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Comet Bennett 1969i as photographed on April 5, 1970 at the Lines Observatory, Mayer, Arizona, by Helen and Richard Lines and Evered Kreimer. The 2-minute exposure on 103F was made with a cooled emulsion camera on the 16-inch telescope shown in Figure 9 on page 100. The photograph is unusual in that it shows both tail streamers and head structure, a result achieved with an out-of-focus printing mask. On pg. 97 *et seq.* of this issue Mr. Lines describes a simple micrometer microscope for off-axis guiding in comet photography.

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ALPO

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IN THIS ISSUE

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JUPITER IN 1967-68: ROTATION PERIODS

By: Phillip W. Budine, A.L.P.O. Jupiter Recorder

The highlights of the 1967-68 apparition were: the appearance of a very dark "Dark Streak" in the middle of the STB (South Temperate Belt) resembling the "Red Streak" of 1891; the return of the NN Temperate Current B along the S edge of the NNTB, which current had been last observed in 1945; observational evidence for a new record for the North Tropical Current "B"; observations of the Circulating Current; and the prominence of the Great Red Spot with its deep brown border.

Some data pertinent to the apparition follow:

Date of Opposition:	1968, February 20 (Universal Time).
Date of East Quadrature:	1968, May 17.
Declination of Jupiter:	12°N (at opposition).
Equatorial Diameter:	44.8 seconds (at opposition).
Zenocentric Declination of Earth:	-1°0 (at opposition).
Stellar Magnitude of Jupiter:	-2.1 (at opposition).

This report is based on 4,155 visual central meridian transit observations submitted by 19 observers of the A.L.P.O. When they are plotted on graph paper 1,759 transits form usable drifts for 103 Jovian spots distributed in 13 different atmospheric currents. The contributing observers are listed below by name and number of transits submitted, along with station of observation and telescope(s) employed.

Budine, Phillip W.	Binghamton, N.Y.	10-in. refl.	1580t.
Delano, Kenneth J.	Fall River, Mass.	12.5-in. refl.	5t.
Dragesco, Jean	Cameroons, Africa	10-in. refl.	73t.
Fite, Ronnie (& Preslar, Tony)	Landis, N.C.	8-in. refl.	99t.
Gordon, Rodger W.	Barrington, N.J.	3.5-in. refl.	191t.
Heath, Alan W.	Nottingham, England	12-in. refl.	4t.
Krisciunas, Kevin	Naperville, Ill.	6-in. refl.	55t.
Loveland, Fred	Binghamton, N.Y.	3-in. refl.	93t.
Mackal, Paul K.	Mequon, Wisc.	6-in. refl.	6t.
McIntosh, Patrick S.	Boulder, Colorado	6-in. refl.	26t.
Moore, Patrick	Armagh, Ireland	10-in. refr.	506t.
Niedfeldt, Dale	Madison, Wisc.	15.6-in. refr.*	9t.
Osawa, Toshihiko	Hyogo, Japan	8-in. refl.	Sectional Drawings.
Ricker, Charles L.	Marquette, Mich.	6-in. refl.	78t.
Stewart, Robert N.	Indianapolis, Ind.	10-in. refl.	934t.
Thiede, Eric	Madison, Wisc.	15.6-in. refr.*	386t.
Wacker, Wynn K.	Madison, Wisc.	15.6-in. refr.*	90t.
Winkler, William R.	Suitland, Md.	8-in. refl.	20t.

*Washburn Observatory.

The distribution of transit observations by months is as follows:

1967,	September	10	1968,	January	306	1968,	May	252
	October	96		February	1290		June	55
	November	190		March	875		July	7
	December	342		April	732			

In the tables which follow, the first column gives an identifying number or letter to each object. The second column indicates whether the object was dark (D) or bright (W) and whether the preceding end (p), center (c), or following end (f) was being observed. The third column gives the first and last dates of observation: the fourth column, the longitudes on those dates. The fifth column gives the longitude at opposition, February 20, 1968. (Some features were not being observed at opposition.) The sixth column gives the number of transits obtained. The seventh column indicates the number of degrees in longitude that the marking drifted in 30 days, negative when the longitude decreased with time. The eighth column shows the rotation period in hours, minutes, and seconds.

S.S. Temperate Current (S. Part of STeZ), System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Dp	Jan. 24-Apr. 30	277°- 185°	250°	18	-27°.9	9:55:02
2	Dc	Feb. 6-May 5	270 - 186	256	19	-28.0	9:55:02
3	Df	Feb. 14-Apr. 30	268 - 200	262	12	-29.5	9:55:00
				Mean Rotation Period:			9:55:02

Object 1-3 above was a dark section of the SSTB which was well observed by A.L.P.O. members. Sato observed it well on March 4; and it is illustrated on his drawing published as Figure 11 in Mr. Mackal's 1967-68 Apparition Report: J.A.L.P.O., Volume 22, Nos. 9-10. The period of 9:55:02 is short for this current, but not so short as the 1929-30 period, which was 9:54:57.

