OF TROUVELOT (1876?).

M. TROUVELOT kindly undertook to make some observations on the nebula with different apertures and eye-pieces according to a scheme which I submitted to him. Unfortunately the notes made by him he has not been able to find, and the following memoranda of the intensity of the light in various portions of the nebula, as marked on a copy of the Index-Chart, are all that now remain.

He noted on the Index-Chart the brightness of various portions on a scale of 1 to 4.

1 was "brilliant."
2 was "half-tint."
3 was "quarter-tint."
4 was "black."

In what follows I have given his results in my own words from the marks on the chart.

η (near *frons*), 3.
Z (half-way from *Sinus* G. to 581), 3.
β (near the letter β on chart), 2.
K (near the letter K on chart), 2.
γ, 4.
3 (near figure 3 on chart), 3.
Channel between ψ and 4 (half way from letter ψ on chart to letter W), 2.
[This is my mass W_2.]
Channel between ψ and χ, 3.
W_3, 3.
W_4, 2.
A, 1.
D, 1.
φ (half way from star 2 to star 652), 2.
Lacus Lassellii (near star 3), 3.
τ', 4.
ξ, 4.
$o\pi$ (⅓ the way from o to π), 3.
σ (¼ the way from σ on chart to 681), 2.
ρ, 3.
following ρ, 4.
μ, 2.
Half way between 708 and 741, and 20″ *north* of the line, 3.
Dark band between x and λ and near 666, 3.

OBSERVATIONS OF LANGLEY (1879).

Professor LANGLEY visited Mount Etna in January, 1879, taking with him a small CLARK equatorial of 3¼ inches aperture, and making observations of various kinds for the purpose of determining the effect of high altitudes upon telescopic vision. This expedition was made under the auspices of the United States Coast Survey, and I am indebted to the Superintendent of the Survey and to Professor LANGLEY for the ready permission to publish the interesting and very valuable drawing shown in Fig. 38, together with the notes accompanying it. It is to be noticed that Professor LANGLEY

has successfully applied to the nebula of *Orion* the method of contour lines imagined and first used by MASON in his drawing of the trifid nebula in 1837.

FIG. 38. LANGLEY, 1879.

"ALLEGHENY OBSERVATORY,
"*Allegheny, Pennsylvania, April* 27, 1880.

* * * * * * *

"I send by this two faithful copies of my original sketches of *Orion* (nebula) made on Etna last year with your Naval Observatory telescope of 3¼ inches aperture. They were made in haste, in intervals of other work which took up nearly all the few clear hours. I think their value (if any) lies in the fact that the person who made them, while having some little experience in such sketches, was by chance almost absolutely ignorant of the aspect of the nebula in large instruments (I have not looked at it for many years), and did not at all know what he *ought* to see. There were two

or three rough sketches, of which the india ink one here [omitted] is the summary, so it does not very closely agree with the outline [Fig. 38], where the contours and inclosures are marked from 1 + (brightest) to 7 (faintest). This was chiefly done on one evening by beginning in the earliest twilight when only a little haziness was visible near θ, and sketching new contours every 10 minutes or so as the sky grew darker. I have scrupulously abstained, even in making the copies, from reference to any published drawing.

* * * * * * *

"S. P. LANGLEY."

We may compare this photometric sketch of the nebula with the previous drawings, as follows: HUYGHENS (1656), Fig. 1, differs largely from LANGLEY's outline 1; the trapezium and 685, 708, 741 are involved in nebula in 1656, and not so later. The region near the *north* shore of *Sinus magnus* was seen much farther by HUYGHENS than light of the same intensity according to LANGLEY. The reverse of this is true just *preceding* the trapezium. HUYGHENS' drawing of 1694 (Fig. 2) is undoubtedly a better representation of the appearance of the nebula in his time than the earlier one. Comparing this with LANGLEY we find a very good agreement with his outlines 111 . . , with the same exceptions as before; *i. e.*, HUYGHENS' region near σ is brighter than LANGLEY's and his trapezium is within the nebula.

It is the same in MAIRAN's Fig. 3 (1731), and also in LONG's (1742) Fig. 5 PICARD (1673) Fig. 4, agrees better with LANGLEY when note is taken of the different kinds of shading than when the simple *outline* is taken, and this seems to be an important point

LE GENTIL (1758), Fig. 6, seems to have seen out to LANGLEY's 222 . . . and towards the *north preceding* portions even as far as 333 . . . . Here again the portion σ is brighter in the older drawing than in LANGLEY's.

MESSIER (1771), Fig. 10, agrees much better with LANGLEY than any of the preceding; a comparison of the two figures should be made; MESSIER's σ is very much as drawn by LANGLEY. He seems to have seen out to LANGLEY's 444 . . . LEFEBVRE (1779), Fig. 13, saw out to LANGLEY's 333 . . . . on the *following* side, but hardly so far just *west* of the trapezium. However, his figure is grossly misdrawn. In SCHROETER (1794), Fig. 14, the neighborhood of the trapezium is very different, the *southern* end of E is, as before remarked, strangely so.

Figs. 29 and 30 should be compared with Professor LANGLEY's, as well as Fig. 12, and the description by DOBERCK in Astronomische Nachrichten, band xci, col. 336, No. 218. The earlier figures all seem to give a greater brightness to the region near σ than Professor LANGLEY's outlines warrant. On the whole I am inclined to regard this as accidental.

An important paper, by my friend Mr. KNOBEL (*Monthly Notices* R. A. S., vol. 41, p. 312), gives the results of his photometric measures on the relative brilliancy of three portions of this nebula. Unfortunately for my purpose different parts of the *Huyghenian region* are not compared in such a way as to assist in the photometry of the various masses laid down in the Index-Chart.

PART II.—WASHINGTON OBSERVATIONS OF THE NEBULA OF ORION, IN CHRONOLOGICAL ORDER.*

1874, January 11.

$11^h\ 30^m$—$12^h\ 15^m$. Companion to 724 not seen. [This companion is laid down in Lassell's chart, *Mem.* R. A. S., vol. xxiii (1854), and was discovered independently by Alvan G. Clark, with the 18½-inch refractor, at Chicago in 1862. It is not in G. P. Bond's Catalogue. It is mentioned as a new star by Tisserand; *Bull. Int. Obs. Paris*, 1876, No. 119, and *Comptes Rendus*, lxxxi, p. 891.]

1874, January 14.

9^h. Mag. power, 400: very good seeing at times. Companion to 724 seen neatly. North of 635 and 641 saw at times quite plainly (1) [see Index-Chart]; suspected strongly a star at (2); saw twice or thrice a point of light at (3); saw a companion to 707, (4). I could see no stars inside the trapezium.

1874, January 16.

7^h to $9^h\ 30^m$. Eye-piece 400: seeing poor; stars bright but unsteady. In the neighborhood of 635, etc., I see only Bond's stars. (641) [one of *O. Σ.*'s variables] *very* faint. 675 not seen, but in looking for (4) I could just occasionally see the companion to 724, (*a*) obliquely, but never by direct vision, although I tried repeatedly. *h.* 78 (= G. P. B. (654)) seen at 7^h and until $7^h\ 20^m$ (approximately), but not after $7^h\ 30^m$. 9^h–$9^h\ 30^m$, the seeing is rather worse.

1874, January 17.

9^h. Eye-piece 400: seeing excellent. Nothing new near 635. 612 seen for the second time double [*i. e.*, 618 also seen well]. (567) very faint. (642) not seen, although its two neighbors [647 and 651] are well seen. 675 not seen: I have never seen it. (*a*) [near 724] seen well. (575) seen. (602) seen faint. Besides the stars mentioned I see near the trapezium 612, 618, 601, 621, and 636, the last very faint.

1874, January 23.

Many and thick clouds. (641) seen once. Suspected *h.* 78 = (654), but too cloudy to verify. Seeing fair. End $10^h\ 30^m$.

1874, January 24.

$9^h\ 30^m$. Prof. C. A. Young examined the neighborhood of 635, 669, etc., with eye-piece 400 [negative]. He put in on a sketch-map my stars (1), (2), and (3) of January 14 without knowing of my observation of that date. (*a*) he sees well. Neither of us see my (4) [near 707]. 675 seen by both of us. It is very faint. Seeing occasionally *fine*. Both observers say there are no stars inside trapezium. No trace of the resolvability spoken of by Lord Oxmantown [*Phil. Trans.*, 1867].

*The observations are recorded as written. Additions and explanations are inserted in square brackets, []. The observer was Holden, unless otherwise mentioned. The times are Washington mean times. The 26-inch telescope was employed with its full aperture, except in a few cases, which are noted.

[The stars (1), (2), and (3) are about the smallest stars that can be seen if immersed in nebulosity.]

1874, JANUARY 25.

(1) and (3) seen, faint, and seen only at times; suspected (2) and could not see (4). Seeing fair. *h.* 78 = (654), (642), and 675 not seen. (*a*) seen.

1874, FEBRUARY 5.

8^h. Haze: stars steady. * * * 9^h. During a short period of good seeing saw (641) and (1) and (3), also 675. This last is extremely difficult. Is 709 variable? It is quite faint this evening.

1874, FEBRUARY 14.

Although seeing had not become good it was steady. * * * (654) and (602) seen. Star suspected *n. f.* the *following* star of the trapezium and not far distant. LASSELL'S *b* [a double between 685 and 708] looked for especially and not found.

1874, FEBRUARY 17.

737 yellow and dull and nebulous; if I am not mistaken in the number (737) it has a small star *preceding* and *north* of it.

1875, JANUARY 22.

[Made various experiments to obtain a method of drawing the nebula *directly*, *i. e.*, to throw its image on a surface by reflection or otherwise, and to trace it. Among other trials, placed a piece of finely ground glass in principal focus, and removing the eye-piece, I saw on the glass the trapezium, 635, 669, 685, 708, and 741, and other stars Made a sketch on the glass.]

1875, OCTOBER 27.

$12^h.3$ to $13^h.2$. Very bad seeing. Wt. = 1. A star (575) *exactly* on *preceding* edge of A, which is very faint compared to *following* edge.

The *north* end of A has dark channels in it of the shape figured by G. P. BOND [drawing omitted].

Order of brightness.

1. A (all the brighter streaks in it).
2. D (*following* edge).
3. F = G (not including the region round X in F).
4. I.
5. N = Q?
6. H = E.

[I note here that the boundaries of N and Q are rather uncertain, under ordinary conditions, and that too great weight must not be given to comparisons of Q and N with O, P, K, etc.] 666 and 667 just seen. Suddenly much brighter, just *north* of 647. 647 > (641); 647 = (671); 647 > (575)? Seeing very bad. [According to BOND, (647) is $12^m.1$; (641) is $14^m.8$; 671 is $11^m.5$; (575) is $11^m.9$.]

1875, October 29.

Begin 12^h, end 13^h. Mag. power, 175. Wt. = 2. 647 = (575) > 671, but not much. (575) > 573. 651 and (654) about equal. (641) not seen. Reading of position-circle for parallel = 165°.2.

Frons.

Micrometer wire placed so as best to coincide with the *frons* (*p.* estimated = 40°), *i e*, to the *south* edges of E, F, N, and Q.

Position-circle readings: 24°.8, 24°.5, 27°.5, 28°.9, 28°.8; *mean*, 26°.9. Concluded position-angle, 48°.3 (5) (= 75°.2 − 26°.9).

Occiput.

Angle of position (est.) 135°; this refers to *preceding* edges of masses E and I.

Position-circle: 112°.0, 112°.2, 114°.4, 114°.4, 112°.3; *mean*, 113°.1 ∴ p = 142°.1 (5). The *occiput* is *exactly* parallel by measure to a line joining 506 with [570].

Position-angle of preceding edges of J and B.

Position-circle: 67°.5, 65°.9, 69°.2; *mean*, 67°.5 ∴ p = 7°.7 (3). B points exactly to 575, which is at the very end of it. The reading 69°.2 above will serve to determine the angle of B from its base [*i. e.*, *north* end] up to 575 ∴ p = 6°.0 (1).

Order of brightness.

1. A. 2. D. 3. F and G. 4. I. 5. N and Q. 6. E. Perhaps the following is better: 1. A. 2. F, G, D. 3. I. 4. H. 5. N. 6. Q = E. The *general* effect of each mass is taken, *i. e.*, the brightest parts have most influence.

1875, November 5.

$11^h.5$ to $12^h.5$. Mag. power, 175. Wt. = 2.

Lacus Lassellii.

652, 657, 663 are on the *preceding* side of a dark space which ends a little to the *south* of 663; they are inclined across it from *s. f.* to *n. p.*, 652 being nearest the *preceding* side of the space. 647 > (575) = (671).

V.

The ground on which the trapezium stands is not totally black.

τ.

The *north* part (*n.* two-thirds) of τ is not black but filled with nebulosity; the *south* one-third is certainly darker, but whether totally black the seeing is not good enough to determine.

Pons Schroeteri.

In the middle of the bridge of Schroeter the nucleus is *not* stellar, * * * at least it does not seem to be so to-night.

σ.

Along the *south* edge of σ it is notably brighter, and at the *preceding* end of this terminating bright streak I think I see a small star.

σ.

The Index-Chart is right in making σ concave towards the *south*. [This was marked to be examined again. It was found to be correct 1877, December 12.]

τ'.

On the *following* side of the *pons* it is quite dark. The line in the Index-Chart seems to limit this dark space properly.

τ''.

North of $o\pi$ it is quite dark.

ξ.

To the *south* of $o\pi$ it is filled with nebulosity.

There is *at least* one dark streak in ξ parallel to $o\pi$ and just *south* of it [contrast?]: also in ξ I think I see a star half way between it and the *Huyghenian region*, on the same meridian as *o*.

σ.

σ much brighter on its *south* edge: then fainter and then all the *preceding* half is brighter than the *following* half (roughly speaking).

c.

Branch *c* extending to 523 is about right in Index-Chart; perhaps a little too much curved. It runs a little to the *north* of 523; but that star is nebulous, at least to-night.

Order of brightness.

1. A. 2. D. 3. F and G. 4. H and I. 5. N and Q. 6. E. In this, however, only the brightest parts of N and Q are included.

I do not think the stars 685, 708, 741 have cometic tails or brushes to them extending towards the *south* as BOND notices. The nebulosity seems darker between 685 and 708 and 708 and 741 (in the parallel nearly), but I take it this is the effect of contrast merely [drawing omitted]. It is darker between 685 and 708 than between 708 and 741.

1875, NOVEMBER 10.

Begin $11^h\ 45^m$, end $13^h\ 20^m$. Mag. power, 175. Wt. = 2.

Measures of $\Delta\delta$ with θ^1 Orionis.

Coincidence of fixed wire and micrometer wire = $64^r.25$. Fixed wire on θ^1, micrometer wire on—

Object measured.	Reading. Moving mic. wire *south.*	Reading. Moving microm. wire *north.*	*Mean.*	$\Delta\delta^1$ Revolutions.	$\Delta\delta^1$ Seconds of arc.
	r.		r.	r.	"
South extremity of E	79.32	78.98 78.94	79.08	− 14.83	−147.5 refr. 0.1
					$\Delta\delta$ −147.6
North extremity of E	74.64 .63 .53	74.16 .34 . .	74.46	− 10.21	−101.6 refr. −0.1
					$\Delta\delta$ −101.7
Brightest part of F, on the same parallel as 685.	74.16	74.62 .40	74.39	− 10.14	−100.9 refr. 0.1
					$\Delta\delta$ −101.0
Brightest part of G	70.63	70.83	70.73	− 6.48	−64.5 refr. 0.0
					$\Delta\delta$ = −64.5
Brightest part of *pons Schroteri* (whose center is an elongated oval) on same parallel as bright star in D [=647].	60.43 .25 .46	60.15 . . 60.11	60.28	+ 3.97	+39.5 refr. 0.0
					$\Delta\delta$ = +39.5
Bright sharp *n. f.* end of D . . .	56.74	56.15 .44	56.41	+ 7.81	+77.7 refr. 0.0
					$\Delta\delta$ = +77.7
S. f. sharp point of σ = "*Spitze*" .	56.57 .29	56.40 .23	56.37	+ 7.88	+78 4 refr. 0.0
					$\Delta\delta$ = +78.4

Order of brightness.

1st	A_1	D_1	F G	I H	N Q	E.
2d	A	D	G F	I H	N Q	E.

$\therefore$ G = F.

There are certainly no wisps or tails to 685, 708, and 741 (for a moment seeing good). *Mag. power*, 400. The star Rosse 56 exists, and the line joining it and 581 is perpendicular to *occiput.*

Sinus Gentilii.

If there is any totally black inlet from the *south* into *Sinus Gentilii* it is very narrow. The *Sinus* is quite black in its *north* end.

τ.

The *north* half of τ is filled with light which join n to *pons Schroeteri.*

W^1 = *lacus Secchii.*

The distance from the hole (*very* black) W_1, just *north* of W, to 685, is about equal to the distance from 635 to 669. W_2 is *north* of it, and is another remarkably black space. W_1 and W_2 wrong in position on Index-Chart.

1875, NOVEMBER 11.

$11^h\ 40^m$ to $12^h\ 30^m$. Mag. power, 175. Wt. = 4.

Occiput.

Position-circle: 114°.0, 114°.2, 115°.9, 115°.5. *Mean*, 114°.9. $\therefore p = 139°.3$. This is a measure of the *preceding* edges of E and I, and it cuts Y off entirely.

Frons.

Position-circle: 22°.0, 22°.3, 22°.1, 21°.8. *Mean*, 22°.1. $\therefore p = 52°.1$.

This measure is the best tangent to the *whole* line of light, but it cuts off some masses at *s. p.* corner of E, and some at Q.

Q, P, R.

Angle of position of *n. f.* sides of Q, P, and R (estimated 100°); the line passes through 654 and 6^4, or nearly so. This cuts off some of R and most of T.

Position-circle: 328°.2, 327°.2 (good), 328°.2, 329°.8. *Mean*, 328°4. $\therefore p =$ 105°.8 (4).

σ.

Angle of position of *south* edge of σ and general *north* shore of *Sinus magnus* up to D (to the *north* bright end of D). [This does not mean that D was one of the points of the line measured.] The measure is of the general trend of the shore. Angle (est.), 95°.

Position-circle: 345°.0, 344°.8, 343°.4, 344°.7. *Mean*, 344°.5. $\therefore p = 89°.7$ (4).

(676) = (654) = or > (641).

(654) > 612 or 618.

(654) = 622 > 631. ?? *Query* 621 ?

(631 is in a black space) 622 on the Index-Chart is properly figured as to edges of A and U.

P, S, M.

The *south* edges of P and S right with respect to 671 and 676. The *north following* edge of M should be a little further off in the Index-Chart.

Pons Schroeteri.

The micrometer wire through the *pons* passes through 685 and 669 nearly. Parallel, 344°.5.

Position-circle: 84°.6, 82°.3, 83°.7. *Mean*, 83°.5. $\therefore p = 170°.7$ (3).

LASSELL's star *b* [a double between 685 and 708] does not exist [as far as can be seen to-night].

685, 708, 741.

It might be said that there is a wisp or tail to the *south* of 685; between 685 and 708 is a darker space [drawing omitted]. The shaded portions [of the sketch] represent the dark spaces of which 685–708 is much the darker. This may be the effect of contrast, and probably is between 708 and 741, but not altogether so between 685 and 708.

Messierian branch.

The *preceding* edge of the *Brachium Mess.* follows 784 and 789 as in drawing [omitted] 675 not seen; indeed I have only seen it once or twice in 1873,–'74,–'75.

686–688 not seen, but not carefully looked for. R. 56 plainly seen. * * * *

A and L.

In the *south* part of A and the *north* part of L the shapes are not caught in the lithograph. It looks like a rope with the strands untwisted so that you may see between them There are at least two such openings.

"*Spitze*," in (σ) τ, τ', 741.

In G. P. BOND's drawing the "*Spitze*" on *south* shore of *Sinus magnus* is too bright [relatively], but not much. The *north* third of that part of the *Sinus magnus preceding* the *pons* (τ) is too bright, and the space just *following* the *pons* is also too bright. It is now quite dark there (τ'). There is certainly no such wisp or tail to 741 as BOND gives.

1875, NOVEMBER 17.

End 12^h. Mag. power, 175. Wt. = 2.

685, 708, 741.

741 has certainly no wisp or tail towards the *south*. 708 and 685 have none as figured by BOND, but the same appearance as previously described is again seen.

Pons Schroeteri and σ.

The middle point of the *pons Schroeteri* is almost stellar; seen by indirect vision it is (comparatively) very bright, almost as much so as the *south* edge of σ which, for the *east* two-thirds of its length, is noticeably and suddenly brighter than the rest of σ.

Differences of R. A. from θ^1.

Coincidence of fixed and micrometer wires $64^r.23$ [fixed wire on θ^1].

Object measured.	Reading of micrometer.	Δ R. A. in revolution.	Δ R. A. in ″
	r.	r.	″
Extreme *following* end of "*Spitze*" of σ.	47.22 46.90 47.34	+ 17.08	+ 169.9
	Mean 47.15		
The *following* end of Q is in the same R. A. as 708. *i. e.*,	. . . . .	. . . .	+ 151
Pons Schroeteri	56.17		
Brightest part	56.53		
The *north* part of this precedes a little *i. e.*, in $p = 355°$ about	56.04 56.31	+ 7.97	+ 79.3
	Mean 56.26		
Apex of E almost exactly *south* of θ^1	. . . . .	. . . . .	0.0
Middle of W^1	67.97	− 3.74	− 37
(Driving clock failed). Refraction corrections.	. . . . .	. . . .	0.0

Order of brightness.

A, D, G, F, I = H, N, Q, E.

The *south* part of F and the middle of G almost stellar in appearance. N and Q not very well defined. These masses in the Index-Chart are perhaps not well drawn

$o\pi$.—τ''.

There *are* two brighter spots (elongated) in $o\pi$, as in the Index-Chart. *North* of $o\pi$ (the whole mass) it is quite dark, close up to the *south* edge of σ.

Sinus magnus.—τ' and V.

The darkest space in the *Sinus magnus* is bounded by the curved line in Index-Chart, *i. e.*, *following* the *pons Schroeteri* Prolong $o\pi$ towards the *west* and the space *south* of this line [prolonged] and *following* the *pons* is blacker than any neighboring part. It is blacker than the ground on which the trapezium stands, for example. *North* of this line ($o\pi$ prolonged) it is brighter, but still very faint.

φ and σ. (*lacus Lassellii.*)

Between φ and σ there is a dark channel; just *south* of 663 it ceases to be very dark, and this darkest portion ends in a curve convex towards the *south.* There is a dark channel connecting this with the *Sinus* or *nearly* connecting it. I think the *south* end of this channel is wider than in the Index-Chart.

τ.

South third is blacker than *north* two-thirds. The bay in which 647 is has never been seen so far.

Messierian branch.

Bond's *preceding* edge of this branch is finely given. Its outline is very hard and

sharp like water-color laid on and allowed to dry at the edge. The *north* edge of the *rostrum* (μ) in BOND strikes me as too bright relatively, but I am not sure that it is so.

MAIRAN'S *nebulous star* [No. 734]

The shape in BOND is not quite right. The brightest part *follows* and is *north* (a little) of the star [737]. There are two dark spaces, one on the *n. p.* and one on the *s. f.* side, but not quite as figured; the bright portions do not seem to be exactly right. [Sketch omitted of a *very* faint star $p = 355°$ $s = 24''$ (both estimated) from [734]. The very faint star above given is a very good test for light.

1875, NOVEMBER 24.

Begin $10^h\ 10^m$, end $11^h\cdot30^m$. *Mag. power*, 175. Wt. = 4. 647 > (575) > (671) or (676) > 589 > (567).

The line through 685 and 708 passes through the brightest part of F (*i. e*, X [?]) and is *parallel* to the black channel between F and (G and H). [Such remarks as this are always founded on an observation of a micrometer wire laid through the stars.]

$o\pi$; $\tau - \xi - \tau'$.

π is brighter than o; o is brighter than the middle of $o\pi$. *North* of $o\pi$ it is black; *preceding* it is black; *south* also black [a narrow channel]. After the channel south of $o\pi$ is crossed, the *Sinus* is filled with nebulosity up to its *south* border. Just following *pons Schroeteri* it is *very* black. Half way from o to *south* border of *Sinus* there is a nucleus, very faint and almost stellar, more nearly stellar than the nucleus in *pons Schroeteri.*

σ.

Following the "*Spitze*," in same parallel, there is a star whose distance from point of *Spitze* is equal, approximately, to the distance of the latter from 669.

Order of brightness.

A, D, G = H, F, N, Q, I, E, J.

Sinus Lamontii.

Although the *Sinus Lamontii* is plain, yet the Harvard College Observatory drawing of 1874 exaggerates the effect as seen now.

Channel between φ and σ. (lacus Lassellii.)

This black channel certainly goes from 652, 663 through to the *Sinus magnus.* It is rounded *south* of 663, and black; then faint and wider than the Index-Chart has it up to the *Sinus.* It is about as bright as *north* half of *pons Schroeteri.*

567.

567 is in a black space half way between B and 1. 575 and 589 in two bright streaks, as in sketch of 1875, October 27.

η.

South shore of η is about right in Index-Chart.

Dark channel between E and F.

p (estimated) 140°. Position-circle: 293°.5, 290.0. *Mean*, 291°.7. $\therefore p = 139°.6$. This is the angle of position of the dark channel between E and F; its direction passes through the star 589. Hence the Index-Chart is wrong in this point. It passes in direction $p = 140°$, and then turns sharp off towards 631. The [vertex of the] angle is sharp, not rounded as in Index-Chart.

671, 676? [possibly 671–686??] prolonged intersect the *frons* in a bright nodule.

The pastel drawing of the Naval Observatory has the dark channels better than the Harvard College Observatory drawing of 1874 [both these are by M. Trouvelot]. The channels are pretty wide and pretty well defined at edges.

The dark channel *following* D *does* connect with *Sinus magnus*.

τ.

The *preceding* and *south* edges of τ are bordered by a very black stripe; then the *south* third is black, its *north* two-thirds full of nebulosity. In the Harvard College Observatory print of 1874 the reverse is the case; *i. e.*, it is darker at the *north* end.

685, 708, 741.

The same remarks as formerly made apply to these stars. It is dark between them, and brighter just *south* of them, but my previous sketches [omitted] are right, or nearly so. Mairan's *nebulous star* [No. 734]. This nebulous star has certainly altered since Bond's time. Between the principal star [734] and that one at the point of the comma [785] there is a broad dark streak extending quite across the nebulosity and dividing it into two parts. Its direction is *s. f.* to *n. p.*

ρ.

Following the "*Spitze*" there is a curious repetition of the prow-like shape of the Spitze itself; it is much fainter, and is close to σ, so that it looks like the shadow of it, a little distorted.

1876, January 3.

Mag. power, 175; end $11^h\ 45^m$. Wt. = 4. Seeing very good.

Order of magnitude.

1. (575). 2 (671) *or* (676) [probably (671)]. 3. 622 *or* 625. 647? is brighter than any of these. It is in a dark space *surrounded* by bright nebulosity even towards the *east*, and this [nebulosity] is suddenly much brighter towards the *north*.

τ.

The *north* half is filled with faint nebulosity; the *south* half is empty. Half way between the *following* edge of D and the *preceding* edge of *pons Schroeteri* there is cer-

tainly a faint bright bridge of light, as sketched [in by me] on the Index-Chart, similar to SCHROETER's second bridge. [See *Beitrage zuden neuesten astronomischen Entdeckungen.*]

[Its base is connected on the *north* to v], and it extends towards the *south* as far as the parallel of the bright nucleus of the *pons Schroeteri.*

Pons Schroeteri (g_0).

This nucleus is seen stellar beyond a doubt; not the whole nucleus, but a point inside the central condensation.

τ.

The *preceding* side of τ is the blacker.
[There is a black stripe bordering D and T.]

Order of blackness (*not brightness*).

1. Space *following pons Schroeteri* and *preceding* ξ [τ']. 2. Space between σ and $o\,\pi$ [τ'']. 3. Space in which trapezium is situated [V]. 4. *South* half of τ. 5. ξ.
N. B. This makes *south* half of τ brighter than usual, but it is right.

μ and σ.

Rostrum = μ is about as bright as σ. [I suppose this to mean, as bright as the main body of σ and not as bright as the brighter *southern* edge of it. 1877.]

Order of brightness.

1. A. 2. D. 3. G, H. 4. N, Q, F, I. 5. E. (654) not seen, although looked for.

1876, JANUARY 4.

$10^h\ 20^m$. Mag. power, 175

Order of magnitude.

1. (671) or (676). 2. (575) almost = 671. 3. 622?. 4. 589. 5. 567.
612 = 618 = (676); 581 and R. 56 both seen; also 636, but not (654).

Order of brightness.

1. A. 2. D. 3. G, H, N. 4. F. 5. I. 6. E: and I = Q nearly.

Rather hazy, and work unsatisfactory. At the same time the small stars are seen very well indeed. No signs of LASSELL's *b* [between 685 and 708]. 709 seems rather fainter than usual; I noticed this also last night, January 3.

1876, JANUARY 10.

$11^h\ 30^m$–12^h. Mag. power, 175. Wt. = 1.

Order of brightness.

1. A. 2. D. 3. G, H, N, Q. 4. F. 5. I, E. Not very good. Strong moonlight, and details faint. *Sinus Lamontii* appears very strongly marked to-night, much as in Harvard College Observatory drawing of 1874. This is simply on account of the moonlight, and not that it is really any stronger. [This remark is based on a great many observations in the years 1873–'74–'75–'76.] The night is so bad that [much] further work is impossible.

A line in the *Huyghenian region* parallel to the *frons* and passing through 602 would pass through a region which is fainter than those on either side of it; that is, there is a fainter bar running through the whole *Huyghenian region.*

$\tau - \tau' - \gamma.$

Even to-night I can see that the *east* side of τ is not so black as the *west*, and that the *north* is not so black as the *south.* τ' is to-night of about the same blackness as τ and as γ, but there is very little weight to be given to work done under such conditions. Nearly full moon, and seeing extremely bad.

1876, JANUARY 30.

10^h. Mag. power, 400: seeing not good. Wt. = 2. (The original paper on which observations were recorded has been mislaid, and the following is from memory [and of course is only a part of work done], but I am certain of everything recorded.)

Pons Schroeteri.

Center distinctly concentrated; almost stellar.

$o\pi.$

o and π like nuclei, verging towards a stellar appearance but not so much as center of *pons.*

τ'' and $\tau.$

Quite black below [*north* of] $o\pi$ and on *preceding* side of τ. A thin black streak edges all the *west* and *north* sides of τ, but the *north* half of τ is decidedly nebulous, while the *south* half is almost jet black.

W^1 and V.

W^1 = *lacus Secchii* seemed blacker than V = space around trapezium.

$\sigma.$

The *south* edge of σ has a quite sharp bright termination; *i. e.*, comparatively much brighter than v, for example.

The black space around 647 is not entirely black, and perhaps it is too well marked on Naval Observatory pastel drawing by TROUVELOT.

V.

I should say, also, that V was too black in that drawing. Two sequences of brightness of masses in *Huyghenian region* recorded which I cannot exactly remember and therefore do not record, but both agreed in making E quite faint.

1876, FEBRUARY.

Begin $7^h\ 30^m$, end $8^h\ 30^m$. Power, 400. Wt. = 4 at first, then = 1.

Order of brightness.

1. A. 2. D. 3. G, H, F. 4. N. 5. I Q or Q I. 6. E.

Order of blackness.

1. $\tau' = \gamma$. 2. τ (*south* half only). 3. V. 4. *North* half τ. Again: 1. τ'. 2. τ''. 3. γ. 4. *South* half τ. 5. V. 6. *North* half τ.

Differences of declination.

Object observed.	Micrometer reading.	$\Delta\delta$ in revolutions.	$\Delta\delta$ in seconds.
			"
South point of E	71.54	— 14.33	— 142.6 } (— 142.7) }
South point of F	69.49	— 12.28	— 122.2 } (— 122.3) }
North point of δ	67.51	— 10.30	— 102.5 } (— 102.6) }
This is about the same declination as *north* point of E.	. .	. .	(— 102.6)
Through the center and brightest part of G.	64.21	— 7.00	(— 69.6)
North end of *Sinus Gentilii* * . . .	63.9	— 6.7-	(— 66.7)
South end of A near star 622 . . .	60.41	— 3.20	(— 31.8)
North end of L on same parallel as 671 and the *east* point of Q.	59.78	— 2.57	(— 25.6)
θ^1 *Orionis*	57.21	0.00	(0.0)
Middle of break in *pons Schroeteri* .	55.0	+ 2.21	(+ 22.0)
Brightest part of *pons Schroeteri* . .	53.0	+ 4.21	(+ 41.9)
All *north* of this in τ is filled with nebulosity, except of course the black channel on its *west* edge; nearly all τ *south* of this is pretty black, though not so black as τ^1.	52.48	+ 4.73	(+ 47.1)
About through the center line of *west* half of $o\pi$: this parallel passes through the break in *pons Schroeteri north* of its nucleus.	51.18	+ 6.03	(+ 60.0)
South side of σ (approximately) . .	48.8	+ 8.4-	+ 83.6 } (+ 83.7) }
South end of E; seeing growing worse.	71.78	— 14.57	— 145.0 } (— 145.1) }
South end of E; seeing growing worse.	71.69	— 14.48	— 144.1 } (— 144.2) }

The $\Delta\delta$'s corrected for refraction are inclosed in brackets.

Now put on mag. power, 175, all the measures having been made with 400.

No *tails* or *wisps* to 708–741 to-night.

G. P. Bond's *Regio subnebulosa* is right. The *rostrum* [μ] in Naval Observatory drawing of 1875 is too narrow. Made sketch-map of stars around and in Mairan's nebula [omitted].

* [Drawing omitted.] The *Sinus Gentilii* is connected by a black channel running to the N. E., with space near trapezium. V is almost perfectly black * * * [in sketch] is a little brighter [* * * . . . is a narrow space bordering V on its *preceding* side], and on its *west* edge is a little ridge [brighter], and *west* of this is the black channel, connecting with that just mentioned [*i. e.*, that one running to the N. E.].

1876, March 6.

8^h–9^h. Mag. power, 175. Wt. = 2. Parallel, 151°.0.

Occiput.

Angle of position of *preceding* edges of E and I.

Position-circle: 102°, 101°, 97°.6, 96°.4; *mean*, 99°.3 . ∴ $p = 142°.7$.

Dark channel between F (on the south) and G and H (on the north).

Its prolongation passes nearly through 685 and 708, whether *exactly* or not the night is not good enough to determine.

Spiral formation of the nebula well seen.

Otto v. Struve's node of nebulosity, by *O. Σ.* 126 (G. P. B. 793), is not seen; [referring to an observation communicated by letter]. (575) > 589 > (567). The last star is quite faint.

622.

Angle of position of 622 from θ'.

Position circle: 42°.0 . ∴ $p = 199°.0$.

The line of 622 and θ' passes through (or nearly so) a bright star *south* of *Huyghenian region* 6′ [570 G. P. B.].

Dark channel between I (on west side) and X and G (on east side).

This is a straight portion of some length whose direction goes through G. P. B. 570 (same star as noted just above).

Position-circle: 213°.7, 215°.7, 216°.8; *mean*, 215°.4 . ∴ $p = 25°.6$.

c.

The direction of the spiral *c* (towards 523) is about right on Index-Chart. The seeing is not good on account of haze, and the weight of the measures is small.

1876, March 14.

Struve's *new nucleus near* 793.

