AURORAL AND MAGNETIC MEASUREMENTS FROM OBSERVATIONS AT HALDDE OBSERVATORY

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Introduction.

The material here dealt with was collected at Haldde Observatory (1) — maintained for observational work from November 1912 to August 1926 — of which the late O. Krogness was director from its opening until about the middle of 1918.

During the years 1912 to 1918 he gathered a very large number of parallactic auroral photos, some hundreds of which were earlier worked up, and the results published (2 and 3). Continued height-measurements and calculations were undertaken especially during the years 1924 and 1925, with Mrs. M. Flordal, B. Stav and E. Tønsberg as assistants. This work was carried on by Krogness himself and nearly concluded where pictures from 1914 and 1915 were concerned.

The second part of the present paper deals with a special type of auroral displays, termed by Krogness "Auroral Clouds," and previously treated in a short report (4).

The third part gives briefly the results of the absolute magnetic measurements taken at Haldde.

Height Measurements.

The present height-measurements are a directe continuation of those published earlier by Krogness and Vegard (2 and 3). All graphical aids and auxiliary calculations worked out in connection with these publications have been at our disposal, and as a matter of course the same working-method (3), of which no repetition seems necessary, has been adopted.

The whole stock of pictures was taken with the cameras previously used, which allow room for six pictures on every plate of magnitude 9×12 cm.

The photographic stations were Haldde ($\varphi = 69° 56'3$, $\lambda = 22° 55'8$ E. Gr.) and Bossekop ($\varphi = 69° 57'9$, $\lambda = 23° 14'9$ E. Gr.). The base-line was short, only 12.53 km., and its direction, unfortunately, nearly parallel to the direction of auroral arcs and bands.

About 550 parallactic pictures have been measured. For various reasons, however, by far the greater number have had to be refused, and not more than a hundred accepted for table I. The principal reasons for refusal were: too small parallactic angle for every long-distant aurora — a consequence of the short base-line — and a too uncertain determination of the parallactic angle for the majority of arcs and bands, the directions of which being nearly parallel to the direction of displacement. On the whole, table I comprises merely pictures for which a purposeful determination of lower limit or mean height had been undertaken.

For classification purposes we have followed "Photographic Atlas of Auroral Forms" (5), and in table I have introduced capital letters representing the different forms: —

H. A. means homogeneous quiet arcs.
H. B. means homogeneous bands.
D. S. means diffuse luminous surfaces.
A. C. means auroral clouds.
R. A. means arcs with ray-structure.
R. B. means bands with ray-structure.
D. means draperies.
R. means rays.

The headings of the columns of table I have the following explanations: —

Gr. M. T. means Greenwich Mean Time.
E. means time of exposure in seconds.
N. means current number.
F. means auroral form.
A. P. means auroral point. Points along one and the same contour have the same Roman number, but are marked out by consecutive Arabic numbers. Head-indexes express increasing heights, and are used for rays.
p. means parallactic angle in degrees, perhaps the best rule of the probable accuracy.

h. means height-angle in degrees.
a. means azimuth in degrees.
D. means the distance in km. along the earth's surface from Haldde to the geographical foot-point of the auroral point. The foot-point is determined by a and D.
H. means height above sea-level in km.
In the column headed. *Notes:*

L. L. means lower limit and U. L. upper limit.
Estim. is an abbreviation of estimated.

Table I.

Date	Gr. M. T.	E.	N.	F.	A. P.	p.	h.	a.	D.	H.	Notes.
9/12 1914	8 25 58	5	1	R. B.	I_1	4.40	40.68	180— 7.93	119	107	Mean L. L. 106.
					I_2	4.47	40.30	180— 7.40	118	104	
					I_3	4.78	45.90	180— 5.43	100	107	
	8 27 48	5	2	H. B.	I_1	2.60	26.20	180—31.30	226	121	Mean H. 118.
					I_2	2.20	22.40	180—37.68	264	118	
					I_3	1.78	18.32	180—41.78	323	118	
					II_1	2.20	20.88	180—34.25	274	114	
					II_2	1.50	14.78	180—41.70	392	117	
	8 28 37	2	3	D.	I	2.45	24.95	180—51.10	203	100	Mean L. L. 100.
					I′	2.00	34.08	180—53.35	224	160	
					II	2.68	22.55	180—33.35	224	99	
					II′	2.27	26.42	180—34.22	253	135	
					III	3.13	26.50	180—29.65	189	100	
					III′	2.77	30.80	180—30.97	203	127	
	8 28 38	2	4	D.	I	2.12	21.58	180—56.07	225	95	Mean L. L. 95.
					I′	1.95	24.32	180—57.94	234	113	
					II	2.52	23.38	180—50.47	201	93	
					II′	2.43	31.20	180—52.17	180	122	
					III	2.70	26.50	180—51.85	206	95	
					III′	2.18	33.27	180—53.47	223	143	
	8 28 44	2	5	D.	I	2.35	21.60	180—44.80	234	99	Mean L. L. 97.
					II	2.45	21.10	180—43.37	229	95	
	8 28 59	2	6	R.	I	3.45	41.20	180—66.85	110	100	L. L. 100.
					I′	3.65	44.80	180—67.75	101	104	
5/1 1915	7 13 49	35	7	H. A.	I_1	2.05	21.22	180—57.70	231	101	Mean L. L. 102.
					I_2	2.00	21.08	180—52.67	253	104	
	8 23 15	3	8	R. B.	I_1	2.97	22.85	180—16.03	217	98	Mean L. L. 101.
					I_2	3.00	24.75	180—15.72	212	104	
	8 24 18	3	9	H. B.	I_1	2.13	15.50	180—29.08	303	94	Mean L. L. 96.
					I_2	2.20	17.40	180—29.45	290	99	
	8 28 32	7	10	D. S.	I_1	3.10	35.68	180—28.40	174	132	Mean H. 133.
					I_2	3.23	39.35	180—29.25	157	135	
	8 28 44	7	11	R.	I	2.68	25.70	180—42.25	204	104	L. L. 104.
					I′	2.26	30.75	180—44.00	228	144	
	8 34 19	6	12	R. A.	I	1.70	12.20	180—18.10	402	102	L. L. 102.
	8 36 02	3	13	R. A.	I	1.60	9.70	180—20.00	432	90	L. L. 90.
7/1 1915	8 32 11	5	14	H. A.	I_1	2.65	16.30	180—22.93	248	84	Mean L. L. 85.
					I_2	2.35	16.30	180—32.25	268	86	

Table I.

Date	Gr. M. T.	E.	N.	F.	A. P.	p.	h.	a.	D.	H.	Notes.
7/1 1915	8 36 39	6	15	H. B.	I_1	1.20	23.45	180—84.35	231	107	Mean L. L. 108.
					I_2	1.30	25.93	180—85.90	215	110	
	8 58 58	8	16	D.	I	1.15	8.65	180—35.57	552	110	Mean L. L. 110.
					II	1.65	13.65	180—30.50	391	110	
	9 01 58	12	17	H. B.	I_1	1.90	20.60	180—60.20	237	96	L. L. 96.
					I_2	1.85	23.30	180—64.40	237	109	
	9 02 12	9	18	H. B.	I	1.63	20.97	180—67.82	241	100	L. L. 100.
	9 04 16	14	19	D.	I	1.37	16.08	180—60.52	331	106	L. L. 106.
					I′	1.35	18.73	180—61.37	329	124	
	9 18 47	13	20	R.	I	1.80	18.66	180—32.30	346	130	Estim. L. L. 125.
					I′	1.75	20.62	180—32.85	350	145	
					I″	1.65	22.65	180—33.24	364	167	
	9 19 14	10	21	R. B.	I_1	1.90	17.07	180—32.52	329	112	Estim. L. L. 110.
					I_2	1.95	18.90	180—33.48	315	118	
	9 21 20	19	22	R.	I	2.58	30.62	180—37.63	211	132	Estim. L. L. 125.
					I′	2.47	33.28	180—37.93	212	149	
					I″	2.40	36.90	180—38.33	212	167	
	9 21 49	26	23	R.	I	3.05	34.60	180—22.20	184	133	Estim. L. L. 130.
					I′	3.20	38.50	180—23.30	166	139	
					I″	3.25	42.38	180—24.10	154	147	Estim. U. L. 170.
	9 22 20	23	24	R.	I	3.27	32.58	180—22.70	177	118	L. L. 118.
					I′	3.17	36.42	180—24.73	173	133	
					I″	2.97	40.30	180—26.10	172	154	Estim. U. L. 200.
	9 25 12	16	25	R.	I	3.90	50.40	180—38.78	106	132	Estim. L. L. 125.
					I′	3.65	56.10	180—40.45	99	152	Estim. U. L. 180.
	9 26 30	19	26	D. S.	I_1	3.80	50.10	180—48.65	104	129	Mean H. 129.
					I_2	4.00	53.65	180—50.35	92	129	
					I_3	3.90	56.68	180—65.20	82	130	
					I_4	4.15	62.17	180—78.40	65	129	
	9 29 08	18	27	D. S.	I_1	1.95	32.90	180—63.75	212	145	N 27, 28 and 29.
					I_2	1.93	34.88	180—66.60	205	151	the same aurora.
					I_3	2.10	37.20	180—68.55	183	145	
	9 30 09	20	28	D. S.	I_1	1.80	33.42	180—72.30	205	143	Mean H. 144.
					I_2	1.87	35.65	180—73.93	193	145	
	9 30 37	26	29	D. S.	I_1	1.71	31.60	180—72.60	214	140	
					I_2	1.70	33.32	180—74.70	210	146	
	9 36 07	9	30	R.	I	1.03	10.53	180—62.95	420	94	L. L. 94.
					I′	0.95	12.58	180—63.77	447	118	
	9 41 48	20	31	R.	I	1.45	17.38	180—49.03	370	130	Estim. L. L. 110.
					I′	1.40	20.43	180—50.25	372	154	Estim. U. L. 220.
					I″	1.35	26.70	180—51.52	369	197	
	9 42 18	25	32	R.	I	1.73	18.46	180—53.95	289	105	N 32 and 33 the
					I′	1.52	22.72	180—55.22	317	145	same ray.
	9 42 46	24	33	R.	I	1.55	14.27	180—47.87	356	102	Estim. L. L. 100.
					I′	1.40	17.50	180—48.80	385	136	Estim. U. L. 150.
21/2 1915	5 51 31	9	34	H. A.	I_1	2.80	17.07	180—29.83	227	76	Mean L. L. 77.
					I_2	2.13	13.22	180—35.73	293	78	
	5 51 31	9	35	R. A.	I_1	2.78	22.12	180—39.42	207	90	Mean L. L. 91.
					I_2	2.31	18.57	180—39.05	255	93	