S. Temperate Current (S. edge STB, STeZ), System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
B	Wp	Oct. 7-June 6	96°- 305°	7°	40	-18°.9	9:55:15
1	Wc	Oct. 7-June 6	103 - 312	16	68	-18.9	9:55:15
C	Wf	Oct. 7-June 6	110 - 319	24	42	-18.9	9:55:15
2	Dp	Jan. 16-Mar. 8	87 - 47	65	5	-22.2	9:55:10
3	Wc	Mar. 25-Apr. 18	42 - 25	--	4	-24.0	9:55:08
4	Dc	Dec. 16-Jan. 7	145 - 133	--	4	-19.7	9:55:14
5	Dc	Apr. 15-June 4	62 - 9	--	5	-23.1	9:55:09
D	Wp	Oct. 3-May 21	233 - 78	135	23	-20.2	9:55:13
6	Wc	Oct. 3-May 21	240 - 85	143	40	-20.2	9:55:13
E	Wf	Oct. 3-May 21	247 - 92	151	26	-20.2	9:55:13
7	Wc	Apr. 16-May 8	133 - 120	---	4	-22.6	9:55:10
F	Wp	Oct. 29-May 22	335 - 208	260	19	-18.7	9:55:15
8	Wc	Oct. 29-May 22	342 - 215	269	26	-18.7	9:55:15
A	Wf	Oct. 29-May 22	348 - 221	277	22	-18.7	9:55:15
				Mean Rotation Period:			9:55:13

The three long-enduring white ovals of the $STeZ_n$ remained prominent throughout the 1967-68 apparition. However, it would appear that they are continuing to contract or shrink in length! The mean length of each oval was as follows: FA, 13°; BC, 14°; and DE, 14°. Let us compare these lengths with the figures for the other apparitions I have reported on:

	FA	BC	DE
1964-65	18°	17°	17°
1965-66	17°	18°	17°
1966-67	16°	16°	16°
1967-68	13°	14°	14°

The oval BC was accelerated in the direction of decreasing longitude from 29° to 26° (a 3° shift) as it was nearing conjunction with the Red Spot on February 2, 1968. The center of the Red Spot was in conjunction with the center of the oval BC on February 9, 1968 at longitude 27° (II); see Figure 1 accompanying this paper. The above change in velocity indicates once again the influence of the Red Spot on the long-enduring ovals when they are nearing conjunction with the Great Red Spot.

Middle STB, System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Wc	Dec. 4-Jan. 21	255°- 225°	---	14	-18°.7	9:55:15
2	Dp	Dec. 17-Mar. 8	257 - 205	213°	17	-18.6	9:55:15
3	Dc	Dec. 17-Mar. 8	267 - 215	223	19	-18.6	9:55:15
4	Df	Dec. 17-Mar. 8	275 - 223	233	17	-18.6	9:55:15
				Mean Rotation Period:			9:55:15

Marking No. 1 was a small bright spot preceding the STB "Dark Streak". Marking 2-4 is the "Dark Streak" in the STB which was very prominent, and was the only dark feature of the STB in a very faint portion of the belt covering 130° of longitude between the long-enduring ovals DE and FA. A very similar faint section was observed in 1964-65 between the ovals BC and DE. This dark feature or Dark Streak was quite similar to the "Dark Red Streak" of 1891. The only other known feature which has been similar is the dark section of 1935.

Red Spot Region, System II

Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
RSp	Sept. 9-June 21	16° - 16°	16°	75	0°.00	9:55:40.5
RSc	Sept. 9-June 21	26 - 26	26	98	0.00	9:55:40.5
RSf	Sept. 9-June 21	36 - 36	36	81	0.00	9:55:40.5
			Mean Rotation Period:			9:55:40.5

The Great Red Spot was very prominent in 1967-68, even more so than in 1966-67. It had a dark border which made the feature even more striking. Visual transits indicate a mean length of 20° in longitude. However, during the latter part of the 1967-68 apparition the length, including the border, was about 23°. Central meridian transit observations of the preceding and following ends of the Red Spot indicate oscillations in longitude. When one studies the drift chart for the p and f ends, the following oscillations are revealed:

RSp

1967,	Sept.	9 - 16°
	Nov.	18 - 18
	Dec.	27 - 20
1968,	Feb.	11 - 17
	Mar.	9 - 17
	Apr.	19 - 15
	May	29 - 13
	June	9 - 15
	June	21 - 16

RSf

1967,	Sept.	9 - 36°
	Nov.	4 - 37
	Nov.	18 - 36
	Dec.	20 - 39
1968,	Feb.	10 - 36
	Mar.	10 - 39
	June	18 - 37
	June	21 - 36

South Tropical Zone, System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Wc	Feb. 25-Mar. 9	329°- 301°	308°	8	-55°.2	9:54:25
2	Dp	Jan. 10-Mar. 6	359 - 312	322	7	-26.1	9:55:05
3	Wp	Oct. 19-Dec. 4	107 - 111	---	4	+ 2.5	9:55:44
4	Wc	Oct. 19-Dec. 4	119 - 118	---	5	- 0.6	9:55:40
5	Wf	Oct. 19-Dec. 4	129 - 125	---	5	- 2.5	9:55:37
6	Wc	Nov. 27-Feb. 17	200 - 215	---	7	+ 5.4	9:55:48
7	Wc	Nov. 27-Feb. 17	220 - 232	---	7	+ 4.3	9:55:47
			Mean Rotation Period:		Nos. 1 and 2		9:54:45
					Nos. 3 - 7		9:55:43