$\Delta\delta$ micrometer wire on 793 - - - - - -	89.91
wire B on new nucleus - - - - - -	93.90
	$\Delta\delta = 3.99 = 39''.8$

Again:

	90.13
	93.90
	$\Delta\delta = 3.77 = 37''.8$
	$\Delta\delta$ *mean* $38''.8$

This nucleus *precedes* 793 = (*O.Σ.* 126), and is quite faint through the light clouds which cover the sky, still it can be steadily seen in a dark field, but not quite steadily

on the bright wire; [the p (estimated) of this object from 793 was about 190° to 200°, and it is probably not *O. Σ.*'s nucleus].

[Sketch of 793 and vicinity omitted.]

The small space [just following 793 and about 20″ to 25″ in diameter] seems to glisten with bright small points, a little like the *Huyghenian region* just *south* of trapezium. [Just *north* of 793 and immediately *preceding* the *Messierian branch*] there is a dark channel which separates the *branch* from the diffused nebulosity of the *Regio subnebulosa.* This channel is like Bond's dark channels in nebula of *Andromedæ.*

Order of brightness.

1. A. 2. D. 3. F, G, H. 4. N. 5. I. 6. Q, E, not a very satisfactory order in spite of good seeing. [Probably just on account of good seeing, so many details confuse a general judgment.] 1. A. 2. D. 3. F. 4. G, I. 5. H, E. 6. N, Q.

This is better, but the mag. power 400 shows too many details to assign this order satisfactorily.

V. — τ'.

V. is by no means as black as the *Sinus Gentilii*, but comparable with [in blackness] and almost equal to the *north* half of τ'.

Differences of right ascension.

575 is just exactly *north* of 573 [according to Bond 575 *follows* 573, 3″], and the line joining them skirts along the *preceding* shore of *Sinus Gentilii*, and is the best tangent to this shore. On re-examination I find 573 *preceding* 575 by not more than 0″.5 [3″ according to Bond]. The line of shore between (β and K) and γ *is* curved, though not quite so strongly as it is drawn in Naval Observatory drawing, 1875; γ, in that drawing, needs to be moved bodily towards the *east* to conform to the line 573–575.

$\Delta\alpha$; *setting* 241°.1, wire A on 685, and at 64ʳ.18.

Object measured.	Micrometer reading.	$\Delta\alpha$ from 685 revolutions.	$\Delta\alpha$ from 685 seconds.	$\Delta\alpha$ from θ^1 seconds.
		ʳ.	″	″
$\Delta\alpha = 575$	82.62	— 18.44	— 183.4	— 86.5
Preceding side of W_1	79.68	— 15.50	— 154.2	— 57.3
This declination-circle *bisects* the rounded apex of the mass I, and limits W^1 on its *following* side; (W^1 narrows here on the *following* side to something like a canal.)	76.85	— 12.67	— 126.0	— 29.1
Bisects the rounded apex of E (not a very good observation) and passes through the *northern* star of the trapezium.	74.45	— 10.27	— 102.2	— 5.3
Tangent to the *preceding* sides of F and G and passes between θ^1 *Orionis* and the 6th star.	73.80	— 9.62	— 95.7	+ 1.2
Tangent to brightest and *following* side of D; tangent to *following* side of G and bisects F very nearly.	71.02	— 6.84	— 68.1	+ 28.8
Nucleus of *pons Schroeteri*. . . .	66.24	— 2.06	— 2.5	+ 76.4
N. B.—$\Delta\alpha$ of 685 = + 96″.9.				

End 8^h 30^m. Power 400, used throughout. Sky hazy, and images quite steady.

793.

Looked at 793 again; saw my star, but nothing else steadily, although the space *following* is certainly full of bright points.

1876, MARCH 22.

7^h $40.^m$–8^h. Mag. power, 400. Wt. = 3.

793.

I see *s. p.* 793, $s = 40''$ the faint star previously measured (March 14); this is, of course, preceding the bright line of [west] nebulosity of the *Messierian branch.*

Inside of the *branch* [and near 793] I am not sure of any point. There may be one $20''$–$25''$ off, a little following, but the night is not good enough to decide. Just *preceding* the *Messierian branch* from 793 *north* to 784 there is a black streak of varying width (not more than $1'$) which extends from 793 towards the *north.* [Drawing omitted.]

Order of brightness.

1. A. 2. D. 3. F. 4. G, I, H. 5. N, Q, E. (Not a very careful observation.)

1876, APRIL 1.

8^h. Very poor seeing. Mag. power, 175.

709 is a little harder to see than the 5th star. [*Query,* 6th star?]

709 = 671 or 647 about. It requires attention to see it.

τ.

North half much brighter then *south* half.

Seeing too poor to go on.

1876, NOVEMBER 5.

Mag. power, 400. End 14^h. Wt. = 3.

675 visible, and well involved in nebulosity.

Figure [omitted] shows two nuclei in N (denoted by *a* and *b* in this night's work), and the nuclei 686, 688 with stars 671 and 676. There is a dark space between 671 and 676. (671) > (676).

South of the line 671–676 it is black, and 676 seems to be on the *preceding* edge of P or O.

The dark channel between O and P not well seen (night not good).

Q.

The *north* side of Q quite bright and sharp.

τ.

The second bridge of SCHROETER is seen much as I have drawn it before.

a. b. 686, 688.

$13^h\ 50^m$. The line joining 676 and 685 passes a little *east* of the points *a* and *b*. These look nebulous, as do 686 and 688 of the figure and not like stars. *a* is on the *following edge* (the exact edge) of N and 688 is on the *north edge* of Q.

636 visible but not 654.

The night is bad and work not satisfactory.

1876, November 11.

12^h. Bad seeing.

Order of brightness.

H, G, F (about equal), I, E.

Dr. C. S. Hastings sees the second bridge of Schroeter.

1876, November 22.

Begin $10^h\ 45^m$, end $11^h\ 15^m$. Mag. power, 175. Wt. = 2.

Frons.

Position-circle: 59°.4, 59°.2, 59°.8, 60°.0; *mean*, 59° .6. Parallel = 108°.9 $p = 49°.3$ (4).

Occiput.

Position-circle: 152°.9, 152°.9, 152°.4, 151°.2; *mean*, 152°.3; $p = 136°.6$ (4).

Best tangent to *south* shore of *Sinus magnus*. (To the general direction of the shore, cutting off a little of the *south* end of *pons Schroeteri*.)

Position-circle: 182°.6, 180°.8, 186°.0, 183°.9; *mean*, 183°.3; $p = 105°.6$ (4).

1876, November 27.

Begin $10^h\ 30^m$, end $11^h\ 0^m$. Mag. power, $175\pm$. Wt. = 2.

Moonlight and flying clouds, which finally prevent work. Preceding edges of J and B (through 575).

Position-circle: 103°.8. Parallel, 108°.9; $p = 5°.1$ (1).

1876, December 5.

Begin $12^h\ 0^m$, end $12^h\ 45^m$. Mag. powers, 400 and 175. Wt. = 1. Parallel = 15°.2.

Differences of declination with θ′ and brightest part of G.

$70^r.55$, $70^r.78$, $70^r.61$, $70^r.87$, $70^r.69$; *mean*, $70^r.70$

Zero, $64^r.12$

Poor measures. $\Delta\delta = 6^r.58 = 65''.5$ (5).

Dark channel between I and E.

Its prolongation *precedes* 671.

Position-circle: 60°.9, 62°.1, 64°.0, 63°.2; *mean*, 62°.6 (4). $p = 42°.6$ (quite uncertain). First three measures with eye-piece 400; last with 175.

$647 > (671), (575)$.

$681 > (676) > 651$; not much difference in these; $709 = 663$ about.

Very cold and seeing bad.

1876, DECEMBER 13.

Begin $12^h\ 40^m$, end $13^h\ 0^m$. Mag. power, $175\pm$.

Order of brightness.

1. A. 2. D. 3. G, H. F. 4. N, I, E.

Mr. H. S. PRITCHETT puts D and A about equal, but thinks D a little the brighter.

The space between 685 and 708 is blacker than that between 708 and 741. Clouds.

1876, DECEMBER 19.

Begin $13^h\ 15^m$, end $13^h\ 35^m$. Wt. = 3.

Order of brightness.

(Mr. PRITCHETT.) 1. D = R. 2. A. 3. I. 4. H and F. 5. B.

SCHROETER'S *second bridge.*

It extends to the *south* as far as the parallel of 647.

τ: τ'.

The *south* half very black; τ' blacker than *north* half of τ.

Order of brightness.

1. A. 2. D. 3. F. 4. Q. 5. N. 6. G. 7. H. 8. I. 9. E.

B = F = W; Y = O (doubtful).

Order of blackness.

1. τ'. 2. τ''. 3. South half of τ. 4. W'. 5. *Sinus Gentilii.*

Sinus Gentilii brighter than W^1.

685–708 in the prolongation of the dark channel between (F and G) and H.

η.

As in Index-Chart.

Pons Schroeteri.

Its direction passes through 685 nearly.

Position-circle: 325°.7, 323°.5, 323°.0; *mean*, 324°.1.

$p = 171°.2$. (3).

Preceding edges of J. and B.

Position-circle: 301°.5, 303°.7, 304°.0; *mean*, 303°.1. (3).

$p = 12°.2$. (3).

[Drawing made, omitted.]

This drawing shows the portion of the *Huyghenian region* following the meridian of θ', as it appears in a general view. It was made particularly to show a darker band which rests on τ, as a base, and extends towards the *south*, ending on the *frons* between H and N. This part is about as bright (in general) as the dark channels. It is apparent at first glance in a general view, and the drawing gives its *general* shape. It looks like a continuation of τ. In this drawing the second bridge of SCHROETER extends *south* to the parallel of 647; 651 is precisely on the edge of τ, [*i. e.*, $\Delta\alpha$ of tangent to following edge of D = 28″.8]; g_0 is shown as a central nucleus, surrounded by an annulus, etc.

τ.

The south third of τ is black, but I seem to be aware of one or two bright stellar points in it, which I cannot fix, but which I believe to be real.

SCHROETER'S *second bridge.*

Its position angle is a little greater than that of *pons Schroeteri.*

Lacus Lassellii.

It is connected with *Sinus magnus.*

Y.

Quite bright and equal to σ near *k.*

g.

Contains a bright star [570].

B.

Extends no farther than 575 as a *bright* mass, certainly not as much farther as is given by Lord ROSSE (1867).

A.

The convolutions in A on its *following* edge give the effect of LASSELL'S drawing of 1862 [unpublished, but most courteously communicated to me in a full size pencil-copy by Miss CAROLINE LASSELL], but some of the details are different now.

1876, DECEMBER 31.

Begin $10^h\ 7^m$, end 11^h. Mag. power, 150 (A_1). Wt. = 2 at beginning. (Moonlight.) Sky very clear, and seeing improving a little toward the end.

709 < 657, 657 = 652 about. 647 and 651 as in Index-Chart. (671) > 676; 575 = 589, although 575 is first caught by the eye on account of its situation, being more free of nebulosity. Both 575 and 589 less bright than 647 and 671, although 647, 671, and 575 are not very unequal.

B, A.

B runs *exactly* through 575, and if it extends beyond (*south*) of 575 as a distinct mass it is considerably fainter. 589 appears at the *south* end of a bright part of A, and between 575 and 589 is an oval dark gulf. [Drawing of convolutions in A omitted.] The branch (B) leading to 575 is brighter than that leading to 589.

V and A.

Dark channel between V and A, much as in Index-Chart. It leads around toward the west in a very regular curve, connecting with the dark space north of *c*. V contains 612 or 618 (the brighter of these two) [618].

W_1.

W_1 connects with the dark channel north of 2, which runs towards 524.

W_4.

W_4 is larger and more toward the *west* than in Index-Chart. W_1 blacker than W_4, but not much, and both much blacker than W_3, *which to-night is not clearly outlined.*

Telescopic meteor crossed lower half of the field of view (25′ in diameter) from *s. p.* to *n. f.*, position-angle about 50° very rapidly, lasting about $0^s.1$; as bright as 724. Channel just *north* [*south ?*] of I is about parallel to *frons.*

685–708 prolonged is in direction of channel between (F and G) and H.

Dark channel *preceding* M has a direction from 685 to a point about half way from 618 to 647. To-night it seems to extend and join with V.

686 seen well. It is probably a cluster of very small stars or a nebulous nucleus.

The *north* half of the second bridge of Schroeter seen. τ is dark, in the same $\Delta\delta$ as g_0.

1877, January 2.

Begin $9^h\ 40^m$, end $10^h\ 20^m$. Temp. $= 2°.5$ F. Mag. power, $175 \pm$. Wt. $= 2$.

Order of brightness.

1. A. 2. D, G, F. 3. H, I, N. 4. E. $E > M > \sigma > \mu$.

B, about half way from 575 to its *north* end, is *about* as bright as the general mass of I; but this comparison is very hard to make. J very faint.

J < space just *south* of W_3 and about W_4, and J < E, but J > σ.

Order of blackness.

$\tau' = \tau''$; τ'' blacker than W_1, which is blacker than the *south* half of τ.

Schroeter's *second bridge.*

It is seen more like Rosse's figure than before. Only the south* two-thirds seen. $558 > 709 > 524$.

* For *south* read *north* probably.

c.

c is about as bright as B (roughly speaking) a little *preceding* 575, and it joins a little more smoothly into the *preceding* edge of A.

ξ.

It is uniformly filled with *v*. F. nebulosity.

(575) = 671 = 647, nearly.

δ and γ as in Index-Chart.

The nuclei of F and G were stellar in appearance; more so than usual, and in a less degree those of I and H. E is always nebulous and uniform in brilliancy, if we except the very small surfaces which give what HERSCHEL calls the "appearance of stippling" to the whole nebula, and which are not to be fixed in position.

Y.

Y is not a marked feature of E, as in LASSELL (1862), but requires a little attention to see it.

γ.

γ is pretty uniformly black, but, of course, not so black as τ', *etc.*, but is *uniform*.

η.

570 (in ζ) has blackness (η) just *south* of it, and this *precedes* it. The blackness *north* of it (between ε and ζ) *precedes* it but little.

The *general effect* of the spirals *north* of *regio Huygheniana* is much as in LASSELL, 1862.

ρ.

Just *north* of the *Spitze* and *following* σ it is pretty black to-night.

654 and 675 have not been seen (though 675 has hardly been specially looked for) since November 1.

M, etc.

The channel just *following* M seemed in the bad seeing to be more nearly *north* and *south* than on December 31, and to run from its *south* point in the *frons* (correctly laid down on Index-Chart) *south* through 671 and 676 (which are on a black ground) to the *Sinus magnus*. This appearance would be produced if the *following* end of M were faint from bad seeing.

R.

The *preceding* part of R quite faint to-night. Among other experiments I tried reflecting the image of the nebula after it had passed through the eye-piece through a 90° prism. This had the general effect of bringing the point Q further into μ, and of making the appearance of the *frons* more like HERSCHEL'S drawing of 1837.

Other experiments seemed to indicate that in a weak telescope the opening of the jaws would be determined by the present *south* shore of *Sinus magnus* and the line 618–669.

1877, JANUARY 5.

Begin $9^h\ 0^m$, end $9^h\ 30^m$. Mag. power, 175 ±. Wt. = 1. Parallel = 18°.0.

Very poor seeing; unsteady and not transparent. The *Hemicylium Liaponovii* is plainly to be traced under these conditions. The *north* side of I appears to connect with the *south* end of A, and this brighter part curves round toward the *west* as far as 589 about (this star not seen), then returning on itself the *following* side of A appears to connect with c. c plainly projects beyond the main *Huyghenian region*. B also is plainly bright, so that, beside the *Sinus Lamontii*, there is a similar gulf between B and the following side of A.

Occiput.

Position-circle: 152°.9, 151°.8, 152°.7; *mean*, 152°.5. $p = 135°.5$ (3); this cuts off Y.

Distance of occiput from θ′.

$74^r.91$; $74^r.74$:; $74^r.85$; *mean*, $74^r.83$
zero, .64 .12

$s = 10^r.71 = 106''.5$

Pons Schroeteri.

Position-circle: 123°.0::; 121°.4::; *mean*, 122°.2. $p = 165°.8$::(2).

This measure gives really the p of a line joining 669 and g_0.

I chose this very poor night for measuring the distance from *occiput* to θ', as the nebula looked more like LAMONT's drawing than I have ever seen it. The distance as I measured it is 106″.5. LAMONT measured it twice, and obtained 97″.8 and 96″.61. HOLDEN–LAMONT = + 8″.7 and + 9″.9. LIAPONOFF obtained 96″.4. HOLDEN–LIAPONOFF = + 10″.1.

Comparison of Lamont's drawing with the nebula.

The bay of LAMONT I see as he did. B is not laid down by him; it is plainly seen to-night, and its absence from his drawing accounts for all the difference in the region between 589 and 575. His "E" is far brighter than it is to-day, and his "I" is far more conspicuous than now. His "F" is nearly round, whereas it is now triangular. The channel north of it is to-night in the prolongation of 685 and 708, but it is not so in his drawing.

His H, if laid down at all, is fainter than to-night. The *north* side of A near W is to-day much brighter than in LAMONT's figure. *Lacus Lassellii* is not figured in his drawing. To-night it was very prominent. The same remark applies to σ as a whole. The extension of Q into μ was remarked to-night to be like LAMONT's figure.

1877, JANUARY 10.

Begin $9^h\ 15^m$, end $10^h\ 15^m$. Mag. power, 175 ±. Wt. = 2.

The night very transparent although unsteady. ROSSE's drawing taken to the telescope and compared.

635 is in a black space.

(641) just barely seen < (575).

But (641) > (567), which is barely visible, = 16^m of ARGELANDER'S scale. There is a channel from 635 to 663, as in ROSSE.

635 is just on the south border of a triangular mass.

Dark channels in Regio Picardiana.

[σ, φ, χ, ψ, etc.]

Beginning on the *following* side and naming the dark channels running approximately *north* and *south* in order they are:

1st. *Lacus Lassellii.* This is better laid down on Index-Chart than in ROSSE.

2d. One entering τ on the *preceding* side of SCHROETER'S second bridge, and continuing towards the north as in ROSSE. (Leaving this order for a moment W_4 connects with W_2 (this again verified); W_3 is just south of 635. W^4 and W^2 by no means so well marked as W^1 = *lacus Secchii.*)

3d. The third channel in order starts from the channel connecting W^4 with W^2 and runs toward the *north*, forming the *preceding* boundary of the triangular mass (apex to the *north*), in which 635 is near the southern borders. (The channel connecting W^4 and W^2 is tolerably black up to and including W^2; from thence it continues to the *west* as in ROSSE, but is not so black after leaving W^2.) W^1 is the origin of another (the fourth) channel towards the *west* as in ROSSE, and then there is a fifth to the *north* of c. These are the principal ones, and they are all nearly exact in ROSSE'S drawing.

A channel goes from 657, 652 towards *s. p.* as in ROSSE, except that I doubt its crossing the *northern* end of the triangular mass just described (635 at *south* end of this mass). If it crosses this mass I do not see it so to-night, and certainly the relative intensities near this point are not as in ROSSE. *North* of this (last described) channel is another across φ parallel to the one just described through 657 and 652, as laid down by ROSSE. This is outside the limits of the Index-Chart.

506 is a few seconds *south* of the dark channel, having its origin in W^1 = *lacus Secchii*, and 516 is still in the same bright wisp. From 524, running towards the *west* and dividing the wisp just spoken of, is a dark streak as in sketch [omitted]. [Probably not due to contrast, 1877, April 3.]

Palus Bondii.

567 is quite in the dark and quite faint = 16 magnitude (ARGELANDER). From 575 *south* of 567 and across to the *southern* edge of c it is a very little brighter in a narrow wisp, so that the space bounded *north* and *northwest* by c, *northeast* by B, and *south* and *southwest* by this narrow wisp is quite dark. It is undoubtedly made darker by contrast near the junction of c with B.

I.

1 is an irregular oval dark mass, separated from the darker space just described by the wisp from 575 to c and bounded on the *south* by an irregular line as in Index-Chart. This (1) is connected to the dark channel just north of K by a darker lane through ω as indicated on Index-Chart. (Sketches made of the parts described which are omitted.) Parallel = 17°.8.

Pons Schroeteri (angle of position).

Position-circle: 293°.7, 292°.8, 289°.6; *mean*, 292°.0. $p = 175°.8$ (3); uncertain.

Sketch of *proboscis* near 793 (omitted).

1877, JANUARY 24.

Begin $8^h\ 30^m$, end $9^h\ 40^m$. Mag. power, 175. Seeing very bad. Moonlight.

Using a pair of tourmalines, lent by Prof. S. P. LANGLEY, back of the eye-piece (first removing the cap which contains the eye-hole). With the *maximum* light which passes through the tourmalines, I see all four stars of the trapezium, 685, 708, 724, 741, 669, etc. I can see the whole of the *Huyghenian region* and plainly trace the *Sinus Lamontii* between two bright nebulosities I and J. No dark channels seen well, but V is evident; therefore V is darker than the bottom of the dark channels. The tourmalines were to-night held in the hand, but I find it will be necessary to make an adapter for them. They, however, indicate that in the *Huyghenian region* M, S, R, P, T, and between J and I it was the *faintest;* then E and the *north* part of I; next G, F, H, and part of I, part of Q (near N, I think), are a degree fainter than A and D. The above results are approximate and tentative, and are not of much weight.

W^1, W^2, W^3, W^4, W^5.

[Sketch omitted.] $> =$ "blacker than"; $W_1 > W_4 > W_5 > W_2$.

612 in nebulosity, or very close to border.

618 inside V.

$(642) = 654$ each is just visible.

$709 > (641) > (676) > (567)$ here $> =$ "brighter than"; $671 = 622? = 575$ nearly, and 589 is a very little fainter than 671. 675 not visible.

A.

589 and 622 are correct on Index-Chart in relation to A. 622 is in a dark space half way from V to A.

$581 > 573$. R 56 not seen to-night.

L.

L, from 621 to 601, and from thence to 595, that is, the *north* [shore], is very bright; almost as bright as A near it.

I.

No nucleus (602) seen in I to-night.

F.

X and F seem to be almost separated by a fainter streak nearly in the parallel. The following end of F extends further *east* than in the Index-Chart, but [this part] is fainter than the rest of F. [Sketch omitted.]

As often before remarked the channel between F and (G and H) is in the line 685–708.

G.

G seems elongated, and to-night resembles closely LASSELL's oil-painting of it (made in 1854,) which is at the Royal Astronomical Society's rooms.

M.

M is elongated in the direction 622–741 (approximately); it is just below M, and to-night seems similar in shape to it.

Frons.

The *frons* is convex to the *east* as ROSSE draws it. The greatest convexity is near 685.

V.

On the *preceding* border of U, about half way (?) from 622 to 628 (half the $\Delta\delta$ of these stars), I twice saw a very faint star = (642) as it is to-night. It is just on the very edge [of V]. Night transparent but very unsteady.

G.

(See above.) Its shape was as in sketch (omitted) brightest at *preceding* side and brushing off to a fainter following point.

1877, JANUARY 27.

C^2 *Orionis* has a small companion 15 *magnitude.*

1877, JANUARY 30.

10^h. Professor LANGLEY's tourmalines mounted back of the eye-piece, new A. (Mag. power, 175.)

[The tourmalines were gradually rotated, and at each stage the appearances through the tourmalines was noted.]

1st. Totally dark.

2d. Three trapezium stars, 685 and 708 visible.

3d. Four trapezium stars, 685, 708, and 741 visible.

Drawing made of the *Huyghenian region* at this stage.

FIG. 7. Drawing made through tourmaline plates.

4th. At this stage and *through the tourmalines* a measure of the position-angle of the north shore of the *Sinus magnus* with a bright wire was made. Position-circle: 259°.5. (Parallel, 33°.4.); $p = 44°$ (1.)

5th. True outline of *frons* seen; E fainter than G and H. *Lacus Lassellii* seen.

This process was repeated several times and a careful crayon sketch made [omitted]. 685 and 708 on *s. f.* edge of the *frons*. 741 free from nebulosity. 635 and 669 seen. 635 just plainly visible. A dark band penetrates the *Huyghenian region* from *Sinus magnus* (which is much blacker than this band) and divides into two, one goes *south* past 685, the other *west* near θ' and then makes a little bay towards the *north* as in PICARD's (1673) drawing [see Figure 4 of this text].

G, H, F, and E? divide the two parts of the dark band.

W_5.

(Without tourmalines.) W_5 is certainly not so black as W^4 and W^1. Has it changed since Lord Rosse's drawing?

End $10^h\ 45^m$. Eye much fatigued.

1877, February 3.

Begin $8^h\ 20^m$, end $9^h\ 25^m$. Mag. power, 175. Wt. = 2.

(654) and (675) just barely seen in moments of quieter seeing. 675 appears to be *east* of the line of the *frons; i. e.*, in the dark space outside of the *Huyghenian region*, but this is not absolutely certain [and it is quite different from all previous determinations].

654 is only rarely visible. The air is exceedingly transparent.

Parallel, 33°.4. Coincidence, $64^r.137$. Difference of R. A. of θ^1 and following end of Q.

Micrometer: $49^r.00$, $49^r.60$, $49^r.70$; *mean*, $49^r.43$; $s = 14^r.71$ (3) $= +147''.3$ (3) (this is rather uncertain and too small rather than too large); refraction $= 0''$.

Difference of R. A. of θ^1 and following end of σ.

Micrometer: $47^r.55$, $47^r.55$, $47^r.51$; *mean*, $47^r.54$; $s = 16^r.60$ (3) $= +165''.1$ (3) refraction, $0''$.

Using Professor Langley's tourmalines—

1st. (When the maximum light was transmitted) careful crayon sketch made [omitted].

2d. (Diminishing the transmitted light.) The portion [of the *Huyghenian region south* of the line 608–741 has vanished]. Along that line, or near it, it is brighter [than somewhat further to the north].

Order of brightness (*through tourmalines*).

E < F, G, H, Q and I.

1877, February 6.

Begin $8^h\ 45^m$, end $9^h\ 50^m$. Mag. power, 175. Wt. = 3.

Measures of $\Delta\alpha$ with θ^1.

Wire put in the meridian of θ'. The meridian of θ' bisects as nearly as possible the apex of E. The *north* corner of E *precedes* this meridian a few seconds. This meridian *precedes* nearly all of F. Only a little (fainter) part *preceding* X being cut by it.

($9^h\ 0^m$.) If the apex of E is not *on* the wire through θ' it does not *precede* it at least, and it may *follow* it $2''$–$3''$.

The *preceding* end of G comes nearly up to the wire through θ'. From the *north* point of E to θ' this wire is nearly entirely in darker portions except near the following end of L, where it cuts off a little. Coincidence $= 64^r.11$.

G (*middle point*).

Micrometer: $62^r.63$, $62^r.84$, $62^r.67$; *mean*, $62^r.71$. $\alpha\Delta = 1^r.40$, $\alpha\Delta = 13''.9$ (3); all these measures somewhat uncertain.

Point where *s. p.* edge of F intersects *frons*.

(It is faintly nebulous here, not bright as in the middle of F.)

Micrometer: $61^r.70$, $61^r.45$, $61^r.78$; *mean*, $61^r.64$. $\Delta\alpha = 2^r.47$, $\Delta\alpha = 24''.6$ (3); all rather uncertain.

Tangent to the *following* edge of D.

The *north* point of D *precedes* this. The point of tangency is near 651. All *north* of this D *precedes* the wire. 651 *very* faint.

Micrometer: $61^r.13$, $60^r.98$, $61^r.00$; *mean*, $61^r.04$. $\alpha\Delta = 3^r.07$, $\alpha\Delta = 30''.5$ (3).

g_0.

g_0 is not well defined to-night.

Micrometer: $56^r.25$, $56^r.36$, $56^r.39$; *mean*, $56^r.33$. $\Delta\alpha = 7^r.78$, $\Delta\alpha = 77''.4$ (3); all quite uncertain.

675 seen only in the evening *in* the nebulosity. The low power *always* shows [small] *stars* the best, as often before noticed. [Probably this indicates that many of the smaller points of light are not true stars but nebulous nuclei or groups of small stars.]

[See 1876, March 14 and March 22.]

OΣ's nucleus near 793.

I cannot see it. My former description [examined and] confirmed. The neighborhood of 793 is glistening [with minute but indefinable points of light], but no one point can be selected following it.

I see (but just see) my former star *preceding* 793 and 40″ (est.) south of it.

1877, February 7.

Begin $9^h\ 0^m$, end $10^h\ 0^m$. Mag. power, 175. Wt. = 1–2; parallel, $33°.4$; coincidence, $64^r.108$.

Measures of $\Delta\delta$ *with* θ'.

South edge of *following* point of σ [sketch omitted].

Micrometer: $56^r.31$, $56^r.43$, $56^r.61$, $56^r.66$; *mean*, $56^r.50$. $\Delta\delta = 7^r.61$, $\Delta\delta = 75''.7$ (4); refraction, zero.

From *lacus Lassellii east* to *Spitze* the *south* shore of σ is concave to the south.

Q (*following point*).

(g_0 and D: The seeing is too bad to measure $\Delta\delta$ of these points.)

Micrometer: $67^r.19$, $67^r.39$, $67^r.40$, $67^r.18$; *mean*, $67^r.29$. $\Delta\delta = 3^r.18$, $\Delta\delta = 31''.6$ (4).

G (*midale point*).

Micrometer: 70r.83, 70r.66, 70r.85, 70r.69; *mean*, 70r.76. $\Delta\delta = 6^{r}.65$, $\Delta\delta = 66''.2$ (4).

Brightest part of F (which is not X).

Micrometer: 74r.40, 74r.42, 74r.32, 74r.34; *mean*, 74r.37. $\Delta\delta = 10^{r}.26$, $\Delta\delta' = 102''.07$ (4); refraction + 0″.06, $\Delta\delta = 102''.1$ (4).

North point of Sinus Gentilii.

Micrometer: 70r.77, 70r.91, 70r.73, 70r.81; *mean*, 70r.81. $\Delta\delta = 6^{r}.70$, $\Delta\delta' = 66''.65$ (4); refraction + 0″.04, $\Delta\delta = 66''.7$ (4).

All the above measures are somewhat more uncertain than usual on account of unsteady images.

Frons.

The *frons* is convex towards the *east*. Its outline is furthest *east* near the parallel of 685. The *following* side of E is nearly a straight line; the *following* side of F is inclined somewhat to the prolongation of the *following* side of E. From the apex of the curve of the *frons* (near 685) the bounding line extends to about half-way between 685 and 708 (in R. A.) when it meets the prolongation of the *following* side of E again and continues on this line to the termination at Q [see Index-Chart].

In spite of the unsteadiness SCHROETER'S second bridge is well seen to-night, best defined on the *following* side.

654 not seen. g_0 not stellar in appearance.

1877, NOVEMBER 20.

Begin 11h 25m, end 11h 55m. Eye-pieces 175 and 400. Images. Wt. = 2

Measures of $\Delta\delta$.

Lacus Secchii (center).

$\Delta\delta' = 69''.74$ (4) with 175.
Refr., 0.05

$\Delta\delta = 69''.8$ (4)

g_0.

$\Delta\delta = 41''.6$ (2) with 400.

D (*north point*).

$\Delta\delta' = 80''.98$:: (2) This point is not well seen to-night; it appears to be curved towards the *preceding* side.
Refr., 0.05

$\Delta\delta = 81''.0$

Q (*following point*).

$\Delta\delta = 25''.67$ (3) This appears to bisect the following point of Q.

G (*brightest part*).

$\Delta\delta'$ = 60″.88
Refr., 0″.04

$\Delta\delta$ = 60″.09

Seeing very bad and satisfactory measures impossible. All the above are very poor.

1877, December 2.

$11^h\ 30^m$ to 13^h. Drew on chart.

1877, December 3.

D.

Begin $9^h\ 30^m$, end $10^h\ 15^m$. Wt. = 1.

The shape of the *following* edge of D is correct in the Index-Chart.

The brightest part of D is within this edge. There is no stellar appearance to this brightest part.

647 seems to be in a bay, whose shape is (to-night) more nearly circular than in Index-Chart.

651 appears (to-night) slightly *preceding* the edge of D.

W_1 . . . . . W_5 as drawn on chart. [Drawing omitted.]

1877, December 7.

End $12^h\ 14^m$. Mag. power, 400. Wt. = 3.

E (*south point*).

Measures of $\Delta\delta$.

$\Delta\delta'$ = 131″.3 (1).
Refr., .07

$\Delta\delta$ = − 131″.4

This is the *extreme* point towards the *north* which could be taken [as the vertex of E] south of this nebulosity is fainter.

$\Delta\delta'$ = 143″.45 (4)
Refr., .08

$\Delta\delta$ = − 143″.5

1877, December 7.

A (*south point*).

$\Delta\delta$ = − 31″.9 (2) not very certain.

W^1 (*lacus Secchii*).

$\Delta\delta'$ = 67″.65 (3)
Refr., .03

$\Delta\delta$ = + 67.7

1877, DECEMBER 12.

Begin $11^h\ 30^m$, end $12^h\ 42^m$. Eye-piece, 600 A, 400 A. Wt. = 3.

Measures of $\Delta\delta$ with θ'.

A (*south point*).

$11^h\ 30^m$.	Micrometer - -	67.17
		67.38
		67.48
		67.40
		67.09
		67.30
	Zero - - -	64.16

$\Delta\delta = 3.14 = -31''.24$

A.

The dark space which includes 622 and 625 on Index-Chart is quite black, blacker than the channel *preceding* A and separating it from L. 622 is in the black channel.

L (*north point*).

$\Delta\delta$ 66.73 66.78	This is in the same $\Delta\delta$ as 671 and as 622.
66.64 66.70	A little less $\Delta\delta$ than 622.
66.71	$\Delta\delta = 2^r.55 = -25''.37$ (4)

(602) not seen; $589 > 567$.

Tangent to the *north* side of the curve in which A joins B.

61.12, .10, .01, .14; *mean*, 61.09 $\Delta\delta = 3^r.07 = 30''.54$ (4)

The point of tangency is marked on the chart.—[N. B.—Only on the MS. chart employed.]

B.

B is much fainter *south* of the parallel of θ' than *north* of it; and it seems hardly to reach (as a bright mass) the star 575.

g_0.

$12^h\ 7^m$. $\Delta\delta$, 60.01, .19, .23, .01; *mean*, 60.11, $\Delta\delta = 4.05 = 40''.29$ (4)

D (*north point*).

The *north* point of D is not well enough defined to measure; it is drawn on chart.

South shore of σ near Spitze.

55.69 : : (shore).
56.05 }
56.40 } south side of *Spitze*.
56.05 }
56.12

56.16 $\Delta\delta' = 8.00 = +79''.59$ (4)
Refr., .05
$\Delta\delta = +79.6$

The *following* point was not clearly seen and these measures refer to the $\Delta\delta$ of the brightest point, and are a little greater than the $\Delta\delta$ of the south edge, as it would be seen under the best conditions.

This *south* shore is concave toward the *south*.

Q (*bisecting the following point*).

67.01, .30, .16; *mean*, 67.16 $\Delta\delta = 3.00 = 29''.85$ (3)

E (*extreme south point*).

79.72, 79.86; *mean*, 79.79 $\Delta\delta = 15.63 = 155''.49$ (2)

South point of F (*in frons*).

75.93, 75.94; *mean*, 75.94 $\Delta\delta' = 11.78 = 117''.19$ (2)
refr., .07
$\Delta\delta = -117''.3$

Extreme north point of F (*X*).

73.75, 73.63; *mean*, 73.69. $\Delta\delta = 9.53 = 94''.81$ (2)
refr., .05
$\Delta\delta = -94''.9$ (2)

When the micrometer wire is set at 73.63 (that part of it following X) it is all in the dark channel. It just intersects the *frons* at the *south* end of H. Zero, $64''.155$ (3)

1877, December 14.