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Date	Gr. M. T.	E.	N.	F.	A. P.	p.	h.	a.	D.	H.	Notes.
21/2 1915	5 51 41	5	36	H. A.	I_1	2.62	17.02	180—31.02	242	81	Mean L. L. 83.
					I_2	1.70	11.33	180—38.57	364	85	
	5 51 41	5	37	R.	I	2.52	22.45	180—66.62	233	103	L. L. 103.
					I′	2.85	29.70	180—66.85	193	116	
	5 51 51	5	38	R. A.	I_1	1.37	11.37	180—37.90	452	109	L. L. 109.
					I_2	2.08	19.00	180—27.28	306	116	
	5 51 51	5	39	R. B.	I_1	2.32	16.67	180—40.03	255	83	Mean L. L. 87.
					I_2	2.85	22.03	180—40.80	200	86	
					I_3	3.20	27.40	180—41.40	170	92	
	5 51 58	4	40	H. A.	I_1	2.80	18.85	180—27.60	228	84	Mean L. L. 83.
					I_2	2.38	15.90	180—32.83	265	83	
	5 51 58	4	41	R. B.	I_1	3.55	30.78	180—42.02	148	92	Mean L. L. 95.
					I_2	3.70	34.43	180—42.22	137	98	
	5 53 23	6	42	D.	I_1	4.20	39.20	180+26.90	120	102	L. L. 102.
					I_2	3.45	43.52	180+26.80	138	136	
	5 53 57	6	43	R. B.	I_1	3.12	28.45	180+ 7.15	195	111	Mean H. 112.
					I_2	3.52	32.38	180+ 7.50	166	111	
					II	2.85	26.30	180— 3.70	222	116	
	5 54 07	5	44	R.	I	4.52	42.07	180— 0.20	116	108	L. L. 108.
					I′	4.40	45.97	180+ 0.05	112	119	
					I″	4.15	50.05	180+ 0.10	109	135	
6/3 1915	7 44 47	6	45	R. A.	I	2.52	22.47	180+22.05	229	101	N. 45, 46, 47 & 48 the same aurora.
	7 44 59	8	46	R. A.	I	3.00	26.02	180+21.16	190	98	Mean L. L. 99.
	7 45 13	10	47	R. A.	I	3.31	28.63	180+17.65	173	100	
	7 45 31	6	48	R. A.	I	2.76	21.75	180+12.45	225	96	
	8 02 12	10	49	R.	I	2.40	25.00	180+20.17	240	119	L. L. 119.
					I′	1.75	30.55	180+20.46	312	199	U. L. 200.
	8 07 56	12	50	D.	I_1	1.95	15.78	180+22.00	303	95	Mean L. L. 95.
					I_2	2.00	16.15	180+20.95	298	95	
8/3 1915	8 24 40	13	51	A. B.	I_1	4.72	56.68	35.30	70	108	Mean L. L. 107.
					I_2	5.27	61.30	29.35	57	107	
	9 22 34	2	52	D.	I	2.30	24.50	—77.32	181	88	Mean L. L. 93.
					II	2.20	24.30	—75.70	193	92	
					III	3.05	30.10	—73.50	148	90	
					IV	3.45	35.00	—72.55	132	96	
					V	3.55	35.90	—74.10	127	95	
	9 48 42	7	53	R.	I	3.39	31.20	180—21.60	174	110	L. L. 110.
					I′	3.43	35.20	180—21.68	163	121	
					I″	3.35	39.12	180—21.70	158	135	
	9 49 00	7	54	R.	I	3.22	29.08	180—26.30	183	107	L. L. 107.
					I′	3.37	32.90	180—26.55	168	114	
	9 50 00	6	55	R.	I	3.08	38.58	180—63.07	132	110	L. L. 110.
					I′	3.08	48.37	180—66.45	118	138	
11/3 1915	7 52 13	10	56	D.	I	4.18	45.62	180—27.25	113	119	Estim. L. L. 115.
					I′	4.22	49.68	180—27.57	103	126	
					II	4.15	45.90	180—22.60	115	122	
					II′	4.15	49.93	180—22.55	106	130	

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Date	Gr. M. T.	E.	N.	F.	A. P.	p.	h.	a.	D.	H.	Notes.
11/3 1915	7 52 47	7	57	R.	I I′ I″	3.35 3.39 3.39	38.00 41.70 45.50	180—41.40 180—41.55 180—41.65	147 138 130	119 127 138	Estim. L. L. 110.
	7 52 59	9	58	R.	I I′	3.90 3.40	44.28 48.10	180—38.13 180—38.50	118 126	119 146	Estim. L. L. 110.
	8 06 47	6	59	R. A.	I_1 I_2	2.18 2.35	16.42 18.23	180+15.58 180+20.63	273 252	88 90	Mean L. L. 89.
	8 22 49	8	60	R. A.	I	1.75	20.43	180—58.95	259	105	L. L. 105.
	8 30 08	18	61	H. B.	I	1.40	13.30	180+29.90	384	105	L. L. 105.
	8 43 50	5	62	R.	I I′ I″	2.05 2.12 2.13	22.38 25.53 28.85	180+35.35 180+36.03 180+36.70	246 236 231	109 121 136	Estim. L. L. 105.
	8 45 39	7	63	D.	I	1.55	15.20	180+29.58	341	104	L. L. 104.
15/3 1915	9 11 56	12	64	H. A.	I	2.40	19.80	180+ 2.00	272	106	N. 64, 65 and 66 the same aurora.
	9 12 11	9	65	H. A.	I	2.35	19.65	180+ 3.33	276	107	
	9 12 30	10	66	H. A.	I	2.50	21.05	180+ 6.00	256	106	L. L. 106.
	9 24 23	24	67	R. A.	I	2.25	18.90	180—29.23	280	105	L. L. 105.
20/3 1915	8 12 57	3	68	R. A.	I_1 I_2 I_3	3.65 3.65 3.90	24.85 26.18 27.40	180+ 0.66 180+ 4.16 180+ 7.66	175 165 157	86 86 86	Mean L. L. 86.
	8 13 06	4	69	H. A.	I_1 I_2	2.90 2.98	24.55 25.58	180+ 1.26 180+ 4.86	219 209	106 107	Mean L. L. 106.
	8 39 41	7	70	R.	I I′	2.05 2.00	21.83 28.48	180+34.00 180+34.57	255 253	110 146	N. 70 and 71 the same ray.
	8 39 54	11	71	R.	I I′ I″	2.05 2.10 2.10	22.90 26.10 29.40	180+35.75 180+36.17 180+36.67	248 240 236	113 125 141	Estim. L. L. 110.
21/3 1915	9 00 16	6	72	R.	I I′	2.10 2.10	31.52 36.93	180—81.40 180—88.95	152 152	98 120	L. L. 98.
3/4 1915	9 40 40	8	73	D.	I_1 I_2 I_3	2.30 2.78 3.05	19.72 22.85 24.40	180—61.50 180—58.00 180—54.80	216 182 170	83 81 82	Mean L. L. 82.
	9 41 05	5	74	D.	I	2.30	23.15	180+34.97	219	100	L. L. 100.
4/4 1915	8 57 39	5	75	R. B.	I_1 I_2	1.78 2.00	31.70 34.30	180—87.20 180—88.65	168 152	109 109	Mean L. L. 109.
	9 13 14	6	76	R. A.	I	1.93	34.32	88.50	151	108	L. L. 108.
	10 03 11	9	77	H. B.	I_1 I_2	5.25 5.15	73.68 70.50	5.70 13.90	37 44	128 127	N. 77, 78 and 79 the same aurora.
	10 03 24	10	78	H. B.	I_1 I_2	5.60 5.60	74.00 71.45	1.40 8.00	34 39	122 118	Mean L. L. 124.
	10 03 38	10	79	H. B.	I	5.42	73.92	0.50	35	125	
	10 07 28	11	80	H. B.	I_1 I_2	6.50 6.65	74.15 70.50	—45.55 —11.95	29 35	107 101	N. 80 and 81 the same aurora.