The above markings had periods similar to those found in the STrZ for 1947, 1948, and 1949. Markings No. 1 and 2 were preceding the Red Spot. Markings No. 3 - 7 were following the Red Spot. Observers may recall that an STrZ Disturbance was recorded during 1966-67 and was observed near the end of that apparition to have a preceding end at 205° (II) and a following end at 246° (II) as of May 14, 1967. Therefore, its length was then 41°. It had a rotation period of 9:55:33. During 1967-68 this STrZ Disturbance was observed only during the early part of the apparition. It was observed best during the period November 27 - December 2, 1967. However, two bright ovals were observed in the STrZ in the vicinity of the STrZ Disturbance. One was located at 200° (II), and the other at 220° (II) on November 27, 1967. They indicated roughly the preceding and following regions respectively of the STrZ Disturbance. After December 2 the dusky Disturbance was not observed, but the bright ovals were observed in the STrZ until February 17, 1968. Markings No. 6 and 7 are these two bright ovals. Marking 3-5 is a bright oval which was very prominent in the STrZ. It was recorded on October 19, 1967 by Paul Mackal and can be seen on Figure 2 of this 1967-68 Report. It was also recorded well by Dragesco and Sato. The STrZ Disturbance activity was recorded well by Dragesco, Sato, and Thiede. See Figures 3, 4, and 5 of Mr. Mackal's report. Markings No. 1 and 2 were a bright oval and a dark festoon respectively recorded in the STrZ regions preceding the Red Spot. Dragesco had an excellent series of observations of these objects.

Circulating Current - South Branch (STB_n), System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Dc	Mar. 14-Apr. 15	5° - 276°	---	6	-89°.0	9:53:39

During 1967-68 the Circulating Current was observed well. This current, of course, is a result of the preceding and following regions of the STrZ Disturbance. Marking No. 1 above was moving in the direction of decreasing longitude and represents the best observed feature of the South Branch.

Circulating Current - North Branch (SEB_s - S. Edge), System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Dc	Nov. 19-Jan. 9	102°- 264°	---	12	+101°.0	9:57:59
2	Dc	Nov. 27-Jan. 18	104 - 258	---	10	+ 96.2	9:57:53
3	Dc	Nov. 27-Feb. 14	116 - 348	---	12	+ 93.0	9:57:48
4	Dc	Nov. 26-Jan. 1	161 - 292	---	5	+101.0	9:57:59
5	Dc	Dec. 23-Feb. 25	150 - 344	325°	10	+ 93.0	9:57:48
6	Dc	Dec. 31-Feb. 11	191 - 305	---	6	+ 82.0	9:57:33
7	Dc	Feb. 14-Mar. 5	295 - 355	313	7	+ 98.7	9:57:56
8	Dc	Mar. 20-Apr. 28	132 - 259	---	11	+ 97.8	9:57:55
9	Dc	Mar. 18-Apr. 28	159 - 272	---	8	+ 80.7	9:57:31
			Mean Rotation Period:				9:57:49

Middle South Equatorial Belt, System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Wc	Jan. 8-Feb. 20	345°- 349°	349°	6	+ 2°.7	9:55:44
2	Dc	Feb. 11-Mar. 7	302 - 268	292	8	-42.0	9:54:43
3	Dc	Apr. 17-May 5	188 - 165	---	7	-45.4	9:54:39
4	Wc	Feb. 12-Feb. 22	49 - 31	35	5	-44.2	9:54:40
5	Wc	Feb. 12-Feb. 20	55 - 35	42	6	-49.2	9:54:33
			Mean Rotation Period: (Without No. 1)				9:54:39

Most of the observers in 1967-68 recorded the high rate of activity in the SEB Z between the components of the South Equatorial Belt and present preceding and following the Red Spot Region. There was a great amount of white oval activity about 25° preceding the Red Spot area. Marking No. 1 was a prominent spot recorded in this region. Markings No. 2-5 were spots moving in decreasing longitude and were moving at the "normal" period for this region.

South Equatorial Current (N. Edge SEB_n, S. part EZ), System I

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Dc	Feb. 5-Mar. 29	76°- 114°	88°	5	+19°.0	9:50:56
2	Wc	Jan. 20-Apr. 15	243 - 293	260	10	+17.8	9:50:54
3	Wc	Feb. 22-May 7	160 - 162	---	15	+ 0.8	9:50:31
4	Wc	Mar. 30-May 5	356 - 357	---	7	+ 0.8	9:50:31
5	Dc	Feb. 15-May 5	169 - 172	169	9	+ 1.3	9:50:32
6	Wc	Feb. 24-May 7	94 - 170	---	7	+32.0	9:51:13
			Mean Rotation Period:			Nos. 1 and 2:	9:50:55
						Nos. 3 - 5:	9:50:31

Marking number 6 is a bright oval moving in the South Equatorial Current "B". It had a period of 9:51:13 and is shown on a sketch by Dragesco published as Figure 7 of Mr. Mackal's 1967-68 report. It can be seen in the EZ_s touching the N. edge of the SEB about mid-way between the preceding limb and central meridian of the planet.

North Equatorial Current (S. Edge NEB, N. part EZ), System I

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Wc	Jan. 18-Feb. 20	24°- 25°	25°	5	+ 0°.9	9:50:31