Begin $11^h\ 0^m$, end $12^h\ 40^m$. Eye-piece, 400. Wt. = 2.

η.

Just *south* of 570 there is a part of *η* much darker than the rest. The line 570–666 is approximately the *south* border of *η*.

On this line about 20″ *preceding* 666 there is perhaps two or three, and pretty certainly one small star. This whole region *preceding* 666 seems occasionally to glisten with small separate points.

β and K.

The line 573–575 is almost exactly the *following* boundary of β and K. (602) not seen.

Channel between I and E.

The *north* border of the channel between I and E prolonged is very approximately tangent to the *n. p.* end of F; *i. e.*, X.

I.

The *s. p.* corner of I projects beyond (*i. e.*, *preceding*) the general line of the *occiput.* (See sketches.)

L.

The *preceding* edge of L near 601 (star not seen) prolonged would pass through the *s. p.* corner of I.

Other notes placed on drawing.

1878, JANUARY 3.

A cap, reducing the aperture to 3.50 inches was put on the telescope and eye-piece 175 used.

10^h 30^m. The sky is very hazy, so that fourth magnitude stars are not visible to the naked eye. In spite of this I see *four* stars in the trapezium.

619 and 628 very easily, 624 and 640 easily, and 640 is very little easier to see than 624.

10^h 40^m. 685, 708, 741, and not 724, 570, and not 669.

No other star seen except 737, and no definite outline to the nebula. The question of HOOKE'S observation of 1666 requires another and a clear night to settle it. ANDERSON also saw the four stars.

11^h. Sky extremely thick, and large stars have halos to the naked eye.

1878, JANUARY 5.

9^h. Aperture, 3.50 inches. Mag. power, 175.

The sky is clear, but very unsteady. The following *stars* seen:

619, 624, 628, 640; all four stars of the trapezium. Also 685, 708, 741, 724; also 570 and 523.

669 and 635 well seen. [635 was not seen by HUYGHENS either in 1656 or 1694.]

There appears to be a star between 635 and θ', too faint to fix in position, but probably 647 and 651 seen as one.

734, 781 (faint) and 848; 449 and 479, also.

Comparing with HUYGHENS' drawing of the nebulosity. In fact, the *frons* and *occiput* are well seen and the angle at E. It is, however, faint. 685, 708, 741 are seen free from nebula. *Sinus Gentilii* and *Sinus magnus* very plain. The stars laid down by HUYGHENS (1656) are, in order of R. A., 523, 570, 619, 628, 640, 669, 685, 708, 724, 741, 734, and 781. The last is quite faint and is out of place in HUYGHENS' drawing.

In HUYGHENS' drawing of 1694 the stars are the same with the addition of 624. [HUYGHENS had probably seen HOOKE's remark that the three stars were in reality five, since that was published in 1666].

The brighter nebulosity seems to end about 669. The *following* point of Q is about in the R. A. of 708.

The whole surface of the *Huyghenian region* is mottled much as in W. C. BOND's MS. drawing of 1848 reproduced in *Annals Harvard College Observatory*, vol. v.

$10^h\ 30^m$. Aperture, 26 inches. Power, 175.

Very clear, but unsteady. The large stars are blurred even with 175, and the 5th and 6th stars are just clearly outside of them. With 400 A stars too much blurred.

675 is pretty steadily seen just *following* H; *i. e.* outside of the *Huyghenian region*. There is no doubt of this [although it was known at the time to disagree with former observations]. In the place of LASSELL's *b* I seem to see something stellar; and it even seems double. This is the second time I have seen such an object.

The first time is, I believe, not recorded, as I was not sure. Nor am I sure to-night. [I have looked many times for this object, and have in general failed to see it.] 622 is certainly in the dark channel *following* A 612 > 618. 612 is just on the edge of the nebulosity, inside of U. 618 is in V. 602 exists, I think, and is a little out of position on my Index-Map. 654 not visible.

567 about as faint as it could be and still be seen. 686 and 688 not seen.

709 is on the following edge of the dark space, between 708 and 685.

675 again seen very close to the edge of *frons*.

Just *south* of E near 666 are certainly some very small stars [or points of nebulosity].

The small star *h* in the channel *following* D looked for and not seen. End 11^h; seeing unsteady, but quite clear.

1878, JANUARY 6.

Aperture, $3^{in}.50$; and mag. power, 175. Sky clear but not particularly steady.

With 400 A I see easily the four stars [of the trapezium] and can fancy I see the 5th and 6th star at intervals, as I know exactly where to look for them.

With 175 I also thought some traces of the 5th and 6th star were to be seen, but I am *sure* that these stars would never have been seen by HOOKE if only of their present brightness. 647 and 651 not seen. End 12^h. Windy.

1877, JANUARY 7.

Photometer.

Brightest part of D (see observations January 12).

I.	II.
$9^h\ 0^m$ 7.20	6.40
6.85	6.55
6.70	7.20
Altered mirror.	6.95
	6.60
6.92 (3)	6.74 (5)

Brightest part of A; in parallel of 624.

	5.55 :
	6.20
	5.45
$10^h\ 40^m$.	6.00
	5.80 (4)

The brightness of D is proportional to $\frac{1}{(6.92)^2}$ and $\frac{1}{(6.74)^2}$ from the construction of the photometer. $A \propto \frac{1}{(5.80)^2}$. Hence the light of D expressed in units of A is $\frac{(5.80)^2}{(6.92)^2}$, etc. Hence from to-night's observations

$$D = 0.70\ A\ (3)$$
$$D = 0.74\ A\ (5)$$

These measures are, as yet, only experimental.

$$A = 1.42\ D\ (3)$$
$$A = 1.35\ D\ (5)$$

1877, JANUARY 12.

Photometer.

Brightest part of D (about midway from 642 to 635 and *following* that line)

$10^h\ 50^m$	4.70
	4.68
	4.10
	4.68
11 0	4.70
10 55 m. t.	4.57 (5)

N. B.—A different combination of glasses was used from that employed January 7, and these were found to be too dark to measure A with.

Brightest part of E (center of mass).

$11^h\ 10^m$	5.17
	4.90
	4.27
	4.80
	4.60
11 19	5.10
11 15 m. t.	4.81 (6)

$\therefore\ E = \frac{[4.57]^2}{[4.81]^2} \cdot D = 0.90\ D\ (5)$

Lamp burned out.

These measures are still experimental. All the adjustments are not thoroughly settled yet.

1878, JANUARY 16.

9^h–9^h 30^m. Moonlight too strong to allow of measures with photometer. Several trials show this.

V, 612 and 618 sketched. [Sketch omitted.]

10^h 0^m. Eye-piece, 175. Wt. = 4. Moonlight.

654 just suspected.

675 just surely seen *following* the line of the *frons*.

G and H (to the eye) both brighter than F.

Occiput.

Zero = 123°.7.

Position-circle: 343°.5, 343°.2, 344°.2; *mean*, 343°.6; $p = 140°.1$ (3)

This is the best tangent from the *south* point of J [LIAPONOFF D_1] to the *south* point of E. It cuts off Y.

Frons.

Position-circle: 72°.0, 71°.9, 72°.6, 72°.9; *mean*, 72°.4; $p = 51°.3$ (4)

This is the best tangent to the whole line from E to Q.

	r.	r.
Length of *frons*,	45.05	84.00
	45.10	83.68
		84.21
	45.08	83.97, 2 *s.* = $38^r.89$, *s.* = $19^r.45$, *s.* = 193″.5

These measures were made for comparison with LIAPONOFF [HN.—L = + 3″.7].

J and B (preceding edges).

Position-circle: 116°.8, 115°.7, 115°.4; *mean*, 116°.0; $p = 7°.7$ (3)

These measures make the edge pass through 575.

567 just visible and a little brighter than 709.

V and 612 and 618 are right in Index-Chart.

Dark channel between E and F.

Position-circle: 342°.5, 338°.8 (half weight); 342°.1, good; *mean*, 341°.6; $p = 142°.1$ (3)

Dark channel between I and E.

Position-circle: 258° $p = 226°$ (1) uncertain.

Pons Schroeteri.

11^h. Position-circle: 314°.2, 315°.6, 318°.7; *mean*, 316°.2; $p = 167°.5$ (3) uncertain. All three measures poor. (654) has not again been seen.

D.

The *north* point of D does not seem sharp to-night, and I believe I have noted this before. This deserves attention in a dark night. [See 1877, Nov. 20, Dec. 12.]

1878, JANUARY 23.

Set micrometer wire on the parallel through $\theta' = 628$.

From 628 to the R. A. of g_0 this line is within the nebula. From 628 to the R. A. of 651 this line is in nebulosity fainter than the surrounding nebulosity. This line is very little *south* of the *south* border of τ. It is immersed in the nebulosity of R; *following* R it passes through a dark space (on the map) and is finally involved in μ. Beyond (*i. e.*, *following*) R it does not intersect the *Huyghenian region* proper.

Preceding 628 this line passes a little *north* of 567. Half way from this line to 575 is about the point where B ceases to be quite bright, and where it begins to be nearly faint up to 575. [This is different from ROSSE, 1867.]

W^1.

$\Delta\delta$ of center.

$57^r.17$, .37, .22, .30, .40, .55, .34; *mean*, $57^r.34$

Zero, 64.15

$\Delta\delta = 6^r.81 = 67''.7$

Refr., 0.3

$\Delta\delta$ $+ 68''.0$

The parallel through 685 cuts off X, and passes (as exactly as I can see to-night) through *s. f.* corner of I. [$\therefore \Delta\delta = -95''.8$, G. P. B.]

Spitze.

The *s. f.* point of σ is *about* on same parallel with *n. p.* point of D and with center of W_1.

Near 793 in $p = 190°$–$200°$, $s = 30''$–$40''$ is a faint star which I have noted [1876, March 14 and 22, and 1880, January 3]. Sketch (omitted).

F, G, H, > I or E.

There are also two surfaces in P? and Q which are brighter than either I or E. End $10^h\ 10^m$.

1878, JANUARY 24.

$11^h\ 45^m$. Eye-piece, 175. Wt. = 2.

709 not brighter than 666.

661 > 676.

1878, JANUARY 26.

A.

Photometer.

Washington Sid. Time.	Readings.	Notes.
h. m.		
4 53	3.95	The part A measured was that following 619. Measures
	4.85	not easy. Lamp flaming.
	3.72	Altered mirror.
	4.30	Good.
5 7	3.90	
$t = 5$ 0	*Mean* 4.14	

In future I shall take D (that part previously used and defined by the line 635–647) as the unit of brightness, as the position of these stars enables me to define the surface used for comparison readily. I notice that much of the uncertainty of readings is to be attributed to the difficulty of selecting the same surface for each comparison.

N. B.—*In what follows the brightest part of each mass is used, unless otherwise mentioned.*

Washington Sid. Time.	Readings.	Notes.
h. m.		D.
5 7	4.30	
	5.10	
	4.45	
	4.72	
5 15	4.28	
5 11	*Mean* 4.57	
5 15	5.35	E.
	5.08	
	4.70	
	4.80	
5 20	5.08	
5 18	*Mean* 5.00	
		F.
5 20	3.88	The lamp was flaming at first, so that much of the light
	4.52	came from the burning wick. It gradually grew
	4.43	fainter until about constant.
5 27	4.42	
5 24	*Mean* 4.31	
5 28	4.08	G.
	4.75	
	4.45	
5 34	4.28	Good.
5 31	*Mean* 4.39	
		D.
5 36	4.08	This measure of D satisfactory; and it shows the lamp
	4.45	to be fainter than at first, since it has to be nearer to
	4.50	the mirror. The first D measure was also good, but
5 41	4.50	not as good as this.
5 39	*Mean* 4.38	
		μ.
5 43	6.55	The part used is on the line 708 to the point of Q
	6.15	and the width of the mirror [15″] *south* of Q. Eye
	7.50	very tired.
5 57	7.78	
5 50	*Mean* 7.00::	

Summary.

t		Mass.	Reading.
h.	m.		
5	0	A	4.14
	11	D	4.57
	18	E	5.00
	24	F	4.31
	31	G	4.39
	39	D	4.38
5	50	μ	7.00 : :

These measures are reduced for each value of D separately.

I. D = 4.57.	II. D = 4.38.	Δ	Mean I and II.
A = 1.22 D	A = 1.12 D	0.10	A = 1.17 D :*
E = 0.83 D	E = 0.77 D	.07	E = 0.84 D
F = 1.12 D	F = 1.03 D	.09	F = 1.07 D :
G = 1.08 D	G = 1.00 D	.08	G = 1.00 D
μ = 0.43 D	μ = 0.39 D	0.04	μ = 0.41 D : :

1878, JANUARY 28.

$8^h\ 54^m$ m. t. begin; $7^h\ 6^m$ sid. t. end. Mag. power, 400. Windy Wt. = 4. At $8^h\ 54^m$ 654 just visible = 618. 675 not seen.

Measures of $\Delta\delta$ (*zero* = $64^r.153$).

E (*south point*).

Mic. $78^r.93$, 78.94, 78.96; *mean* 78.94 (3) $\Delta\delta' = 14^r.79$
$= 147''.1$
refr. .08
$\Delta\delta = -147''.2$ (3)

F (*brightest part*).

$5^h\ 42^m$, sid. t.

Mic. $74^r.47$, 74.62, 74.48, 74.41; *mean*, $74^r.495$ (4) $\Delta\delta' = 10^r.34 = 102''.86$, refr. $''.06$; $\Delta\delta = -102''.9$ (4)

G (*south point*).

Mic. $71^r.61$, 71.59, 71.93, 71.90; *mean*, 71.76; $\Delta\delta' = 7^r.61 = 75''.705$
refr., .04
$\Delta\delta = -75''.7$ (4)

*This part of A is not that previously used. It is to be remarked that the same zero for D (4.57) was obtained to-night and January 12.

N (*south point in frons*).

Mic. $71^r.61$, 71.59; *mean*, $71^r.60$; $\Delta\delta' = 7^r.45 = 74''.11$
refr., .04

$\Delta\delta = -74''.2$ (2)

I (*bisecting the preceding angle of I, near* A_1).

Mic. $71^r.93$ $\Delta\delta' = 7.78 = 77''.40$; refr., $.''04$; $\Delta\delta = -77''.4$ (1)

G (*brightest part*).

Mic. $70^r.67$, 70.94, 70.87; *mean*, $70^r.83$; $\Delta\delta' = 6.68$
$= 66''.45$
refr., .04

$\Delta\delta = -66''.5$ (3)

Star 654.

$\Delta\delta$	Mic	63.356	$\Delta\alpha$ Mic.	60.96
		.29 star extremely faint.		61.10
		63.29		60.82
		63.31		60.96
$\Delta\delta'$	=	0.84	$\Delta\alpha'$ =	3.19
$\Delta\delta$	$= +8''.36$ (3)		$\Delta\alpha$ =	$31''.74$ (3)

G. P. Bond gives the co-ordinates for 1870.7 $\Delta\alpha = +32''.6$ $\Delta\delta = +9''.2$.
Holden–Bond (in α) $= -0''.9$; (in δ) $= -0''.8$.

D.

D has to-night no sharp bright *north* point upon which to measure the $\Delta\delta$. It has been so during this whole opposition, and I believe this is quite different from the appearances in 1874–'75–'76. The *north* part of D is uniform in tint, *i. e.*, the extreme *north* point is not suddenly bright. The air very clear and images good. Drawing made of D [omitted] in which the surface *h* (see Index-Chart), once called s star, is represented as about in the center of the triangle 635–669–651. It is really a little *north* of the center of this triangle. 647 is shown within a dark bay, but further within than formerly drawn. The darkness extends an equal distance from 647 towards the *west*, *north*, and *south*. *h* is as bright as the neighboring part of D, on the line joining *h* and 647 and two-fifths of the way from *h*.

South shore of σ. (*Spitze.*)

$\Delta\delta$. Mic. $55^r.88$, 56.06, 56.16, 56.06; *mean*, 56.04 . $\Delta\delta' = 8^r.11$
$= 80''.68$
refr., .05

$\Delta\delta = +80''.7$ (4)

Measures of $\Delta\alpha$ follow.

Spitze (σ).

Mic. $47^r.83$, 47.74, 47.80; *mean*, $47^r.79$; $\Delta\alpha' = 16^r.36$
$= +162''.75$
refr., $+ .01$
$\Delta\alpha = +162''.8$ (3)

Q (*following point*).

Mic. $48^r.62$, 48.92, 49.02, 48.68; *mean*, 48.81; $\Delta\alpha = 15^r.34$
$\Delta\alpha' = +152''.60$ (4)
refr., $+ .02$
$\Delta\alpha = +152''.6$

g_0 (*no nucleus visible, brightest part taken*).

Mic. $56^r.37$, 56.50, 56.48; *mean*, $56^r.45$; $\Delta\alpha' = 7.70$
$\Delta\alpha = +76''.6$ (3)

This is in same $\Delta\alpha$ as 676, which is according to G. P. Bond for 1877.0 $\Delta\alpha = +77''.9$

Holden–Bond, $= -1''.3$

F (*brightest part*).

Mic. $61^r.32$, 61.60; *mean*, 61.46; $\Delta\alpha' = 2.69$
$= 26''.76$
$\Delta\alpha = +26''.8$

N. B. G > F.

G (*brightest part*).

Mic. $62^r.46$, 62,78, 62.41; *mean*, 62.55; $\Delta\alpha' = 1.60$
$= 15''.92$
$\Delta\alpha = +15''.9$ (3)

D (*following edge*).

$7^h\ 8^m$ sid. t.
Mic. $60^r.17$, 60.20, 60.18; *mean*, $60^r.18$.
$\Delta\alpha' = 2.97$, $\Delta\alpha = +29''.55$ (3). [Error of 1 revolution; *mean*, 61.18.]

Notes.

On G. P. Bond's MS. (unpublished) drawing of 1861, March 11, Schroeter's second bridge is indicated.

709.

In my drawings and notes I have placed 709 exactly on the *following* edge of the dark space between 685 and 708, or exactly on the *preceding* edge of what G. B. BOND described as the cometic tail to 708. In Lord ROSSE's drawing it is included within this cometic tail, and on several of G. P. BOND's elaborate drawings (lent me by the kindness of Prof. E. C. PICKERING, director of Harvard College Observatory), it is in exactly the same position as ROSSE, 1867. I am confident that it is not so now, but I will again examine it.

Night very clear and images good.

Zero, $64^{r}.153$ (3)

1878, FEBRUARY 4.

Photometer.

E (*brightest part*).

Sid. t.

$6^{h}\ 43^{m}$; $6^{in}.00$, 5.70, 6.00, 6.30; *mean*, 6.00. [Flame too high.]

D.

[I intended to choose the same part of D as formerly used, *i. e.*, on line 647–635 and about 10″ *north* of 647, but I was not as successful as I desired. The third reading particularly was on a surface from 15″ to 20″ *preceding* the part used before.]

$6^{h}\ 51^{m}$. 4.35, 4.55 [5.00], 4.50; *mean*, 4.47 (5)

Flame still too high, but a little lower than for E.

D.

$7^{h}\ 3^{m}$; 3.90, 3.90, 3.87; *mean*, 3.89. Lamp lower.

The part of D used here (and above) was in the line of 642 and 647.

G.

$7^{h}\ 11^{m}$; 3.78, 3.68; *mean*, 3.73. Lamp lower a very little.

The bright mirror of the photometer is a semi-circle with a diameter of about 15′ on the edge, *i. e.*, about 0.027 inches.

Removed photometer. Eye-piece 175 put on. Air beautifully clear, but unsteady.

675 just seen, about on edge of the *frons* with this power.

∇b LASSELL's *b*. Something is certainly in this place. I should say it was a double star.

654 and 602 looked for, and neither seen. (New) small star between *a* and 709. I am not thoroughly certain of it, as I do not see *a* satisfactorily. ANDERSON sees it. End 11^{h}.

[The reduction of the photometer measures gives E = 0.55 D. This is doubtful, for the reasons given above. G = 1.09 D. This again is not thoroughly satisfactory.]

1878, February 5.

Photometer.

E.

$6^h\ 28^m$ sid. t. 9.10, 9.08, 8.83; *mean*, 9.00. The photometer has been slightly changed, so that more rays fall on the screen. The change consisted in making the holes through the body of the tube a little larger.

D.

$6^h\ 31^m$; 7.77, 8.08, 8.50, 8.35; *mean*, 8.18. The nebula is so far beyond the meridian that the part of D which I am forced to use is not *exactly* the same as that chosen for the unit surface, although it varies very little from it.

G.

$6^h\ 34^m$; 7.52, 7.63, 7.85; *mean*, 7.67.

F.

$6^h\ 38^m$; 7.98, 8.57, 7.60, 7.73; *mean*, 7.97.

The difficulty with these measures is to fix upon the brightest part of the mass F [The same difficulty has been always experienced in the measures of $\Delta\alpha$ and $\Delta\delta$ of this brightest part.]

I.

$6^h\ 45^m$; 9.48, 9.05, 9.95, 9.40, 9.41; *mean*, 9.46. The measure 9.95 was taken too near to the *following* side of I.

D.

$6^h\ 49^m$; 8.53, 7.79, 8.70, 8.70; *mean*, 8.43.

Q.

$6^h\ 56^m$; 8.86, 8.88, 9.23, 8.90; *mean*, 8.97. The surface used has one edge in the *frons* in the line joining the *Spitze* with 605.

A.

$7^h\ 12^m$; 5.28, 5.27, [4.60::], 5.31; *mean*, 5.29.

A is a difficult mass to measure, as it is hard to fix upon the surface to be measured.

E.

$7^h\ 18^m$; 7.80, 8.12, 8.25; *mean*, 8.06.

D.

$7^h\ 22^m$; 7.00, 6.90, 6.72, 7.06; *mean*, 6.92.

G.

$7^h\ 28^m$; 7.05, 7.04, 7.27; *mean*, 7.12.

The images are quite tremulous; but the photometer is working very well, as I have a more certain adjustment for making the beam of light from the lamp move along the axis of the rod than that formerly used. The lamp was satisfactory through out, but continuously diminished. It was certainly lower to the eye after 7^h.

The rough reduction of the photometer measures gives:

Sid. Time.	Mass.	D = 8.18.	D = 8.43.
h. m.			
6 28	E	0.83	0.88
31	D		
34	G	1.14	1.21
38	F	1.05	1.12
45	I	0.75	0.79
49	D		
6 56	Q	0.83	0.88
		D = 6.92.	
7 12	A	1.71	
18	E	0.74	
22	D		
7 28	G	0.94	

1878, FEBRUARY 20.

$7^h\ 6^m$ sid. t. Eye-piece, 175 A. Wt. = 2.
(The images are too unsteady for 400.)

$\Delta\delta$ south point of F.

Mic. 76.27; zero, 64.15. $\Delta\delta' = 12.12 = 120''.57$
refr., = .07

$\Delta\delta = 120''.6$ (1)

F extends to the south beyond this, but it is so faint and uncertain a boundary to-night that measures should not be made on it. It is easily seen, however, in the absence of bright wires.

$\Delta\delta$ south point of F.

Mic. 75.77, 75.54, 75.75; *mean*, 75.69. $\Delta\delta' = 11.54$
$= 114''.80$
refr., = .07

$\Delta\delta = 114''.9$ (3)

These measures refer to the well-defined and brighter southern edge, which is, however, *within* the mass of F. 654 suspected; 675 invisible; 709 barely visible. Then drew on large chart [omitted] End $10^h\ 10^m$ m. t. Work very unsatisfactory.

1878, February 25.

Drew on chart; clouds $8^h\ 15^m$.

1878, February 26.

[Drew V, H, D on chart.]

F to the eye seems brighter than usual. Seeing very poor; images unsteady and ill-defined.

Photometer.

F (*brightest part*).

$6^h\ 0^m$ sid. t.	5.25 : wt. 1	
	4.60 wt. 2	
	4.65 wt. 2	
	4.45 wt. 2	Good.
	4.66 mean by weights.	

D.

$6^h\ 10^m$; 4.80, 4.20, 4 50 (good), 4.25; *mean*, 4.44; eye estimated F > G, but not much; also G > H, ditto. These estimates very difficult [G]. (These estimates belong, not to the brightest part of G, but to a point marked on chart.)

$6^h\ 15^m$; 4.10, 4.70, 4.40; *mean*, 4.40.

This point is towards the *following* end of G. At first this was chosen as brightest part, and the error was only discovered at $6^h\ 40^m$ on remeasuring G. This shows me that a chief source of error is certainly the difficulty of settling on the point to be compared. Some means must be adopted for fixing on the same point night after night. If this is not done the measures will not be strictly comparable.

I > E (eye).

E.

$6^h\ 22^m$; 4.30 (wt. 1), 4.80 (good), wt. 2, 4.65, wt. 2; *mean*, by weights, 4.64.

I.

$6^h\ 29^m$; 4.45, 4.55 (very good), 4.40; *mean*, 4.47.

D (*brightest part ?*).

$6^h\ 29^m$; 3.90; this is a little *s.* and *f.* of the proper unit. Taken by mistake.

D (*unit surface*).

4.40, 4.05, 4.20; *mean*, 4.22.

H.

$6^h\ 35^m$; 4.10, 4.20, 4.00; *mean*, 4.10.

[G].

$6^h\ 40^m$; 4.0. This is the *following* part, same as at $6^h\ 15^m$.

G (brightest).

3.90, 4.00; *mean*, 395.

A not well enough seen to measure.

Eye-pieces, 175 and 400.

a near 724 seen; distance quarter (709–724) = 12″. 709 is on the *following* edge of a *darker* part of the dark space between 685 and 708, but the darkest and most obvious space between the two has its *following* edge *west* of 709, so that G. P. Bond appears to be right in his position of this star relative to the cometic tail to 708. This requires examination on a better night.

U.

Prolong the lines 640, 625, and 624, 619 to the *following* side of A; between these lines the channel between U and A is darkest; *north* of the last line (624, 619) it is brighter for about 10″, measured, along the axis of the channel, and then darker again.

654 not looked for. 675 just barely seen.

h well seen as before. Liaponoff's points F and *c* [near 651 and 654] are neither of them well enough defined to measure.

Reduction of Photometer measures.

Mass.	I. D = 4.44.	II. D = 4.22.
F	0.91	0.82
[G]	1.02	0.92
E	0.92	0.83
I	0.99	0.89
H	1.17	1.06
[G]	0.97	0.88
G	1.26	1.17
Brightest D	1.30	1.17

1878, February 28.

A > D; F > G = H; I > E by eye.

Photometer.

D.

$6^h\ 23^m$; 4.90, 5.30, 4.80, 5.15; *mean*, 5.04 (4)

E.

$6^h\ 27^m$; 5.95, 5.75, 5.35, 5.25, 5.40; *mean*, 5.54 (5)

F.

$6^h\ 35^m$; 4.70, 4.70, 4.30, 4.55 (good); *mean*, 4.56 (4)

H.

$6^h\ 40^m$; 5.25, 4.90, 5.25, 4 70; *mean*, 5.03 (4)

D.

$6^h\ 46^m$; 5.65, 4.60 (good), 5.20, 5.50, 4.30; *mean*, 5.05 (5)

I.

$6^h\ 54^m$; 5.10, 5.40, 5.25, 535; *mean*, 5.28 (4)

D (*brighter*).

$6^h\ 68^m$; 4.65, 4.75, 4.55; *mean*, 4.65 (3)
This is on the line 645–663.

1878, MARCH 4.

Eye-piece, 175. Wt. = 1.
8^h 654, seen; 675 and 602, not seen. Drew all the black channels on large chart, and all the details that could be seen [omitted]. Images too poor for measures. Too windy for photometer.

$8^h\ 30^m$. *Order of brightness.*

1. A. 2. D. 3. G, H, F. 4. I, E.
M quite bright; brighter than usual. M = I, E ? ?

1878, MARCH 5.

Begin $7^h\ 10^m$, sid. t.
Eye-piece, 400 A. Measures of $\Delta\delta$; zero = $64^r.13$. Wt. = 3.

F (*south point preceding frons*).

That is, these measures refer rather to the *s. p.* edge, which is, perhaps, not so far *south* as the part of F in the *frons*.

Mic. $75^r.55$, 75.43, 75.61; *mean*, 75.53. $\Delta\delta' = 11.40 = -113''.41$
refr., $= -\ 0.07$
$\Delta\delta' = -113''.5$ (3)

H (*south edge*).

This, again, is *preceding* the *frons*, and is the limit of the brighter parts of F about in the meridian of 666.

Mic. 71.81, 72.00, 71.94; *mean*, 71.92. $\Delta\delta' = 7.79 = -77''.49$
refr., $-\ 0.05$
$\Delta\delta \quad -77''.5$

This parallel is only a very little *south* of the *south* point of N. All of G is *north* of $-77''$.

This parallel is almost the axis of the curve of the *following* edge of I, *s. f.* 602. It is, however, a little *north* of the axis of that curve.

N (*south point*).

Mic. 71.66. $\Delta\delta' = 7.53 = -74''.91$ (1)
refr., $= -\ 0.04$
$\Delta\delta = -75''.0$ (1)

F.

A faint channel is visible through the *following* end of F, as before.

Q.

Drawing of masses in and near Q. N, *n*, *q*, etc. [Omitted.]

n (*north end*).

Mic. 67.70; $\Delta\delta = 3.57 = -35''.52$ (1)

q (*middle*).

Mic. 66.48; $\Delta\delta = 2.35 = -23''.38$ (1). Stopped $7^h\ 35^m$, sid. t.

γ (*north end*).

Mic. 69.62,* 69.94,* 70.17, 70 22; *mean*, 69.99. $\Delta\delta = 5.86 = -58''.3$ (4)
* Recorded, 70^r; if it really is 70^r, as is possible, the borders being here very uncertain, then

$\Delta\delta = -63''.37$ (3)
refr., $= -\ 0.04$
$\Delta\delta = -63''.3$ (4)

δ (*south end*).

Mic. 73.67, 74.27, 74.34; *mean*, 74.09. $\Delta\delta = -99''.08$
refr., $-\ .07$
$\Delta\delta = -99''.2$ (3)

The last two measures pass nearly through the brightest part of F. $\therefore \Delta\delta' = -101''.17$; refr. $= -0''.07$, and $\Delta\delta$ brightest part of F $= -101''.2$ (2).

I (*s. f. corner*).

Mic. 73.93; $\Delta\delta' = 9.80 = -97''.49$; refr. $= -0''.07$. $\therefore \Delta\delta = -97''.6$.

I (*corner near* A_1).

$8^h\ 15^m$, mic.; 72.22, 72.36; *mean*, 72.29. $\Delta\delta' = 8.16 = -81''.28$
refr., $-\ 0.06$
$\Delta\delta = -81''.2$ (2)

This parallel $-81''$ is still a little *north* of the axis of the curve of the *following* edge of I near 602; the $\Delta\delta - 81''.2$ for I near A_1 is uncertain, as the point is not well defined.

V (*south point*) *or* M (*north edge*).

Mic. 66.30, 66.48, 66.44; *mean*, 66.41; $\Delta\delta = 2.28 = -22''.68$ (3)
refr., $= -\ 0.01$
$\Delta\delta = -22''.7$ (3)

Images unsteady towards the last. Apparently some haze.

1878, March 9.

675 seen by Professor Hall outside *frons* by $2'' \pm$. The seeing is very steady. *b* seen by Professor Hall, but not double. Very faint. *a* seen. $a > 675$. 647 is on the *following* and *north* side of a channel.

Photometer.

E. 6.50, 6.80, 6.80; *mean*, 6.70 (3)
D. 5.90, 6.00, 5.80; *mean*, 5.90 (3)
[G]. (On line through 647 and tangent to the preceding side of F.) 6.50 (1)
G. 5.80, 5.70, 5.90; *mean*, 5.80 (3)
I. 5.60, 5.70, 5.95; *mean*, 5.75 (3)
Lamp lower? This note put in because the reading for I appears so large. On looking at I with the eye-piece it certainly appears much brighter than E. I > E (eye).

1878, March 9

[F]. (On line through 676 and apex of F.) 6.30, 6.60, 6.40; *mean*, 6.43 (3)
F. 5.60, 5.40; *mean*, 5.50 (2)
I. (On line from 628 to apex) 5.90, 5.95; *mean*, 5.93 (2)
I returned to this mass to verify the former measures.
D. 5.60, 5.40, 5.50 (good); *mean*, 5.50 (3)
E. 6.20, 6.30 [5.40:: rejected], 6.10 (good); *mean*, 6.20 (3). End $7^h\ 37^m$ sid. t.

1878, March 20.

J (*preceding point*).

Eye-piece 400. Wt. = 2.
$7^h\ 35^m$ sid. t. $\Delta\alpha'$ $73^r.69$, $74^r.16$, $73^r.96$, $73^r.92$; *mean*, $73^r.92$
zero, 64.15

$\Delta\alpha' = 9.78 = 97''.29$
refr., $.01$

$\Delta\alpha = 97''.3$ (4)

W_1.

68.86, 68.98:: ; *mean*, 68.92. $\Delta\alpha = 4^r.77$
$= 47''.4$

1878, December 6.

Begin $4^h\ 25^m$, sid. t., end $5^h\ 35^m$, sid. t. Eye-piece, 400 A. Wt. = 1.

Measures of $\Delta\alpha$; zero of micrometer $64^r.09$.

I.

West point = Liaponoff's A, approximately. The point on which I endeavored to measure is in the straight line of the occiput itself, and therefore it is inside the edges of I which extends *west* of this point some seconds with tolerably bright nebulosity. The bright nebulosity ends about at this point, which is about the $\Delta\delta$ of 685.

I.

$4^h\ 35^m$; $\Delta\alpha' = 70^r.61,\ 70.31,\ 70\ 25,\ 70.43$; *mean*, 70.40.
$\Delta\alpha' = 6^r.31 = -62''.77$ (4); refraction, $+0''.01$.
$\Delta\alpha = 62''.8$ (4).

W_1.

$4^h\ 50^m$; $\Delta\alpha' = 68.91,\ 68.81,\ 69.00,\ 69.00$; *mean*, 68.93.
$\Delta\alpha' = \Delta\alpha = 4^r.84 = -48''.15$ (4).

D.

$5^h\ 10^m$; tangent to the following side of D.
$\Delta\alpha' = 61.^r.26,\ 61.21,\ 61.09,\ 61.10$; *mean*, 61.15.
$\Delta\alpha' = \Delta\alpha = 2^r.94 = +29''.25$ (4).

Second bridge of Schroeter.

About $4^h\ 29^m$; I could see this very well in spite of the moonlight; *preceding* it as far as D the channel was very black (the blackest part of τ) *following* it to g_0 the channel way not so well defined.

Lassell's *b* (*near* 685).

At about $4^h\ 25^m$ this object was suspected just as on previous occasions. I am by no means sure of its existence. I am certain that there is some objective cause for so many suspicions. At 5^h it was not to be seen.

Neither 654 nor 675 are visible.

g_0.

$5^h\ 20^m$; $\Delta\alpha' = 56^r.37,\ 56.28,\ 56.48,\ 56.39$; *mean*, 56 38.
$\Delta\alpha' = \Delta\alpha = 7^r.71 = +76''.70$ (4).

σ (*following point.*

$5^h\ 30^m$; $\Delta\alpha' = 47^r.95,\ 47^r.71,\ 47^r,83,\ 48^r.02$; *mean*, $47^r.88$.
$\Delta\alpha' = \Delta\alpha = +16^r.21 = +162''.26$ (4).
Images very unsteady. Moonlight.

1878, DECEMBER 11.

Begin $11^h\ 15^m$, end $12^h\ 5^m$. (Cloudy.) Mag. power, 175. Wt. = 1.
Moonlight. Images too unsteady for measures.

E.