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Date	Gr. M. T.	E.	N.	F.	A. P.	p.	h.	a.	D.	H.	Notes.
4/4 1915	10 07 43	9	81	H. B.	I_1	6.60	73.20	—50.60	31	105	Mean L. L. 104.
					I_2	6.82	72.00	—26.75	32	101	
					I_3	6.25	70.30	— 8.55	37	107	
	10 21 04	12	82	H. B.	I_1	2.10	30.50	180+64.50	180	112	Mean L. L. 111.
					I_2	1.52	24.13	180+62.35	231	110	
	10 21 42	14	83	H. B.	I	3.02	38.30	180+68.10	133	109	Mean L. L. 108.
					II	3.35	40.55	180+67.60	120	107	
	10 22 31	16	84	H. B.	I_1	3.60	40.10	180+67.70	112	98	Mean L. L. 97.
					I_2	2.47	31.00	180+65.88	154	97	
					I_3	1.43	21.03	180+63.00	232	96	
	10 22 56	26	85	H. B.	I_1	2.00	28.00	180+63.10	187	105	N. 85 and 86 the same aurora.
					I_2	1.30	21.32	180+61.88	258	108	
					II	2.00	27.77	180+64.48	184	102	
	10 23 25	24	86	H. B.	I_1	3.10	38.32	180+66.40	130	106	Mean L. L. 105.
					I_2	1.58	24.10	180+63.70	219	104	
	10 24 51	22	87	H. B.	I_1	2.55	35.30	180+69.75	152	112	Mean L. L. 110.
					I_2	2.00	29.60	180+68.90	182	109	
9/3 1915	0 33 02	11	88	A. C. I	I	2.60	30.1	30.8	175	106	Mean H. 106.
	0 33 19	13		,,	I	2.70	30.6	30.0	170	106	
	0 33 40	18		,,	I	2.70	31.2	28.4	172	111	
	0 34 06	24		,,	I_1	2.61	38.2	31.7	171	112	
					I_2	3.04	32.7	26.6	155	102	
	0 34 32	15		,,	I_1	2.66	30.5	31.7	169	104	
					I_2	3.22	36.7	24.1	142	110	
					I_3	3.30	32.9	24.5	145	98	
	0 34 54	17		,,	I	3.35	34.7	22.6	143	103	
	0 33 02	11	89	A. C. II	I	3.35	35.0	19.9	148	108	Mean H. 106.
	0 33 19	13		,,	I	3.45	35.9	20.2	141	106	
	0 33 40	18		,,	I_1	3.60	38.4	16.8	134	111	
					I_2	4.13	40.0	8.8	120	105	
					I_3	3.93	36.1	9.0	133	101	
	0 34 06	24		,,	I	3.70	37.1	15.1	133	106	
	0 40 22	26	90	A. C. III	I	5.17	48.1	—16.1	91	105	Mean H. 110.
	0 41 08	11		,,	I	4.57	45.9	—19.0	107	114	
	0 41 49	25		,,	I	4.75	51.4	—47.6	90	116	
	0 44 42	22		,,	I	5.32	50.6	—36.2	84	106	
	0 45 21	19		,,	I_1	4.55	39.9	—36.7	116	101	
					I_2	4.58	44.7	—34.2	108	111	
	0 40 22	26	91	A. C. IV	I_1	4.70	46.2	— 4.9	101	109	Mean H. 109.
					I_2	4.68	47.8	— 0.1	97	110	
	0 41 08	11		,,	I_1	5.14	42.3	— 5.3	99	94	
					I_2	4.88	46.3	— 8.0	98	106	
	0 41 49	25		,,	I	4.27	42.5	— 5.3	119	113	
	0 42 40	24		,,	I_1	4.25	44.0	2.1	114	114	
					I_2	4.55	44.6	—10.4	110	112	
	0 44 42	22		,,	I_1	5.10	53.1	—34.0	83	114	
					I_2	5.42	49.9	—30.0	84	103	
	1 07 53	10	92	A. C. V	I_1	4.92	57.4	13.5	71	115	Mean H. 110.
					I_2	4.87	53.1	15.0	79	109	
	1 08 13	10		,,	I_1	4.23	47.4	21.0	98	110	
					I_2	4.97	55.9	19.4	72	109	
					I_3	5.27	62.3	27.1	55	109	
					I_4	4.97	54.9	14.7	75	110	
					I_5	4.72	50.3	17.3	85	107	
	1 08 33	15		,,	I_1	4.70	50.3	17.5	85	107	
					I_2	4.83	54.8	15.8	77	112	
					I_3	4.53	53.2	13.4	85	118	
					I_4	4.88	57.7	11.7	72	117	

Table I.

Date	Gr. M. T.	E.	N.	F.	A. P.	p.	h.	a.	D.	H.	Notes.
9/3 1915	1 08 51	20		A. C. V.	I_1	5.00	50.9	15.2	80	102	
					I_2	5.15	55.3	13.9	72	106	
					I_3	5.03	53.6	21.2	77	107	
					I_4	4.91	49.1	22.0	85	101	
	1 08 13	10	93	A. C. VI	I	5.40	52.7	— 0.4	76	104	Mean H. 110.
	1 08 33	15		,,	I_1	5.00	50.7	5.1	83	106	
					I_2	4.70	52.6	6.3	86	116	
					I_3	4.90	51.5	— 4.1	87	113	
	2 00 00	40	94	A. C. IX	I_1	5.45	58.9	18.4	61	104	Mean H. 106.
					I_2	5.60	60.0	22.0	57	102	
	2 01 15	40		,,	I_1	5.88	62.1	13.5	52	102	
					I_2	5.65	62.9	19.3	52	105	
					I_3	5.70	64.8	20.8	49	106	
	2 02 00	40		,,	I	5.73	65.4	18.8	48	107	
	2 03 25	29		,,	I_1	6.08	68.0	5.8	40	106	
					I_2	5.85	68.5	15.7	41	109	
	2 05 00	26		,,	I	6.17	74.5	8.2	29	109	

The statistical treatment of the results in table I will be limited to a summary table of lower limit of different auroral forms, and a diagram showing the frequency of auroral displays in different height-intervals. We will deal with *individual pictures* as distinct from *single points,* to avoid any accidental circumstance in the height-distribution. In future work we should like to be able to give a graphical representation of the height-interval of each individual aurora along a consecutive time-scale, just as practised by Störmer (7, fig. 12 & 17) for several years, but to be able to do so the auroral points must be carefully selected for this purpose.

The fixation of limits — especially the upper one — may be very problematic, and we cannot be sure that another sort of plate — different from the one used with respect to absolute and selective sensitivity and softness, — might have given a different result. Time of exposure and development may cause limit-variations as well.

As seen from the " Notes " -column in table I we have for subsequent pictures — perhaps two or more — of one and the same aurora given only *one* lower limit or mean height. This practice is a further consequence of our consideration of pictures instead of points in the statistical treatment. We do not mean, however, to postulate that an auroral display from appearance to disappearance should remain on exactly the same height-level.

Table II below gives the height-distribution for different auroral forms — marked by capital letters — of lower limit and mean height together, because in the present case we consider the mean height to be the real lower limit.

Table II. Height-distribution of Lower Limit.

Height.	H. A.	H. B.	D. S.	A. C.	R. A.	R. B.	D.	R.	Total Number.	Number.
77	1								1	
82							1		1	
83	2								2	4
85	1								1	
86					1				1	
87						1			1	
88										4
89					1				1	
90					1				1	
91					1				1	
92										
93							1		1	6
94								1	1	
95						1	2		3	
96		2							2	
97		1							1	
98							1	1	2	11
99					1				1	
100		1					2	2	5	
101						1			1	
102	1				1		1		3	
103								1	1	13
104		1					1	1	3	
105		2			2			1	5	
106	2			3		1	1		7	
107		1						1	2	
108		2			1			1	4	28
109				1	1	1			3	
110		1		3		1	1	6	12	
111		1							1	
112						1			1	
113										3
114										
115							1		1	
118		1						1	2	3
119								1	1	
124		1							1	4
125								3	3	
129			1						1	
130								1	1	3
133			1						1	
144			1						1	1
Number	7	14	3	7	10	7	12	21	81	
Mean H.	92	106	135	108	98	103	100	110	105.2	

Let us give a graphical representation of the last column of table II (see next page).

The predominant number in the interval 106—110 km. (fig. 1) may partly be due to the *estimated* value of 110 km., naturally chosen in preference to 111 or 112 when we are not sure all the same.

Regarding table II we find a mean height of homogeneous arcs of 92 km. This low value may be due to an accident because of the diminutive number. On the other hand, height-measurements of arcs, at The Auroral Observatory, Tromsö, during the last years often give results of 80 km., a value particularly usual for arcs with red-coloured lower border.

It may be said, however, that the relative few heights here determined are in good agreement with earlier results from Northern Norway.

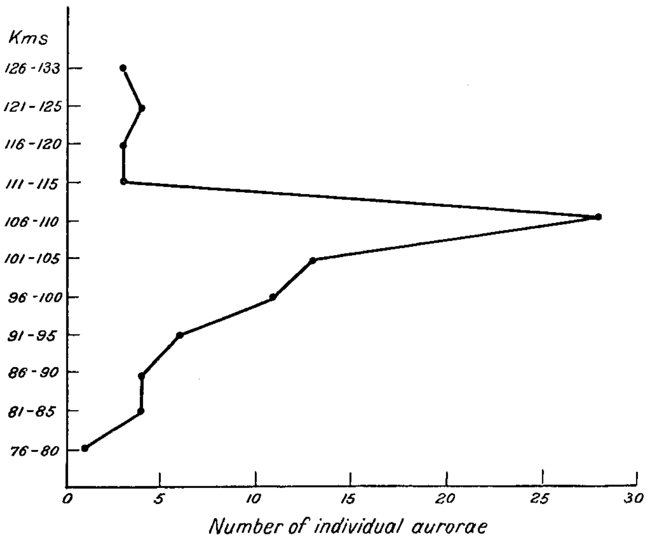

Fig. 1.