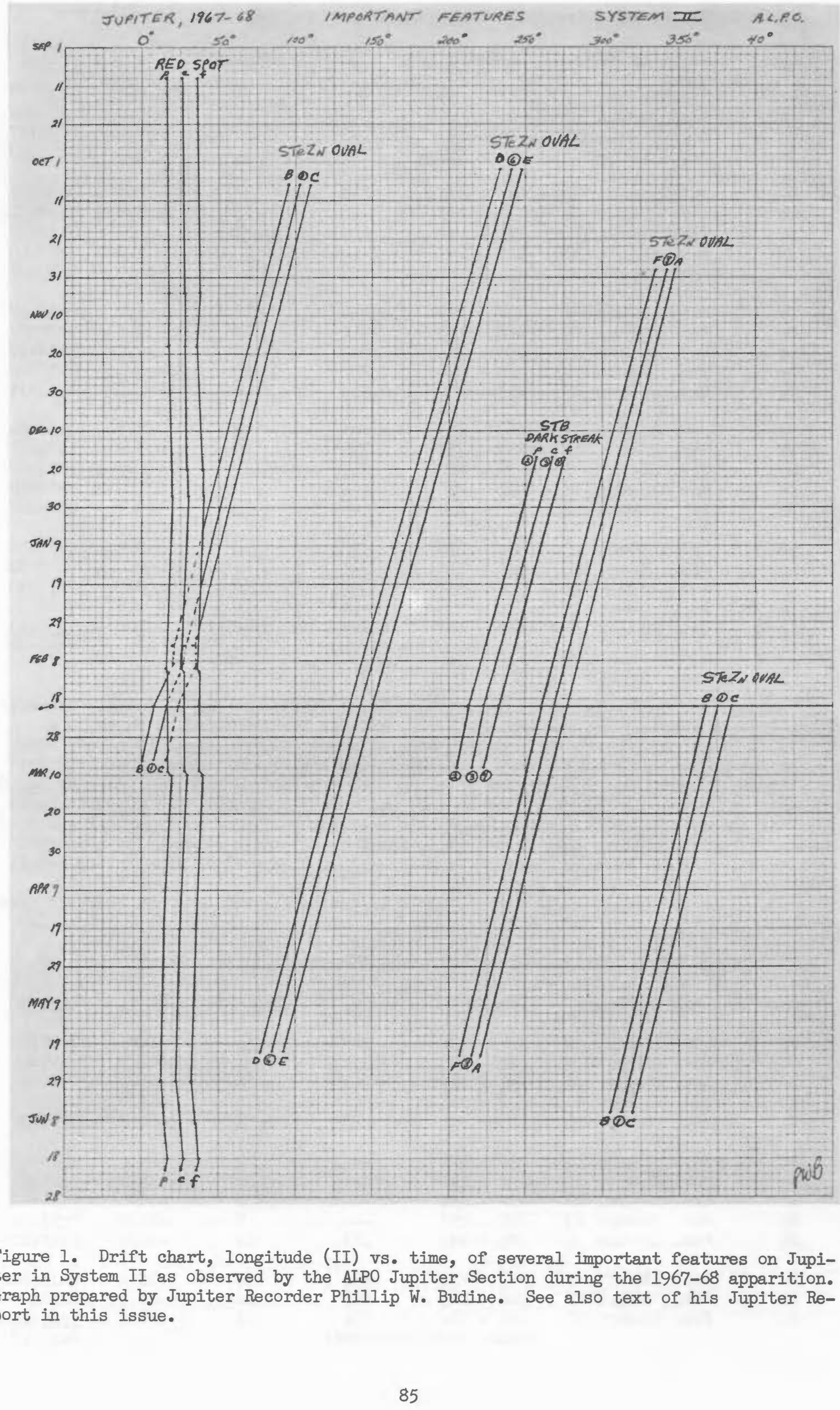

Figure 1. Drift chart, longitude (II) vs. time, of several important features on Jupiter in System II as observed by the ALPO Jupiter Section during the 1967-68 apparition. Graph prepared by Jupiter Recorder Phillip W. Budine. See also text of his Jupiter Report in this issue.

North Equatorial Current (S. Edge NEB, N. part EZ), System I (cont.)

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
2	Dc	Mar. 31-June 5	41°- 46°	---	10	+ 2°2	9:50:33
3	Dc	Mar. 20-Apr. 16	80 - 90	---	10	+ 5.6	9:50:38
4	Wc	Feb. 17-Mar. 30	82 - 90	83°	6	+ 5.3	9:50:37
5	Dc	Feb. 15-May 7	102 - 102	102	14	0.0	9:50:30
6	Dc	Oct. 30-Apr. 8	125 - 123	125	38	- 0.4	9:50:29
7	Wc	Nov. 4-Dec. 29	132 - 137	---	15	+ 2.6	9:50:34
8	Wc	Feb. 15-Feb. 26	144 - 147	143	12	+ 1.9	9:50:33
9	Wc	Feb. 28-Mar. 30	143 - 127	---	10	-16.0	9:50:08
10	Dc	Feb. 14-Apr. 12	157 - 128	153	14	-15.3	9:50:09
11	Wc	Mar. 24-June 8	147 - 142	---	18	- 1.9	9:50:27
12	Dc	Mar. 24-June 6	162 - 160	---	17	- 0.8	9:50:29
13	Dc	Mar. 25-June 15	155 - 154	---	16	- 0.4	9:50:29
14	Dc	Jan. 10-Mar. 6	210 - 200	205	10	- 5.6	9:50:22
15	Dc	Mar. 27-Apr. 25	219 - 220	---	6	+ 1.0	9:50:31
16	Wc	Nov. 28-Feb. 3	263 - 257	---	16	- 2.6	9:50:26
17	Wc	Feb. 17-Mar. 21	257 - 250	256	9	- 5.8	9:50:22
18	Dc	Nov. 28-May 8	272 - 267	267	35	- 0.9	9:50:29
19	Wc	Mar. 24-May 8	261 - 260	---	9	- 0.7	9:50:29
20	Dc	Feb. 24-Apr. 2	323 - 319	---	10	- 3.7	9:50:25
21	Wc	Feb. 3-Mar. 14	339 - 335	338	6	- 2.9	9:50:26
22	Dc	Feb. 3-May 22	345 - 345	345	17	0.0	9:50:30
23	Dc	Feb. 4-May 13	352 - 352	352	16	0.0	9:50:30
24	Wp	Mar. 4-May 21	174 - 185	---	16	+ 4.8	9:50:36
25	Dc	Oct. 30-Dec. 29	155 - 153	---	16	- 1.0	9:50:29
			Mean Rotation Period: (Without Nos. 9 and 10)				9:50:29