E is nearly uniform in brightness all over; the *n. f.* corner appears, however, a little brighter. [This may be erroneous.]

Y.

Y is very faint; [the outlines are barely seen] it is fainter than the neighboring parts of E.

Z.

Z, up to and including 581 and 573 is quite marked by brighter than the masses *n.* and *e.* of it. The contrast seems more striking than I remembered it from former years.

F, G, H.

All of about the same brightness, but F is, perhaps, the brighter. This is doubtful.

F.

The brightest part of F is south of X.

H.

The axis of H appears to be nearly in the line 685–622.

H and M.

The line of the following edges of H and M (prolonged) passes between 640 and 624.

P.

676 is in the dark channel; but very close to the preceding edge of P.
$12^h\ 10^m$; sky all cloudy.

1878, DECEMBER 23.

11^h; 671 > 709; 709 > 647, but not much brighter. 709 not much more easily seen than 666. Images very bad. $12^h\ 45^m$ no better.

1879, JANUARY 10.

8^h–10^h. Mag. power, 400. Wt. = 5. Prof. A. HALL, observer.

"At about $8^h\ 22^m$ I looked at the nebula of *Orion* with power 400 A. The images were very good. I could see no star inside the trapezium where Professor Boss reports a companion. On examining the region near [685, 708, 741] I saw two faint stars near the places indicated in the sketch [omitted]. The faint stars are denoted by *a* and *b*. On looking again at $9^h\ 40^m$ I could not see either, the seeing not being so good. *a* and *b* were about of same brightness."

[*Note* by E. S. H.—*a* is in the position of LASSELL's double, "*b*" (see Index-Map) *b* is from 708 in $p = 45°$ $s = 48''$ est. from sketch].

1879, JANUARY 18.

End $11^h\ 20^m$. Eye-piece 200. Wt. = 1.

Occiput.

$p = 330°.6, 331.8, 330.5, 333.2$; *mean*, $331°.5$

474.7

$p = 143.2$ (4)

Frons.

$p = 244°.7, 244.6, 245.1, 247.5$; *mean*, $245°.5$

294.7

$p = 49.2$ (4)

None of the faint stars are visible; 709 is just barely seen; 633 and 617 not seen. Images very bad.

1879, JANUARY 20.

$9^h\ 55^m$. Mag. power, 400 A. Wt. = 3.

Measures of $\Delta\delta$; *zero* $= 64^r.13$.

Brightest part of F.

Mic. $74^r.47, 74^r58, 74^r.40, 74.37$; *mean*, $74^r.46$

$\Delta\delta' = 10.33 = -102''.76$

refr., -0.06

$\Delta\delta = -102''.8$ (4)

N. point of E.

$9^h\ 55^m$.

Mic. $73^r.92$; clouds; $73^r.76$; *mean*, $73^r.84$

$\Delta\delta' = 9.71 = -96''.60$

refr, -0.05

$\Delta\delta = -96''.7$ (2)

The *n.* point of X (F) is further north still.

Brightest part of G.

Mic. $70^r.77, 70.64, 70.55, 70.64$; *mean*, 70.65

$\Delta\delta' = -6.52 = -64''.86$

refr., 0.04

$\Delta\delta = -64.9$ (4)

Clouds constantly passing, hiding 42 (*c*) *Orionis* to the naked eye.

1879, February 23.

Photometer. (*Very windy.*)

D, brightest part: 5.5, 5.0, 4.8; *mean*, 5.10 (3)
E, brightest part: 5.1, 5 3, 5.5; *mean*, 5.30 (3)
E = 0.98 D

1879, March 1.

8^h 40^m. Eye-piece, 400. Wt. = 3.

654 visible; also Lassell's *b* (double ? ?).
h visible; 651 visible; 642 ? visible; not quite sure of it.

Schroeter's second bridge.

Visible as far south as 647; south of this τ is black.

g_0.

No real stellar nucleus g_0, but a condensation of nebulous matter 10″–20″ large is there, separated from the rest of the nebula by dark channels *n.* and *s.* of it. That channel to the *south* is the blacker.

D.

It is not quite certain if the *following* edge of D extends further *south* than 647 as a continuous edge. All the attention I could give will not decide to-night.

1879, March 7.

Photometer.

D, 6.4, 5.6, 6.5, 6.9; *mean*, 6.4 (4)
This part of D is defined thus: join 669 and 641; bisect this line, join its middle point with 647. The mirror is 10″ north of this line.
E, 7.1, 7.3, 6.5, 7.0; *mean*, 7.0 (4)
D (brightest), 6.3, 6.3, 6.1; *mean*, 6.2 (3)
A, 4.1 :, 4.2 :, both doubtful; *mean*, 4.2 (2)
F, 5.4, 5.9, 5.4; *mean*, 5.6 (3)
In the reductions I have used $D_0 = 6.3$.

1879, December 26.

Power, 175. Wt. = 1. Strong moonlight, but sky very clear.
612 and 618 both seen; *h* near the point of D seen like a nebulous mass and not like a star; a clear dark space is between *h* and the *following* side of D.

D.

The bright *following* edge of D does not (seem to) extend further *south* than 647 as *very* bright. South near T it is definite but fainter.

Order of brightness.

1. A, D. 2. G, H, F, I, Q, E.
G and H notably brighter than F.
Moonlight too strong to examine the neighborhood of 793.

1880, JANUARY 3.

Begin 10^h, end 12^h. Power, 175. Wt. = 4, and very clear.

675 seen just outside of *frons*. LASSELL'S *b* seen. 612 > 618. 618 > 567. 567 = 636 very faint. 647 in a dark space. 651 just on the edge of D [with 175; with 400 A it was slightly within D].

h visible; nebulous and not stellar.

$10^h\ 5^m$, 654 just barely visible.

Neighborhood of 793.

The apex of the curve of the *Messierian* branch near 793 is probably *n. p.* that star a little, but the shapes of the edges north and south of this star are such that if a drawing were made by continuing the outline of the edge from the *south* of 793 northwards, the Cape would be put *south* of 793, while, if the drawing were begun *north* of 793 and continued toward the south the Cape would be put north of 793. In fact there are really two capes like this one [the southern and fainter one ends in an exceedingly minute star, *t*, of the drawing (omitted), which is in $p = 200°–210°$, $s = 30''$ from 793. This star *t*, even if not seen, gives a point for the eye to rest on in approaching 793 from the south, and would cause the apex of the *Messierian* branch to be put at *t;* approaching 793 from the north the apex would be put at that bright star (793)].

I am satisfied that the nature of the object is such that no evidence of a change can be based on the position of this Cape in relation to 793. [See observations of 1876, March 14 and March 22. These drawings (omitted) confirm and agree with tonight's.] On an unpublished drawing af G. P. BOND'S I find the statement that the nebula reaches exactly to 793 (about March 11, 1861).

Near 793 are three or four bright points which could probably be located by measures if it were worth while. They *may be* very minute stars. One of these is at *t*, in the figure (omitted), *i. e.*, $p = 200°–210°$, $s = 30'' \pm$ from 793.

D.

The *following* edge of D up to 647 is brighter considerably than the *following* edge of T just *south* of 647.

1880, JANUARY 3.

Photometer.

$10^h\ 50^m$.

The flame of the lamp does not seem to burn satisfactorily.

E. 4.6
4.2
4.1

4.30 (3)

I. *Southern end.*

4.50 (1)

The above will do for a comparison of E and I.

Flame too low and wick changed; then

D. 5.0
5.1
4.8
———
5.00 (3)

Clock not running regularly.

E. 4.9
5.0
4.8
———
4.90 (3)

Measures of D rejected, not in proper part of D

I. 5.3
5.6
5.3
———
5.40 (3)

E. 4.9
5.0
4.7
5.0
———
4.90 (4)

G. 4.7
4.8
4.5
———
4.67 (3)

D. 5.1
5.2
4.9
———
5.07 (3)

End 12^h. The clock stopped several times and the measures not satisfactory.

1880, JANUARY 10.

Photometer.

Images very unsteady.

The mirror was put in D on the line joining 641 and 647, and with its *south* end at 647 (its *north* end was therefore about 15″ north of 647).

Begin 9^h.

D. 6.1
6.3
6.3
6.23 (3)

This is not by any means the brightest part of D; the brightest of D is farther east.

E. 7.3
7.0
7.1
7.13 (3)

F. 5.9
5.1
5.6
5.53 (3)

G. 4.9
5.2
4.8
4.97 (3)

F. 5.0
5.5
5.3
5.27 (3)

D. 4.6
5.1
5.4
5.4
5.12 (4)

G. 4.9
4.7
5.0
4.87 (3)

F. 4.8
5.2
5.2
5.07 (3)

E. 6.3
6.1
6.3
———
6.23 (3)

D. 4.6
5.2
5.0
———
4.93 (3)

Summary.

			D_0.
1.	D.	6.23	6.20
2.	E.	7.13	6.10
3.	F.	5.53	5.80
4.	G.	4.97	5.50
5.	F.	5.27	5.30
6.	D.	5.12	5.10
7.	G.	4.87	5.10
8.	F.	5.07	5.00
9.	E.	6.23	5.00
10.	D.	4.93	4.90

As the lamp was perpetually growing fainter, I have used interpolated values of the readings on D, as in the second column.

1880, JANUARY 10.

Looked with the finder and with low power (175) for the star LE GENTIL puts furthest north in his drawing. It does not exist. I can only explain it at all by supposing it may be 570 G. P. B.. put *north* of θ' in δ instead of *south*, but in the same $\Delta\alpha$.

1880, JANUARY 13.

Photometer.

D (*same part as before observed*).
7.8
7.9
7.6
———
7.77 (3)

E (*brightest*).
7.3
7.3
7.2
———
7.27 (3)

I (*brightest*).

7·7
7.6
7.0
7·5
———
7·45 (4)

F (*brightest*).

5·7
5·7
5·4
———
5.60 (3)

G (*brightest*).

6.5
5·5
6.0
6.4
———
6.10 (4)

D. 6.7
6.3
6.3
———
6.43 (3)

Then set the lamp at 7.9, the same reading as at first, and found the mirror just barely illuminated; so that the lamp certainly has grown fainter.

The above observations seem to me very good, the best this year, and comparable with those of last winter.

Summary.

		D_0.
E.	7.27	7.50
I.	7.45	7.20
F.	5.60	6.90
G.	6.10	6.60

[As before, I have used interpolated values for the readings on D, as I experimentally proved that the lamp grew fainter.]

1880, JANUARY 14.

Photometer.

D; 5.8, 5.6 6.0, 6.1; *mean*, 5.88 (4)
E; 5.9, 6.0, 6.4, 6.8, 6.0; *mean*, 6.22 (5)
I; 5.2, 5.4, 4.8; *mean*, 5.13 (3)
D; 5.0, 5.9, 5.5, 5.5; *mean*, 5.48 (4)
F; 4.8, 4.8, 5.0; *mean*, 4.87 (3)
G; 4.6, 4.9, 4.2, 4.1; *mean*, 4.45 (4)
E; 5.0, 5.2, 4.8; *mean*, 5.00 (3)
D; 5.2, 5.2, 5.1; *mean*, 5.17 (3)
H; 5.4, 5.7, 5.4; *mean*, 5.50 (3)

Summary (using interpolated values of D).

D; 5.88, ——
E; [5.80], 6.22
I; [5.60], 5.13
D; 5.48, ——
F; [5.40], 4.87
G; [5.30], 4.45
E; [5.20], 5.00
D; 5.17, ——
H; [5.20], 5.50

1880, JANUARY 16.

Photometer.

D; 5.6, 5.8, 55; *mean*, 5.6 (3)
E; 5.3, 5.2; *mean*, 5.3 (2)
I; 5.0, 5.5, 6.0, 5.4; *mean*, 5.5 (4)
F; 4.8, 5.1, 5.0; *mean*, 5.0 (3)
G; 4.5, 5.0, 5.2; *mean*, 4.9 (3)
D; 5.6, 5.7, 5.5; *mean*, 5.6 (3)
E; 5.4, 5.5; *mean*, 5.5 (2)
I; 5.5, 5.0; *mean*, 5.3 (2)
[E] 15″ south of the brightest parts; 6.4, 6.6, 6.9; *mean*, 6.6 (3)

1880, JANUARY 21.

Eye-pieces 400, 600 A.

D.

The nebulous patch *h*, near the *n. f.* point of D, is 2″–3″ on a side; it has dark spaces all round it. The Index-Chart compared with the sky as follows:

E.

The *n. f.* angle of E in the chart is about 90°; in fact, it is less than 90°.

F.

The *n.* point of F is correctly drawn; that is, it is *north* of the *north* point of E considerably.

Channel between X and F.

This (although barely seen to-night) is not correct on the chart; it is not perpendicular to the channel separating E and F.

I.

The *south* side of I (chart) is too long compared to the *north* side of E.

F, G, H.

The channel between F and (G and H) is right in the chart at the *east* and *west* ends, but it is rhomboidal in shape; and the width, as given in the Index-Chart, just *north* of the letter F, is not more than one-third of the true width there. In fact, the whole mass H (in the chart) should be moved *north* and *east* a considerable distance as my measures show. Otherwise, G and H are about right, *i. e.*, as to shape.

Q.

The details of Q cannot be made out in this bright sky, but the shaded portions of the chart near stars 676 and 686, while they are right enough in themselves, give a wrong impression. The whole space directly *south* of τ should be shaded far enough to join with the space η.

The *Sinus Lamontii* is not satisfactorily laid down.

A.

This mass is not well drawn, but the figure, with the explanations as given in my various measures, will explain it. A good figure of this mass would be very complex

W_1 (*lacus Secchii*).

Should be more nearly circular, and its position in the chart as to $\Delta\alpha$ and $\Delta\delta$ is not correct.

D.

is tolerable well drawn as to shape.

T.

should be faint.

W_2, W_3, etc., cannot be well seen in this bright sky, nor can any of the fainter and outlying parts.

1880, JANUARY 29.

Eye-piece, 400 A. Wt. = 3.

612 and 618 visible; *north* and *east* of them is a dark space, which is only partly shown on the Index-Chart.

W^1.

is not well drawn as to shape, and W^4 is correct; W^2 and W^5 not well seen on account of moonlight.

B.

575 is the *southern* limit of B [this is different from Lord Rosse's drawing].

C.

The dark curved channel just *north* of C is darker than that south of it.

T.

The *south* edge of T is near the place of 654 (not visible to-night), and it is tolerably sharply defined, more so than is shown in the Index-Chart; it seems as if the *Sinus Lamontii* should be continued past 622, 625, 648, and 654 in a nearly straight line to join with τ near [c].

τ.

The *south* edge of τ from [c] to the bridge of Schroeter, is much fainter than the edge of T].

The moonlight is too strong for the finer details.

Synopsis of the Preceding Detailed Observations.

In the pages immediately following I have collected all or nearly all the single observations relating to each particular bright mass, dark channel, etc., and have arranged them chronologically for convenience of reference. The measures in this section are corrected for differential refraction. In general, the essential portions of the original observations are alone given, but occasionally where the description is too long or too unimportant to be repeated, I have added, after the *date*, "*see observations*."

By this arrangement it will be easy for any one to examine into the accuracy of the original observations, for under each head each statement can be examined in detail and verified or disproved. The various masses, etc., are here arranged nearly in the order of right ascension. In the following pages are given the observations of supposed *variable stars*, the *examination of various drawings*, the *order of brightness* of the various masses, etc.

Frons.

1875, Oc. 29. $p = 48°.3$ (5)

1875, Nov. 11. $p = 52°.1$ (4). This is the best tangent to the *whole* line of light, but it cuts off some masses at *s. p.* corner of E and some at Q.

1876, Nov. 22. $p = 49°.3$ (4)

1877, Jan. 24. The *frons* is convex to the east, as remarked by Lord Rosse. The greatest convexity is near 685.

1877, Feb. 7. Convex as above.

1878, Jan. 16. $p = 51°.3$ (4), $s = 193''.5$ (3). The measures of s [length of *frons*] were made to compare with Liapunoff; but they are very uncertain from the nature of the case. Holden–Liapunoff $= + 3''.7$.

1879, Jan. 18. $p = 49.2$ (4). Wt. $= 1$.

Occiput.

1875, Oct. 29. $p = 142°.1$ (5). Occiput *exactly* parallel to line 506–570.

1875, Nov. 10. The line joining R 56 and 581 is perpendicular to occiput.

1875, Nov. 11. $p = 139°.3$ (4). This measure cuts Y off entirely.

1876, Mar. 6. $p = 142°.7$ (4)

1876, Nov. 22. $p = 136°.6$ (4). This measure cuts off a little of E, and is hardly satisfactory.

1877, Jan. 5. $p = 135°.5$ (3). This measure cuts off Y. Wt. = 1.

N. B. The last two observations are not comparable with the preceding three.

1877, Jan. 5. s (from θ') 106″.5 (3); HOLDEN–LAMONT = + 10″.2; HOLDEN–LIAPONOFF = + 10″.1.

1878, Jan. 16. $p = 139°.6$ (7). This is the best tangent from *south* point of J to *south* point of E. It cuts off Y.

1879, Jan. 18. $p = 143.2$ (4). Wt. = 1. Preceding edges of E and I.

Sinus Gentilii (β, K, and γ).

1875, Nov. 10. If there is any totally black inlet from the *south* in the *Sinus* it is very narrow.

1876, Feb.? The *Sinus Gentilii* is connected with V by a channel running NE. (See observations.)

1876, Feb.? $\Delta\delta$ north end = − 66″.7.

1876, Mar. 14. The line joining 573 and 575 is the best tangent to the *preceding* shore of γ.

1877, Jan 2. As in Index-Chart. It is pretty uniformly black, but not so black as τ', etc.

1877, Feb. 7. *North* point of *Sinus Gentilii* $\Delta\delta = + 66''.7$ (4)

1877, Dec. 12. The line 573–575 as on 1876, March 14.

1878, Mar. 5. *North* end of γ; $\Delta\delta = - 58''.3$ (4) *or* $- 63''.3$ (4). (See observations.)

δ

1876, Feb.? *North* point; $\Delta\delta = - 102''.6$.

1877, Jan. 2. As in Index-Chart.

1878, Mar. 5. *North* end; $\Delta\delta = - 99''.2$ (3)

J.

1877, Jan. 2. See observations.

1878, Mar. 9. *Preceding* point; $\Delta\alpha = - 97''.3$ (4)

c.

1875, Nov. 5. The branch is about right in the Index-Chart, perhaps a little too much curved. It runs a little to the *north* of 523, but that star is involved in nebulosity to-night.

1876, Mar. 6. About right on Index-Chart.

1877, Jan. 2. *c* about as bright as B (roughly speaking).

J AND B.

1875, Oct. 29. $p = 7°.7$ (3) angle of *preceding* edges.

1876, Nov. 27. $p = 5°.1$ (1) angle of *preceding* edges, which pass through 575 in this measure.

1876, Dec. 19. $p = 12°.2$ (3)

1878, Jan. 16. $p = 7°.7$ (3) this measure passes through 575.

B.

1875, Oct. 29. B points exactly to 575, which is at the very end of it. Position angle of B from its north end to $575 = 6°.0$ (1)

1875, Nov. 24. 567 half way from B to 1, in a dark space.

1876, Dec. 19. B extends no further than 575 as a bright mass, certainly not as much further as is given by Lord ROSSE, 1867.

1876, Dec. 31. B runs *exactly* through 575, and if it extends *south* of 575 as a distinct mass it is considerably fainter. The branch (B) leading to 575 is brighter than the branch (in A?) leading to 589.

1877, Jan. 2. About half way from 575 to *north* end, B is about as bright as the general mass of I.

1877, Dec. 12. Tangent to the *north* side of the curve in which B joins A, $\Delta\delta = +30''.5$ (4). B is much fainter *south* of the parallel of θ' than *north* of it; it seems hardly to reach 575, as a bright mass.

1878, Jan. 23. See observations on brightness of B.

1880, Jan. 29. 575 is the *southern* limit of B. This is very different from Lord ROSSE's drawing.

W^1, W^2, W^3, W^4, W^5.

W^1 = *lacus Secchii* (discovered by SCHROETER, 1794).

1875, Nov. 10. The distance from [the center of] W^1 to 685 is about equal to the distance 635–669. W^2 remarkably black.

1875, Nov. 17. Middle of W^1, $\Delta\alpha = -37''$: (1)

1876, Jan. 30 W^1 blacker than V.

1876, Mar. 14. *Preceding* side of W^1, $\Delta\alpha = -57''.3$; *following* side of W^1, $\Delta\alpha = -29''.1$. Middle of W^1, $\Delta\alpha = -43''.2$, according to above, but the *preceding* end of W^1 is very narrow, almost a canal.

1876, Dec. 19. W^1 brighter than *Sinus Gentilii.*

1876, Dec. 31. W^1 connects with dark channel *north* of 2, which runs towards 524. W^1 blacker than W^4, and both blacker than W^3, which is not clearly outlined to-night.

1877, Jan. 10. W^4 connects with W^2 (verified); W^3 is just *south* of 635.

1877, Nov. 20. $\Delta\delta$ of middle $= +69''.8$ (4), not very certain.

1877, Dec. 7. $\Delta\delta$ of middle $= +67''.7$ (3), much better than observation of November 20.

1878, Jan. 23. $\Delta\delta$ of middle $= +68''.0$ (7)

1878, Mar. 9. $\Delta\alpha$ of center $= -47''.4$: (2)

1878, Dec. 6. $\Delta\alpha$ of center $= -48''.2$ (4)

A.

1875, Nov. 11. See observations.

1876, Feb. ? *South* end of A near star 622, $\Delta\delta = -31''.8$.

1876, Mar. 6. Star 622 from θ' *Orionis*, $p = 199°.0$ (1)

1876, Dec. 19. See observations. Some of the details are different from LASSELL, 1863.

1876, Dec. 31. See observations. 589 at *south* end of a bright part of A.

1875, Oct. 27. 589 *exactly* on *preceding* edge of A. This edge is very faint compared to *following* edge.

1877, Dec. 7. $\Delta\delta$ *south* point $= -31''.9$ (2), not very certain.

1877, Dec. 12. $\Delta\delta$ *south* point $= -31''.2$ (5). See observations for position of 622.

I.

1876, Mar. 14. The rounded apex (*south* point) of I is bisected in $\Delta\alpha = -29''.1$.

1877, Jan. 24. No nucleus (602) seen to-night. [It, however, exists. See 1874, January 17, etc.]

1877, Dec. 12. The *s. p.* corner of I projects beyond [*preceding*] the general line of the *occiput*.

1878, Jan. 23. *S. f.* corner of I; $\Delta\delta = -95''.8$.

1878, Jan. 28. *S. f.* corner (near A_1); $\Delta\delta = -77''.4$ (1).

1878, Mar. 5. See observations for the relation of I to the parallel $\Delta\delta = -77''$; also, this date *s. f.* corner; $\Delta\delta = -97''.6$ (1); corner near A_1; $\Delta\delta = -81''.2$.

1878, Dec. 6. *West* point of I (near A_1); $\Delta\alpha = -62''.8$ (4)

Dark channel between U and A.

1876, Dec. 31. Much as in Index-Chart. See observations.

1877, Jan. 24. 622 in the channel half way from edge of U to edge of A.

L.

1875, Nov. 11. See observations.

1876, Feb. ?. *North* end on same parallel as 671, and the *east* point of Q; $\Delta\delta = -25''.6$.

1877, Jan. 24. L from 621 to 601, and from thence to 595 (*i. e.*, the *north* shore) is very bright, nearly as bright as A near it.

1877, Dec. 12. $\Delta\delta$ *north* point $= -25''.4$ (4); about the same at 671.

1877, Dec. 12. The *preceding* edge of L near 601 prolonged would pass through the *s. p.* corner of I.

η.

1875, Nov. 24. *South* shore about right in Index-Chart.

1875, Dec. 19. As in Index-Chart.

1875, Jan. 2. See observations.

1877, Dec. 12. The line 570–666 is approximately the *south* border of η.

Y.

1877, Jan. 2. Y is not a marked feature of E, as in LASSELL, 1863, but requires attention to see it.

1878, Dec. 11. See observation.

E.

1875, Nov. 10. *South* extremity; $\Delta\delta = -147''.6$
1875, Nov. 10. *North* extremity; $\Delta\delta = -101''.7$ } $\Delta = 45''.9$.

1875, Nov. 17. Apex of E almost exactly *south* of θ'; *i. e.*, $\Delta\alpha = 0''.0$.

1876, Feb. ? *South* point of E, $\Delta\delta = -142''.7$, $145''.1$, $144''.2$; *mean*, $-144''.0$.

1876, Feb. ? *North* point of E, $\Delta\delta = -102''.6$ (approximately).

1876, Mar. 14. Apex of E, $\Delta\alpha = -5''.3$ (poor images).

1877, Jan. 2. E nebulous [no nuclei] and uniform in brilliancy.

1877, Feb. 6. The apex of E certainly does not *precede* θ'. It appears to be in same R. A. ($9^h.0$). It *may follow* it $2''$–$3''$.

1877, Feb. 7. The *following* side of E is nearly a straight line.

1877, Dec. 7. $\Delta\delta$ of *south* point $-143''.5$ (4); the smallest $\Delta\delta$ which smaller telescopes could give is not less than $131''.4$ (1)

1877, Dec. 12. $\Delta\delta$ of *south* point $-155''.6$ (2) [extreme]?

1878, Jan. 28. $\Delta\delta$ of *south* point $-147''.2$ (3)

1878, Feb. 28. The brightest part is the center of the mass.

1878, Dec. 11. E uniform in brightness all over; the *n. f.* corner appears, possibly, a little brighter?

1880, Jan. 21. The *n. f.* angle of E is less than 90°.

Z.

1878, DECEMBER 11 (see observations).

Dark channel between I and (X and G).

1876, Mar. 6. A straight portion of some length, whose direction prolonged passes through 570, $p = 25°.6$ (3).

Dark channel between I and E.

1876, Dec. 5. Its prolongation *precedes* 671. $p = 42°.6$ (4); quite uncertain.

1876, Dec. 31. It is *about* parallel to *frons* [$p = 50°$?].

1877, Dec. 12. Its *north* border prolonged is very approximately tangent to the *n. p.* end of F; *i. e.*, X.

1878, Jan. 16. $p = 46°$ (1); uncertain.

Dark channel between E and F.

1875, Nov. 24. $p = 139°.6$ (2). Its direction passes through the star 589. For further description, see observations.

1878, Jan. 16. $p = 141°.7$ (3)

Dark channel between F and (G and H).

1875, Nov. 17. See under F, synopsis.
1876, Mar. 6. Its prolongation is in the line 685–708.
1876, Dec. 19. Same as March 6.
1876, Dec. 31. Same as March 6.
1877, Jan. 5. Same as March 6.
1877, Jan. 24. Same as March 6.

V.

1875, Nov. 5. The ground on which the trapezium stands is not totally black.
1875, Nov. 17. V not so black as τ'.
1876, Jan. 30. V not so black as W_1
1876, Mar. 14. V not so black as *Sinus Gentilii*, but comparable with and almost as black as north half of τ'.
1877, Jan. 24. 618 inside V; 612 in nebulosity or very close to border.
The extent of V towards the north is therefore (612); $\Delta\delta = +24''.0$.
1878, Mar. 5. *South* point; $\Delta\delta = -22''.7$ (3)

F.

1875, Nov. 10. Brightest part, $\Delta\delta = -101''.0$ (= LIAPONOFF'S a_0); his measures give $97''.4$.
1875, Nov. 17. The *south* part of F almost stellar in appearance.
1875, Nov. 24. The line through 685 and 708 passes through the brightest part of F (*i. e.*, X [?]), and is parallel to the black channel between F and (G and H).
1876, Feb. ? *South* point, $\Delta\delta = -122''.3$.
1876, Mar. 14. Tangent to *preceding* sides of F and G, $\Delta\alpha = +1''.2$.
Mem. X must be too far east in Index-Chart.
1876, Mar. 14. F is bisected very nearly in $\Delta\alpha = +18''.8$ ($28''.8$).
1877, Feb. 3. Intersection *s. p.* edge with *frons*, $\Delta\alpha = 19''.2$: (3)
1877, Feb. 7. (Brightest part which is *not* X), $\Delta\delta = -102''.1$ (4)
1877, Jan. 2. Nucleus stellar to-night.
1877, Jan. 24. X and F seem to be almost separated by a fainter streak nearly in the parallel; *following* end of F fainter than the rest of the mass.
1877, Dec. 12. *South* point of F in *frons*, $\Delta\delta = -117''.3$ (2)
Extreme *north* point (X), $\Delta\delta = -94''.9$ (2)
1878, Jan. 28. Brightest part, $\Delta\delta = -102''.9$ (4); $\Delta\alpha = +26''.8$ (2). G > F.
1878, Mar. 5. $\Delta\delta$ *south* point *preceding* the *frons*, $-113''.5$ (3). See observations.
1878, Mar. 5. A faint channel visible through the following end of F.
1878, Mar. 5. Brightest part, $\Delta\delta = -101''.2$ (2)
1878, Dec. 11. F, G, H about equal in brightness, and perhaps F is the brightest. This is doubtful. The brightest part of F is south of X.
1879, Jan. 20. Brightest part of F, $\Delta\delta = -102''.8$ (4).
1880, Jan. 21. The *north* point of F is *north* of the *north* point of E.

G.

1875, Nov. 10. Brightest part, $\Delta\delta = -64''.5$ (= LIAPONOFF's b_0); he gives $-63''.3$.
1875, Nov. 17. The middle part almost stellar.
1876, Feb.? Center and brightest part, $\Delta\delta = -69''.6$.
1876, Mar. 14. Tangent to *preceding* edges of F and G, $\Delta\alpha = +1''.2$.
1876, Mar. 14. Tangent to *following* side of G, $\Delta\delta = +28''.8$.
1876, Dec. 5. $\Delta\delta$ (brightest part), $-65''.5$ (5); poor measures.
1877, Jan. 2. Nucleus stellar.
1877, Jan. 24. See observations.
1877, Feb. 3. G (middle point), $\Delta\alpha = +13''.9$: (3)
1877, Feb. 6. The *preceding* side of G comes *nearly* to the R A. of θ'.
1877, Feb. 7. G (middle point), $\Delta\delta = -66''.1$ (4)
1877, Nov. 20. $\Delta\delta$ (brightest part), $= -60''.9$ (3). Images very poor.
1878, Jan. 28. $\Delta\delta$ (brightest part), $= -66''.5$ (3); $\Delta\delta$ (*south* point) $= -75''.7$ (4)
1878, Jan. 28. $\Delta\alpha$ (brightest part), $= +15''.9$ (3)
1878, Mar. 5. All of G is north of $-77''$.
1879, Jan. 20. Brightest part of G, $\Delta\delta = -64''.9$ (4)

H.

1877, Dec. 12. $\Delta\delta$ *south* end of H in *frons* $= -94''.21$ (1)
1878, Mar. 5. $\Delta\delta$ *south* edge $= -77''.5$ (3). [This is, of course, within the line of *frons*.]
1878, Dec. 11. The axis of H is nearly in the line 685–622. The line of the following edges of H and M (prolonged) passes between 640–624.

M.

1878, Mar. 5. *North* edge of M, $\Delta\delta = -22''.7$ (3)

D.

1875, Oct. 27. It is suddenly much brighter just *north* of 647.
1875, Nov. 10. Bright, sharp *n. f.* end, $\Delta\delta = +77''.7$ (3)
1876, Mar. 14. Tangent to brightest and *following* side, $\Delta\alpha = +28''.8$.
1876, Dec. 19. 651 is precisely on the edge of D; *i. e.*, $\Delta\alpha = +28''.8$.
1877, Jan. 12. The brightest part follows the line 635–647 a little.
1877, Feb. 3. Tangent to *following* edge, $\Delta\alpha = 30''.5$ (3)
1877, Nov. 20. [$\Delta\delta = 81''. : :$] See observations.
1877, Dec. 12. $\Delta\delta$ of *north* point not seen well enough to measure.
1878, Jan. 16. The *north* point is not sharp nor bright to-night.
1878, Jan. 28. Ditto. See observations in detail.
1878, Jan. 28. $\Delta\alpha$ (*following* edge) $= +29''.6$ (3)
1878, Dec. 6. $\Delta\alpha$ (*following* edge) $= +29''.3$ (4)
1879, Mar. 1. See observations.
1878, Feb. 28. The brightest part is on the line 647–663.
1878, Mar. 9. 647 is on the *following* and *north* side of a channel.

1879, Dec. 26. The bright following edge of D does not (seem to) extend farther *south* than 647 as very bright; south near T it is definite but fainter. See observations, 1880, Jan. 3.

1880, Jan. 3. 651 just on the edge of D (with 175) with 400 A it was slightly within D.

1880, Jan. 21. The nebulous patch *h* is 2″–3″ on a side.

Dark channel following D and preceding ν.

1875, Nov. 24. It certainly does connect with τ.

τ.

1875, Nov. 5. *South* third is darker than *north* two-thirds.

1875, Nov. 10. *North* half is filled with light which joins on to *pons Schroeteri.*

1875, Nov. 11. *North* third is too bright in G. P. Bond's drawing.

1875, Nov. 17. *South* third is blacker than *north* two-thirds.

1875, Nov. 24. The *preceding* and *south* edges of τ are bordered by a very black stripe. (Contrast??) The *south* third is black, the *north* two-thirds full of nebulosity.

1876, Jan. 3. The *north* half is filled with faint nebulosity; the *south* half is empty. Half way between the *following* edges of D and the *preceding* edge of *pons Schroeteri*, there is certainly a faint bright bridge of light as sketched to-night on the Index-Chart, similar to Schroeter's second bridge. Its base is connected on the *north* to *v*, and it extends towards the south as far as the parallel of the bright nucleus of *pons Schroeteri*, [$\Delta\delta = 39''$ approximate].

1876, Jan. 3. The *preceding* side of τ is blacker; *i. e.*, there is a black stripe bordering D and T.

1876, Jan. 3. *South* half of τ brighter than usual. See observations.

1876, Jan. 4. The *east* side of τ not so black as the *west;* the *north* part not so black as the *south.*

1876, Jan. 30. Quite black on *preceding* side; a thin black streak edges all the *west* and *north* sides of τ; the *north* half of τ is decidedly nebulous, while the *south* half is almost jet black.

1876, Feb.? All *north* of $\Delta\delta = +47''.1$ in τ is filled with nebulosity, except, of course, the black channel on its *west* edge; nearly all *south* of this is pretty black, though not so black as τ′.

1876, April 1. *North* half much brighter than *south* half.

1876, Dec. 19. *South* half very black. 651 is precisely on the edge of τ.

Schroeter's second bridge (in τ).

1876, Jan. 3. See under τ.

1876, Nov. 5. It is much as previously drawn.

1876, Dec. 19. It extends to the *south* as far as the parallel of 647 [*i. e.*, $\Delta\delta = +38''.0$.
G. P. B.]. Its position angle is a little greater than that of *pons Schroeteri.*

1876, Dec. 31. Does not extend *south* of g_0.

1877, Jan. 2. Only *north* two-thirds seen. Its general appearance like Lord Rosse's figure.

1877, Feb. 7. It is best defined on the *following* side.

1878, Dec. 6. See observations.

1879, Mar. 1. Visible as far south as parallel of 647; *south* of this τ is black.

Pons Schroeteri (g_0).

1875, Nov. 5. The nucleus does not seem to be stellar.

1875, Nov. 10. Brightest part, $\Delta\delta = +39''.5$ (5) on same parallel as 647 [$+38''.0$, G. P. B.].

1875, Nov. 11. The micrometer wire through the *pons* passes through 685 and 669 nearly. $p = 170°.7$ (3)

1875, Nov. 17. The nucleus is almost stellar. It is very bright, almost as much so as the *south* edge of σ.