Cloud-resembling Aurorae.

Among the more seldom types of auroral displays — even in the auroral zone — are the pulsating and diffuse surfaces. As a rule they appear relatively late in the night after vivid and intense displays of rays and draperies. They look faint, usually of a bluish-white colour, most frequently with sudden, rhythmical changes of the light-intensity. Sometimes, however, the changes — both with respect to light-intensity and formation — are more continuous or gradual. Up to several minutes this cloud-resembling auroral display — named " auroral cloud " — remains in the sky, evidently slowly moving across it.

Such auroral clouds have been observed and described, and successful series of photos of them obtained both by Störmer (5, pag. 10 and 6, pag. 46 & 65) and Vegard & Krogness (3, pag. 93 & 98 and 4, pag. 3—5). Their height-measurements give about the same results, an altitude of around 100 km. For one series, Störmer has determined the average velocity in horizontal direction and finds 41 metres per second.

For the present series of auroral clouds — Nos 88—94 in table I — the mean altitudes are determined to 106—110 km. Regarding the said table I, we find considerable differences in H for subsequent pictures of the same cloud. This was expected, however, on account of the difficulty in obtaining an accurate drawing of outlines for the very faint pictures from Bossekop. Thus we may hold the probable inaccuracy in the determination of the heights responsible for the variations found, and calculate with a constant mean height for every series of pictures, for each individual auroral cloud. But we would emphasize that we do not mean to postulate that an auroral cloud from appearance to disappearance remains at exactly the same level, although the height-measurements up to this time seem to indicate so approximately. For our picture-series photographed from one single station, we have estimated the height to be 110 km., a value not far from the real one.

The above mentioned visual impression of a moving across the sky of some auroral clouds can be decided by the relative position between stars and clouds from time to time. For the auroral clouds to be dealt with here — the Haldde pictures reproduced on plate I & II — such a displacement could easily be stated only by regarding subsequent pictures. To study the development and magnitude of this displacement we select from the enlarged images — already drawn for the height-determinations — some fragments of outlines which can be identified on a certain number of subsequent drawings. These outline-fragments for the whole picture-series are then — by means of stars and time-intervals between subsequent exposures — drawn on one single figure which illustrates the development of displacement fairly well. The different series are reproduced on figs 4 & 5. To avoid confusion by crossing lines the front-contour and back-contour are usually drawn on separate figures. The time-intervals in seconds between subsequent pictures or contours are put down in respective intervals on the figures, and the times for the first and the last exposure of every series are also given.

Let us determine the velocity of the displacement of an auroral cloud, regarding its altitude as constant and calculating with the earth level as a plane for the territory in question.

On fig. 2 P is an auroral point with altitude H, height-angle h and azimuth a. The distance d is then determined by:

$$d = H \cdot \operatorname{cotg}\, h.$$

Now calculating the distances d for a whole series of intersection points

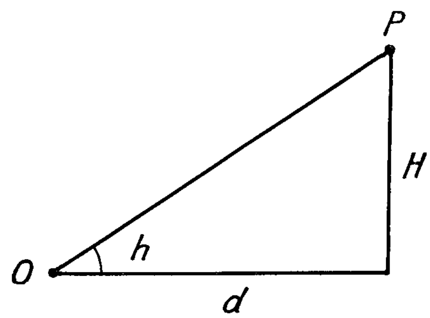

Fig. 2.

along a cut-line, and knowing the respective azimuths of the points we have the necessary data. The distances $S_{1,2}$ . . $S_{n,n+1}$ between successive observed points are equal and parallel to the real travel of the auroral point considered in the respective time-intervals $t_{1,2}$ . . $t_{n,n+1}$. The mean horizontal velocity $V_{n,n+1}$ in the timeinterval $t_{n,n+1}$ is determined by:

$$V_{n,n+1} = \frac{S_{n,n+1}}{t_{n,n+1}}$$

and the average mean velocity by:

$$V_{1,n} = \frac{\sum S_{n,n+1}}{t_{1,n}}$$

The distances $S_{n,n+1}$ can be calculated from the formula:

$$S_{n,n+1} = d^2_n + d^2_{n+1} - 2\, d_n\, d_{n+1} \cos(a_n - a_{n+1}).$$

They are, however, read off direct on *fig. 3* which illustrates the displacements in magnitude and direction of all auroral clouds dealt with.

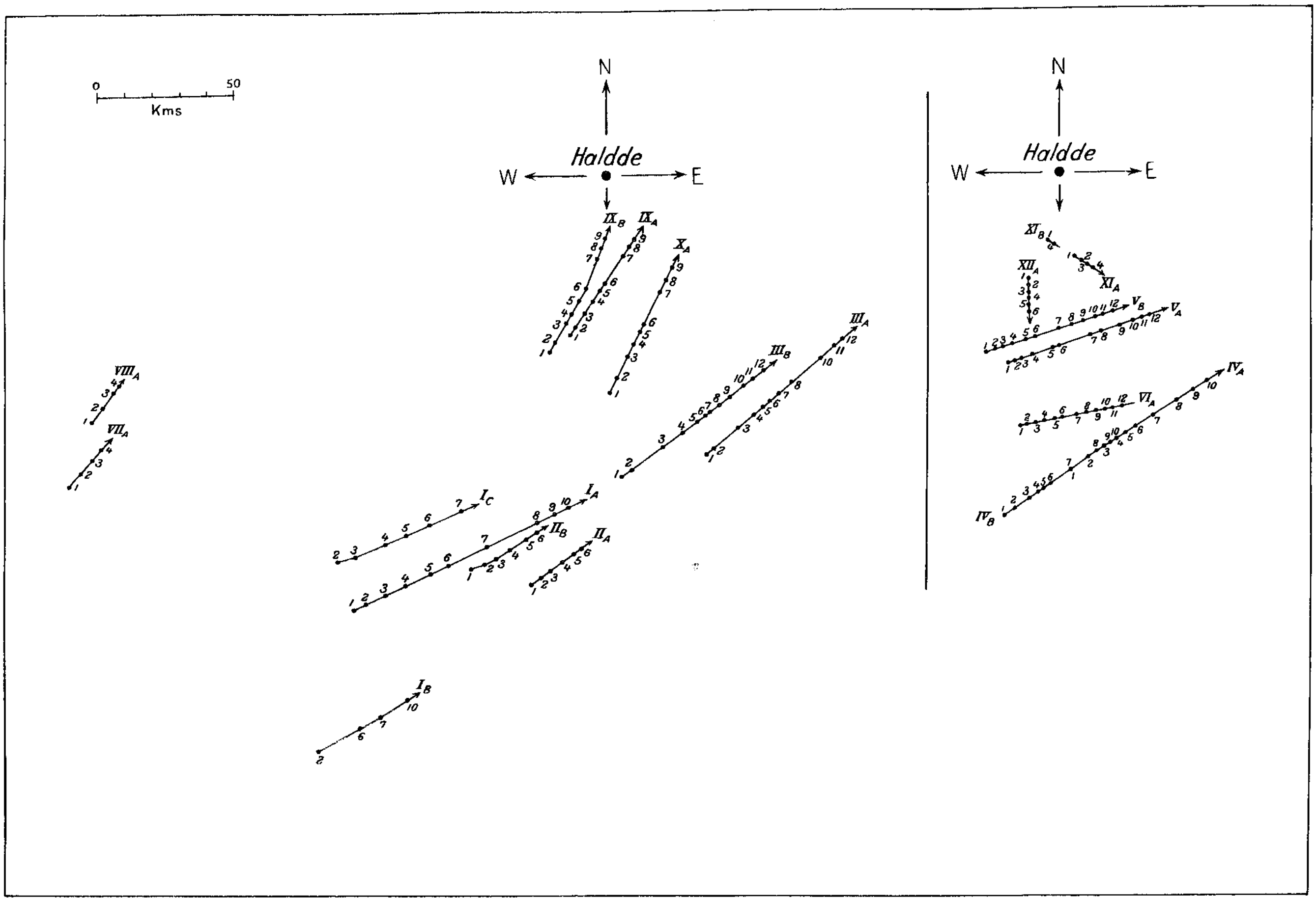

Fig. 3.

The numbers and letters on fig. 3 correspond to those in fig. 4 and 5 and in table III below. In this table, the headings of the columns need the following explanation: —

A. C_N means auroral cloud number, P_N picture number but also consecutive number along the corresponding cut-line Cl. H altitude in km., h and a height and azimuth in degrees, d the distance H-cotg h in km., S the distance $S_{n,n+1}$ in km., t the time-interval $t_{n,n+1}$ in seconds, v the mean velocity $v_{n,n+1}$ and V the average mean velocity $V_{1,n}$, both in metres per second.

Table III.