Markings No. 8-10 were nost interesting. No. 8 started moving in rapidly decreasing longitude on February 28, see marking No. 9, and was last recorded on March 30 at 127° (I); it had a period then of 9:50:08. Marking number 10, it should be noted, also had a similar behavior. From February 14 to 26 it was moving with a period of 9:50:34; after February 28 until April 12 it was rotating with a period of 9:50:09. Marking No. 8 and 9, which of course is the very same object, was a very prominent oval somewhat "triangular" in shape. It can be seen on Dragesco's sketches published as Figures 7 and 8 of Mr. Mackal's report. During that period it is No. 8 in the table above. Its appearance as Marking No. 9 can be seen in Figure 9 by Heath and in Figure 11 by Sato in the report by Paul Mackal for 1967-68. See J.A.L.P.O., Volume 22, Numbers 9-10; pages 149-150. Marking No. 11 is illustrated well on Dragesco's sketch as Figure 18 in Mr. Mackal's cited report.

North Tropical Current (N. Edge NEB, NTrZ), System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Dp	Nov. 18-May 1	7°- 296°	326°	41	-12°9	9:55:23
2	Dc	Nov. 18-May 5	15 - 306	335	34	-12.1	9:55:24
3	Df	Nov. 18-May 6	21 - 315	343	38	-11.6	9:55:25
4	Wc	Jan. 24-Mar. 29	3 - 333	347	13	-13.6	9:55:22
5	Wc	Nov. 4-May 6	93 - 312	22	62	-22.8	9:55:09
6	Dc	Nov. 8-Jan. 25	240 - 174	---	12	-24.4	9:55:07
7	Dc	Mar. 24-May 27	194 - 161	---	14	-15.0	9:55:20
8	Wc	Mar. 30-Apr. 28	234 - 204	---	9	-15.0	9:55:20
9	Wp	Mar. 7-Mar. 30	271 - 253	---	7	-22.2	9:55:10
10	Dp	Feb. 11-June 5	290 - 232	283	23	-14.9	9:55:20
11	Dc	Feb. 13-May 8	297 - 254	291	35	-15.4	9:55:20
12	Df	Feb. 3-Apr. 28	304 - 265	295	24	-13.5	9:55:22
13	Wc	Feb. 13-Mar. 30	304 - 284	304	12	-12.5	9:55:24
			Mean Rotation Period:				9:55:18