1875, Nov. 17. Brightest part, $\Delta\alpha = +79''.3$ (4). The *north* part *precedes* this a little, $p = 175°$ about (estimated).

1876, Jan. 3. Nucleus stellar beyond a doubt, not the whole nucleus but a central point.

1876, Jan. 30. Center distinctly concentrated, almost stellar.

1876, Feb.? Middle of the break, in the *pons Schroeteri*, which is *south* of the nucleus, $\Delta\delta = +22''.0$ (1)

1876, Feb.? Brightest part, $\Delta\delta = +41''.9$.

1876, Feb.? Middle of the break in the *pons Schroeteri*, which is *north* of the nucleus, $\Delta\delta = +60''.0$ (1)

1876, Mar. 14. Nucleus, $\Delta\alpha = +76''.4$.

1876, Dec. 19. $p = 171°.2$ (3)

1877, Jan. 5. $p = 165°.8$ (2). Wt. = 1. This is rather to be considered as the p of a line joining 669 and g_0, and is a poor measure.

1877, Jan. 10. $p = 175.8$ (3). Wt. = 1. Images unsteady but brilliant.

1876, Dec. 19. g_0 is in a central nucleus surrounded by an annulus.

1877, Feb. 3. g_0, $\Delta\alpha = 77''.5$: (3)

1877, Feb. 7. g_0 not stellar in appearance.

1877, Nov. 20. g_0, $\Delta\delta = +41''.6$ (2). Images poor.

1877, Dec. 12. g_0, $\Delta\delta = +40''.3$ (4)

1878, Jan. 16. $p = 167°.5$ (3) uncertain { 1878, Jan. 28. $\Delta\alpha = +76''.6$ (3); no nucleus. 1878, Dec. 6. $\Delta\alpha = +76''.7$ (4)

1879, Mar. 1. For description of g_0, see observations. Not stellar.

σ.

1875, Nov. 5. Along the *south* edge it is notably brighter.

1875, Nov. 5. Much brighter on *south* edge, then fainter. Roughly speaking, the *preceding* half is brighter than the *following* half; the *north* shore is *concave* towards the *south*??

1875, Nov. 10. *S. f.* sharp point of σ = Spitze; $\Delta\delta = +78''.4$ (4)

1875, Nov. 11. $P = 89°.7$ (4); general trend of *south* shore.

1875, Nov. 11. In G. P. Bond's drawing the Spitze is relatively too bright, but not much.

1875, Nov. 17. The *south* edge of σ for the *east* two-thirds of its length is noticeably and suddenly brighter than the rest of σ.

1875, Nov. 17. Extreme *following* end of σ; $\Delta\alpha = +169''.9$ (3).

1876, Jan. 30. *South* edge terminates in a sharp and bright edge; *i. e.*, comparatively much brighter than ν, for example.

1876, Feb. ? *South* edge of σ; $\Delta\delta = +83''.7$ near *pons Schroeteri?* (approximately).

1877, Jan. 30. *P* of *south* shore (through tourmalines to compare with Le Gentil, etc.); $p = 44°$ (1)

1877, Feb. 3. $\Delta\alpha$ *following* point of $\sigma = +165''.1$ (3); *good.*

1877, Feb. 7. *South* edge of *following* point; $\Delta\delta = 75''.7$ (4). From *lacus Lassellii* east to *Spitze* the *south* shore of σ is concave to the *south.*

1877, Dec. 12. *South* shore concave toward *south;* $\Delta\delta$ of Spitze $79''.6$ (4) ?

σ and Spitze.

1878, Jan. 23. The *south following* point of σ is about on same parallel with *n. p.* point of D, and with center of W^1; *i. e.*, $\Delta\delta = +68''$ approximately.

1878, Jan. 28. *South* shore of *Spitze;* $\Delta\delta = +80''.7$ (4); $\Delta\alpha = +162''.8$ (3)

1878, Dec. 6. $\Delta\alpha = +161''.3$ (4)

Lacus Lassellii.

This is laid down in Schroeter's map of 1794.

1875, Nov. 5. 652, 657, 663 *precede* its axial line.

1875, Nov. 17. See observations.

1876, Dec. 19. It connects with *Sinus magnus.*

τ'.

1875, Nov. 5. On the *following* side of *pons Schroeteri* it is quite dark; the line in Index-Chart seems to limit this dark space properly.

1875, Nov. 11. G. P. Bond's drawing gives its north third too bright relatively. It is now quite dark there.

1875, Nov. 17. τ' blacker than any neighboring part. *North* of $o\pi$ prolonged (towards the *west*) it is brighter, but still very faint. τ' blacker than V.

1875, Nov. 24. Just following *pons Schroeteri* it is *very* black.

P, S, M.

1875, Nov. 11. See observations.

1878, Dec. 11. 676 is in the dark channel, but very close to the preceding edge of P.

Dark channels preceding and following M.

1876, Dec. 31. See observations.

1877, Jan. 2. See observations.

N.

1876, Nov. 5. Two nuclei seen in N (see observations for details).

1878, Jan. 28. *South* point (in *frons*); $\Delta\delta = -74''.2$ (2)

1878, Mar. 5. *South* point; $\Delta\delta = -75''.0$ (1)

Q, P, R.

1875, Nov. 11. Angle of position of *n. f.* sides of Q, P, and R. The line passes through 654 and 624, or nearly so. This cuts off some of R and most of T. $p = 105°.8$ (4)

1876, Nov. 22. $p = 105°.6$ (4). This cuts off some of R.

Q.

1875, Nov. 17. *Following* end of Q in the same R. A. as 708 [+ 150″.6, G. P. Bond].

1876, Feb. ? *East* point of Q, $\Delta\delta = -25''.6$.

1876, Nov. 5. *North* side of Q quite bright and sharp; 688 is on the *north* edge of Q.

1877, Feb. 3. *Following* end of Q a little *preceding* 708, $\Delta\alpha = +147''.3$ (3) Wt. = 2. The extreme point is undefined, and these measures place the point rather too far *west* than too far *east*.

1877, Feb. 7. *Following* point, $\Delta\delta = -31''.6$ (4)

1877, Nov. 20. *Following* point, $\Delta\delta = -25''.7$ (3). This line bisects the *following* point.

1877, Dec. 12. *Following* point, $\Delta\delta = -29''.9$ (3)

1878, Jan. 28. *Following* point, $\Delta\alpha = +152''.6$ (4)

1878, Mar. 5. Nuclei in Q, { *north* end of *n*, $\Delta\delta = -35''.5$. middle of *q*, $\Delta\delta = -23''.4$.

O and P, and the dark channel between them.

1876, Nov. 5. *South* of the line 671–676 it is black, and 676 seems to be on the preceding edge of P or O.

τ''.

1875, Nov. 5. *North* of $o\pi$ it is quite dark; to the south of $o\pi$ it is filled with nebulosity.

1875, Nov. 17. *North* of $o\pi$ it is quite dark close up to the *south* edge of σ.

1875, Nov. 24. *North* of $o\pi$ it is black.

1876, Jan. 30. Quite black north of $o\pi$.

$o\pi$.

1875, Nov. 17. $o\pi$ both seen; they are elongated.

1875, Nov. 24. π is brighter than o; o is brighter than the middle of $o\pi$.

1876, Jan. 30. o and π like nuclei verging towards a stellar appearance, but not so much so as center of *pons Schroeteri*.

1876, Feb.? The parallel $\Delta\delta = +60''$ passes about through the center line of the west half of $o\pi$.

Sinus magnus.

1876, Nov. 11. Best tangent to *south* shore; $p = 105°.6$ (4). See observations.

1877, Jan. 27. Measure of position angle of the *north* shore of *Sinus magnus* through tourmalines. See observations; $p = 44°$ (1)

ξ.

1875, Nov. 5. Filled with nebulosity. There is *at least* one dark streak in ξ parallel to $o\pi$ and just south of it. [Contrast?]

1875, Nov. 24. Just *south* of $o\pi$ is a narrow black channel. After this channel is crossed (going southwards) the *Sinus* is filled with nebulosity up to its *south* border.

1877, Jan. 2. Uniformly filled with faint nebulosity.

ρ.

1875, Nov. 24. *Following* σ there is a curious repetition of the prow-like shape of the *Spitze* in σ; it is much fainter and is close to σ, so that it looks like the shadow of σ a little distorted.

1877, Jan. 2. (See observations.)

Cometic tails to stars 685, 708, 741.

1875, Nov. 5. I do not think such exist as figured by G. P. Bond. It is darker between 685–708 than between 708–741.

1875, Nov. 10. No wisps to these stars seen.

1875, Nov. 11. (See observations.) There is certainly no such wisp or tail to 741 as given by G. P. Bond.

1875, Nov. 17. 741 (same as Nov. 11) 708, 641 (same as Nov. 11).

1875, Nov. 24. As above.

1876, Feb.? No tails to these stars. Mag. power, 175. Seeing poor.

1876, Dec. 13. The space between 685 and 708 is blacker than that between 708 and 741. This is what gives the appearance of veritable cometic tails, which never appeared to me as they are figured by Bond.

Remarks upon the general form of the Huyghenion region.

See observations, as follows: 1876, Jan. 10; Dec. 19. 1877, Jan. 2; Jan. 5; Jan. 10; Jan. 24; Jan. 30; Feb. 3. 1878, Jan. 23.

Comparison of drawings directly with the nebula.

G. P. Bond. See observations of 1875, Nov. 11; Nov. 17. 1876, Feb.?, etc.

Lamont. See observations of 1877, Jan. 5, etc.

Rosse. See observations of 1877, Jan. 10, etc.

Winlock and Trouvelot. See observations of 1875, Nov. 24. 1876, Jan. 10, etc.

Huyghens. See observations of 1877, Jan. 3 and 5.

Comparison of Index-Chart, as here published, with the sky. 1880, Jan. 21, Jan. 29.

COLLECTION OF THE SEPARATE RESULTS OF OBSERVATIONS OF STARS.

Stars within the trapezium.

It may be once for all said that never, under the most favorable circumstances, were any stars or points of light seen or suspected within the trapezium. These have been looked for on various occasions, by myself and by others, and in most of the cases when they have been especially looked for, the fact is noted in the observations given in chronological order, but I do not think it worth while to bring together in this place the particulars of such searches, since they would be at the most but a mere catalogue of dates.

Stars in and near the trapezium.

The best summary which can be given of the evidence in regard to the stars alleged to have been seen in and near the trapezium by De Vico and others is given by Otto v. Struve (p. 99 of his Memoir).

"Quant aux étoiles que Dumouchel et De Vico ont cru voir en dedans ou tout près du trapèze je dois dire que malgré tous les soins, je ne les ai jamais aperçus. Ayant eu des preuves de variabilité dans l'éclat des étoiles situées près du trapèze, la supposition devait se présenter à moi que ces étoiles avaient également changé de lumière dans l'intervalle entre les observations romaines et les miennes. Mais cette supposition perd tout son poids si l'on considère que les astronomes de Rome n'ont pas reconnu la sixième étoile découverte par Herschel et que, d'un autre côté ni Sir John Herschel au Cap, ni M. Lamont à Munic, quoique leurs observations portent à peu près la même date que celles de Dumouchel et De Vico, n'ont réussi à voir les dites étoiles. Tout cela porte donc à croire que dans ces cas, les astronomes romains ont été sujets à des déceptions optiques. La même remarque s'applique également à l'étoile qu'à Paris en 1857, M. Porro a cru voir à l'intérieur du trapèze, observation qui en apparence a trouvé une confirmation dans une remarque faite à peu près à la même époque à Rome par M. Secchi. Au moins je dois dire qu'ayant examiné soigneusement l'intérieur du trapèze par chaque nuit favorable du printemps 1857, et plus tard, je n'ai jamais aperçu une trace de l'étoile en question, tandis qu'en même temps l'étoile de Herschel, qui n'a pas été vue par M. Porro, ne m'offrait aucune difficulté." There have been many stars reported in this space, but the various cases are not worth reporting; but the careful examinations which Struve, Bond, and others have given show these to have been delusions.

We find in *Mon. Not.* R. A. S., xxii, p. 164, a portion of a letter of Lassell's, dated Malta, 1862, January 30, in which he announces the discovery of a new star within the trapezium of *Orion*. "It is situated near *theta*, the principal star; appears to be about a full magnitude less than that known as 'the sixth star,' and is about one-sixteenth* of its distance from *theta*. Its angle of position from *theta* is about 100°

* This was afterwards corrected to read six-tenths (*Mon. Not.* R. A. S., xxii, p. 277).

less than that of 'the sixth star,' and consequently points a little eastward of the star at the opposite angle of the trapezium. For verification I annex a diagram:

"I suspect that the position-angle of 'the sixth star' has considerably increased since 1852." This star has not been seen here.

Otto v. Struve's *variable stars.*

These are distinguished on the Index-Chart by being surrounded with a small circle, and attention was paid to their magnitudes as compared to the magnitudes of other stars in the neighborhood not so suspected of variability. Still, it will be found that the materials for a discussion of the relative magnitudes of these stars are very poor, poorer than I should have supposed before bringing them together. Their observation was considered of secondary importance, as it was soon found (as early as 1874) that their accurate observation would require an amount of attention quite inconsistent with the main object in view, which was to accurately describe (and, if possible), to picture the *nebulous masses* themselves in their relation to each other. It must be remembered, too, that atmospheric conditions have much to do with the brightness of small stars, and that it is easy to become convinced of variations in magnitude of small stars from their variation in brightness from night to night, whereas in many cases such a change is due largely, if not entirely, to changes in the transparency of the air.

One exception to my usual practice of never allowing the observations on the nebula to suffer on account of time spent upon its contained stars, must be noted in the case of h 78 = 654. This was usually looked for; if it was not at once visible, ordinarily this fact was noted; if it became visible during the work, this was also noted with the time, and if it was visible a comparison of it with other stars was made.

With this preface I collect below all the observations on the brightness of the small stars of the *Huyghenian region.**

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* It may be worth while to record the following star-magnitudes according to W. Herschel's MS. observations (unpublished):

	W. Herschel's mags.	G. P. Bond's mags.
1776, Nov. 11.	1. 685 = 628	685 = 8.3 628 = ?
	2. 708 = 741	708 = 9.6; 741 = 10.0
	3. 640, = 619 < 708	640 = ?; 708 = 9.6
	4. 669 very small	619 = ? 669 = 9.8
	5. 624 smaller still.	
1778, Jan. 26.	640 a little larger than 619.	
1810, Dec. 31.	734 a little larger than 741 . .	734 = 9.0 741 = 10.0

Sir John Herschel gives some evidence of the variability of the fifth star of the trapezium in *Mem.* R. A. S., vol. iii, p. 187, *et seq.*

Observations of the Variable Stars.

1874, Jan. 14. No stars inside trapezium.
1874, Jan. 16. (641) = 16^m Arg.; 675 not seen; 654 seen 7^h to 7^h 20^m.
1874, Jan. 17. 647 and 651 > (575) > (602) > (567) and (642) not seen.
1874, Jan. 17. 675 not seen.
1874, Jan. 23. (641) seen; clouds. 654 suspected. (Cloudy.)
1874, Jan. 24. No stars inside trapezium.
1874, Jan. 25. (642) not seen; 654 not seen; 675 not seen.
1874, Feb. 5. (641) seen. "Is 709 variable? it is quite faint."
1874, Feb. 5. 675 seen.
1874, Feb. 14. Lassell's *b* not seen.
1875, Oct. 27. 666 and 667 just seen.
1875, Oct. 27. 647 > (641), 647 = (671), 647 > (575).
1875, Oct. 29. 647 = (575) > (671), but the inequality is not great.
1875, Oct. 29. (575) > (573), 651 = (654), (641) not seen.
1875, Nov. 5. 647 > (575) = (671).
1875, Nov. 11. (676) = (654), (654) > (641), but not much.
1875, Nov. 11. (654) > 612 or 618. Lassell's *b* not seen.
1875, Nov. 11. (654) = 622 > 631. Query 621?
1875, Nov. 11. 686 and 688 not seen, although not particularly looked for.
1875, Nov. 11. 675 not seen.
1875, Nov. 24. 647 > (575) > (671) or (676) > 589 > (567).
1876, Jan. 3. 647 > (575) > (671) > 622 or 625, 676? 647? See observations.
1876, Jan. 4. (671) or (676) > 575 almost = 671 > 622? [or 625] > 589 > 567.
1876, Jan. 4. 612 = 618 = (676), 581 and R. 56 both seen; also 636, not (654).
1876, Jan. 4. 709 rather fainter than usual. Lassell's *b* not seen.
1876, Mar. 6. (575) > 589 > (567), 622. See observations.
1876, April 1. 709 is a little harder to see than the 5th star of the trapezium. [Query, 6th star? it is probably the 6th star.]
1876, April 1. 709 = 671 or 647 about. It requires attention to see it.
1876, Nov. 5. 675 visible. (671) > 676; 636 visible but not (654).
1876, Dec. 5. 647 > (671), (575).
1876, Dec. 5. 681 > (676) > (651); not much difference in these.
1876, Dec. 5. 709 = 663 about.
1876, Dec. 31. 709 < 657, 657 = 652 about.
1876, Dec. 31. (671) > 676, (575) = (589).
1876, Dec. 31. 647 and 671 > (575) and (589) although 647, 671, and (575) are not very unequal. 686 seen well.
1877, Jan. 2. 558 > 709 > 524, (575) = 671 = 647 nearly.
1877, Jan. 2. 654 and 675 have not been seen since Nov. 5.
1877, Jan. 10. (575) > (641) [just seen] > (567) [barely visible].
1877, Jan. 10. 567 = 16th mag., Argelander.
1877, Jan. 24. (642) = (654) each is just visible.

1877, Jan. 24. 709 > (641) > (676) > (567), 671 = 622 ? = (575) nearly.
1877, Jan. 24. 671 > (589), but not much. (675) not visible; 581 > 573.
1877, Feb. 3. (654) and (675) just barely visible.
1877, Feb. 6. 651 *very* faint. 675 seen.
1877, Dec. 7. (602) not seen, 589 > 567.
1877, Dec. 14. (602) not seen.
1878, Jan. 3, Jan. 5, Jan. 6. See observations with aperture of 3.50 inches.
1878, Jan. 5. 675 seen *following frons;* LASSELL'S *b* suspected; 612 > 618; 602 seen ?; 654 not seen; 567 = 16.3 *mag.;* 686 and 688 not visible. *h* not seen.
1878, Jan. 16. 10^h; 654 seen?; 675 just visible *following* the *frons;* 567 > 709; 567 just visible. 654 not visible at 11^h.
1878, Jan. 24. 709 not brighter than 666. 771 > 676.
1878, Jan. 28. 8^h 54^m; 654 just visible = 618. 676 not seen.
1878, Jan. 28. Position of 654, $\Delta\alpha = +8''.4$ (3), $\Delta\delta = +31''.7$ (4)
1878, Jan. 28. 709. See observations.
1878, Feb. 4. 675 seen about on edge of *frons* with 175. LASSELL'S *b* seen ?
1878, Feb. 4. 654 and 602 not seen; new star near 709? *a* not well seen.
1878, Mar. 9. 675, *b; a* seen, Professor HALL. (See observations.) *a* > 647.
1878, Dec. 6. LASSELL'S *b* suspected at 4^h 25^m sid. t.; not visible at 5^h.
1878, Dec. 6. 654 and 675 not to be seen.
1879, Jan. 10. No star inside the trapezium (HALL and HOLDEN); LASSELL'S *b* seen (HALL); also a star in $p = 45°$, $s = 48''$ from 708 (HALL).
1879, Mar. 1. 654 seen ($8^h.40^m$); *b* seen; *h* visible; 651 visible.
1879, Dec. 26. 612 and 618 seen; *h* seen like a nebulous mass and not like a star; a clear dark space between *h* and the following side of D.
1880, Jan. 3, 10^h; 675 seen just outside of *pons Schroeteri; b* seen; 612 > 618; 618 > 567; 567 = 636 very faint; 647 in a dark space; *h* visible, nebulous, and not stellar. 10^h 5^m, 654 just barely visible.

h 78 = 654.

1874, Jan. 16. 7^h–7^h 20^m; seen, but not after 7^h 30^m.
1874, Jan. 17. 9^h; not seen; (*a*) seen well; 636 seen faint.
1874, Jan. 23. 10^h; suspected, but too cloudy to verify.
1874, Jan. 24. 9^h 30^m; (*a*) seen; 654 not mentioned ? ?
1874, Jan. 25. Not seen; (*a*) seen.
1874, Feb. 5. 8^h; 675 seen; 654 not mentioned ? ?
1874, Feb. 14. Seen; (602) also seen.
1875, Oct. 27. 12^h–13^h; not seen.
1875, Oct. 29. 12^h–13^h; (654) = 651 nearly.
1875, Nov. 5. $11^h.5$–$12^h.5$; not seen, although no mention is made.
1875, Nov. 10. $11^h.7$–$13^h.3$; not seen although no mention is made.
1875, Nov. 11. $11^h.7$–$12^h.5$; (654) > 612 or 618, (654) = 622 > 621.
1875, Nov. 17. 12^h; not seen, although no mention is made.
1875, Nov. 24. $10^h.2$–$11^h.5$; not seen, although no mention is made.

1876, Jan. 3. $11^h.7$; not seen, although no mention is made.
1876, Jan. 4. $10^h.3$; not seen; 612, 618, and 636 seen.
1876, Jan. 10. $11^h.5$–12^h; it is doubtful whether 654 was looked for.
1876, Jan. 30. 10^h; not seen although no mention is made.
1876, Feb. 30. $7^h.5$–$8^h.5$; it is doubtful whether 654 was looked for.
1876, Mar. 6. 8^h–9^h; not seen, although no mention is made.
1876, Mar. 14. Not seen, although no mention is made.
1876, Mar. 22. $7^h.7$–8^h. It is doubtful if 654 was looked for.
1876, Nov. 5. 654 not visible, although no mention is made.
1876, Dec. 5. 654 not visible, although no mention is made.
1876, Dec. 31. 654 not visible, although no mention is made.
1877, Jan. 2. 654 not visible, although no mention is made.
1877, Jan. 10. 654 not visible, although no mention is made.
1877, Jan. 24. 654 = 642.
1877, Feb. 3. 654 just visible.
1877, Dec. 7. 654 not visible, although no mention is made.
1877, Dec. 14. 654 not visible, although no mention is made.
1878, Jan. 5. 654 not visible.
1878, Jan. 16. 10^h; 654 seen? not seen at 11^h.
1878, Jan. 24. 654 not visible, although no mention is made.
1878, Jan. 28. $8^h\ 54^m$; 654 = 618. $\Delta\alpha + 8''.4$ (3) $\Delta\delta = +31''.7$ (4)
1878, Feb. 4. 654 not seen.
1878, Dec. 6. 654 not seen.
1879, Jan. 10. 654 not seen, although no mention is made.
1879, Mar. 1. $8^h\ 40^m$; 654 seen.
1879, Dec. 26. $8^h\ 40^m$; 654 seen.
1880, Jan. 3. $10^h\ 5^m$; 654 just barely visible.

With regard to the small nebulous mass *h* (at first supposed to be a star, and so marked with a ? on my observing copy of the Index-Chart) I have to say that I am absolutely certain it did not exist in its present form from 1874, January, till 1878, January. Since this time it has been constantly seen, and is growing brighter.*

Also, it may be recorded here that the nucleus to *pons Schroeteri*, which others have called stellar, and which seemed so to me during the first of the work, is not so at present (1879–1880).

Cooper's star *c'*, near 516, I have never seen.

Lassell's double star *b*, near 685, certainly exists. It is very faint. I have never seen his star *g* (near 676), and I doubt its existence. These stars are laid down in his Plate III (and p. 56) of *Mem.* R. A. S., xxiii.

The others I identify as follows: $a = 675$; $k = 671$ and 676; $l = 647$ and 651; $i = 612$; $h = 618$; $c = 621$; $d = 625$; $e = 595$; $f = 608$.

With regard to 675, it seems to me that this extremely faint star is not proved to

* I have not been able to see this mass with the admirable 15½-inch Clark telescope of the Washburn Observatory, although I have repeatedly looked for it under the best conditions.

be variable. Atmospheric changes will account for all the variations I have observed. It is very close to the edge of the *regio Huygheniana,* perhaps even within it.

709 is certainly variable between the magnitudes of about 11.5 and 13.0 on G. P. BOND'S scale.

The few new stars I have myself added to those laid down by BOND, I regard as of no special importance. The list could be slightly extended if it were desirable, but not more than five or six stars above 16.0, ARGELANDER, exist in the limits of the Index-Chart which were not laid down by BOND.

The *minimum visibile* of BOND'S telescope is 15.1 magnitude (ARGELANDER'S scale extended), and for the Washington refractor it is $16^m.3$.

It seems to me that the fact that so few additional stars have been seen is of great importance in throwing light on the question of the depth of the stellar universe in this direction.

It will be interesting to know if other large telescopes (as Mr. COMMON'S new reflector) can detect any stars fainter than 675, my 1, 2, 3 (near 663) or LASSELL'S *b*. Lord ROSSE has, I believe, but one star (R. 56) on the Index-Chart, not laid down by BOND.

SYNOPSIS OF THE MORE IMPORTANT MEASURES.

From the preceding synopsis I collect the most important measures for purposes of comparison:

Frons.

Date.	p	No. of obs.	Remarks.
	°		
1875, Oct. 29	48.3	5	Length of *Frons*; 1878, January 16; $s = 193''.5$ (3).
Nov. 11	52.1	4	
1876, Nov. 22	49.3	4	
1878, Jan. 16	51.3	4	
Adopted	$p = 50.3$	(17)	

Occiput.

Date.	$p =$	No. of obs.	Remarks.
	°		
1875, Oct. 29	142.1	5	Perpendicular distance of *Occiput* from $\theta^1 = 105''.5$ (3)
Nov. 11	139.3	4	1877, Jan. 5.
1876, Mar. 6	142.7	4	
1877, Nov. 22	[136.6]	(4)	These two measures cut off Y altogether and give $p =$
1877, Jan. 5	[135.5]	(3)	136°.1 (7).
1878, Jan. 16	140.1	3	
Adopted	$p = 141.1$	(16)	

γ (*Sinus Gentilii*).

1876, Feb.? *North* end of Sinus, $\Delta\delta = -66.7$ (1)
1877, Feb. 7. *North* end of Sinus, $\Delta\delta = -66.7$ (4)
1878, Mar. 5. See observations, $\Delta\delta = -58.3$ (3)
1878, Mar. 5. See observations, $\Delta\delta = -63.3$ (3)
Adopted $\Delta\delta$ north end of *Sinus*, $= -66.7$ (5)

δ.

1876, Feb.? *North* end of *δ*, $\Delta\delta = -102.6$ (1)
1878, Mar. 5. *North* end of *δ*, $\Delta\delta = -99.2$ (3)

Adopted, $\Delta\delta = -100.9$ (4)

J and B.

Date.	$p =$	No.	Remarks.
	°		
1875, Oct. 29	7.7	3	Angle of *preceding* edges.
1876, Nov. 27	[5.1]	1	Omitted; the first depending only on 1 observation; the second is doubtful. See observations.
1876, Dec. 19	[12.2::]	3	
1878, Jan. 16	7.7	3	
Adopted	$p = 7.7$	(6)	

B.

1877, Dec. 12. Tangent to the *north* side of the curve in which B joins A, $\Delta\delta = +30''.5$ (4)

W^1 (*center*).

Date.	$\Delta\alpha$	No.	$\Delta\delta$	No.	
	″		″		
1875, Nov. 17	− 37.0:	1			
1876, Mar. 14	− 43.2	1			$\Delta\alpha$ *p* edge = − 57″.3 (1)
1877, Nov. 20	. .	.	. .	.	$\Delta\alpha$ *f* edge = − 29″.1 (1)
1877, Dec. 7	. .	.	+ 68.8	4	Wt. = 1.
1878, Jan. 23	. .	.	+ 67.7	3	Wt. = 2.
1878, Mar. 20	− 47.4::	2	+ 68.0	7	Wt. = 2.
1878, Dec. 6	− 48.2*	4	. .	.	The distance from the center of W^1 to 685 is about equal to the distance 635–669.
Adopted	− 45.0:	(8)	+ 68.2	(14)	* Double weight.

The distance from the center of W^1 to 684 is about equal to the distance 635–669.

From the shape of W_1 the $\Delta\alpha$ of the *center* is necessarily doubtful; it is not so with the $\Delta\delta$.

J.

1878, Mar. 20. $\Delta\alpha$ of the point D of LIAPONOFF = *preceding* point of J, 97″.3.

A.

Date.	$\Delta\delta$	No.	Remarks.
	″		
1876, Feb. ?	− 31.8	1	$\Delta\delta$ *south* end of A near 622.
1877, Dec. 7	− 31.9	2	
Dec. 12	− 31.2	5	
Adopted	− 31.6	(8)	

I.

1876, Mar. 14	The rounded apex (*south* point) is bisected in $\Delta\alpha = -29.''1$.	
1878, Jan. 23	*s. f.* corner, $\Delta\delta = -95.''8$ (1)	Adopted $\Delta\delta = -96.''7$ (2)
1878, Mar. 5	*s. f.* corner, $\Delta\delta = -97.''6$ (1)	
1878, Jan. 28	corner near [A_1], $\Delta\delta = -77.''4$ (1)	Adopted $\Delta\delta = -79.''3$ (3)
1878, Mar. 5	corner near [A_1], $\Delta\delta = -81.''2$ (2)	
1878, Dec. 6	corner near [A_1], $\Delta\alpha = -62.''8$ (4)	

L (*north end*).

Date.	$\Delta\delta$	No.	Remarks.
	″		
1876, Feb. ?	− 25.6	1	On same parallel as 671.
1877, Dec. 12	− 25.4	4	Near parallel of 617 and 622. (See observations.)
Adopted $\Delta\delta$ =	− 25.5	(5)	(See observations.)

E.

Date.	South point. $\Delta\delta$	No.	North point. $\Delta\delta$	No.	Apex. $\Delta\alpha$	No.
	″		″		″	
1875, Nov. 10	− 147.6	3	− 101.7	5	. .	.
Nov. 17	. .	.	. .	.	0.0	.
1876, Feb. ?	− 144.0	3	− 102.6	1	. .	.
Mar. 14	. .	.	. .	.	5.3*	1
1877, Feb. 6	. .	.	. .	.	+ 2″, + 3″ (est.)	.
Dec. 7	− 143.5	4	. .	.	. .	.
Dec. 7	− 131.4†	1	. .	.	. .	.
Dec. 12‡	− 155.6§	2	. .	. .	. .	.
1878, Jan. 28	− 147.2	3	. .	.	. .	.
1879, Jan. 20	. .	.	− 96.7	2	. .	.
Adopted $\Delta\delta$ =	− 144.6	(16)	− 100.3	(8)	From + 0″ to + 1″ (est.)	.

* Poor observations.

† This is the extreme point towards the *north* which could be taken as the vertex.

§ This is the extreme limit of E towards the south. The mean of these is about the true $\Delta\delta$.

Dark channel between I and (X and G).

1876, Mar. 6. $p = 25°.6$ (3)

Dark channel between I and E.

Date.	p.	No.	Remarks.
	°		
1876, Dec. 5	42.6	4	Uncertain.
Dec. 31	[50±]	est.	
1878, Jan. 16	46.0	1	
Adopted	$p = 44.0$	(5)	

Dark channel between E and F.

Date.	p	No.	Remarks.
	°		
1875, Nov. 24	$p = 139.6$	2	It passes through the star 589, 1875, Nov. 24.
1878, Jan. 16	$p = 142.1$	3	
Adopted	$p = 140.9$	(5)	

Dark channel between F and (G and H).

Its prolongation is in the line 685–708, from many measures.

V.

Extreme *north* point in same $\Delta\delta$ as 612; *i. e.*, $\Delta\delta = +24''.6$; $\Delta\delta$ *south* edge of *n.* edge of M, $\Delta\delta = -22''.7$ (3); good.

F.

Date.	Brightest part.				North point.		South point.		Middle point.	
	$\Delta\alpha$	No.	$\Delta\delta$	No.	$\Delta\delta$	No.	$\Delta\delta$	No.	$\Delta\alpha$	No.
	″		″		′		″		″	
1875, Nov. 10	. .	.	− 101.0	3	. .	.	. .	.	. .	.
1876, Feb. ?	. .	.	. .	.	. .	.	− 122.3	1	. .	.
Mar. 14	. .	.	. .	.	. .	.	. .	.	+ 28.8	1
1877, Feb. 7	. .	.	− 102.1	4	. .	.	. .	.	. .	.
Dec. 12	. .	.	. .	.	− 94.9	2	− 117.3*	2	. .	.
1878, Jan. 28	+26.8	2	− 102.9	4	. .	.	. .	.	. .	.
Feb. 20	. .	.	. .	.	. .	.	− 120.6	1	. .	.
Mar. 5	. .	.	− 101.2	2	. .	.	[−113.5]†	.	. .	.
1879, Jan. 20	. .	.	− 102.8	4	. .	.	. .	.	. .	.
Adopted	+26.8	(2)	− 102.0	(17)	− 94.9	(2)	− 120.1	(4)	+ 28.8	(1)

* In *Frons.* † This is the *s. p.* corner; see observations.

1876, Mar. 14. Tangent to *preceding* sides of F and G, $\Delta\alpha = +1''.2$.
1877, Feb. 6. Point where *s. p.* edge intersects *frons*, $\Delta\delta = -24''.6$ (3)
1878, Feb. 20. The bright part of F first begins to be fainter at $\Delta\delta = -114.''9$.
1879, Jan. 20. The north point of X (F) is further north than $\Delta\delta = -97''$.

G.

Date.	Brightest part.				Middle point.				Remarks.
	$\Delta\alpha$	No.	$\Delta\delta$	No.	$\Delta\alpha$	No.	$\Delta\delta$	No.	
	′		″		″		″		
1875, Nov. 10	. .	.	−64.5	2	. .	.	. .	.	Tangent to *following* side of G, 1876, March 14; $\Delta\alpha = +28''.8$.
1876, Feb. ?	. .	.	−69.6	1	. .	.	−69.6	1	Tangent to *preceding* side of G, 1876, Mar., 14; $\Delta\alpha = +1''.2$; 1877, Feb. 6, about 0″ ±.
Mar. 14	. .	.	. .	.	+14.2				
Dec. 5	. .	.	−65.5	5					
1877, Feb. 3	. .	.	. .	.	+13.9:	3			
Feb. 7	. .	.	. .	.	. .	.	−66.2	4	South point; $\Delta\delta = -75''.7$ (4); 1878, Jan. 28.
Nov. 20	. .	.	−60.9	3	. .	.	. .	.	1878, March 5. All of G is *north* of $\Delta\delta = -77''$.
1878. Jan. 28	+15.9	3	−66.5	3					
1879, Jan. 20	. .	.	−64.9	(4)					
Adopted	+15.9	(3)	−65.3	(18)	+14.1	(3)	−67.9	(5)	

H.

1877, Dec. 12. $\Delta\delta$ of south end of H [in *frons*] $= -94''.2$: (1)
1878, Mar. 5. $\Delta\delta$ of south edge of H along channel $= -77.5$ (3)
} these not comparable.

D.

Date.	n. f. point.		Following edge.	
	$\Delta\delta$	No.	$\Delta\alpha$	No.
	″		″	
1875, Nov. 10	+77.7	3	. .	.
1876, Mar. 14	. .	.	+28.8	1
Dec. 19	. .	.	+28.8	.
1877, Feb. 3	. .	.	+30.5	3
Nov. 20	81::	.	. .	.
1878, Jan. 28	. .	.	+29.6	3
Dec. 6	. .	.	+29.3	4
Adopted . .	+78	(3)	+29.4	(11)

Pons Schroeteri and g_0.