Date.	A . C_N P_N	Cl.	H.	h.	a.	d.	s.	t.	v.	V.
9/3 1915	I (88) 1	A	106	30.1	30.8	183				
	2			30.6	30.0	179	4.7	17	276	
	3			31.7	28.4	172	8.3	21	395	
	4			32.6	26.6	166	8.5	26	327	
	5			33.9	24.2	158	10.0	26	385	
	6			34.7	22.6	153	7.1	22	323	
	7			36.8	18.2	142	15.5	49	316	
	8			39.4	11.8	129	20.5	53	387	
	9			40.3	9.2	125	6.5	33	197	
	10			41.0	7.0	122	6.4	20	320	*327*
	I 2	B	106	24.3	27.1	235				
	6			25.7	24.7	220	17.1	95	180	
	7			26.5	23.8	213	9.0	49	184	
	10			27.6	21.3	203	11.5	106	108	*150*
	I 2	C	106	31.8	35.2	171				
	3			32.6	33.9	166	7.0	21	333	
	4			34.0	31.7	157	11.3	26	435	
	5			35.3	29.7	150	8.7	26	335	
	6			36.8	27.3	142	9.5	22	432	
	7			38.6	24.1	133	12.5	49	255	*340*
	II (89) 1	A	106	35.1	11.2	151				
	2			35.6	10.0	148	4.4	17	159	
	3			36.1	9.0	145	4.0	21	190	
	4			36.9	7.3	141	5.0	26	192	
	5			37.6	5.7	138	5.4	26	208	
	6			37.9	4.8	136	3.4	22	155	*198*
	II 1	B	106	35.0	19.9	151				
	2			35.6	18.0	148	5.7	17	335	
	3			36.2	16.8	145	4.2	21	200	
	4			37.1	15.1	140	6.0	26	231	
	5			38.1	13.0	135	7.6	26	292	
	6			38.8	11.8	132	4.1	22	186	*246*
	III (90) 1	A	110	45.6	—19.2	107.5				
	2			45.9	—21.0	106.6	3.5	17	206	
	3			46.6	—26.9	104.0	11.5	91	126	
	4			46.9	—31.2	102.9	7.6	42	181	
	5			47.0	—33.4	102.5	4.1	46	89	
	6			47.1	—35.2	102.2	3.6	41	88	
	7			47.4	—37.8	101.0	4.2	24	175	
	8			47.5	—41.2	100.8	6.0	27	222	
	10			47.4	—49.2	101.2	14.0	81	173	
	11			47.1	—52.5	102.2	6.0	41	146	
	12			46.7	—54.8	103.6	4.0	39	103	*144*
	III 1	B	110	45.0	— 2.4	110				
	2			45.7	— 3.2	107	4.5	17	265	
	3			47.5	—11.4	101	14.0	91	154	
	4			48.4	—16.0	97.5	9.0	42	214	
	5			49.0	—20.1	95.6	6.8	46	148	
	6			49.3	—22.0	94.6	3.7	41	90	
	7			49.5	—23.2	94.0	2.4	24	100	
	8			49.7	—25.8	93.3	3.9	27	145	
	9			50.0	—28.8	92.3	4.9	38	129	
	10			50.3	—32.8	91.3	6.8	43	158	
	11			50.4	—36.0	91.0	5.0	41	122	
	12			50.5	—38.5	90.7	4.0	39	102	*145*
	IV (91) 1	A	109	45.6	— 2.0	106.7				
	2			46.5	— 5.5	103.4	7.2	42	171	
	3			47.5	— 9.0	99.9	7.0	46	152	
	4			48.1	—12.0	97.8	5.2	41	127	
	5			48.4	—14.1	96.8	3.8	24	158	
	6			48.8	—16.3	95.4	3.8	27	141	
	7			49.4	—21.2	93.4	7.8	38	205	

Table III.

Date.	A . C_N P_N	Cl.	H.	h.	a.	d.	s.	t.	v.	V.
$^9/_3$ 1915	8			49.8	—27.5	92.1	10.6	43	246	
	9			49.9	—31.7	91.8	7.2	41	176	
	10			49.9	—35.5	91.8	6.3	39	162	*173*
	IV 1	B	109	40.9	9.8	125.8				
	2			41.8	8.0	121.9	5.2	42	124	
	3			42.7	5.8	118.1	6.0	46	130	
	4			43.3	4.2	115.7	4.1	41	100	
	5			43.7	3.2	114.1	2.5	24	104	
	6			44.1	2.2	112.5	2.7	27	100	
	7			45.6	— 2.0	106.7	10.0	38	263	
	8			47.0	— 7.4	101.6	11.0	43	255	
	9			47.7	—10.4	99.2	6.0	41	146	
	10			48.1	—12.0	97.8	3.0	39	77	*148*
	V (92) 1	A	110	57.2	15.7	70.9				
	2			57.8	14.0	69.3	2.5	20	125	
	3			58.3	12.0	67.9	3.0	20	150	
	4			58.9	9.6	66.3	3.3	18	183	
	5			60.3	2.7	62.7	8.2	40		
	6			60.6	0.6	62.0	2.5	20		
	7			61.7	—10.6	59.2	11.7	60		
	8			61.8	—14.6	59.0	4.3	30		
	9			61.8	—21.3	59.0	7.0	30		
	10			61.6	—26.4	59.5	5.1	30		
	11			61.4	—29.7	60.0	3.7	30		
	12			61.2	—31.9	60.5	2.5	abt. 270	abt. 167	abt. *165*
	V 1	B	110	57.8	22.7	69.3				
	2			58.4	21.5	67.7	3.3	20	165	
	3			59.2	18.9	65.6	3.0	20	150	
	4			59.9	16.2	63.8	3.5	18	194	
	5			61.2	12.0	60.5	5.5	40		
	6			61.7	9.2	59.2	3.5	20		
	7			63.2	0.7	55.6	9.0	60		
	8			63.7	— 4.6	54.4	4.8	30		
	9			64.0	— 8.9	53.7	4.2	30		
	10			64.2	—13.8	53.2	4.7	30		
	11			64.2	—17.0	53.2	3.0	30		
	12			64.1	—20.3	53.4	3.5	abt. 270	abt. 142	abl. *150*
	VI (93) 1	A	110	50.2	9.2	91.6				
	2			50.5	7.6	90.7	2.8	20	140	
	3			50.8	5.5	89.7	3.2	20	160	
	4			51.0	3.8	89.1	3.0	18	167	
	5			51.3	1.2	88.1	4.0	40		
	6			51.5	— 0.9	87.5	3.1	20		
	7			51.8	— 4.2	86.6	5.1	60		
	8			51.8	— 6.8	86.6	3.7	30		
	9			51.9	— 8.7	86.3	3.5	30		
	10			51.9	—10.9	86.3	3.1	30		
	11			51.9	—12.8	86.3	3.0	30		
	12			51.9	—14.8	86.3	3.5	abt. 270	abt. 107	abt. *115*
	VII 1	A	110	26.0	60.4	226				
	2			26.6	61.0	220	6.8	44	154	
	3			27.2	61.5	214	6.4	46	139	
	4			27.8	62.0	208	5.5	46	120	*137*
	VIII 1	A	110	27.9	64.9	208				
	2			28.6	65.8	202	7.0	44	159	
	3			29.3	66.8	196	6.7	46	146	
	4			29.7	67.2	193	4.0	46	87	*130*
	IX (94) 1	A	106	60.5	13.6	60.0				
	2			61.8	12.5	56.8	3.7	40	93	
	3			64.6	9.6	50.3	6.8	75	91	
	4			66.6	7.0	45.9	5.0	45	111	
	5			68.6	4.1	41.5	4.7	44	107	

Table III.

Date.	A . C_N P_N	Cl.	H.	h.	a.	d.	s.	t.	v.	V.
9/3 1915	6			69.9	1.6	38.8	3.3	41	80	
	7			74.4	—11.5	29.6	12.0	95	126	
	8			75.8	—18.5	26.8	4.2	37	114	
	9			76.8	—24.0	24.9	3.5	37	95	*104*
	IX 1	B	106	57.5	18.5	67.5				
	2			59.0	17.8	63.7	4.5	40	113	
	3			62.5	15.7	55.2	8.0	75	107	
	4			64.1	14.6	51.5	4.0	45	89	
	5			66.6	12.8	45.9	5.3	44	120	
	6			68.5	11.0	41.8	5.2	41	127	
	7			74.1	7.2	30.2	11.5	95	121	
	8			76.3	4.6	25.8	4.5	37	122	
	9			78.0	1.1	22.5	4.2	37	114	*114*
	X 1	A	110	54.0	0.3	80				
	2			56.1	— 2.5	74	6.8	40	170	
	3			59.0	— 6.3	66	9.3	75	124	
	4			60.6	— 8.7	62	4.8	45	107	
	5			62.1	—11.7	58	5.4	44	123	
	7			67.1	—24.0	46	16.0	136	118	
	8			68.5	—29.0	43	4.7	37	127	
	9			69.6	—34.2	41	5.0	37	135	*125*
8/12 1914	XI 1	A	110	74.7	— 8.8	30.1				
	2			73.6	—12.8	32.4	3.2	52	62	
	3			72.5	—16.0	34.7	3.0	53	57	
	4			71.6	—18.3	36.6	2.4	52	46	*55*
	XI 1	B	110	77.5	11.8	24.4				
	2			77.3	9.0	24.8	1.0	52	19	
	3			77.0	7.2	25.3	1.0	53	19	
	4			76.8	5.5	25.7	0.9	52	17	*18*
	XII 1	A	110	70.3	17.1	39.4				
	2			69.1	15.9	42.0	2.8	37	76	
	3			68.1	15.0	44.2	2.5	40	63	
	4			67.1	14.0	46.5	2.4	52	45	
	5			66.0	13.1	49.0	2.5	48	52	
	6			65.0	12.5	51.3	2.2	34	65	*59*

A predominant feature in the column of mean velocities is the great and sudden jumps or fluctuations within one and the same series of pictures. But this is not very surprising. The faint and indistinct limited auroral clouds in motion, here dealt with, nearly exclude a precise drawing of outlines, because the mutual situation of those ones (fig. 4 and 5) must be somewhat uncertain. In this respect, however, there is a considerable difference between different pictures. The uncertainty in the drawing of outlines is without doubt the principal source of error in the determination of mean velocities, but the graphical method, the drawing of *straight* cut-lines and the assumption of a displacement strictly on the same level may also involve errors. Nevertheless the great majority of velocity-jumps cannot be due to these technical infirmities, but to the real development of the formation of the auroral clouds. Only by glancing at successive pictures do we get an impression in favour of this view. For a more particular study of velocityjumps, form-changes and limitation-uncertainty table III, fig. 4 and 5, and the pictures (Plate I & II) assist us.