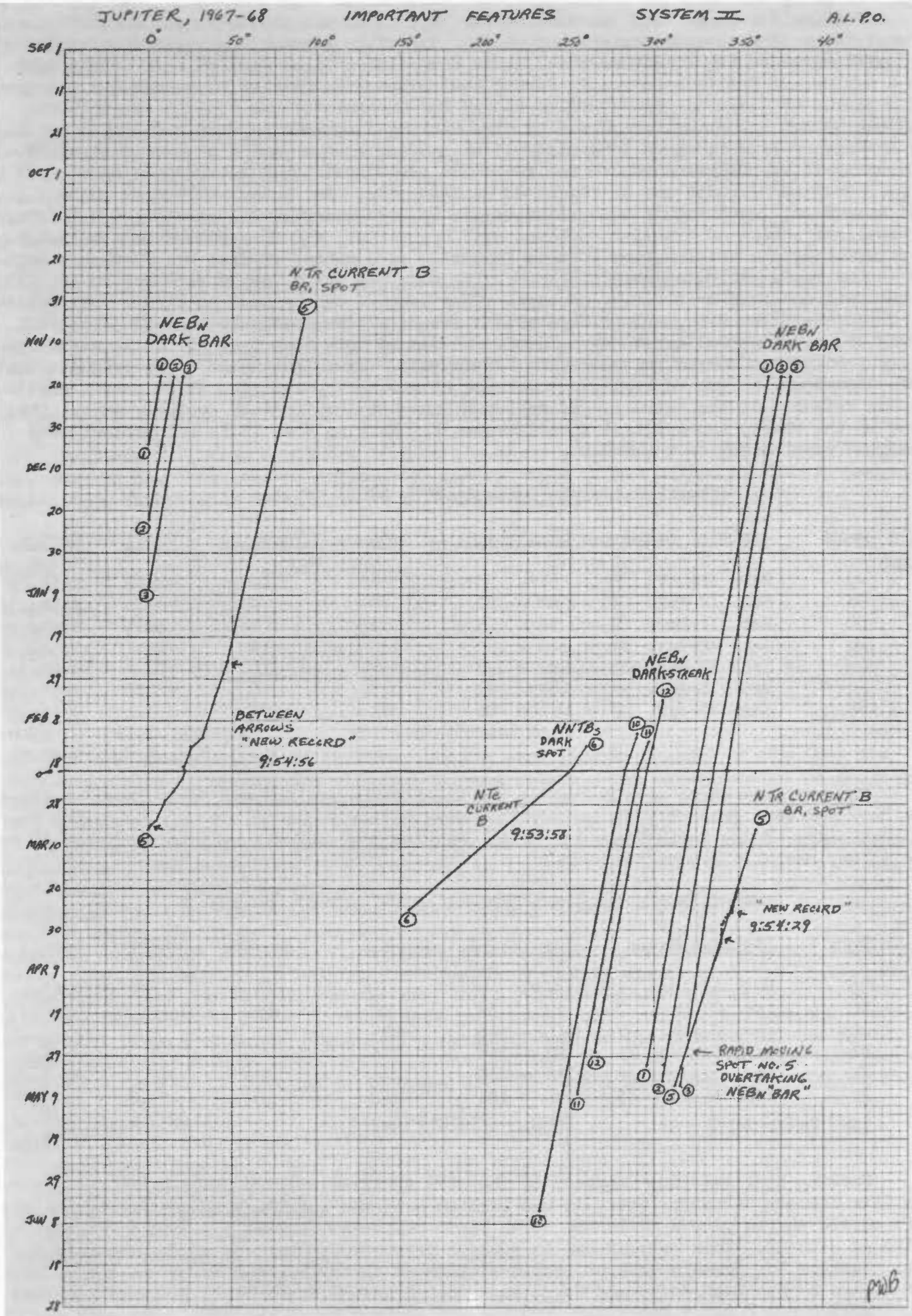

Figure 2. Drift chart, longitude (II) vs. time, of several important features on Jupiter in System II as observed by the ALPO Jupiter Section during the 1967-68 apparition. Graph prepared by Jupiter Recorder Phillip W. Budine. See also text of his Jupiter Report in this issue.

Marking No. 5 was truly an outstanding object; it was moving in the North Tropical Current "B" with an average rotation period of 9:55:09. However, on close examination of its drift curve on the longitude chart it is very evident that in 1968 this bright spot set a new record for this current! During the period from January 25 to March 5 the spot had a period of 9:54:56! The previous record for Current "B" was 9:55:00 set in both 1943 and 1967. For a shorter period of time Marking 5 was moving even more rapidly. During the period from March 26 to April 2 it was moving with a period of 9:54:29!! Referring again to Mr. Mackal's report for 1967-68: white spot No. 5 may be seen on Figures 4, 7, 8, and 13 by Dragesco and on Figure 12 by Sato. Spot No. 5 was well observed by A.L.-P.O. observers, resulting in the valuable data in this report. Robert Stewart submitted an excellent series of transits centered near opposition, and they proved most valuable in determining the acceleration of this feature. As a matter of fact Mr. Stewart commented on the rapid motion at that time! Marking Nos. 1-3 was a very dark "bar" in the NEB_n. It was well observed by A.L.P.O. members. This feature can be seen on Figure 7 by Dragesco, on Figure 12 by Sato, and on Figure 14 by Wacker in Mr. Mackal's report. This dark streak was not observed after May 6, 1968. It was at this time that the white rapid-moving spot No. 5 was overtaking this dark bar feature. There continues to be evidence that spots disappear, or are replaced, or coalesce with other spots. The drift charts continue to show evidence of the intrusion of one spot into the longitude of another; and at that point on the chart, the original spot disappears. Marking Nos. 10-12 was another very prominent dark streak on the NEB_n.

North Temperate Current (NTB, NTeZ), System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Dp	Feb. 12-Mar. 7	57°- 73°	62°	12	+19°7	9:56:08
2	Dc	Feb. 12-Mar. 7	62 - 81	69	9	+23.4	9:56:13
3	Df	Feb. 12-Mar. 7	80 - 95	83	9	+18.5	9:56:06
4	Dp	Jan. 22-Apr. 30	120 - 185	140	13	+19.1	9:56:07
5	Dc	Jan. 22-Mar. 25	129 - 178	150	12	+22.2	9:56:11
6	Dc	Feb. 6-Apr. 30	169 - 198	175	18	+10.0	9:55:54
7	Df	Jan. 25-Apr. 30	178 - 208	184	19	+ 9.4	9:55:54
			Mean Rotation Period:			Nos. 1-5:	9:56:09
						Nos. 6-7:	9:55:54

The markings above were moving in the North Temperate Current "A". These markings were dark and were generally elongated; they were either found on, or were projected from, the north edge of the North Temperate Belt. Marking Nos. 4-5 can be seen on Figure 10 by Sato in Mr. Mackal's report for 1967-68.

North North Temperate Current (NNTB, NNTeZ), System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Dp	Feb. 14-June 4	25°- 9°	25°	23	- 4°2	9:55:35
2	Dc	Jan. 25-Mar. 7	44 - 38	35	15	- 4.3	9:55:35
3	Dp	Jan. 22-Mar. 7	105 - 105	105	11	0.0	9:55:41
4	Dc	Jan. 26-Feb. 21	195 - 196	195	6	+ 1.2	9:55:42
5	Wc	Dec. 31-Jan. 18	258 - 200	---	8	-81.7	9:53:49
6	Dc	Feb. 14-Mar. 25	259 - 154	250	10	-75.0	9:53:58
			Mean Rotation Period:			Nos. 1-4:	9:55:38
						Nos. 5-6:	9:53:54

Marking Nos. 1-2 is a fragment of the NNTB observed well by the A.L.P.O. observers from late January to early June. It was located near the longitude of the Red Spot. Its drift on the charts placed it in the North North Temperate Current "A" with a rotation period of 9:55:35. This marking can be seen on Figure 7 by Dragesco of Mr. Mackal's report. Marking No. 3 was a dark projected section of the $NNTB_n$, and No. 4 was a dark section of the NNTB. Both No. 3 and No. 4 were moving in the North North Temperate Current "A". Marking No. 6 was a small dark spot on the south edge of the NNTB. The spot was moving in the rarely observed North North Temperate Current "B". This rapid current was first observed by Hargreaves in 1929-30. It was also observed during the apparitions of 1940-45. Marking No. 5, a small bright spot on the south edge of the NNTB, was also moving in the North North Temperate Current "B".