Date.	$\Delta\alpha$	g_0 No.	$\Delta\delta$	No.	p	No.	Remarks.
	″		″		°		
1875, Nov. 10	. .	.	+ 39.5	5	. .	.	
Nov. 11	. .	.	. .	.	170.7	3	
Nov. 17	+ 79.3	4	. .	.	175 ± est.	.	
1876, Feb. ?	. .	.	+ 41.9	1	. .	.	See observations 1876, Feb. 2.
Mar. 14	+ 76.8	(1)					
Dec. 19	. .	.	. .	.	171.2	3	
1877, Jan. 5	. .	.	. .	.	165.8::	2	
Jan. 10	. .	.	. .	.	175.8	3	(Uncertain.)
Feb. 3	+ 77.4	3					
Nov. 20	. .	.	+ 41.6	(2)			
Dec. 12	. .	.	+ 40.3	(4)			
1878, Jan. 16	. .	.	. .	.	167.5:	3	
Jan. 28	+ 76.6	3					
Dec. 6	+ 76.7						
Adopted .	+ 77.4	(15)	+ 40.8	(12)	170.2	(14)	

M.

1878, Mar. 5. *North* edge, $\Delta\delta = -22''.7$ (3)

σ (*Spitze*).

Date.	Spitze. $\Delta\alpha$	No.	$\Delta\delta$	No.	Remarks.
	″		″		
1875, Nov. 10	. .	.	+ 78.4	4	1875, Nov. 11, *south* shore σ; $p = 89°.7$ (4)
Nov. 17	+ 169.9*	3	. .	.	1877, Jan. 30. *south* shore σ; through tourmalines to compare with Le Gentil $p = 44°$ (1)
1877, Feb. 3	+ 165.1	3	. .	.	1876, Feb.? south shore σ near *pons S.* $\Delta\delta = +83''.7$.
Feb. 7	. .	.	+ 75.7	4	*South* edge of point.
Dec. 12	. .	.	+ 79.6	4	See observations.
1878, Jan. 23	. .	.	[+ 68::	1]	*South* edge.
Jan. 28	+ 162.8	3	+ 80.7	4	
Dec. 6	+ 161.3	4			
Adopted .	+ 164.8	(13)	+ 78.6	(16)	*Extreme point.

Q, P, R.

1875, Nov. 11. The line of their *n. f.* sides passes through 654 and 624 nearly. Same date $p = 105°.8$ (4); this cuts off some of R.

N.

1878, Jan. 28. *South* point in *frons*, $\Delta\delta = -74''.2$ (2)
1878, Mar. 5. *South* point in *frons*, $\Delta\delta = -75''.0$ (1)

Q.

Date.	Following point.				Remarks.
	$\Delta\alpha$	No.	$\Delta\delta$	No.	
	″		″		
1875, Nov. . 17	+ 150.6	1	. .	.	Masses inside of Q are called *n* and *q*.
1876, Feb. ?	. .	.	— 25.6	1	*North* end of *n*; $\Delta\delta = -35''.5$ (1)
1877, Feb. 3	+ 147.3	3	. .	.	Middle of *q*; $\Delta\delta = -23''.4$ (1)
Feb. 7	. .	.	— 31.6	4	
Nov. 20	. .	.	— 25.7	3	
Dec. 12	. .	.	— 29.9	3	Bisecting the following point $\Delta\delta = -29''.9$ (3)
1878, Jan. 28	+ 152.6	4			
Adopted .	+ 150.2	(8)	— 28.2	(11)	

oπ.

1876, Feb.? The parallel $\Delta\delta = +60''$ passes through the center line of the *west* half of *o*π.

Sinus magnus.

1876, Nov. 11. Best tangent to *south* shore, $p = 105°.6$ (4)

Although a comparison between the measures of LIAPONOFF and myself is no, very valuable on account of the different brightness of the nebula to the two telescopes, I have added a short catalogue of our measures on the same points. Other comparisons have been given in the preceding sections.

Comparison of positions of nebulous masses determined at Kasan and Washington.

Name of mass.	Kasan.		Washington.		$A_w - A.$	$D_w - D.$	Remarks.
	A.	D.	A_w.	D_w.			
	″	″	″	″	″	″	
n. f. pt. J=[D]	— 94.3	— 39.9	— 97.3	. .	— 3.0	. .	
[A_1]	— 61.5	— 76.4	— 62.8	— 79.3	+ 1.3	— 2.9	
[T]	— 35.2	+ 22.0	. .	+ 24.0	. .	+ 2.0	
[A]	— 4.4	— 138.0	+0″	+1″ — 144.6	+ 3.9	— 6.6	
[b_0]	+ 18.5	— 63.3	+ 15.9	— 65.3	— 2.6	— 2.0	Brightest point.
[F]	+ 26.5	+ 69.6	+ 29.4	. .	+ 2.9	. .	
[a_0]	+ 28.6	— 97.4	+ 26.8	— 102.0	— 1.8	— 4.6	Brightest part.
[g_0]	+ 71.9	+ 42.3	+ 77.4	+ 40.8	+ 5.5	— 1.5	
[K]	+ 143.6	+ 71.5	+ 164.8	+ 78.6	+ 21.2	+ 7.1	
[B]	+ 146.5	— 22.0	+ 150.2	— 28.2	+ 3.7	— 6.2	

NOTE.—The letters in [ ] give LIAPONOFF's nomenclature.

Reduction of Photometric Observations made at Washington.

§ 1. *Results from eye observations of order of brightness.*

In making the eye estimates of the order of brightness of the various bright masses of the *Huyghenian region*, it was the object simply to give the *order*, without attempting to assign how much brighter one was than another. Again, as these masses have a sensible magnitude, it was impossible to estimate the effect of the mass as a whole, and to compare it with the total effect of another mass, perhaps three minutes of arc distant. Hence, these estimates must be understood to refer to the brightest parts only of each mass, and they give the facts as faithfully as was possible. "F is brighter than H," for example, means that after carefully examining these two masses I believed that there was a considerable portion of the surface of F which was brighter than any considerable portion of the surface of H. Again, 1876, January 4, I estimated the order of brightness as follows:

1. A. 2. D. 3. G, H, N. 4. F. 5. I, Q. 6. E. The numbers 1 . . . . . 6 simply indicate the order, and it must not be supposed that the ratio of A to D is the same as that of D to G, or that the steps are equal.

The difficulty in obtaining the relative brightness of the various masses from the observed sequences follows chiefly from the want of a numerical ratio between the different steps, and also from the fact that the possibility remains that different portions of a certain mass are taken at different times, as representing the mass. These two objections are inseparable from the method, and perfectly definite results can only be obtained from some form of photometer. If a drawing could be made each night which would represent the various portions of the nebula as they appeared on that night, and if such drawings could be continued without bias or prejudice from night to night, then it is possible that increased accuracy might result, as something like a numerical ratio of the brilliancy of the various masses might be obtained. But this process is impracticable, *first*, because the nebula is too large to sketch carefully in one night; and *secondly*, because after becoming familiar with its parts it is extremely difficult to avoid (in drawings) inserting the results of past observations instead of present appearances.

The published drawings of various astronomers, in so far as they relate to the order of brightness of the various masses, are, in general, but imperfect evidence. The final drawing, which has probably required weeks to make, may be said in general to give the average *forms* of masses and parts which are well seen, with accuracy, and the *forms* of the fainter masses will also approach to correctness. With the brightness of these masses it is different; the completed drawing gives the average appearance to the observer so far as his artistic skill enables him to render it, together with a number of imperfect or even false representations due to the imperfections of the telescope, etc., the state of the atmosphere, the bias or prejudice of the observer (which mostly is due to his good remembrance of previous views of the object in question), and above all to the shortcomings of the engraver.

In Part III, I have more particularly considered the value of the evidence which may be had from drawings, and I have suggested the use of a terrestrial eye-piece as a check upon this kind of work.

In the sequences of brightness here given, I endeavored to avoid, as far as possible, all bias or prejudice by not collecting and examining the results of observations until some two years had elapsed since beginning the work.

The examination of the sequences that follow raised a strong suspicion of variability among some of the bright masses of the *Huygbenian region*, and to get further light upon this the photometric observations of §2 were made. The eye observations, however, are independent and may be considered by themselves.

Table showing order of brightness of the various masses (by eye estimates).

Date.	Decimal of a year.	1	2	3	4	5	6	7	8	9	Remarks.
1875.											
Oct. 27	.82	A	D	F = G	I	N = Q	H = E	.	.	.	See observations.
29	.83	A	D	F and G	I	N and Q	E				
29	.83	A	F, G, D	I	H	N	Q = E	.	.	.	Perhaps better than last preceding.
Nov. 5	.85	A	D	F and G	H and I	N, Q	E	.	.	.	Only brightest parts of N and Q included.
10	.86	A	D	F, G	I, H	N, Q	E	.	.	.	∴ G = F.
10	.86	A	D	G, F	I, H	N, Q	E	.	.	.	
17	.88	A	D	G	F	I = H	N	Q	E		
24	.90	A	D	G = H	F	N	Q	I	E & J		
1876.											
Jan. 3	.01	A	D	G, H	N, Q, F, I	E					
4	.01	A	D	G, H, N	F	I, Q	E	.	.	.	I = Q nearly.
10	.03	A	D	G, H, N, Q	F	I, E	. .	.	.	.	Poor obs'n; moonlight.
30	.08	.	.	. .	.	.	. .	.	.	..	E is the faintest mass of the principal ones.
Feb. ?	.09	A	D	G, H, F	N	I, Q	E	.	.	.	5. I, Q *or* Q, I.
Mar. 6	.18	[A	D	F, G, H	N	I	Q, E]	.	.	.	"Not very satisfactory"; rejected.
6	.18	A	D	F	G, I	H, E	N, Q	.	.	.	This is better.
22	.22	A	D	F	G, I, H	N, Q, E	. .	.	.	.	Approximately.
Nov. 11	.86	.	.	H, G, F*	.	I	E	.	.	.	*About equal.
Dec. 13	.95	A	D	G, H, F	N, I, E	.	.	.	.	.	"Mr. H. S. Pritchett thinks D > A a little."
19	.97	D = R	A	I	H, F	B	.	.	.	.	Mr. Pritchett.
19	.97	A	D	F	Q	N	G	H	I	E	B = F = W; γ = o; γ = σ near K.
1877.											
Jan. 2	.00	A	D	G, F	H, I, N	E	[M	σ	μ]	.	J < E, J > σ
1878.											
Jan. 28	.08	.	.	. .	. .	.	.	.	.	.	G > F.

For observations of relative brightness by means of tourmaline plates see observations of 1877, Jan. 24, Jan. 30, and Feb. 3.

1878, Jan. 23. F, G, H, and two surfaces in P? and Q are brighter than I or E.

1878, Dec. 11. F = G = H; perhaps F is a little brighter than G or H, but this is doubtful.

1879, Dec. 26. 1. A, D. 2. G, H. F, I, Q, E, G, and H notably brighter than F.

Discussion of the Results from the preceding Table.

It will be convenient to consider the masses in pairs, and the following nomenclature is used. G = F means that these masses were considered equal. G > F that one was decidedly brighter than the other, and that they are in different compartments of the table. $G^1 = F$ means that they are in the same compartment of the table, but that G is written first and was brighter, though not greatly so. This nomenclature was used during the observations themselves.

A and D.

From my own observations from 1875 to 1877, January, the result is that A > D. By this is meant that the bright strip on the *following* edge of A is brighter than any considerable part of D. It will be noticed that Mr. PRITCHETT makes D > A. There is little doubt but that this is erroneous.

F and G.

The following are the separate inequalities, the last line showing the *means:*

Date: Ratio.	Date: Ratio.	Date: Ratio.	Date: Ratio.	Date: Ratio.	Date: Ratio.	Date: Ratio.
1875.82, F=G	1875.88, G > F	1876.09, $G^1 = F$	1876.18, F > G	1876.86, $G^1 = F$	1876.97, F > G	1877.00, $G^1 = F$
75.83, F=G	75.90, G > F	*1876.18, $F^1 = G$	1876.22, F > G	1876.95. $G^1 = F$	. . . .	1878.08, G > F
75.85, F=G	76.01, G > F	*Unsatisfactory.				
1875.86, F=G	76.01, G > F					
	1876.03, G > F					
1875.84, F=G	1875.96, G > F	1876.09. $G^1 = F$	1876.20, F > G	1876.91, $G^1 = F$	1876.97, F > G	1877.00, $G^1 = F$ 1878.08, G > F

Following the last line of this table, it appears that 1875.84 F and G were equal; G was brighter than F a little later, then passed through equality with F to G < F. A similar consistent fluctuation is shown from 1876.91 to 1878.08.

It should be noted that in the above table there are no cases like this: F > G, F = G, and then F > G; and, again, there are no cases like F > G, and then G > F without passing through F = G. These results, taken alone, *appear* to indicate fluctuations in the relative brilliancy of F and G. Whether these are irregular or periodic is not to be decided by observations of this nature, but it will require a careful and long-continued series of photometric experiments conducted with every possible precaution against systematic errors and against preconceived opinions and bias.

I and H.

1875.82, I > H 1875.83, I > H	1875.85, H = I 1875.86. I^1 = H 1875.88, I = H	1875.90, H > I 1876.01, H > I 1876.01, H > I 1876.03, H > I 1876.09, H > I	1876.18, I > H
1875.83, I > H	1875.86, H = I	1876.01, H > I	1876.18, I > H
1876.22, I^1 = H	1876.86, H > I 1876.95, H > I	1876.97, I > H 1876.97, H > I	1877.00, H^1 = I
1876.22, I^1 = H	1876.91, H > I	18.6.97, H = I?	1877.00, H^1 = I

This table is not so clear as the preceding one. The comparison was more difficult. It seems to me to indicate changes, however.

N and Q.

1875.82, N = Q 1875.83, N = Q	1875.83, N > Q	1875.85, N^1 = Q 1875.86, N^1 = Q 1875.86, N^1 = Q	1875.88, N > Q 1875.90, N > Q .	1876.01, N^1 = Q
1875.83, N = Q	1875.83, N > Q	1875.86, N^1 = Q	1875.89, N > Q	1876.01, N^1 = Q
1876.01, N > Q	1876.03, N^1 = Q	1876.09, N > Q	1876.18, N^1 = Q 1876.22, N^1 = Q	1876.97, Q > N
1876.01, N > Q	1876.03, N^1 = Q	1876.09, N > Q	1876.20, N^1 = Q	1876.97, Q > N

As the difference between Q and N in any event is but small, the above comparisons, taken alone, indicate that N = Q, and that the variations of the above table are accidental.

I and Q.

Date: Ratio.	Date: Ratio.	Date: Ratio.	Date: Ratio.
1875.82, I > Q 1875.83, I > Q 1875.83, I > Q 1875.85, I > Q 1875.86, I > Q 1875.86, I > Q 1875.88, I > Q	1875.90, I < Q 1876.01, I = Q 1876.03, I < Q 1876.09, I = Q	1876.18, I > Q 1876.22, I > Q	1876.97, I < Q
1875.85, I > Q	1876.0 I? = Q?	1876.20, I > Q	1876.97, I < Q

It is possible, almost probable, that variations in brightness are here indicated, taking these observations alone.

I and N.

Date: Ratio.	Date: Ratio.	Date: Ratio.	Date: Ratio.	Date: Ratio.
1875.82, I > N	1874.90, I < N	1876.18, I > N	1876.95, I < N	
1875.83, I > N	1876.01, I = N	1876.22, I > N	1876.97, I < N	
1875.83, I > N	1876.01, I < N	. . . . .	1877.00, I = N	
1875.85, I > N	. . . . .			
1875.86, I > N	1876.03, I < N			
1875.86, I > N	1876.09, I < N			
1875.88, I > N				
1875.85, I > N	1876.01, I < N	1876.20, I > N	1876.96, I < N	1877.00, I = N?

Taking the tables N and Q, I and Q, and I and N together, it would seem pretty certainly that Q = N, and that variations in I place it sometimes brighter and sometimes fainter than Q and N. These *may* vary also, but if they do they vary together.

E.

E is pretty uniformly the faintest of the principal masses (A, D, E, F, G, H, I, N, and Q). It is to be noted that the position thus assigned to E in order of brightness is different from that of the older drawings, 1837–67. My observations since 1878.0 indicate that E was brighter than before this date.

E and J.

1875.90. $E^1 = J$; 1877.00, J < E.

σ.

1876.97. $Y = \sigma$, and $Y = o$. ∴ $Y = O = \sigma$.
1877.00. $E > J > \sigma$, and $M^1 = \sigma$.

μ.

1877.00. $\sigma^1 = \mu$.

Probably the foregoing observations are not in themselves sufficiently exact to merit any better reduction. Without giving them any great weight they still seem to show that several of the masses of the central region are subject to variations of brightness. The periods of these and the amount of change cannot be deduced. I should add to the above recorded observations my strong impression that in the years 1878–1879 the mass D was fainter relatively than formerly, and the mass E brighter.

§ 2. Observations with Hastings's Photometer.

In view of the foregoing results, I requested Dr. Charles S. Hastings, of the Johns Hopkins University, to devise for me some form of photometer for measuring the suspected changes, which he kindly did. The conditions were somewhat restricted, as the filar micrometer could not be removed to insert a photometer without changing the zero of position, which was undesirable, and therefore some form had to be adopted which could be inserted beyond the micrometer box.

The form finally chosen was as follows (see Fig. 39, which is drawn to half the natural size):

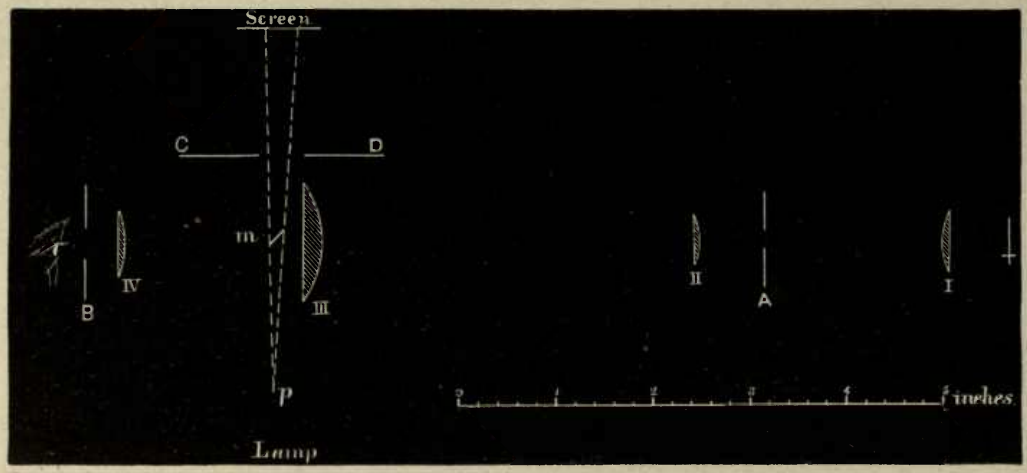

FIG. 39. Dr. C. H. HASTINGS'S nebula photometer.

A terrestrial eye-piece I, II, III, IV was screwed in the micrometer box in the same thread as the ordinary micrometer eye-piece, which was removed. The principal focus of the objective is at the ⊥ in the figure. A and B are diaphragms. C D is the side of the eye-piece tube. In the focus of IV was placed a silver mirror, *m*, which was illuminated by a movable *lamp*. *m* was semi-circular in shape, and about 15″ on the straight edge (diameter). A *screen* was fixed in position outside the tube C D. This screen was covered with a bit of paper cut from BOND'S engraving of the nebula (see frontispiece). It was illuminated by the (movable) lamp. In looking into the photometer a semi-circle (*m*) of precisely the same color as the nebula, was seen illuminated by the lamp. This semi-circle was projected upon the nebula, and to measure the brightness of any part, as E, for example, the *m* was placed next to the brightest part of E, and the brightness of *m* changed by moving the lamp until it matched E or until the line of separation vanished.

This was done sometimes by increasing, sometimes by diminishing the brightness of *m*. The position of the lamp relative to the screen was read off on the graduated rod that bore it. These are the essential features of the apparatus. The observations were never easy. The chief difficulties with this apparatus were *first*, that the illumination from the small lamp was never constant, and I had continually to return to the mass D, which I used as a zero mass; and *second*, there was a difficulty in being sure of the exact portion of the surface of D used as a zero. That is, there was a possibility of using different parts of D for zeros at different hour-angles. Both these difficulties were purely mechanical and could easily be overcome, but it was impracticable to do this under the actual circumstances. The results are somewhat less consistent on these accounts, but after all, systematic errors are more to be feared here than comparatively small accidental ones.

If d is the reading of the graduated rod for the zero mass D, and if e is the reading for any other mass, as E, then

$$\text{brightness of E; brightness of D} = \frac{1}{e^2} : \frac{1}{d^2} \text{ or E} = \text{D.} \frac{d^2}{e^2}.$$

Following I give the reductions of all the photometer measures made.

The reductions previously given in the observations of each night were preliminary, though only slightly different from the ones here set down.

Collection of single results of photometer observations.

Mass. / Date.	A.	F.	G.	[G].	H.	I.	E.	Q.	μ.
1878.									
Jan. 7	1.42* 1.35*	. .	. .	. .	. .	. .	. .	. .	. .
12	. .	. .	. .	. .	. .	. .	0.90†	. .	. .
26	1.22‡	1.12	1.08	. .	. .	. .	0.84	. .	0.43
26	1.12‡	1.03	1.00	. .	. .	. .	0.77	. .	0.39
Feb. 4	. .	. .	1.09	. .	. .	. .	[0.55] see obs.	. .	. .
5	1.71	1.05	1.14	. .	. .	0.75	0.83	0.83	. .
5	. .	1.12	1.21	. .	. .	0.79	0.88	0.88	. .
5	. .	. .	0.94	. .	. .	. .	0.74	. .	. .
								[D]†	
26	. .	0.91	1.26	1.02	1.17	0.99	0.92	1.30	. .
26	. .	0.82	1.14	0.92	1.06	0.89	0.83	1.17	. .
26	. .	. .	. .	. .	. .	. .	. .	. .	. .
26	(By eye)	F > G	G > H	. .	. .	I > E	. .	. .	. .
28	(By eye)	A > D	F > G	G = H ; I > E	. .	. .	. .	. .	. .
28	. .	1.23	. .	. .	1.01	0.91	0.83	1.18	. .
Mar. 9	. .	[1.15]	1.04	[0.82]§	. .	1.05	0.78	. .	. .
9	. .	1.90	0.90	[0.71]	. .	0.91	0.67	. .	. .
9	. .	[0.84] part.	. .	. .	. .	0.99	0.91	. .	. .
9	. .	[0.73] part.	. .	. .	. .	0.86	0.79	. .	. .
1879.									
Feb. 23	. .	. .	. .	. .	. .	. .	0.98	. .	. .
Mar. 7	2.25:: see obs.	1.27	. .	. .	. .	. .	0.81	. .	. .
1880.									
Jan. 3	. .	. .	. .	. .	. .	[I = 0.91 E] [I = 0.82 E]	. .	. .	. .
3	. .	. .	1.18	. .	1.07	0.88	1.07	. .	. .
10	. .	1.10	1.23	. .	. .	. .	0.73	. .	. .
10	. .	1.01	1.07	. .	. .	. .	0.62	. .	. .
10	. .	0.97	. .	. .	. .	. .	. .	. .	. .
13	. .	1.52	1.17	. .	. .	0.93	1.06	. .	. .
14	. .	1.23	1.42	. .	0.90	1.19	0.87	. .	. .
14	. .	. .	. .	. .	. .	. .	1.08	. .	. .
16	. .	1.28	1.31	. .	. .	1.04	1.12	. .	. .
16	. .	. .	. .	. .	. .	1.14	1.04	. .	. .

* Preliminary observations.

† The *brightest* part of D compared with the standard part of D.

‡ This is not the same part of A as Jan. 7. [G] is a part of G defined in obs. Feb. 26, *q. v.*; [D] is the brightest part of D, not the part used as the standard of comparison.

§ Not the same part as Feb. 26.

In the preceding table I have given the separate results of each set on each mass. The numbers in the table are those by which the brightness of the standard part of the mass D must be multiplied to give the brightness of the mass measured. The sources of error were two: *First*, all masses were compared with a part of D, and it was intended to compare them with the same part of D; this may not have always been done. *Second*, the lamp did not maintain a constant brilliancy, and in spite of precautions taken to eliminate the bad effects of this change, errors still remain due to this cause.

Taking the difference between the greatest and least readings on each mass for each night when more than one determination was made, we have the following table. The range here given is in per cent. of relative brightness.

	Mean.
On the mass A; range = .07, 10 - - - - - -	0.09
F; .09, .07, .09, .15, .11, .13 - -	0.11
G; .08, .27, .12, .14, .16 - - - -	0.15
[G]; .10, .11 - - - - - - - -	0.11
H; .11 - - - - - - - - - - -	0.11
I; .04, .10, .19, .09, .10 - - - -	0.10
E; .07, 14, .09, .24, .11, .21, .08 -	0.13
Q; .05 - - - - - - - - - -	0.05
μ; .04 - - - - - - - - - -	0.04
[D]; .13 - - - - - - - - - -	0.13
Mean - -	0.10

The probable accidental error is thus much below 10 per cent.

It should also be noticed that for every night where there is more than one determination for the same mass, and where the second of such ratios is smaller than the first, it is the same for every other mass on that night. This shows that much of the error is in assuming the zero for the lamp, but that the *relative* brightness of two masses F and G, for example, is still to be depended on. Having regard to what goes before, I conclude that the mass A is certainly brighter than D, though, probably, not very much brighter.

F and G.

Collecting the results of these measures, we see that

1878, Jan. 26. F > G
1878, Feb. 5. G > F (probably).
1878, Feb. 26. G > F (this differs from the eye observation of this date).
1878, Mar. 9. F > G
1880, Jan. 10. G > F
1880, Jan. 13. F > G
1880, Jan. 14. G > F
1880, Jan. 16. G > F

It seems to me clear, after making allowance for all sources of error, that F and G change in relative brightness, as was suggested by eye observations alone.

G and H.

1878, Feb. 26. G > H (this agrees with eye estimate).
1878, Feb. 28. G = H (by eye estimate).
1880, Jan. 3. G > H
1880, Jan. 14. G > H
From these I conclude G to be a brighter mass than H.

H, I, and E.

1878, Feb. 5. ——— ——— I < E.
1878, Feb. 26. H > I, H > E, I > E (also by eye).
1878, Feb. 28. H > I, H > E, I > E.
1880, Jan. 3. H > I, H = E, I < E.
1880, Jan. 14. H < I, H > E, I > E.

The observation of Jan. 3 gives H > I and H = E, therefore E > I, and in fact it was so observed. On other occasions I was certainly brighter than E, whence it is concluded that I and E vary in relative brightness, as do also H and I.

E.

In general the photometer results corroborate my strong impression previously and independently recorded, that E became brighter relative to D in the last years of observation. D has also grown fainter according to my eye observations, and the photometric observations I have made agree with this conclusion, since the brightness of all the masses relative to D is greater in 1880 than in 1878. The conclusions which I am disposed to draw from the above observations are these:

A has been throughout my observations the brightest mass of the *Huyghenian region*. E has grown brighter from 1874 to 1880, while D has grown fainter in the same time. The masses F, G, H, and I change in absolute brightness. Although at first sight it might seem that such observations as I have made should have yielded definite numerical results, yet, I think, that a consideration of the difficulties and uncertainties will excuse me from attempting to draw any more exact conclusions from this part of the work. I conceive that I have demonstrated the existence of certain changes of brightness, and I am disposed to leave, for the present, the question as to the exact amount of these, open.

It will be noticed that the results independently obtained from the eye observations of 1875–1878 and from the photometric observations of 1878–1880 agree.

Part III.—Summary of all the Observations (1656–1880) which have been previously given in detail.

In what follows I have collected all the observations which have been given in detail in the preceding pages, and have separated them into divisions. Each division treats of the observations which have been made on some separate mass or channel or point, and the various observations are arranged in chronological order under each head. In this way it will be easy to see if there are evidences of progressive and regular change in any of the masses considered. Irregular changes can hardly be detected in this (or any other) way, since the observations and drawings considered are the work of so many different observers so variously equipped and in so many different stations.

I desire to call attention to the way in which the following summary has been made. The evidence presented is derived from the recorded observations and from the drawings of all the observers since 1826. Blank forms were prepared, one for each mass, as A, E, etc., and on the edge the names of the various observers, with the dates of observation, were written.

As the various memoirs came into my hands I read them carefully and entered any important remarks under their appropriate headings. In this way these sheets were filled up in an irregular order (not chronologically), and my judgment was left entirely unbiassed. The drawings were treated in the same way. The original engravings, and in many cases the original pencil drawings, or photographs of them were consulted, and all the evidence I obtained from them was entered in its appropriate place. After the sheets were full or nearly so (in 1880) each sheet was considered by itself and my final conclusion reached. This conclusion can be tested by any one at a glance. The testing of the summary itself will require a reference to the original paper, which is not always easy. To facilitate this I have in many cases added here a reference to the page from which the statement was taken. I trust I have made it plain that not only was the summary made without any preconceived notions of what was to be expected, but that such ideas, even if present, could not have been recorded in these tables, owing to the way in which they were constructed.

The final discussion of these sheets was put off till the last moment, when all the evidence was in. With regard to the nature of the drawings themselves it may not be out of place to say a few words. I am acquainted with but one drawing of the nebula which is entirely above criticism, that of the late G. P. Bond. (See frontispiece.) He was himself a skilled artist, and he had been familiar with the nebula for fifteen or twenty years. He made scores of drawings in white and black and the reverse, in colors, etc. Each of these was revised and re-revised many times. The final drawing in water-color was copied by Mr. Watts, a skillful engraver, who himself was extremely familiar with the nebula from repeated views and studies of it through the Harvard refractor.

The revisions of the original plate lasted many months, and I have myself examined from fifteen to twenty *final* revises of the plate. Color, form, and relative brilliancy were all successively and exhaustively criticised, and Professor Bond expressed himself as fully satisfied with the plate in every essential feature.

Add to this, that with the exception of a few points, elsewhere considered, this engraving has been constantly satisfactory to me in my very frequent comparisons of it with the nebula even under the severest criticism which I could apply, and it is safe to say that this nebula *as it appears in a refractor* is satisfactorily represented.

The drawing (white on black) of Lord ROSSE appears to deserve almost equally high praise, but as I have never seen the nebula through a reflector, and as the pictorial effect of the nebula, as seen in Washington, is somewhat different from that presented by Lord ROSSE's large engraving, I cannot speak with proper certainty upon this point. *As a map of the nebula* the drawing of Lord ROSSE (black on white) is, as has often been said, almost perfect, but I presume that it was not intended in any way as a pictorial representation, but rather as a scheme for representing by conventional signs (as in topographical color-drawing) the features examined. As pictorial representations the original pastel drawings of M. TROUVELOT, with the Harvard College refractor and with that of the Naval Observatory, are extremely fine, but, as in these cases, sufficient time was not available for the study of the various objects they are lacking in minute accuracy of detail. Most other drawings of the *Orion* nebula, except those mentioned, fall into the class of maps, which give by conventional signs the features examined. The nature of these signs is not perfectly fixed, and has in each case to be determined from the drawing itself on the supposition that some features, at least, are *now* as they were at the time of the drawing.

Their examination is rendered more difficult by the shortcomings of the engraver or of the process of delineation adopted, and this is why the examination of so many original drawings has been made. I have expressed elsewhere my thanks to the numerous gentlemen who have aided me in obtaining access to the various originals, and particularly to Miss CAROLINE LASSELL, who has made for my use a fine *fac simile* drawing of the (unpublished) Malta drawing of 1864.

There is only one way, of which I am aware, for avoiding undue bias in the drawing of nebulæ, and that is in making one drawing in the ordinary way with an inverting eye-piece, and others through reflecting prisms, or erecting eye-pieces which will so alter the usual appearances, without changing the real brilliancy and shape, that an unbiased judgment can be made by the artist; I should rather say, from trials by myself, so that it is scarcely possible for him to have a hurtful bias. This method I confidently commend to those possessed of more artistic skill than myself. In my own case I am certain from repeated trials that a definite amount of time can be more advantageously expended in measures and verbal descriptions than in sketches, and this is why I have not attempted to add another drawing to the many excellent ones already available, but have confined myself to the outline Index-Map. Even this is by no means correct even as to form. The results of my work must be looked for in the preceding and following summaries of Washington observations.

LAMONT (*Ueber die Nebelflecken*, Munich, 1837, p. 22) gives an account of the obvious reasons for the different appearances of the same nebula in various telescopes, which is at the same time so brief and so clear that I quote it in full: "Stellen wir uns eine Fläche vor, die aus kleinen Abtheilungen von verschiedenen Lichtstärke besteht, durch geringe Zwischenräume von einander getrennt, so werden die schwächeren Abtheilungen in kleineren Fernröhren unsichtbar bleiben: die Stärkeren aber wenn

sie nahe an einander liegen, durch Verschwinden der Zwischenräume in eine gleichförmig erleuchtete Fläche übergehen. Diess ist nun gerade der Erfolg, den die Beobachtung an den Nebeln nachweist. Ein schwaches Fernrohr zeigt den mittleren Theil des Orion-Nebels gleichförmig erleuchtet, ein stärkeres giebt ihm ein flockenartiges Ansehen, und der hiesige Refractor löst ihm in einzelne messbare Abtheilungen auf, wie in Fig. XI (our Fig. 20) zeigt. Eben so muss ein Nebel, der gegen die Grenze immer schwächer wird bis er sich gänzlich verliert, in einem grossen Fernrohre viel ausgedehnter erscheinen, als in einem kleineren Fernrohre, welches dieselbe vergrösserung hat."

The evidence to be obtained from all the drawings of the nebula is presented and discussed in the tables that follow. If two or more drawings are made cotemporaneously, the points in which they agree may be taken to be correct. Points of difference must be examined in the light of the conditions under which the drawings are made. The presumption is always against differences of delineation corresponding to real differences in the surfaces and features drawn.

With this preface I proceed to the detailed consideration of the history of each particular mass. This is contained in the pages immediately following, where the masses are arranged in order of right ascension (nearly).

Reference should be made to the Index-Chart and to my detailed observations in doubtful points.

Connection between the nebula of Orion and its contained stars.

A physical connection between the nebula of *Orion* and its contained stars is suggested by several circumstances. One of the most striking indications is found in a comparison between the number of stars in the same area in different parts of the nebula, with similar instruments, such as the Pulkova and Harvard College refractors, for example.* If the stars observed by BOND in the whole nebula had been uniformly distributed through it, we should have expected to find about 72 in the central portion worked over by STRUVE; as a matter of fact STRUVE has 155 (and BOND even more), which alone constitutes a strong argument for a connection between brightness in the nebulous matter and number of stars. As has been pointed out (V. J. S. *der Ast. Gesell*, 1868, p. 31), it is necessary to this argument that BOND should have given equal attention to all parts of the nebula. Accurate information as to this point is not attainable, but from what is known of BOND'S method of working, and of the exceeding patience and minuteness with which this research was prosecuted, there can be no doubt that much force attaches to this consideration.

Order of brightness of the various masses.

This order has usually been derived from the drawings published, but sometimes from original pencil drawings or from the notes of observation. The order of brightness is usually given in three grades—1, 2, 3; 1 being the brightest. The interval between these grades is by no means equal. Where a letter is inclosed in a parenthesis, as (A), only a *part* of the designated mass is referred to. The letters are arranged under each head in the order of brightness, so far as it can be made out.