Although Nos I and II occur on the same pictures the average mean velocities differ by about 100 metres. Particularly I exhibits great and irregular velocity-jumps. The widely different values from cut-lines A and B on one and the same contour seem to be due especially to a characteristic development in exterior, most prominent from pictures 7 to 10.

Nos III and IV also occur on the same pictures, and their average mean velocities are about in agreement. We notice great velocity-jumps and

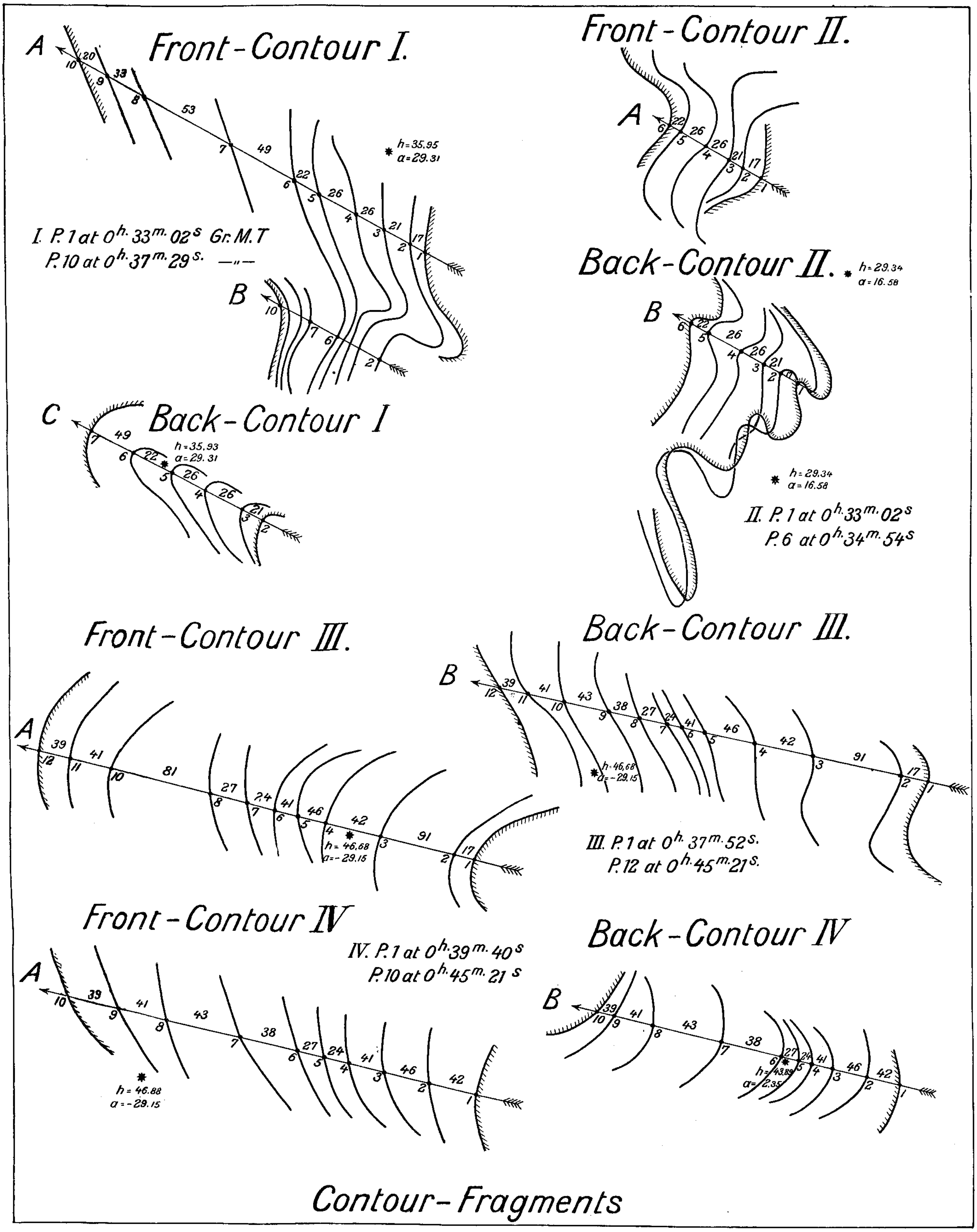
Front-Contour I.
I. P. 1 at 0h. 33m. 02s Gr. M. T
P. 10 at 0h. 37m. 29s. —„—
h = 35.95
a = 29.31
Back-Contour I
h = 35.93
a = 29.31
Front-Contour II.
Back-Contour II.
h = 29.34
a = 16.58
II. P. 1 at 0h. 33m. 02s
P. 6 at 0h. 34m. 54s
Front-Contour III.
h = 46.68
a = -29.15
Back-Contour III.
III. P. 1 at 0h. 37m. 52s.
P. 12 at 0h. 45m. 21s.
Front-Contour IV
IV. P. 1 at 0h. 39m. 40s
P. 10 at 0h. 45m. 21s
h = 46.88
a = -29.15
Back-Contour IV
Contour-Fragments

Fig. 4.

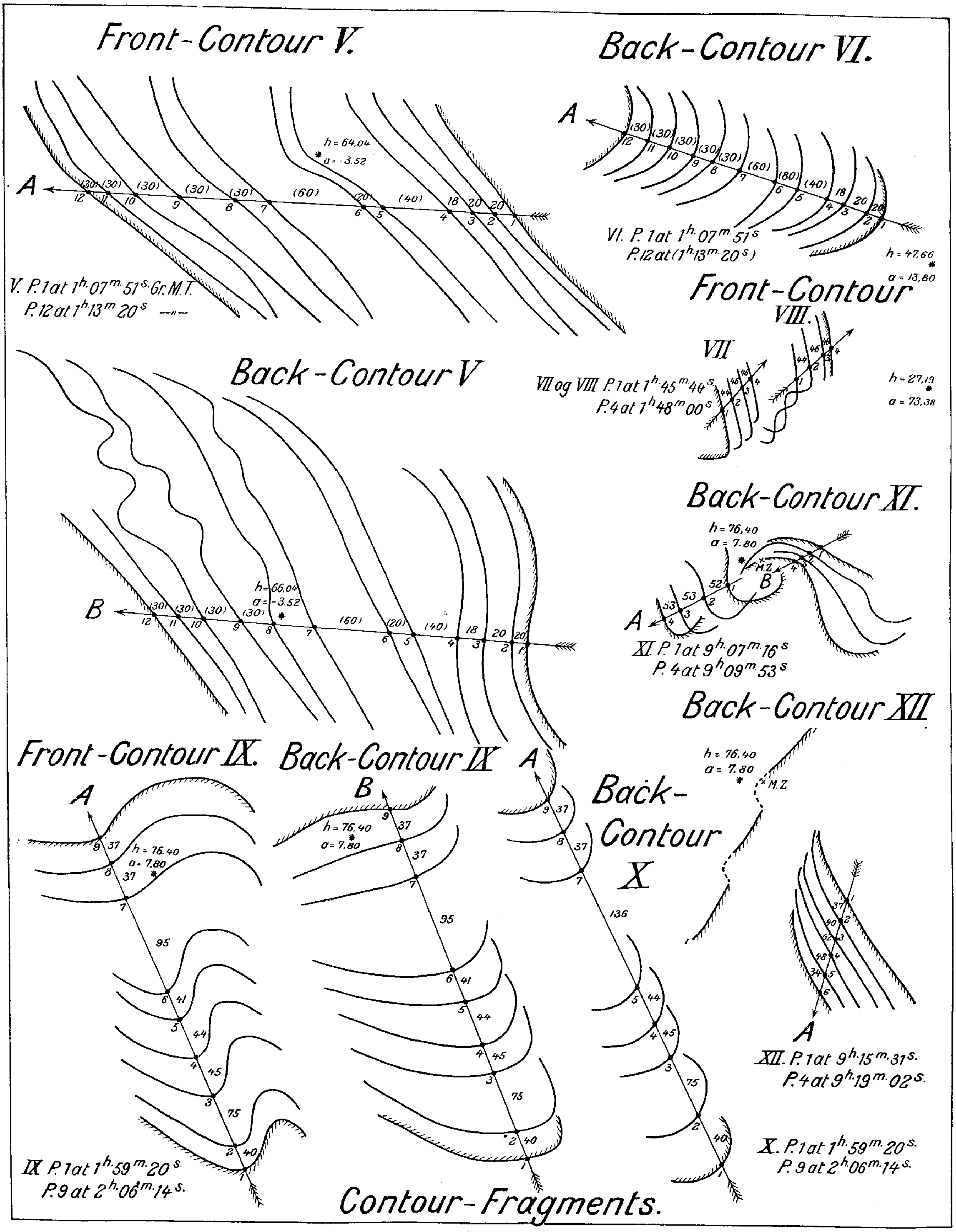
Front-Contour V.
V. P.1 at 1h·07m·51s·Gr.M.T.
P.12 at 1h.13m.20s —"—
h = 64.04
a = -3.52
Back-Contour VI.
VI. P.1 at 1h·07m·51s
P.12 at (1h.13m.20s)
h = 47.66
a = 13.80
Front-Contour VIII.
VII
VII og VIII P.1 at 1h·45m44s
P.4 at 1h48m00s
h = 27.19
a = 73.38
Back-Contour V
h = 66.04
a = -3.52
Back-Contour XI.
h = 76.40
a = 7.80
XI. P.1 at 9h·07m·16s
P.4 at 9h09m·53s
Back-Contour XII
h = 76.40
a = 7.80
XII. P.1 at 9h·15m·31s.
P.4 at 9h·19m·02s.
Front-Contour IX.
IX P.1 at 1h·59m·20s.
P.9 at 2h·06m·14s.
Back-Contour IX
Back-Contour X
X. P.1 at 1h·59m·20s.
P.9 at 2h·06m·14s.
Contour-Fragments.