In closing, it is most interesting to note that during 1967-68 most of the outstanding activity was in the Red Spot longitudes for a period of time including: the long enduring oval "BC", the "Dark Bar" on the NEB_n, the bright spot No. 5 of the North Tropical Current "B", and the NNTB fragment Nos. 1-2. Many thanks to each observer for his contributions for 1967-68! Your continued support of our Jupiter programs is most appreciated. It is a great pleasure to be working on the A.L.P.O. Jupiter Staff again, and I am looking forward to many years of service with this fine Association.

Postscript by Editor. Figures 1 and 2 will exhibit the motions of a number of the more interesting Jovian features discussed by Mr. Budine in his report above. It is from drift-charts of this kind, where longitude is plotted as a function of time, that the rotation-periods which he listed were determined. The slope of the drift-line gives the amount of the difference from the arbitrary basic period of either System I or System II, whichever is appropriate.

REPORT ON SATURN IN 1969-70: SOME CORRECTIONS AND ADDITIONS

Saturn Recorder Julius Benton's report on the 1969-70 apparition of the Ringed Planet appeared in Journal A.L.P.O., Vol. 24, Nos. 1-2, pp. 27-35. Since its publication, we have learned of a few errors and a few omissions, the reasons for which would probably be of little interest to most of our readers. However, it appears worthwhile to give here the needed information for the use of Saturn specialists.

In Table III,+ Mean Latitudes of Saturn's Belts and Zones During the 1969-70 Apparition, some of the latitudes determined by Haas by means of his method of direct visual estimates were erroneously reduced. The correct values for his measures are:

Feature	Saturnigraphic Latitude	Saturnicentric Latitude	Eccentric Latitude
N Edge SEB_n	-24°.2	-19°.7	-21°.9
S Edge SEB_n	-24.4	-19.8	-22.0
N Edge SEB_s	-27.0	-22.3	-24.5
S Edge SEB_s	-33.0	-27.4	-30.1
N Edge SPB	-68.7	-64.1	-66.4
S Edge SPB	-75.3	-71.7	-73.6

The extreme narrowness of the SEB_n and the much greater breadth of the SEB_s are merely observational errors; the observer did not estimate the same features in every set of visual estimates.

A table of observed average numerical intensities of different features was accidentally omitted. The scale used is 0 (shadows) to 10 (most brilliant features) on which the outer one-third of Ring B is assigned an arbitrary intensity of 8.0. The table below, communicated by Julius Benton, summarizes the visual intensity estimates by ALPO Saturn observers during the 1969-70 apparition. Dr. Benton remarks: "To be able to establish a meaningful comparison [of intensities] among recent apparitions one would need a suitable observational sample, and it is quite unfortunate that this writer must report that such an analysis is not possible due to the very small number of observations submitted during the period from 1966 to 1970. Perhaps more individuals will realize the extreme importance of such observations and begin active participation in the programs of the Saturn Section; under the present organization of the Section, the Recorder has some confidence that a suitable body of data can be obtained in 1971-72 and subsequent observing seasons."

Feature	Number of Observations	Mean Intensity
Equatorial Zone	12	6.9
North Polar Region*	8	5.1
South Equatorial Belt Zone	4	4.9
South Temperate Zone	8	4.4
South Polar Region	8	3.8
South Polar Cap	4	6.0
Equatorial Band	4	3.9
South Polar Band	6	3.4
South Equatorial Belt South	12	3.2
South Equatorial Belt North	12	2.9

*In view of the large negative tilt of the axis of Saturn to the Earth in 1969-70, it appears clear that the "North Polar Region" must really have been the portion of the ball visible to the north of the projected rings.

+Some further errors found in the published Table III are corrected under "Announcements".

Feature	Number of Observations	Mean Intensity
Ring B, inner part	12	6.5
Ring A, outside Encke's	4	6.5
Ring A, inside Encke's	4	6.2
Crape Band	4	2.0
Ring C (off ball)	4	1.5
Shadow Ball on Rings	4	0.1
Shadow Rings on Ball	4	0.0

Recorder Benton has also supplied an omitted Table IV, given below. Readers interested in more background on the curious "bicolored aspect" should read the short descriptive paragraph on pg. 34 of the Report on Saturn in 1969-70 and also the related postscript on pg. 35, which gives a quantitative example of extreme atmospheric dispersion. In Table IV the red filter used by both observers was Wratten No. 25. However, the blue filter was Wratten No. 47 for Haas and Wratten No. 47B for Heath. West is here used as a direction in the sky; the west arm of the rings is the left arm in a simply inverted view with south at the top.

TABLE IV. BICOLORED ASPECTS OF SATURN'S RINGS DURING 1969-70.