* See also Lord ROSSE on this subject in the extracts from his memoir previously given, p. 87.

HERSCHEL, 1824 (published engraving). There are no separate masses laid down, and the comparison is somewhat doubtful from this cause. It appears to be, 1. E, F, G, H, N, M, O, Q, D. 2. A, *g*, B, W. The last not much brighter than σ.

HERSCHEL, 1837 (published engraving). 1. E, I, G, N, Q. 2. F, H, S, M, R, P (all equally bright). 3. D = σ (this is *very* different from other drawings). 4. A.

LAMONT, 1837 (published engraving). 1. (W) I, E, (A), (*h*), G, F, (Q). 2. D, S, *or* R, ε = Z, K (W); part of A? E and I brighter than all the rest, D = Q.

LAMONT, 1837 (from an original pencil-drawing kindly lent me by Dr. DOBERCK). 1. I, E, F, G, A, Q, D, H. 2. C, B, W, J, and all the rest about equal.

DE VICO, 1839 (published engraving). No separate masses; and therefore the order here set down is somewhat doubtful. 1. D, W, A, *h*. 2. Q, H, G, F, E, I.

LASSELL, 1847 (engraving). 1. E? — I, D, (σ) F, G; the *south* shore of σ is the part referred to. 2. Q, W, Q, P, S, A, J, and A = μ 3. B, etc.

W. C. BOND, 1848 (from published engraving). 1. (J), (I) (preceding parts of these). 2. (G), (N), (F), (D). 3. The following part of A quite faint; as faint as σ.

W. C. BOND, 1848 (from original note-books and drawings kindly put at my disposition by the director of the Harvard College Observatory, Prof. E. C. PICKERING). 1. D, B, A, and G, H. 2. E and F, I; again in other places D; J?, I, G, H, F?, Q, N, A. See observations.

LIAPONOFF, 1851 (published engraving). 1. A. B. 2. D^1, F^1, O, I; all these not very different. 3. G (p. 75) H, E (from text of memoir). In general the *s.* half of the *Huyghenian region* is brighter than the *n.* half (p. 82). D > F, but not much; Q = D (p. 77); I = H (p. 75). G > H > E and I > E; A very bright, and W very faint (p. 75). SECCHI says that LIAPONOFF gives B F the maximum light.

LASSELL, 1854. Some copies of the published engraving are poor on account of the plate having worn, but I have made these estimates from a beautiful fresh copy kindly given me by Mr. LASSELL. 1. F, G, I. 2. D, *g* (B?). 3. H, N (O?). A, *totally wanting.*

SCHMIDT, 1861 (from original drawing kindly given to me by Dr. SCHMIDT). R, Q, I, L, G, H, E, F, A and B faint.

LASSELL, 1862 (a careful copy of his original drawing). 1. A, B, D. 2. W, I, G, R, (P), E, and Y. Perhaps this is not very certain, although I had the advantage of a copy of Mr. LASSELL's original drawing made by Miss LASSELL.

G. P. BOND, 1865 (published engraving). 1. A. 2. D, I. 3. F, G, H, E. All of classes 2 and 3 nearly equal.

G. P. BOND, 1863. Completed drawing based on many studies, and "compared with the heavens about Feb., 1863." 1. A, part of B? 2. D, I, Q, F, G, E, H (σ). H is next to A in brightness, determined photometrically by the order in which the masses appeared as twilight disappeared. It certainly is not so now. Note of 1859, March 23.

WEBB, 1866 (from original drawing, etc., kindly lent me by Dr. WEBB). H "very feeble." D > A. E nearly equal to to G, F, and I.

ROSSE, 1867. See extracts from the memoir *ante*, where the order of brightness is carefully given. From the drawing it is about as follows: N, G, F, I, E, A, (B), Q, N, P, etc.

SECCHI, 1868. 1. E, I, F, H, N, D. 2. (W), (B), and? A. E > G, F. B and J < north shore of K. The line of maximum light is G F of LIAPONOFF (that is [G] [F] of our Index-Chart). The description by SECCHI gives the following results: E > G and F; G and H > M? and S? SECCHI's a = Washington F; b = G; c = H; d = I. G is one of the brightest masses (p. 14); [D] > E; D, E, B > K. According to LIAPONOFF the line of maximum brightness is along the line 647 to point of Q; according to SECCHI from 647 to W^1. W? and D? are the brightest masses.

D'ARREST, 1872 (published engraving). 1. W, D, Q, P, R, O. 2. J, I, E, (H and G), F. 3. A = brightest part of μ.

WINLOCK and TROUVELOT, 1874 (published engraving). 1. A. 2. D, (σ), (ν). 3. Q. 4. J, G. 5. H, F. 6. I, E.

TEMPEL, 1876 (from a photograph kindly sent me by M. TEMPEL). All the principal masses about equal in light, and σ about the same brightness.

TROUVELOT, 1876? Reference is made to M. TROUVELOT's observations, *ante*, p. 105.

HOLDEN, 1877. For a *résumé* of the conclusions to be derived from the Washington Observations reference is made to the pages where they are given in detail. The conclusions there given are corroborated by the facts summarized here.

LANGLEY, 1879. Reference is made to Professor LANGLEY's observations and Fig. 39.

Frons.

Observer.	Date.	p	Remarks.
		°	
HERSCHEL . . .	1826	43.0	Convex to 685.
HERSCHEL . . .	1837	56.0	Concave to 685.
LAMONT	1837	45.0	Only of that part between E and the R. A. of 685. [Concave towards 685.] N. B.—Those remarks under LAMONT which are inclosed in [] refer throughout these tables to his original pencil sketch, kindly communicated by Dr. DOBERCK.
DE VICO . . .	1839	47 ±	
LASSELL	1847	. .	
W. C. BOND . .	1848	49.7	
LIAPONOFF . . .	1851	37.0	
LASSELL	1854	60.0	
SCHMIDT . . .	1861	52.1	
LASSELL	1862	52.7	
G. P. BOND . . .	1865	47.2	A little brighter along the edge than within this line. The brighter strip is about 10″ wide.
ROSSE	1867	49.5	Convex to 685.
SECCHI	1868	42.0	
D'ARREST . . .	1872	51.0	
WINLOCK . . } TROUVELOT . . }	1874	53.5	
TEMPEL	1876	49.0?	The original photograph is on too small a scale to permit of accurate measures on the enlarged copy, especially of measures of $\Delta\alpha$ and $\Delta\delta$.
HOLDEN	1877	50.3	The *frons* is convex towards 685.

There is no evidence of any change since 1826 in the *frons*. The error of making the *frons* concave towards 685 is easily committed, as Lord ROSSE pointed out to me in 1875 in a letter.

I must, however, point out the singular shape of the apex (E) of the *Huyghenian region* during the period 1771–1800. LE GENTIL (1758) shows the angle of *frons* and *occiput* obtuse. MESSIER (1771) gives a prolongation of E southwards. SCHROETER (1794) has the same horn-like protuberance towards the south in *all* his drawings. He was familiar with MESSIER's work, and in his first drawing (1794) may have copied this feature from MESSIER, though it is not likely. In his drawing of Feb., 1800, which is probably independent of the other, the same figure is repeated. From HERSCHEL (1824) to the present time there can have been no material change. I regard, then, this feature as constant.

Occiput.

Observer.	Date.	p	Remarks.
MESSIER . . .	1771	142.5?	
HERSCHEL . . .	1826	133.0	HERSCHEL remarks that it is perpendicular to the *frons*.
HERSCHEL . . .	1837	142.5	
LAMONT	1837	134.0	[Parallel to the *preceding* edge of F, and outline better defined and more sharp than that of the *frons*.]
DE VICO . . .	1839	130.0	
RONDONI . . .	1841	. .	
LASSELL	1847	. .	
W. C. BOND . .	1848	147.5	1847, Dec. 6 (Harvard College Obs. Note Book). "575 is just on the edge of the nebula."
LIAPONOFF . . .	1851	137.0	
LASSELL	1854	140.0?	
SCHMIDT . . .	1861	143.0?	Only of that part *south* of J.
LASSELL	1862	139.0	Exclusive of Y.
G. P. BOND . . .	1865	136.0	G. P. BOND says (1864, Jan. 17) that "575 is just on the edge of the nebula with an uncertainty of 1″". 1864, Feb. 12, "It is critically placed on the *preceding* edge of the bright edge of strong light [B].
ROSSE	1867	136.0	
SECCHI	1868	138.5	Angle at E of *frons* and *occiput* "almost 90°" (text, p. 13).
D'ARREST . . .	1872	142.1	
WINLOCK . . } TROUVELOT . . }	1874	142.0	
TEMPEL	1876	134.0?	
HOLDEN	1877	141.1	$p = 136°.1$ of the *occiput* exclusive of Y (see LASSELL, 1862).

Probably constant.

It should be remarked that the angle between the *frons* and *occiput* is 116°, according to HUYGHENS (1694); 129°, according to LE GENTIL (1758); .91° at the present time (1824 to 1880).

Parallel through θ′ (628) towards the east.

The numbers in the column $\Delta\alpha$ indicate the length of that portion of the above line which is involved in nebulosity. Only so much of the line is considered as lies between 628 and 708. This line is about 150″ in length.

Observer.	Date.	$\Delta\alpha$	Remarks.
Herschel . . .	1826	all	It is all involved in the bright nebulosity.
Herschel . . .	1837	all	It is all involved in the bright nebulosity.
Lamont	1837	[41″]	[About three-elevenths of the distance.]
De Vico . . .	1839	50″:	About one-half involved.
Lassell	1847	?	Only a portion involved.
W. C. Bond . .	1848	150″	All involved.
Liaponoff . . .	1851	60″	
Lassell	1854	?	
Schmidt. . . .	1861	all	
Lassell	1862	all	
G. P. Bond . . .	1865	37″.5	
Rosse	1867	42″	
Secchi	1868	150″	All involved.
D'Arrest . . .	1872	100″	
Winlock . . } Trouvelot . . }	1874	150″?	All involved?
Tempel	1876	50±	Only about one-third of the line 628–708.
Holden	1878	. .	Set wire on parallel through $\theta' = 628$. From 628 to g_0 this wire is immersed in nebula (77″). From 628 to the R. A. of 651 (29″) this line is in a darker space. It is only a little *south* of the *south* border of τ. It is immersed in R; *following* R it passes through a dark space, and finally is involved in μ.

North point of Sinus Gentilii.

Observer.	Date.	$\Delta\tilde{}$	Remarks.
		″	
Herschel . . .	1826	122.6	
Herschel . . .	1837	87.5	
Lamont	1837	. .	[Not laid down.]
De Vico	1839	55.8?	
Lassell	1847	. .	
W. C. Bond . . .	1848	73.5	
Liaponoff . . .	1851	58?	
Schmidt	1861	40.8?	
Lassell	1862	109.4	
Webb	1863	. .	See text, p. 78, *et seq.*
G. P. Bond . . .	1865	57.5	On original drawing from which engraving was made, a few seconds *south* of this.
Webb	1866	. .	In same $\Delta\delta$ as *south* point of G.
Rosse	1867	70	
Secchi	1868	97.3	
D'Arrest . . .	1872	60	
Winlock . . } Trouvelot . . }	1874	77.5	
Holden	1877	66.7	

Probably constant.

c.

With regard to *c* it should be remarked that D'ARREST makes it *concave* towards the north. This is different from all other authorities.

Z.

ROSSE, 1867, $\Delta\delta$ of north point $-120''$.
SECCHI, 1868, $\Delta\delta$ of north point $-140''$.

δ.

BOND, 1865, $\Delta\delta$ of north point $-105''$, $\Delta\alpha = -60''$.
ROSSE, 1867, $\Delta\delta$ of north point $-94''$.
D'ARREST, 1872, $\Delta\delta$ of north point $-134''$. (Very probably this is a part of Z, seen differently from the other drawings).
HOLDEN, 1877, $\Delta\delta$ of north point $-100''.9$.
Probably constant.

L.

W. C. BOND, 1848, $\Delta\delta$ north point $= 0''$??
ROSSE, 1867, $\Delta\delta$ north point $-40''$?
HOLDEN, 1877, $\Delta\delta$ north point $-25''.5$.
It is difficult to say if this corresponds to any real difference; most probably not.

Angle of preceding edges of J and B.

Observer.	Date.	*p*	Remarks.
		°	
HERSCHEL	1826	- -	
HERSCHEL	1837	- -	
LAMONT	1837	[24°]	[J tolerably bright.] [B does not point towards 575, but to the west of it. At least the maximum brightness (20″ to the *north* of 575) is on a meridian half way between 575 and 589.]
DE VICO	1839	174?	
LASSELL	1847	- -	
W. C. BOND	1848	39?	For position of 575 see "Occiput".
LIAPONOFF	1851	10.2	B forms with the following edge of A and part of I the *hemicyclium Liaponovii*.
LASSELL	1854	- -	The *south* part of J and the *north* part of I have *sometimes* appeared to L. "perfectly black," text p. 78.
SCHMIDT	1861	172.5	These masses are further towards the east than in other drawings.
LASSELL	1862	180±	
G. P. BOND	1865	6.1	"1864, Apr. 16. BOND says, 'This edge of nebula in meridian precisely through 575.'" This is the angle of the preceding edges of the entire two masses. For position of 575 see "*Occiput*".
ROSSE	1867	0.2	Do.
SECCHI	1868	13	This includes only that part *south* of θ'.
D'ARREST	1872	165	The shape of these edges quite different from those in any modern figure.
WINLOCK, TROUVELOT	1874	7.2	This refers only to the part *south* of θ'.
TEMPEL	1876	30??	
HOLDEN	1877	7.7	

Probably constant in position. There may have been changes in brightness of B and J. See B following.

B.

Observer.	Date.	*p*	Remarks.
G. P. BOND. . .	1865	. .	About as seen in the heavens by me (1874–'79).
ROSSE	1867	. .	B extends one-third of its length beyond (*s.*) of [575]. Quite different from BOND, 1861.
SECCHI	1868	. .	B begins to curve to the west immediately *north* of the parallel of θ'.
D'ARREST . . .	1872	. .	Quite different from other drawings; see his figure.
WINLOCK . . } TROUVELOT. . }	1874	. .	Different in form and brightness from other drawings. Consult the figure.
HOLDEN . . .	1877	. .	About as in BOND'S drawings, published and unpublished.

The brightness in Lord ROSSE'S drawing is different from that in preceding and following ones.

W, W^1, W^2, W^3, W^4, W^5.

Observer.	Date.	W^1.		Remarks.
		$\Delta\alpha$	$\Delta\delta$	
		″	″	
SCHROETER. . .	1794	. .	. .	W^1 = *lacus Secchii* discovered by SCHROETER.
HERSCHEL . . .	1824	. .	. .	W^1 not laid down; W = I, E, etc., in brightness.
HERSCHEL . . .	1837	. .	. .	W^1 not laid down; W = I in brightness.
LAMONT. . . .	1837	. .	. .	W^1 not laid down; W = T in brightness.
DE VICO . . .	1839	. .	. .	W^1 not laid down; W almost as bright as any mass.
RONDONI . . .	1841	. .	. .	
LASSELL. . . .	1847	. .	. .	W^1 not laid down; W almost missing.
W. C. BOND . .	1848	. .	. .	W^1 not laid down.
G. P. BOND. . .	1865	− 45	+ 59	Center of W^1.
ROSSE	1867	. .	+ 68	$\Delta\delta$ of center of W^1; diameter in δ 24″; W^1 and W^2 are black; $W^1 > \tau$ (brighter than); $W^1 > \xi$; $V > W^1$.
SECCHI	1868	− 62	+ 82	Center of W^1.
D'ARREST . . .	1872	. .	. .	W^1 not laid down; W = D in brightness.
WINLOCK . . } TROUVELOT . . }	1874	− 50	+ 74	Center of W^1; $W^1 > \tau$; $\xi > W^1$; $W^1 > V$, *i. e.*, different from 1867.
HOLDEN. . . .	1877	− 45	+ 68	

Probably constant.

A.

Observer.	Date.	$\Delta\alpha$	$\Delta\delta$	Remarks.
		″	″	
HERSCHEL . . .	1826	. .	. .	A is not laid down as a separate mass, but it is of the second order of brightness; by no means one of the brighter parts.
HERSCHEL . . .	1837	. .	. .	A; the following portion is very faint. There is *no* bright nebulosity preceding the star 619, except a portion of I.
LAMONT	1837	. .	. .	[The axis of the brightest parts of A begins near star 608 (not laid down), and is further towards the *west* than now, though generally similar in shape.] 622 is on its following edge. A < I, E, F, G.
De VICO	1839	. .	. .	There is no separate mass laid down, but the space *preceding* θ^1 is of the first order of brightness.
LASSELL	1847	. .	. .	There is no brighter mass A.
W. C. BOND . . .	1848	. .	. .	The bright following part of A is not laid down at all. On the contrary, this portion is very faint. From a MS. drawing (no date) I find both D and E brighter than A.
LIAPONOFF . . .	1847	. .	. .	Very bright; text, p. 77.
LASSELL	1854	. .	. .	A is totally wanting, and its absence and that of the adjacent parts is one of the most striking features of thisdrawing.
SCHMIDT . . .	1861	. .	. .	A is rather of the second order of brightness; A = Q, etc.
LASSELL . . .	1862	. .	. .	A full of singular convolutions and very bright.
WEBB	1863	. .	. .	A is by no means the brightest mass. A < G or F.
G. P. BOND . . .	1865	. .	. .	The brightest mass, according to a sketch 1864, April 16. A terminates pretty exactly at 608.
WEBB	1866	. .	. .	Same as WEBB, 1863.
ROSSE	1867	3 to 4	36	South point. A is much as in G. P. BOND's drawing.
SECCHI	1868	. .	. .	Not so bright as other masses.
D'ARREST . . .	1872	. .	. .	Probably not so bright as other masses.
WINLOCK . .	1874	. .	. .	A and the base of B the brightest parts.
TROUVELOT . .	1874	. .	. .	
TEMPEL	1876	. .	. .	A, just *preceding* the trapezium (U?), is perhaps the brightest mass.
HOLDEN	1879	. .	31.6	A is the brightest mass. Up to 1839 the part A is not conspicuously bright.

In 1847–'48, two authorities make A faint, the other very bright. In 1854 it is totally wanting (LASSELL), while the same authority in 1862 makes it the brightest mass, and later authorities in the main confirm this. It certainly seems to me that A about 1847–'48, and up to 1861 was not of its present brilliancy. Compare LASSELL 1847, 1854, and 1862. LIAPONOFF (1847) is opposed to this, and his observations are entitled to the greatest weight.

In spite of this I can reconcile the observations in no way but by supposing some change of brilliancy, and I believe any careful examination of the originals will lead to the same conclusion.

E.

Observer.	Date.	Of line joining 628 and south point.	South point.		North point.		Diam. in dec.	Remarks.
		p	$\Delta\alpha$	$\Delta\delta$	$\Delta\alpha$	$\Delta\delta$		
		° ′	″	″	″	″	″	
SCHROETER	1794	- -	- -	- -	- -	- -	- -	It has a nucleus (e) which SCHROETER calls a star.
HERSCHEL	1826	- -	— 10.2	175.2	- -	- -	- -	Not a separate mass.
HERSCHEL	1837	- -	+ 15.0	140.0	- -	92.5	46.5	Uniformly bright oval.
LAMONT	1837	180 27	precedes	152.6	- -	119.9	32.7	[E is inferior in brightness only to I. Its center is brighter than its borders. It is more sharply terminated on the side towards I than towards F.]
DE VICO	1839	- -	0.0	163.7	- -	- -	- -	Not a separate mass.
RONDONI	1841	- -	- -	- -	- -	- -	- -	
LASSELL	1847	- -	- -	- -	- -	- -	- -	
W. C. BOND	1848	- -	*0.0	*161	- -	- -	- -	Quite different from all other figures. The curious channel in E does not exist at present. *See his memoir, p. 94.
LIAPONOFF	1851	181 49	— 4.4	138.0	- -	- -	- -	"E is considerably fainter than G, H, F, etc." Text, p. 75.
LASSELL	1854	- -	- -	- -	- -	- -	- -	
SCHMIDT	1861	- -	0.0	127.8	- -	- -	- -	Rec angular.
LASSELL	1862	- -	precedes	127.7	- -	- -	- -	The masses E and Y appear as one of uniform brightness.
WEBB	1863	- -	- -	- -	- -	- -	- -	Apex precedes θ'. E < F, G, I.
G. P. BOND	1865	-	— 1.3?	140.0	- -	105	35.0	
WEBB	1866	- -	0.0	- -	- -	- -	- -	E about the same brightness as F, G, I, E < D.
ROSSE	1867	- -	+3 to 4	135.0	- -	99	36.0	
SECCHI	1868	- -	+ 4.7	187±4	- -	140.4	47	Distinctly divided into three oval masses.
D'ARREST	1872	- -	+ 4	146	- -	(?)	- -	
WINLOCK / TROUVELOT	1874	- -	— 10.0	155.0	- -	105	50	
TEMPEL	1876	- -	- -	- -	- -	- -	- -	Scale too uncertain; E has much the same shape as in the Naval Obser'y drawing.
HOLDEN	1876	- -	— 0.1	144.6	- -	100.3	44.3	

Probably constant in form.

It is possibly fainter now than 1837.

Dark channel between I and [X and G].

[The straight portion of this is alone referred to.]

Observer.	Date.	*p*	Remarks.
		°	
HERSCHEL	1837	180 / 90	The *south* half; then it turns at right angles.
LAMONT	1837	..	[Inclined to *frons*; X not laid down. The *preceding* end of this channel is perpendicular to *occiput*.]
LAMONT	1837	[44]	
LASSELL	1854	60?	
LASSELL	1862	53?	Parallel to *frons?*
G. P. BOND	1865	29?	On original drawing from which engraving was made *p* seems rather larger than this.
ROOSE	1867	28	
SECCHI	1868	90	
D'ARREST	1872	57	The *west* portion only.
WINLOCK / TROUVELOT	1874	42.5??	
HOLDEN	1877	25.6	

Constant since 1865, and probably the earlier observations differ only on account of errors. But compare HERSCHEL (1837).

Dark channel between E and F.

Observer.	Date.	*p*	Remarks.
		°	
HERSCHEL	1837	160??	
LAMONT	1837	134??	[F alone is sharply terminated; E fades off towards F.]
W. C. BOND	1848	147??	
SCHMIDT	1861	143?	About parallel to *occiput*.
LASSELL	1862	130?	
WEBB	1863	..	Nearly perpendicular to *frons*; it is best terminated on the following side; [*i. e.*, F > E ?]
G. P. BOND	1865	132.5?	Its prolongation passes nearly through 575 on original drawing from which engraving was made.
WEBB	1866	..	Same as WEBB, 1863.
ROSSE	1867	134.1	
SECCHI	1868	135	This channel is much shorter than in ROSSE.
D'ARREST	1872	142	
WINLOCK / TROUVELOT	1874	144.5	
TEMPEL	1876	134?	Parallel to *occiput*.
HOLDEN	1877	140.9	

Probably constant.

V.

[The mark $a > b$ signifies here a brighter than b.]

Observer.	Date.	Remarks.
HERSCHEL . . .	1826	V is a marked feature; see text. $V > \xi$; $V >$ south half of τ.
HERSCHEL . . .	1827	V is a marked feature; it is totally black. See text.
LAMONT	1837	[V is not laid down on his original pencil drawing.] V very much brighter than τ.
DE VICO	1839	V is as bright as any portion.
W. C. BOND . .	1848	$V > \tau$. $V < W^1$. $V <$ *Sinus Gentilii*.
LIAPONOFF . . .	1851	"V perfectly black;" text, p. 78.
LASSELL	1854	V perfectly black.
SCHMIDT . . .	1861	$V > \tau$; $V >$ *Sinus Gentilii*.
STRUVE	1861	V is in general quite dark. See (*a*) text, p. 115.
LASSELL . . .	1862	$V > \tau$; $V = W^1$?; V much brighter than *Sinus Gentilii*.
WEBB	1863	V is not a marked feature.
G. P. BOND . . .	1865	V is nearly symmetrically disposed about the trapezium. $V > \tau$; $V > W^1$; $V >$ *Sinus Gent.*
WEBB	1866	V better marked than in WEBB, 1863.
ROSSE	1867	$V > \tau$; $V = W^1 = W^2$.
SECCHI	1868	$V > \tau$; $V >$ *Sinus Gentilii*.
D'ARREST . . .	1872	$V > \tau$, but not much so.
WINLOCK . . } TROUVELOT . . }	1874	$V = \tau$; $V =$ *Sinus Gentilii*; $V < W^1$.
HOLDEN	1877	$V < \tau^1$; $V <$ *Sinus Gentilii*; $V < W^1$.

Compare the relation of V with *Sinus Gentilii*: 1861–1868, V > S. G.; 1874, V = S. G.; 1877, V < S. G. But there has probably been no marked change in V and S. G. Such observations are extremely difficult, especially when the area to be compared are not contiguous. I do, however, think a change has taken place in the general brightness of τ; see under the heading SCHROETER'S *second bridge in* τ in this section.

F.

Observer.	Date.	South point.	North point.	Brightest point.		Remarks.
		$\Delta\delta$	$\Delta\delta$	$\Delta\alpha$	$\Delta\delta$	
		"	"	"	"	
Herschel	1837	- -	- -	- -	107.5?	Only the following part laid down; *i. e.*, no mass X. Middle point is $\Delta\delta$.
Lamont	1837	- -	- -	- -	98.1?	Same as Herschel, 1837.
De Vico	1839	- -	- -	- -	- -	[F is a right angle triangle in shape; the hypothenuse is parallel to the line (612–618) to 647; the *base* lies in the *frons*; the perpendicular is half as long as the base.] No mass X.
W. C. Bond	1848	- -	- -	- -	- -	The brightest part is near the *frons*.
Liaponoff	1851	- -	- -	28.6	97.4	"Almost equal to D;" text, p. 75.
Lassell	1854	- -	- -	- -	- -	The part of F near X is the brightest.
Schmidt	1861	- -	- -	- -	68?	The part near X the brightest.
Lassell	1862	- -	- -	- -	- -	*West* point in $\Delta\alpha = 0''.0$.
Webb	1863	- -	- -	- -	- -	F is best terminated o its *n. p.* edges.
G. P. Bond	1865	117.5	87.5?	- -	- -	F is an equilateral triangle. 1863, Jan. 30.
Webb	1866	- -	- -	- -	- -	F is oval in shape.
Rosse	1867	114	- -	- -	- -	
Secchi	1868	144.1	103.0	- -	125.4	The south point is in *frons*.
D'Arrest	1872	86	- -	- -	- -	The triangular shape is like Rosse and Bond, but it is differently situated. The channel between F and [G and H] is different from any other.
Winlock, Trouvelot	1874	132.7	90	- -	- -	South point is in the *frons*.
Holden	1876	120.1	94.9	+26.8	102.0	The part of F not near X is the brightest.

Probably constant in form. It is possibly changed in brightness, but even this is by no means proved.

G.

Observer.	Date.	Brightest part.		Remarks.
		$\Delta\alpha$	$\Delta\delta$	
		"	"	
Herschel	1837	- -	62.5?	
Lamont	1837	- -	61.0?	[G is a circular bright mass of uniform brilliancy.]
W. C. Bond	1848	- -	- -	G apparently divided into three parts?
Liaponoff	1851	18.5	63.3	G is fainter than the other masses (F, G, H); text, p. 75.
Lassell	1854	- -	- -	G is very bright; of the first order of brightness.
Schmidt	1861	- -	33?	G very bright; its brightest part is certainly not so far as $\Delta\delta = 50''$.
Lassell	1862	- -	- -	G very bright, and larger than in Bond, etc.; not square, but elongated in $p = 53^\circ = \pm$.
Webb	1863	- -	- -	G is very bright, but G < I. Its preceding edge precedes F.
G. P. Bond	1865	- -	75.0	[The dark channel between F and G is situated just as in 1877.)
Webb	1866	- -	- -	G > I. The preceding edges of F and G in same meridian.
Rosse	1867	- -	72	83" *south* point: $\Delta\delta$. [1877, *south* point: $\Delta\delta$ 76", Holden.] 61" *north* point: $\Delta\delta$.
Secchi	1868	- -	- -	G quite unlike Bond and Rosse, and present appearance.
D'Arrest	1872	- -	- -	G and H are one mass.
Winlock, Trouvelot	1874	- -	72.5	
Tempel	1876	- -	- -	Brightest point *precedes* 628 (*a Trapezii*).
Holden	1877	15.9	65.3	One of the brightest masses.

Probably no change in form.

H.

Rosse, 1867, $\Delta\delta$ south point $-83''$?
Rosse, 1867, $\Delta\delta$ brightest point $-78''$?
Holden, 1877, $\Delta\delta$ south point $-94''$. Probably no change.

D.

Observer.	Date.	p	*n. f.* point.		Remarks.
			$\Delta\alpha$	$\Delta\delta$	
		″	″	″	
Herschel	1826		27.7	74.5	The point of D plainly laid down. B is *concave* towards the *east*.
Smyth	1834				In a coarse sketch in the celestial cycle, ii, p. 132, D is *concave* to the east and the brightest mass.
Herschel	1837				There is no bright sharp following point, 647 and 651 as in Naval Observatory drawing. D is fainter than E, F, G, H, Q, etc., and concave to the east.
Lamont	1837		17.4?	98.1	647 and 651 as in Naval Observatory drawing. [651 on exact edge of D. D has no north sharp point, but its north end is rounded.] [D brighter than II? but fainter than I, E, F, G, (A), Q, just as in Herschel, 1837.]
De Vico	1839				
Stoney	1851				D is partly concave, partly convex to the east, in an unpublished drawing made at Lord Rosse's Observatory.
W. C. Bond	1848		16.6	56.8	647 and 651 as in Naval Observatory drawing. See *text*.
Liaponoff	1851		26.1*	55.5*	$\Delta\delta = 69''.6$ and $\Delta\alpha = 26''.5$ of point of intersection of *following* edge of D with north shore of *Sinus magnus*. [* Co-ordinates of α_6.]
Lassell	1854				*Following* side quite bright.
Schmidt	1861				Tangent to bright *following* side, $\Delta\alpha = 13''.6$. There is no *sharp northern* point; the mass is oval.
Struve	1861				D seemed to be subject to considerable variation both in form and brilliancy.
Lassell	1862		11.4	66.1	641 and 657 in Naval Observatory drawing. 651 as exactly on edge.
Webb	1863				D is not so bright as F; no sharp *north* point laid down.
G. P. Bond?	1865	?	36.2	69.8	Measured 1864, April 15, following edge of D, $\Delta\alpha$ (measured) $= 26''.6$ same date. 647 and 651 as in Naval Observatory drawing except that 647 is not in a bay. "647 far within nebulosity," 1864, April 15.
Webb	1866				D is the brightest mass; no sharp *n. f.* point laid down.
Rosse	1867		26	69	Same as Naval Observatory drawing.
Secchi	1868		44.9		$\Delta\alpha$ of tangent to brightest of following side of D. D has no bright sharp following point, and is clearly different from its present appearance.
D'Arrest	1872		32?	44?	D quite bright, but outlines are not so sharp as in Lord Rosse's or Naval Observatory drawing.
Winlock, Trouvelot	1874		11.3	92.5	As in Naval Observatory drawing.
Holden	1877			7.8	$\Delta\alpha$ of tangent to brightest part of following side $29''.4$. D is convex towards the east.

The form seems to have varied from concave to the east (1826 and subsequently), to convex to the east (1865 and subsequently). If the mass had been always of its

present brilliancy, the question of convexity or concavity could not have taken a moment to decide it. I, however, agree with O. STRUVE in believing this mass to have varied in brilliancy, and I am inclined to believe that the (possible) changes of form are due to this fact. The star 651 seems to have remained in a fixed position relative to the following edge, and no change of form is shown there. The extreme north point, however, has certainly varied in brightness during the period 1826–1877; it has even so varied during my own observations 1874–1880.

τ.

Observer.	Date.	Remarks.
HERSCHEL	1826	*North half:* Streaks of nebulosity. *South half:* Black.
HERSCHEL	1837	τ uniformly completely black.
LAMONT	1837	Do.
DE VICO	1839	Do.
RONDONI	1841	
LASSELL	1847	*North half:* Partially nebulous. *South half:* Black.
W. C. BOND	1848	τ uniformly completely black.
LASSELL	1854	*North half* brighter than *south half.*
SCHMIDT	1861	Pretty uniformly black.
LASSELL	1862	Pretty uniformly black, except for SCHROETER'S second bridge.
WEBB	1863	All filled with nebula.
G. P. BOND	1865	The *north preceding* part is brighter than the *south following* part. Black streak near *pons Schroeterii.* The *south* shore of τ reaches to the declination of θ'; *i. e.*, $\Delta\delta = .0''$.
ROSSE	1867	Two black streaks in it on its *west* and *east* sides; the *north half* brighter than *south half.*
WEBB	1866	Completely filled with nebula.
SECCHI	1868	On the whole, $n. \frac{1}{2} > s. \frac{1}{2}$, although somewhat doubtful on account of absence of definite outline to *pons Schroeterii.* The *preceding* edge is brighter than the other portions; and τ extends to the south of θ'. τ much darker in 1867 than in 1857.
D'ARREST	1872	Pretty uniformly filled with faint nebulosity.
WINLOCK TROUVELOT	1874	Pretty uniformly black.
TEMPEL	1876	Do.
HOLDEN	1877	All north of $\Delta\delta = 47''$ filled with faint nebulosity, except, of course, the dark streak on its *preceding* edge. South of this pretty black, but less so than τ'.

No change in τ except with regard to SCHROETER'S second bridge, *q. v.*

The second bridge of SCHROETER (*in* τ).

Observer.	Date.	Remarks.
SCHROETER	1797	Jan. 25 (see Fig. 13). The second bridge is plainly laid down.
HERSCHEL	1826	The *north half* is plainly indicated.
HERSCHEL	1837	No bridge laid down.
LAMONT	1837	Do.
DE VICO	1839	Do.
LASSELL	1847	Do.
W. C. BOND	1848	Do.
LIAPONOFF	1851	Do.
LASSELL	1854	Do.
SCHMIDT	1861	Do.
LASSELL	1862	The *north* one-third is plainly indicated.
WEBB	1863	Not laid down.
G. P. BOND	1865	No bridge laid down in engraving, but plainly drawn on several different charts.
WEBB	1866	No bridge laid down.
ROSSE	1867	A second bridge without nucleus is laid down.
SECCHI	1868	No bridge laid down.
D'ARREST	1872	Do.
WINLOCK TROUVELOT	1874	Do.
TEMPEL	1876	Do.
HOLDEN	1877	Second bridge, as in LASSELL, 1862, and SCHROETER, 1794.

SCHROETER, 1797, lays down the second bridge in τ, HERSCHEL in England (1826) shows it. Having this first drawing before him in 1837 at the Cape of Good Hope, he does not show it. LASSELL, 1862 (4-foot reflector), shows it faint. BOND (1865) does not show it in the engraving, but it is faintly but plainly shown in his drawings. ROSSE (1867) shows it. In 1874–1875 I did not see it, although τ was examined in 1875 carefully. It was first seen here in 1876. It is now brighter than at that time. These facts, taken in connection with the general details given under the heading τ, seem to me to prove a change in its brightness; for how otherwise could SCHROETER see in 1797 what escaped HERSCHEL (1837) and LASSELL (1854) with superior advantages?

Pons Schroeteri and g_0.