Fig. 5.

form-changes for both. The majority of pictures are very diffusely limited, and consequently the drawing of outlines would be difficult and uncertain. The first and last pictures look very different in size and form.

Nos V and VI — simultaneous too — are, unfortunately, lacking for time-notes after picture 4, estimated time-intervals are given in brackets, the final-time proposed is not far from the true one. The first pictures of V look more like an *ordinary* auroral display, than like an auroral cloud.

Nos VII and VIII are a couple of auroral patches, probably of the pulsating type. Some changes in appearance are evident from the pictures.

Nos IX and X — simultaneous too — have in many cases very diffuse limitations, nevertheless the displacements are found to be more regular than ever.

The auroral clouds briefly described above appeared on an early morning during violent magnetic activity, just as is usually found for this special type of auroral displays. Nos XI and XII, however, were photographed relatively early in the night and during fairly quiet magnetic conditions. They belong to the very faint and most probably pulsating type, and exhibit a shape, characteristic for auroral displays near magnetic zenith. The magnetic zenith point is marked with a cross on the figures. The drawn contour for XI shows a remarkable difference in displacement along the two cut-lines A and B.

The problem of the interpretation of the auroral clouds, has been discussed both by Störmer (6, pag. 65) and Krogness (4, pag. 3—5). Störmer raises the question whether the auroral clouds are to be interpreted as a secondary phenomenon of a violent electric ray-bombardment, thus being individual afterglowing atmospherical patches drifting away, or whether, according to usual auroral displays, they may be caused by an electric bombardment direct, and that it is the bombard area in the atmosphere which is successively, or more gradually, displaced from time to time. Such a displacement of auroral displays frequently takes place. It is particularly evident for some homogeneous arcs arising on the northern sky, but it can easily be seen for more vivid aurorae as well. Series of pictures which could prove this visual impression must have been taken several times, but investigation with respect to this point is probably lacking.

A discussion of the auroral clouds has been given by Krogness (4). He expresses the view that the peculiar pulsating type may be of a more " atmospheric " nature than ordinary aurorae, perhaps a sort of " ion-cloud," intermittingly illuminated by some sort of electric radiation. And about the more stable cloud-resemblig type he expresses : " I consider it probable that these formations in many cases are real atmospheric self-illuminating ' ion-clouds ' that are moving with the atmosphere in the high strata." In favour of this view Krogness gives the following report : " During the night between the 22nd and 23rd of January 1926 I observed a dark red ' auroral cloud.' This was well limited and not very large. Through this ' cloud ' shot some very long green rays of a large drapery. Both above and below this red 'cloud ' the green colour was distinctly visible in the streamer. In the ' cloud ' the colour of the streamer was red. In the course of about a quarter of an hour the red ' cloud ' moved across the sky. When the rays passed through the ' cloud ' the red colour became stronger. Otherwise the intensity of light was very faint. This observation, I think, must, at any rate, most naturally be interpreted by the assumption that the red ' cloud ' was a real, definite and well limited atmospheric formation. Further observations of this kind, however, will, of course, be desirable."

The light intensity distribution of the auroral clouds has been examined both by means of filters and spectrographs. By his filter-investigations Harang (8, pag. 20) has found that the relative intensity of violet to green is considerably greater than for ordinary aurorae. This effect has been stated by the spectographic results of Vegard (9, pag. 27 and 28). A comparison of the relative intensity between the green line of 5577 Å and the blue band of 4278 Å for diffuse auroral areas against auroral arcs gives an intensity-reduction of the green line up to 23 per cent. Since the height-measurements of the auroral clouds have always given 100—110 km., the above stated effect can hardly be interpreted as an altitude-effect, but rather as a type-effect, according to the view of Harang (8). This means, however, that the luminescence from the auroral clouds is somewhat exceptional.

A very interesting phenomenon with some points of outward resemblance to the auroral clouds are the *luminous night-clouds* (10 and 11). From observations both by O. Jesse (1885—91) and C. Störmer (1932—34) an average mean height of 82 km. has been calculated for these particular clouds, and the total number of heights measured does not differ more than a few kilometres from this value. Also the velocity — both in magnitude and direction — of the luminous night-clouds have been determined. From the observations of O. Jesse, velocities are found from 30 up to 300 metres per second, and with a direction most frequently from NE and ENE. The accurate measurements of Störmer give velocities from about 40 to 85 metres per second and a predominant direction of displacement of about E to W. The drift-directions of our auroral clouds are seen on fig. 3. The predominant northerly direction may be general, or only special for one evening, a question which future observations may decide.

As seen from the results given, both heights and velocities of the luminous night-clouds are not very different from those found for our auroral clouds. Another point of outward resemblance is the current changes in limitation, form and mutual situation. The question arises if these points of outward resemblance are not merely occasional, but *general* for any other " cloud " at height-levels of 80 to 110 km. A definite answer is hardly possible. The two " cloud " -phenomena here compared, however, are most likely widely different in origin and nature. If we accept the opinion of Vestine and Störmer (11), the luminous night-clouds are sun-lit dust of matter from interplanetary space, while, on the other hand, the auroral clouds — according to the prevailing auroral theory — should be atmospherical areas, the luminescence of which, excited by bombardment of an electric radiation from the sun, the possibility of an afterglow not being altogether out of the question. And with that problematic possibility stands and falls the interpretation of the auroral clouds once proposed by Krogness.

It does not seem necessary, however, to introduce any self-luminous atmospherical areas to explain the particular displacement and development of the auroral clouds. An analogous moving across the sky — a displacement of the field of bombardment — is really often seen in connection with arcs and bands.

Magnetic Measurements.

The apparatuses used for absolute magnetic measurements at Haldde were a theodolite and an inclinatorium of the Tesdorph construction. The constants and corrections of these instruments were determined by measurements undertaken by Krogness at Potsdam 1912 and " Rude Skov," Copenhagen, 1928. As to the method for determination of the constants, we refer to an earlier description by Krogness (12).

The magnetic observations at Haldde were performed in a small house, specially arranged and set apart for this purpose. The observations are relatively few in number, a natural consequence of various difficulties and circumstances. By means of the magnetic records the observed values could be reduced to *quiet normal-values* of the dates of observation.

Declination.

The reduction to normal-values may introduce an error of say $\pm 3'$, corresponding to ± 2 mm. on the records.

The results of calculation are:

1914. $^{23}/_4$: D = 2° 33′ W. $^{12}/_8$: D = 2° 33′ W.
1915. $^{5}/_6$: D = 2° 24′ W.
1917. $^{4}/_7$: D = 2° 9′ W.
1921. $^{14}/_3$: D = 1° 37′ W.
1922. $^{28}/_3$: D = 1° 38′ W. $^{2}/_5$: D = 1° 38′ W.
1926. $^{4}/_8$: D = 1° 3′ W.

In the course of 12 years the declination at Haldde has turned eastward by 90′, that means an average variation of 7′.5 per year, a value in good agreement with the corresponding one from Bossekop (13), which is only 12.5 km. distant from Haldde.

Horizontal Intensity.

The horizontal intensity was determined by oscillations and deflections.

In the reduction to normal-values may be included an inaccurascy of say $\pm 10\,\gamma$ corresponding to ± 2 mm. on the records.

The results of calculation are:

1913. $^{26}/_4$: H = 12190 γ.
1914. $^{23}/_4$: H = 12167 γ. $^{24}/_4$: H = 12159 γ.
$^{30}/_4$: H = 12162 γ. $^{12}/_8$: H = 12145 γ.
1915. $^{4}/_6$: H = 12130 γ.
1917. $^{5}/_7$: H = 12063 γ.
1920. $^{25}/_8$: H = 11945 γ.
1922. $^{2}/_5$: H = 11880 γ.
1926. $^{4}/_8$: H = 11695 γ. $^{5}/_8$: H = 11700 γ.

During 13 years H has decreased around 470 γ, or 35 γ per year as an average, just the same value as found at The Auroral Observatory, Tromsö, for the last 4 years. A surprising fall, however, compared with the annual average decrease at Bossekop, of about 15 γ between 1882 and 1932.

Inclination.