Observer.	Date.	*Pons S.*	g_0.		Remarks.
		p	$\Delta\alpha$	$\Delta\delta$	
		°	″	″	
Herschel	1826	175	- -	- -	North half alone given.
Herschel	1837	163.5	72	61	
Lamont	1837	- -	80	52	[The south end of *pons Schroeteri* is 28″ north of 6′] [g_0 not given].
Lamont	1837	[160??]	- -	- -	
Lassell	1847	180??	- -	- -	
W. C. Bond	1848	154	- -	- -	
Liaponoff	1851	- -	71.9	42.3	In the direction of 669 and 685 (text, p. 79).
Lassell	1854	180??	- -	- -	
Schmidt	1861	139	- -	- -	No nucleus; the *north* two-thirds only are laid down.
Struve	1861	- -	- -	- -	The *pons* crosses the whole of *Sinus magnus*, and g_0 is usually the brightest part; but g_0 is sometimes wanting.
Lassell	1862	175	- -	- -	No nucleus; the *north* two-thirds only are laid down.
Webb	1863	- -	- -	- -	On the line joining 669 and 685. g_0 not drawn.
G. P. Bond	1865	157.5	70	44	Bridge continuous; break nearly as in Rosse in various drawings.
Webb	1866	- -	- -	- -	Parallel to line 669–685, but following this line a little.
Rosse	1867	175	70	39	Length of bridge 78″. There is a decided break in the bridge about its middle point.
Secchi	1868	- -	- -	- -	g_0 formerly visible, but not seen in 1868 (text, p. 19). In 1857 the *pons Schroeteri convex* towards the west. In 1867 *concave*.
D'Arrest	1872	175	- -	- -	Length of bridge 40″.
Winlock Trouvelot	1874	168.2	- -	- -	Perhaps a break indicated. g_0 not given.
Tempel	1876	- -	- -	- -	Nucleus very much brighter than the rest.
Holden	1877	170.2	77.4	40.8	There is a break on each side of g_0, one in $\Delta\delta = 22''$, and the other in $\Delta\delta = 60''$. g_0 stellar at first; not so later in the work.

Variations in brightness seem to me to be proved, as remarked by Otto Struve and Secchi. See their memoirs as previously referred to.

σ and lacus Lassellii.

Observer.	Date.	South edge.	s. f. bright point.		σ.	*Lacus Lassellii.*
		p	$\Delta\alpha$	$\Delta\delta$		
		°	″	″		
SCHROETER	1794	. .	. .	. .	. . . . .	Discovered *lacus Lassellii*.
HERSCHEL	1826	. .	. .	. .	681 on *following* edge	Plainly laid down.
HERSCHEL	1837	. .	152	117.5	681 in middle of σ. South edge of σ suddenly much brighter.	Plainly laid down though different from its present appearance.
LAMONT	1837	. .	. .	. .	681 on *following* edge	No *lacus Lassellii*.
					[681 on *following* edge]	No *lacus Lassellii*.
DE VICO	1839	. .	. .	. .	No bright sharp following point.	
LASSELL	1847	. .	. .	. .		
W. C. BOND	1848	. .	. .	. .		
LIAPONOFF	1851	. .	143.6	71.5		
LASSELL	1854	. .	. .	. .	Concave towards the south; south edge brighter.	
SCHMIDT	1861	. .	. .	. .	No sharp *following* point, at least not as in BOND.	Does not extend quite to *Sinus magnus*.
STRUVE	1861	. .	. .	. .	. . . . .	Connects with *Sinus magnus*.
LASSELL	1862	90.4	136.8	68.4	. . . . .	Does not connect with *Sinus magnus*.
G. P. BOND	1865	95.0	150	83	*South* edge convex towards *south* if at all; nearly straight.	
WEBB	1866	. .	. .	. .	See *Notes*.	
ROSSE	1867	91.0	144	81–87		
SECCHI	1868	$p>90$	192.8	79.6	Roughly speaking the *preceding* half > *following* half; a *little* brighter on the south edge, but not much; its south shore is "directed towards the north."	*Lacus Lassellii* is continuous to *Sinus magnus* on moonlightnights, but interrupted on dark nights.
D'ARREST	1872	90	192	55	*South* edge concave towards the south.	
WINLOCK, TROUVELOT	1874	. .	170	76.3	General shape as in Naval Observatory drawing, but brightness different.	
TEMPEL	1876	. .	. .	. .	*Following* half > *preceding* half . .	Connects with *Sinus magnus*.
HOLDEN	1877	89.7	165	79	The *preceding* half > *following* half.	Ditto, only on moonlight nights, but the south part of it is in fact filled with faint nebulosity which moonlight destroys.

Possibly a change in $\Delta\delta$ since HERSCHEL (1837).

Angle between the line 685–741 *and the north shore of Sinus magnus.*

I have thought it worth while to tabulate the values of this angle, as follows: The angle is from 5° to 10° for—

WINLOCK and TROUVELOT (1874).
W. C. BOND (1848).
LIAPONOFF and ROSSE (1857 and 1867).
D'ARREST (1872).
HERSCHEL (1824).
HUYGHENS (1656).
HOLDEN (1877).

It is 15° for PICARD (1673).

It is 30° for HERSCHEL (1837); LAMONT's (1837) drawing confirms HERSCHEL.

It will be noted that HERSCHEL (1837) and LAMONT (1837) are strangely different from all the rest, and that they agree. The discrepancy is too great to explain by small errors. If this is an error it is a gross one.

τ'.

Observer.	Date.	Remarks.
HERSCHEL . . .	1826	All equally black.
HERSCHEL . . .	1837	Do.
LAMONT	1837	Not laid down.
W. C. BOND . .	1848	*South* part brighter than *north* part.
LASSELL	1854	Not entirely black.
SCHMIDT . . .	1861	Faintly nebulous. It is *probable* that SCHMIDT has seen σ and part of $o\pi$ near π as connected.
LASSELL	1862	Black.
WEBB	1863	Do.
G. P. BOND . . .	1865	Completely black. See *Mon. Not.*, R. A. S., vol. 24, p. 178. Its *south* border is 10″ or 12″ *south* of θ'.
WEBB	1866	Black.
ROSSE	1867	The *north* half the brighter.
SECCHI	1868	Not laid down.
D'ARREST . . .	1872	Filled with faint nebulosity.
WINLOCK . . } TROUVELOT . . }	1874	*Following* half brighter than *preceding* half.
TEMPEL	1876	*South* part nebulous; *north* part black.
HOLDEN	1876	*North* part brighter, but all very dark.

Probably constant.

Q, P, R.

Observer.	Date.	North edges. p	Remarks.
		°	
HERSCHEL . . .	1837	93–95	
LAMONT	1837	104 5?	[R, P, and S not laid down.]
DE VICO	1839	117?	
W. C. BOND . .	1848	97.5	Cuts off a little of R.
SCHMIDT . . .	1861	105?	
LASSELL	1862	98	Cuts off a little of R.
G. P. BOND . . .	1865	115	Do.
ROSSE	1867	101.0?	Cuts off R.
SECCHI	1868	. .	Angle not easily measurable. It does not agree with ROSSE and BOND.
D'ARREST . . .	1872	105	
WINLOCK . . } TROUVELOT . . }	1874	97.0	Cuts off a little of R.
HOLDEN	1876	105.7	

Probably constant.

Q.

Observer.	Date.	Following point.		Remarks.
		$\Delta\alpha$	$\Delta\delta$	
		″	″	
Le Gentil	1758	. .	. .	Same R. A. as 708.
Lamont	1837	162.4	40.2?	[671 on *north* edge of brightest nebulosity, or a little north of the edge in a slightly fainter part.]
Lassell	1847	. .	. .	
W. C. Bond	1848	*150	. .	[Same R. A. as 708.] *A diagram of 1848. Jan. 17, gives 150″. *Annals Harv. Coll.*, v, p. 176.
Liaponoff	1851	146.5	22.0	Precedes 708 by 4″.6. Q well defined.
Schmidt	1861	. .	. .	*Follows* 708 by from 7″ to 8″.
Lassell	1862	124.3	6.8	Same R. A. as 708.
Webb	1863	. .	. .	The line joining 669 and the extreme point of Q cuts the line 708–741 at $\frac{29}{46}$ths of its length measured from 708. Q, N, O, P quite bright.
G. P. Bond	1865	145	20	Q and N quite bright.
Webb	1866	. .	. .	Appears to have its *following* point in same R. A. as 708. Q, N, O, P are all fainter than E, F, G, I, H, D, and [A?]
Rosse	1867	135	21	
Secchi	1868	153.5	. .	
D'Arrest	1872	192	32	
Winlock Trouvelot	1874	155	. .	
Tempel	1876	. .	. .	Same R. A. as 708.
Holden	1877	150	28	Do.

Probably constant.

τ'' and ξ.

Observer.	Date.	τ''.	ξ.
Herschel	1826	Perfectly black	Perfectly black.
Herschel	1837	Filled with faint nebulosity	Almost empty of nebulosity.
Lamont	1837		Same.
De Vico	1839		Black.
Lassell	1847		
W. C. Bond	1848	Filled with faint nebulosity	Full of curdled nebulosity.
Lassell	1854	Contains nebulosity	Contains nebulosity.
Schmidt	1861	Not laid down	Pretty nearly totally black.
Lassell	1862	Almost totally black	Nebulous particularly on *following* one half.
G. P. Bond	1865	Completely black. See *Mon. Not.*, R. A. S., vol. 24, p. 178.	Faintly nebulous.
Rosse	1867	. . do	Very faintly nebulous.
D'Arrest	1872	Uniformly filled with faint nebulosity.	
Winlock Trouvelot	1874	Same	Very faint nebulosity.
Tempel	1876	Black	Nebulous.
Holden	1877	Quite dark—empty	Filled with nebulosity, except a black streak close to $o\pi$.

The various evidence points to changes in brightness.

$o\pi$.

Observer.	Date.	Whole mass. p	Remarks.
		○	
HERSCHEL . . .	1826	. .	No nucleus o, but a detached brighter spot about where π now is.
HERSCHEL . . .	1839	110?	No nuclei o and π.
W. C. BOND. . .	1848	99.5	No nuclei o and π.
LASSELL. . . .	1862	90	No nuclei o and π; at the *following* end it joins quite marked nebulosity.
G. P. BOND. . .	1865	93?	In original drawing from which engraving was made $p = 90 \pm$.
ROSSE	1867	93.0	No nucleus o; the nucleus π in $\Delta\alpha = 144''$.
WINLOCK . . . } TROUVELOT . . }	1874	90±	o and π not laid down.
TEMPEL. . . .	1876	. .	The mass $o\pi$ is laid down.
HOLDEN . . .	1875	. .	$\pi > o$; both stellar in appearance, but not so much so as $\frac{1}{50}$.

Probably constant.

SPECTROSCOPIC OBSERVATIONS OF THE NEBULA.

The spectroscopic apparatus of the Naval Observatory and the relation of aperture and focal length of the 26-inch equatorial were such that no advantage could have been gained by devoting time to the re-examination of the spectrum of the nebula. A few extracts from work done by other astronomers, notably HUGGINS, SECCHI, and VOGEL are given herewith, and for similar observations reference is made to the original papers, whose titles will be found in the List of Books and Memoirs at the end of the Introduction. The most important of these is the paper of Professor D'ARREST published in 1872. The main facts to be noted seem to be that this nebula is certainly gaseous and similar in constitution to other gaseous nebulæ. The changes made out in the brightness of its parts are thus more credible than if it were a true stellar nebula, for, as is remarked by GEORGE BOND, "the variability of nebulæ, if dependent on the variability of the stars of which they may be supposed to be formed, would require the greater portion of these stars to grow faint at one and the same time. The improbability of this explanation is greatest where the number of stars of which the nebula is composed is the greatest, *i. e.*, where it is brightest." The gaseous nature of some, at least of the small stars near the trapezium, is, I think, indicated by their peculiar behavior under different magnifying powers. As has been before remarked most of them are best seen with low powers.

The space within about the trapezium is really nebulous and not void. This was first suspected by BOND and HERSCHEL. The spectrum of the nebula seems to consist of four lines. The positions of the three brightest are about

A 500.4
B 495.8
C 485.9

These seem to indicate the presence of hydrogen and nitrogen in the nebula, and that these are its principal constituents. We have yet to learn the true interpretation of the third line in the spectrum. A fourth line Hγ has been occasionally seen.

Dr. HUGGINS' paper in the Proceedings of the Royal Society, 1865, January 26, contains the important remark that "the positions in the spectra of α, β, γ, δ, *trapezii*, which correspond to the positions in the spectrum of the three lines of the nebula were carefully examined, but in no one of them were dark lines of absorption detected" as might have been expected if the nebula was nearer to us than these four stars.

In Dr. HUGGINS' paper "on the spectra of some of the stars and nebulæ,"* he describes at some length his later observations of the nebula of *Orion* (p. 541), and corroborates his former measures, and after some general considerations as to the extinction of light in space, says (p. 544), "the result of the re-examination of the spectrum of this nebula appears to give increased probability to the suggestion * * * that the substances hydrogen and nitrogen are the principal constituents." * * * "I am still unable to find any terrestrial line which corresponds to the middle line."

Dr. HUGGINS† shows that the nebula of *Orion* is not receding from the earth with a velocity greater than 10 miles *per* second, nor approaching the earth faster than 20 or 25 miles *per* second. In general, nebulæ have not shown motions to or from the earth as the fixed stars have. In the Proceedings of the Royal Society for 1874, March 26, Dr. HUGGINS returns to this question. His results are the same except that it is possible that the *Orion* nebula may be approaching the earth as fast as 30 miles *per* second approximately.

Mr. LE SUEUR,‡ in reporting his measures of the spectrum of the *Orion* nebula, states that the nebulosity within the trapezium is comparable in brightness with that immediately surrounding it, as is shown by the relative brightness of the spectra.

In the Proceedings of the Royal Society (1872, p. 383), Dr. HUGGINS gives the results of a new examination of the spectrum. The principal point to be noted is that it is possible that the brightness of the 3d (and 4th) lines may vary in brightness relative to lines 1 and 2 from time to time.

SECCHI,§ after describing his previous observations of the spectrum of this nebula in which the line Hβ of hydrogen was seen while none of the other characteristic lines of the substance could be observed, examines the question as to whether the presence of this line indicates that hydrogen is indeed present in the nebula.

A Geissler tube containing hydrogen gave, in his spectroscope, the three lines Hα, Hβ, Hγ; when the light from this tube was enfeebled by reflection before entering the spectroscope only one line, Hβ, was seen. He concludes, first, that the presence of a single line is sufficient to prove the existence of an elementary substance in a celestial body; second, that the monochromatic nature of the light of nebulæ is probably only apparent, and that there are probably other spectral lines not seen

* *Philosophical Transactions*, 1868, p. 529.
† Proceedings of the Royal Society, 1868, May 14, p. 384.
‡ Proceedings of the Royal Society, 1870, March 3, p. 242.
§ In the *Comptes Rendus*, vol. 66, p. 643.

on account of their faintness; third, that, as we do not see certain lines whose absolute brilliancy is greater than Hβ, we may conclude that certain substances are not present in the nebula; and fourth, that substances there present act by radiation and not by absorption, as in stars.

Dr. VOGEL* gives the results of four nights' observations in 1871 on the spectrum, as below:

1. W. L = 500.4 M. M.
2. = 495.8 "
3. = 486.1 "

The uncertainty is about $\pm$ 0.15 M. M. The first line is the brightest, the second the faintest; no fourth line was seen. The different parts of the nebula gave always the same spectrum, and the relative brightness of the three lines was always the same. The first line coincides with a double line in the atmospheric spectrum. The second line does not agree in position with the lines of any known terrestrial substance. The third line coincides with the hydrogen line Hβ.

Dr. BREDICHIN† gives as the normal spectrum of gaseous nebulæ the following positions of the three brightest lines:

A = 5003.9 $\pm$ 1.2
B = 4957.9 $\pm$ 1 1 4
C = 4859.2 $\pm$ 3.1

The probable errors are computed by supposing the nebulæ G. C. 4964, 4628, 4234, 4447, 4390, 4510, and 4373 to have the same spectrum, in fact, and the small differences to be due to accidental errors of observation.

* Ast. Nach., p. 78, col. 245.
† In the Moscow Observations, vol. ii, p. 60.

Part IV.—Conclusions to be derived from the foregoing memoir.

It may be well to summarize the foregoing work, in order to review, briefly, the ground over which we have gone and the conclusions which are to be gained. The *object* of the work was twofold: First, to make such a detailed study and description of the central and brighter portions of this nebula, that a repetition of the work would be easy and short, and so that the question of any future change in the parts considered can be settled definitely and beyond a doubt and without any great labor. The form in which the observations are classified in Part II seems to me to satisfy this condition. The accuracy of the micrometer measures is sufficient for the purpose, and greater than I anticipated; for example, the $\Delta\delta$ of the brightest part of F is $-102''.0 \pm 0''.3$ (5 nights); of the brightest part of G is $-65''.3 \pm 0''.8$ (6 nights); the position-angle of the *frons* is $50°.3 \pm 0°.5$ (4 nights), and so on. These are surfaces and not points it will be remembered. It will be noted that the first object of my work is precisely that proposed to himself by Le Gentil in 1758. The second object was to completely and thoroughly discuss the large mass of material already on hand derived from the observations of 224 years (1656–1880). All available drawings were examined, and thirty-eight are here engraved (nearly all on the same scale), and abstracts have been made of all available observations and are here given. Several unpublished series and drawings have been printed for the first time, notably those of Lassell, Schmidt, and Langley. By this examination the epoch of the first trustworthy observations has been carried back from 1824 to 1758. Le Gentil's figure of the central part yields evidence comparable in value with the first figure of Sir John Herschel.

I conclude that there have been—

(1) possible changes of brightness in the masses of J and B;

(2) changes in the brightness of A;

(3) changes in the brightness of E;

(4) changes in the brightness of D;

(5) undoubted change in the brightness of Schroeter's second bridge;

(6) undoubted changes of brightness in Schroeter's bridge and in the appearance of g_0, its nucleus;

(7) a possible change in the position of the south edge of σ since 1837;

(8) a probable change in the brightness of τ'';

(9) a probable change in the brightness of ξ;

(10) a certain change in the development of the mass h near D.

There is no evidence whatever for any change of form other than that which may be due to such changes of brightness; as in the cases of A, D, h, etc. I do not find any change of the *Messierian* branch near 793.

The connection of the stars of the trapezium with the nebula appears to me to be settled by the conclusions of my paper reducing Professor Hall's observations of these stars, and by various former observations, such as the important one by Dr Huggins of those portions of the spectra of α, β, γ, δ, *trapezii*, near the places of the nebula spectral lines 1, 2, 3, and others.

The change in the brightness of D, *h*, and other masses, is shown by the Washington Observations taken alone. These also show the feasibility of making tolerably accurate photometric observations of the relative brightness of two nebulous masses. Certain of the masses have varied in brightness during the period of observations. A new nebulous patch (*h*) has been seen from the time of its origin, when it was stellar in appearance and faint, until now, when it is bright and of measurable dimensions.

It appears to me, then, to have been shown that the figure of the nebula of *Orion* has remained the same from 1758 to now (if we except a change in the shape of its apex (E) about 1770, which appears quite possible); but that in the brightness of its parts undoubted variations have taken place, and that such changes are even now going on.

I have not hesitated to give the conclusions to which I have been led in the course of this work, although I am aware that all of these may not be accepted on a first reading.

With regard to any subject of this kind, every competent judge has a body of opinion derived partly from his own experience and partly from judgments formed from time to time by examinations of the work of others. In general, this body of opinion leans to the view that the phenomena presented by the celestial bodies, are, for long periods of time, quite constant. For example, accounts of supposed changes in the conformation of the lunar craters are received and rightly received with a measure of grave doubt, and yet no one is disposed to deny that real changes are now taking place from moment to moment, just as they have in the past; but each particular recorded evidence of change is regarded with doubt, and a full measure of proof, depending on sufficient observation, is justly demanded. A competent observer is, however, still bound to put his observations on record.

It appears to me that I have less reason to hesitate in recording my own judgments upon the phenomena here described, as the observations themselves are given in full detail, and the materials for an adequate judgment are spread out for inspection.

At least, I can be sure that all the existing evidence is impartially presented in such a way as to be readily added to in the future, and I cannot myself doubt but that the principal conclusions here set down will be confirmed by others.

ADDENDUM.

Photographic Results of Dr. Henry Draper.

The first photograph of the nebula of *Orion* was made by Dr. Henry Draper in September, 1880, and the unavoidable delay which has occurred in printing the present memoir enables me to include an account of the astonishing results which he has attained. A wood-cut which I had prepared from his first photograph was found to be so unsatisfactory that Dr. Draper most generously offered to supply the necessary photolithographic reproductions of his last negative (taken March 14, 1882) to accompany the brief account I had prepared. The full page photolithograph is here given as figure 40.

I requested Dr. Draper to prepare some account of his work to be presented with it, and I print below a memorandum which he has kindly furnished.

"MEMORANDUM TO ACCOMPANY THE PHOTOGRAPH OF THE NEBULA IN ORION SENT TO PROFESSOR HOLDEN FOR HIS MEMOIR.

By Henry Draper, M. D.

"As far as I know, no photograph of any nebula has been taken except in my observatory. The first photograph of the nebula in *Orion* was made on September 30, 1880, with my Clark telescope of 11 inches aperture and an exposure of 51 minutes. It comprised the brightest parts of the region in the neighborhood of the trapezium and showed the condensed masses well. In March, 1881, a number of photographs of this object were taken, the best being on March 11 with an exposure of 104 minutes. By comparison with the former picture this made a marked advance, and minute stars down to the 14.7 magnitude of Pogson's scale were shown. An account of it was read before the French Academy of Sciences and printed in the *Comptes Rendus*, April 18, 1881.

"On March 14, 1882, the negative was made from which the photolithographic enlargement in this memoir was produced. The instrument used was the Clark telescope of 11 inches aperture mounted on the equatorial stand and driven by the clock which I had constructed. The exposure was from $7^h\ 08^m$ to $9^h\ 25^m$; that is, 137 minutes: gelatino-bromide plates were employed. The night was clear but cold and windy. The mean temperature was 27° Fahr.; the wind NNW. and in gusts, the strongest pressure being 5 pounds per square foot about nine o'clock; the whole travel of the wind during the exposure was 35 miles. The variation in the force of the wind is one reason why the stars show some ellipticity under this magnifying power; the gusts of course displaced the telescope somewhat, though the mounting is firm and the clock-work strong.

"In the photograph the larger stars are much overexposed, the proper time to make a good picture of the trapezium being about 2 minutes. The twinkling of these stars is therefore recorded on the sensitive plate, and gives to them an excess of size. If a photograph should be taken on a steady night the stars of the trapezium would be easily separated, and in the original negative of this picture, in a strong light, the separation can be seen. The variation in size of the stellar images gives an idea of

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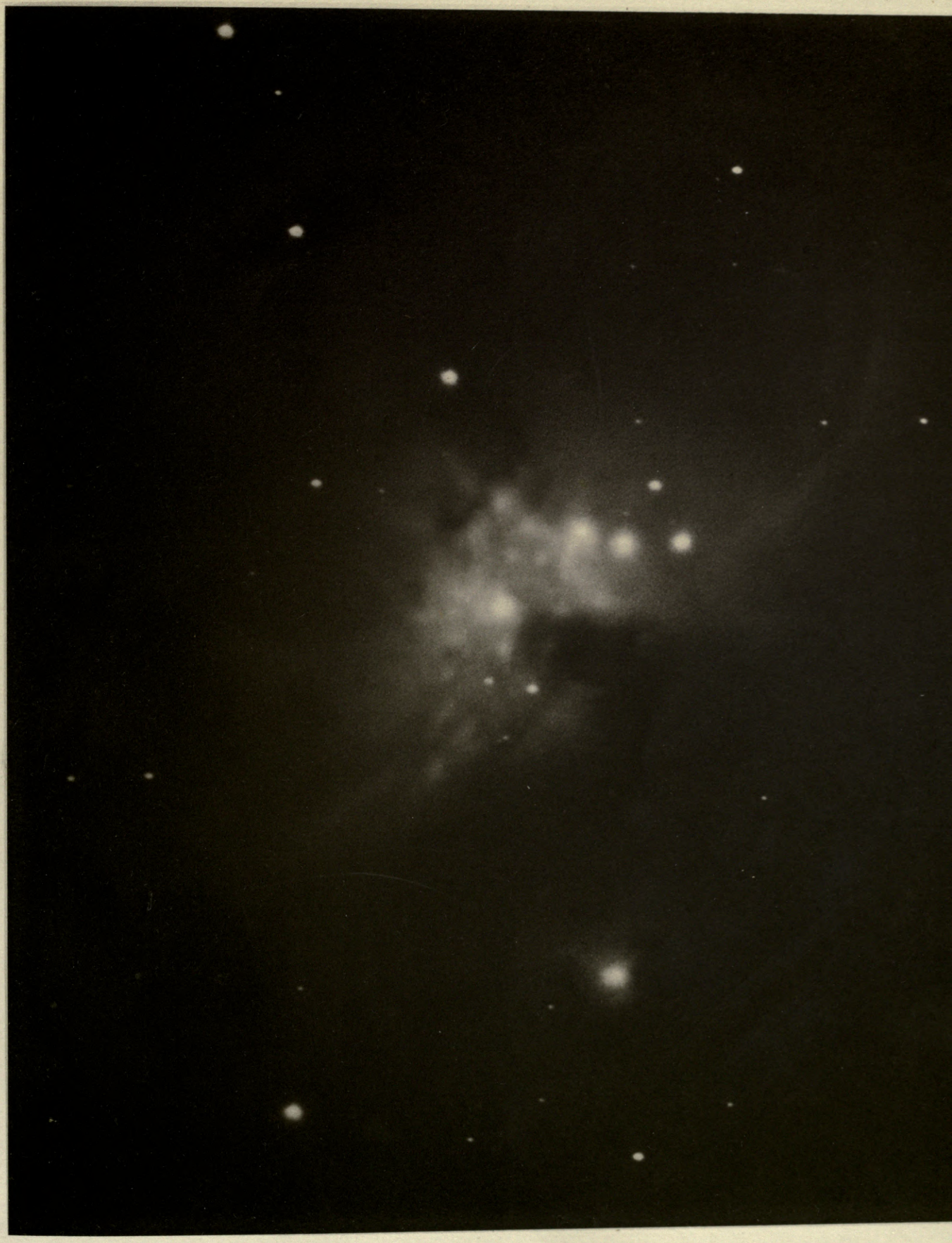

PHOTOGRAPH OF THE NEBULA IN ORION.

Taken by Professor Henry Draper M.D. March 14th 1882. Exposure 137 minutes.

This photograph is an artotype enlargement by E. Bierstadt from the original negative. The large stars be
brighter then the nebula are overexposed. This picture when compared with that taken Sept. 30th 1880,
increased extent and shows stars of the 14.7 magnitude of Pogson's scale.

Fig. 40

the relative magnitude of the stars, though that estimate requires correction for the color of the stars. It must be remembered that no one enlargement can do justice to the original negative; various exposures, various intensities of light, and various points of view are necessary for a complete examination.

"During the month of March, 1882, I also made four photographs of the spectrum of the nebula in *Orion*, which are described in the number of the *American Journal of Science* for May, 1882. Two of these were made with the slit spectroscope that I usually employ for photographing spectra of the stars and they show two lines in the ultra-violet plainly, beside the traces of two others. The first-mentioned two are hydrogen γ, λ 4340, and hydrogen δ, λ 4101; the others are too faint to give a good estimate of the wave length.

"The other spectrum photographs, taken without a slit, show that two of the condensed masses preceding the trapezium give a continuous spectrum, and, therefore, contain either gas under pressure, or liquid, or solid matter.*

"271 MADISON AVENUE, *New York*, *April* 29, 1882."

Although it is still too soon to give a final discussion to the photographic results attained by Dr. DRAPER, I cannot refrain from pointing out some of the conclusions which may be drawn from this marvelously perfect representation of the nebula.

If we compare the frontispiece with Fig. 40 we shall be able best to appreciate the important advance which has been made. BOND'S engraving is the most accurate drawing that has been made, even as a map, and as a picture it is decidedly the best representation of a single celestial object which we have by the old methods. The work of observing alone extended over years and consumed many precious hours. I have before said how much labor was spent upon the mechanical execution of the steel plate; scores of revises were criticised and read.

Dr. DRAPER'S negative was made in 137 minutes, and for nearly every purpose is incomparably better than the other. The color and tint of the nebula, which is wonderfully preserved in BOND'S engraving, is lost in the photograph; and yet, if the latter is held up between the eye and a window, the pictorial effect is most striking.

The amount of preparation for the two works is not to be estimated by years or hours, but it may be left out of account in a comparison. It required the best efforts of each observer to attain the results.

The telescope used by Dr. DRAPER is an 11-inch photographic refractor, made by ALVAN CLARK & SONS.

The *minimum visibile* for such an aperture is 14.4 on ARGELANDER'S scale.

In the accompanying Table A, I have given a list of the stars laid down by BOND which are found upon two photographic prints which Dr. DRAPER has sent me. Table B contains a list of such of BOND'S stars as are exterior to the brightest central nebula, and absent from these two prints. Naturally the original negative would show far fainter stars; but in my comparisons I have been confined to the use of these two prints, and I have included no star in Table A which is not shown in its true position on *both* the photographic prints examined.

* A private letter of Dr. HUGGINS informs me that in a photograph of the spectrum of the nebula taken in April, 1882, five lines are shown; the four previously known in the visible spectrum, and a new one, λ 3730.—E. S. H.

Taking Table A we see that stars as faint as 11.5 are plainly and well shown. No. 793, which is immersed in nebulosity and is only of the 11.7 magnitude, is yet clearly seen.

There are shown in the *photolithographs* five stars fainter than the 13.0 magnitude, viz, Nos. 435, 650, 653, 657, 778, whose magnitudes on ARGELANDER'S scale are 13.1, 13.1, 13 9, 13:1, 13.1, respectively.

In Table B the brightest star is of the 11.9 magnitude, and this star (808) is marked variable by BOND.*

TABLE A.

BOND'S number.	ARGELANDER'S magnitude.	Remarks.	BOND'S number.	ARGELANDER'S magnitude.	Remarks.
427	10.7	Very faint in photograph.	670	10.8	
430	11.7	Very faint in photograph.	685	8.3	
435	13.1	Very faint in photograph.	690	10.3	
449	10.5		700	11.5	
458	11.2	Very faint in photograph.	705	11.5	
467	8.7		707	11.2	
479	10.0		708	9.6	
505	9.6		709*	12.3	
506	11.3		724	10.5	
523	10.1		732	11.5	
551*	10.1		734	9.0	
554	9.0		741	10.0	
558	10.7		746	10.8	
570	9.4		750	10.8	
580	12.3		757	10.0	
598?	12.3	Doubtful in photograph.	778*	13.1	
635	10.5		781	10.8	
647*	12.1	Just visible.	784	10.8	
650	13.1		785	10.8	
653	13.9		793	11.7	In the nebula; faint in photograph.
657*	13.1		822	10.7	
663*	11.7		848	9.9	
669	9.8		863*?	12.5	Doubtful in photograph.

TABLE B.

BOND'S number.	ARGELANDER'S magnitude.	Remarks.	BOND'S number.	ARGELANDER'S magnitude.	Remarks.
508	12.3		641*	14.8	
510	13.1		652*	13.9	
516	13.5		767	13.9	
524*	12.5		789	14.8	
532	14.2		797*	15.0	
545	13.1		805	13.9	
552	14.9		808*	11.9	
566	13.3		826	14.8	
615	14.2		832	13.9	

N. B.—Those stars marked with the asterisk (*) were reported to be variable by BOND.

* It should be borne in mind that if these minute stars have a slightly reddish tint that also might account for their absence in the photograph.—[H. D.]

The stars marked with asterisks were counted variable by BOND, and the positions of some of them in the lists are suggestive. Undoubtedly No. 778 was near its maximum, and this instance suggests an important application of photography in the detection of variable stars.

It is, however, when we examine the details of the nebulous structure, as shown by the photograph, that we can best appreciate the astonishing advances which have been made.

The most important evidence to be obtained from Dr. DRAPER'S photograph is in relation to the brightness of the different portions of the *Huyghenian region.* The photograph gives, of course, the brightness as shown by the chemical decomposition of the salts of silver on the plates used. This is not directly comparable with their brightness estimated by the eye or measured with a photometer. Still it must be remembered that the plates used by Dr. DRAPER are sensitive to rays lower in the spectrum than *b*, for example, and therefore represent the results of eye observations far more nearly than ordinary sensitive (wet) plates would do. The brightest part of the photograph is in the region about A, agreeing with all my own photometric work. D is faint; about as bright as E. My photometric results of 1880 give in the mean E = 0.95 D. The earlier ones make E relatively considerably fainter. My conclusion from my own observations was that E is now brighter with respect to D than in 1878, and from the whole series of eye observations of all astronomers, that E has certainly increased in brightness. Formerly it was undoubtedly fainter than D. This was so from 1850 up to 1878 and even 1879. Now, by my photometer observations, and by the testimony of Dr. DRAPER'S photograph, it is about of the same brilliancy.

In the case of the mass A, also, the photograph gives undeniable evidence of change. For quite a time A was not the brightest mass of the nebula; now, it certainly is. In the photograph F is the brightest of the three masses F, G, H. My photometric observations agree with this. The mass N is the only one whose relative brilliancy is materially different in the photograph from its brilliancy as given in my own results. I attribute this in part, at least, to the effect of the proximity of the image of the star 685 to the mass N. This would alter the relative chemical effect of the masses near it and those far from any such influence, to some degree.

It will be of interest to compare Dr. DRAPER'S photograph and Fig. 7, which gives a drawing made by myself through tourmaline plates, arranged so as to cut off the fainter portions of the *Huyghenian region.*

The shape of the dark space bounded by E, F, and G, and I, is the same in both. The *Sinus Lamontii* is alike in both; the darker space, S, connecting τ with the *Sinus Lamontii*, is also similar, and so in other cases. The photograph, however, represents relatively far *more* light than Fig. 7, and if we were arranging our work in a series in the order of light, we should put first BOND'S drawing (the frontispiece), then DRAPER'S photograph (Fig. 40), and lastly, Fig. 7. To comprehend the extreme faintness of some of the nebulous masses represented in the photograph a study should be made of the *Messierian* branch, of the *regio Picardiana*, and especially of the mass $o\pi$ of the Index-Chart.

The comparison of the photograph with the drawing of Lord ROSSE (Fig. 33),

and of BOND (frontispiece), or with the Index-Map, should be made in order to appreciate their marked agreement.

I have not given such comparisons in detail for the obvious reason that this photograph comes as the beginning of a new epoch in such observations, and it will receive its proper discussion as the very first of a series of exact and automatic representations which we must thank the skill of Dr. DRAPER for inaugurating. I feel that the present memoir receives a new value in that it brings the work of the old period together for discussion, and leaves a clear field for the employment of the new, and far more satisfying methods. At the same time I must point out that the evidence to be derived from this photograph lends a great strength to the best previous drawings of the nebula, such as those of Lord ROSSE, BOND, and LASSELL. It has always been easy to object to drawings, estimates, and even photometric measures made on objects of so great faintness and difficulty as the nebulæ; and the conclusions derived from such work have often been met with the criticism, easy to make and hard to answer, that the personality of the observer was so much to be feared that such conclusions remained doubtful. I desire to emphasize the fact that all the important conclusions as to the present state of the nebula which I have derived from an examination of such drawings as those I have mentioned, are confirmed by this photographic representation, at least in so far as it is capable of giving any evidence at all, and that it comes to confirm, and not to destroy, our confidence in the faithful work of competent observers by the ordinary methods.

{ U. S. NAVAL OBSERVATORY, *Washington, D. C., December*, 1880. }
{ WASHBURN OBSERVATORY, *Madison, Wisconsin, May*, 1882. }