The results of calculation without any reduction by means of normal-values of horizontal- and vertical-intensity are:

1914. $^{24}/_{3}$: I = 76° 36′ $^{24}/_{4}$ & $^{1}/_{5}$ & $^{12}/_{8}$: I = 76° 30′.
$^{26}/_{11}$: I = 76° 40′.
1915. $^{4}/_{6}$: I = 76° 33′.
1917. $^{4}/_{7}$: I = 76° 37′.
1919. $^{20}/_{1}$: I = 76° 40′. $^{5}/_{6}$: I = 76° 43′.
1920. $^{25}/_{8}$: I = 76° 44′.
1922. $^{2}/_{5}$: I = 76° 52′.
1926. $^{4}/_{8}$: I = 76° 53′. $^{6}/_{8}$: I = 76° 55′.

The values are mutually in bad agreement. An annual increase of about 2′ is perhaps probable.

If we calculate with a decrease in H of 35 γ, and an increase in I of 2′ per year, it would mean a nearly constant vertical-intensity. To-day the vertical-intensity at Tromsö is very slowly increasing. For Bossekop we have found an annual increase of 2 γ from 1882 to 1932.

A graphical representation of the series of measurements is given in fig. 6.

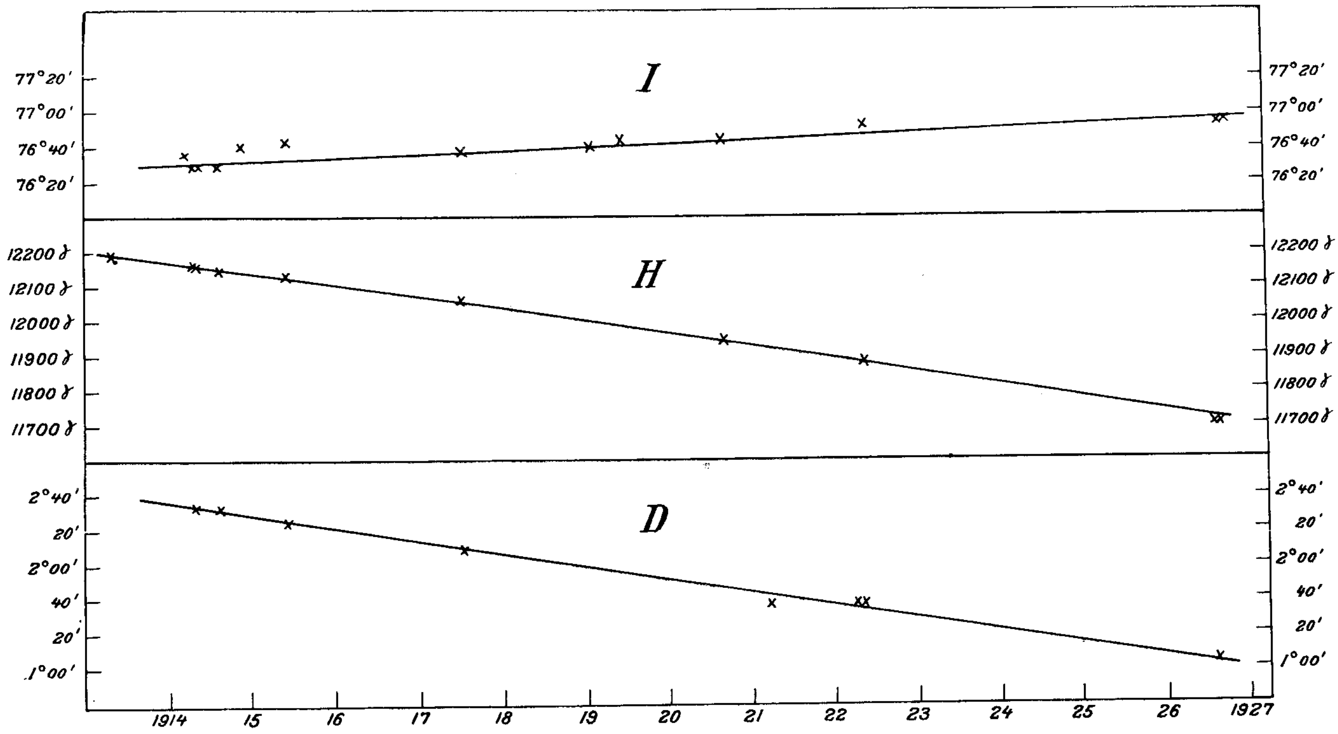

Fig. 6.

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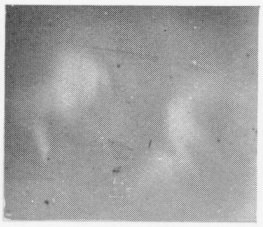
13. Norwegian Publications from The International Polar Year 1932—33. Publikasjoner fra Det Norske Institutt for Kosmisk Fysikk. No. 6. 1935.

Plate I


$II_1\ I_1$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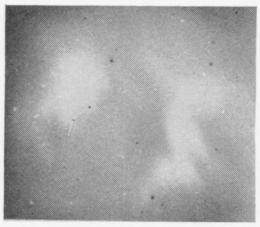
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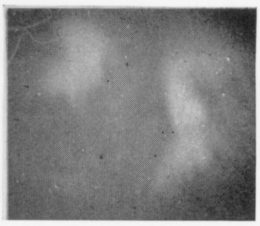
$II_4\ I_4$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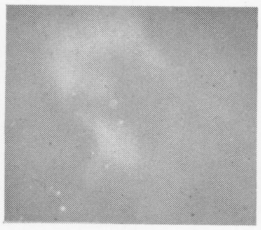
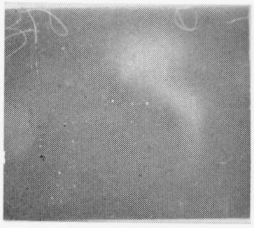
$II_6\ I_6$


I_7


I_8


I_9


I_{10}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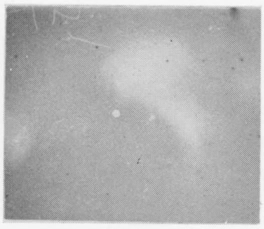
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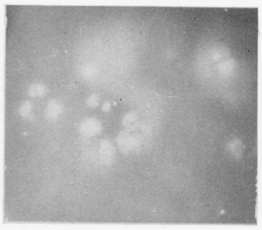
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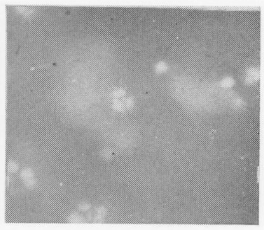
$III_4\ IV_2$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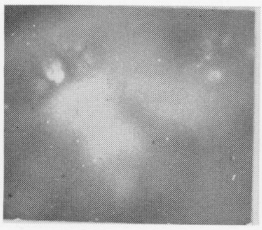
$III_7\ IV_5$


$III_8\ IV_6$


III_9


$III_{10}\ IV_8$


$III_{11}\ IV_9$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$VI_2\ V_2$


$VI_3\ V_3$


$VI_4\ V_4$


$VI_5\ V_5$


$VI_6\ V_6$


$VI_7\ V_7$


$VI_8\ V_8$

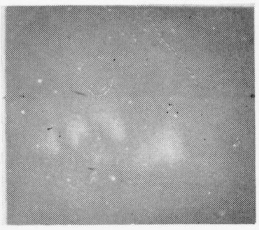
Plate II


VI_9 V_9


VI_{10} V_{10}


VI_{11} V_{11}


VI_{12} V_{12}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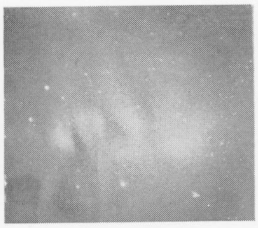
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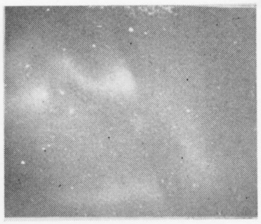
VII_4 $VIII_4$


X_1 IX_1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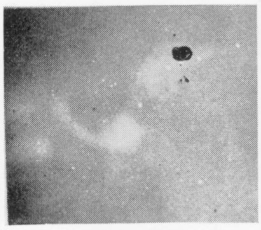
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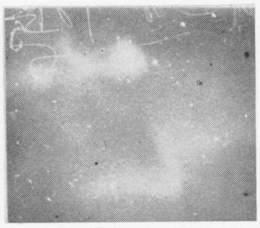
X_4 IX_4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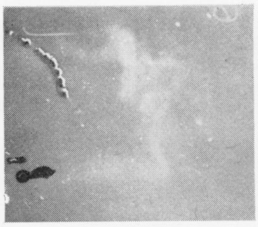
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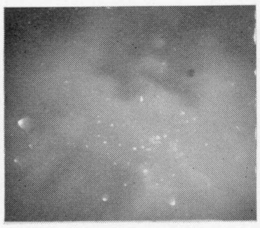
X_7 IX_7


X_8 IX_8


X_9 IX_9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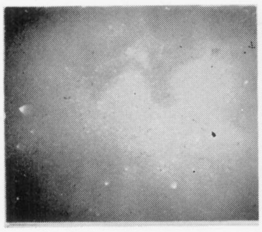
XI_2


XI_3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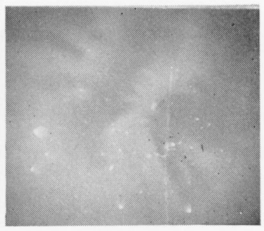
XII_1


XII_2


XII_3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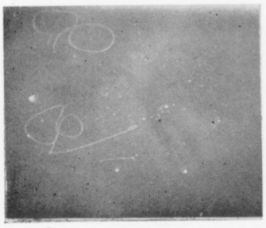
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XII_6