Date (U.T.)	Observer	Time (U.T.)	Red Filter	Blue Filter	No Filter
1969, Sept. 7	Haas	$9^h 2^m$- $9^h 14^m$	W = E	E brighter	W = E
Sept. 27	Haas	8 5 - 8 20	W = E	W brighter	W = E
Oct. 10	Heath	21 30 -22 0	W = E	W brighter	W = E
Oct. 15	Haas	3 57 - 4 7	W = E	W = E	W = E
Oct. 17	Heath	21 0 -21 30	W = E	W = E	W = E
Nov. 2	Heath	21 0 -21 30	W = E	W = E	W = E
Nov. 8	Heath	21 0 -21 55	W = E	W = E	W = E
Nov. 15	Heath	20 0 -21 0	W = E	W = E	W = E
Nov. 22	Heath	20 0 -21 15	W = E	W brighter	W = E
Dec. 8	Heath	19 0 -20 0	E perhaps brighter, Ring A only	W = E	W = E
Dec. 18	Heath	18 20 -19 0	W perhaps brighter	W perhaps brighter	W = E
Dec. 22	Heath	21 0 -21 20	W = E	W = E	W = E
Dec. 26	Heath	17 10 -17 35	W = E	W brighter	W = E
Dec. 27	Heath	17 15 -17 20	W = E	W = E	W = E
1970, Jan. 3	Heath	19 0 -19 20	W = E	W = E	W = E
Feb. 10	Heath	18 0 -18 20	W = E	W brighter	W = E
Mar. 15	Haas	2 16 - 2 35	W = E	W = E	W = E

THE NORTH POLAR HOOD OF MARS IN 1969

By: Bruce Salmon

(Foreword by Editor. The author of the following article, Mr. Bruce Salmon, is an active member of the ALPO Mars Section. He now lives at Orlando, Florida, though in 1969 he observed from Oklahoma City, Oklahoma. His article is surely interesting in itself, and we would also hope that his work would show our readers how much an attentive student of Mars can glean from his own observations alone. Readers may want to compare Mr. Salmon's results with Mars Recorders Capen and Cave's discussion of the north polar regions of the Red Planet in 1969, Journal A.L.P.O., Vol. 23, Nos. 3-4, pp. 67-75 and Nos. 5-6, pp. 79-85. The data used in their discussion included Mr. Salmon's observations.)

Each autumn I enjoy those special evenings when the towering cumulus clouds gather, transforming my yard into a canyon floor. Billowy cliffs catch the rays of the lowering Sun, and shadow the steep, purple gorges. Even as I watch, diastrophic forces open broad rift valleys and push up massive pinnacles, while Teton-like thunderheads erode into vast blue-gray badlands.

Equally as thrilling for me is the sight of changing cloud patterns on other planets. With a good telescope, ordinary eyesight, and experience, an observer can follow and record the atmospheric phenoemena on several planets in our Solar System. Two planets in particular are good subjects for daily (and even hourly) meteorological studies -- Jupiter and Mars.

Any amateur astronomer who can find these planets without circles is familiar with the maelstroms of Jupiter. However, he probably has no personal knowledge of the meteorology of Mars. The reason for this is simple: whereas Jupiter is 100% cloud covered, Martian skies are less than 10% obscured. The great masses of dull white vapor which persist during the formation of the Martian polar caps are the most easily observable clouds on the planet.

The cloudy cap or polar hood forms above the polar ice fields near the autumnal equinox. In 1969 this event fell on our June 25 for the Martian northern hemisphere. Though the polar hood may daily change its shape, not until the vernal equinox does it lift, then revealing the snow cap underneath.

In 1969 I became fascinated with the north circumpolar region of Mars while engaged in a program of nightly observations. In the following 15 sketches (Figure 3) I've portrayed the general aspect of the area about the Martian north pole on the respective dates. Note carefully that the dates are not consecutive. Instead, I have chosen three broad regional views to illustrate what the passage of time did to the shape of the polar hood.

Sketches 1-6 portray the major developments over a five-week period observed in the Phlegra-Cebrenia region. A few excerpts from my observing log follow:

(Sketch 1) June 15, 1969 5:50 U.T. First sign of the polar hood. Autumn in this hemisphere begins in about 10 days, and a great whitish mantle rests over Cebrenia, almost adjacent to the small polar whiteness.

(Sketch 2) July 13, 1969, 2:30 U.T. Back now where a respectable polar hood ought to be, the great cloud is centered not far from 90° N. lat. The hood has left its sanctuary near the terminator, and has ventured to brave the mid-morning Sun now just N. of Elysium.

(Sketch 3) July 14, 1969, 2:10 U.T. Here's something new for me -- the polar mantle has developed a deep notch in it just W. of the C.M. Surrounded, but still in the clear, is a prominent oasis I tentatively identify as Stymphalius Lacus.

(Sketch 4) July 15, 1969, 2:00 U.T. In the last 24 hours the shroud has re-covered the oasis, obscuring it completely.

(Sketch 5) July 16, 1969, 2:00 U.T. Visible through the polar hood tonight is an E.-W. linear feature which may be the S. border of Panchaia. A striking sight!

(Sketch 6) July 20, 1969, 2:40 U.T. Now the hood shows an even stronger preference for the morning terminator.

Drawings 7-13 portray the major changes in the polar hood over a six-week period in the Tanais-Mare Acidalium region.

(Sketches 7-9) June 21, 1969, 2:30 U.T. This sketch and the next two were made on the same night, and show what $2\frac{1}{2}$ hours can do to the cloudy cap. At 2:30 U.T. the left hand lobe of the hood covered the long dark feature, Tanais. An hour later, at 3:30 U.T., Tanais had emerged and lay in the late morning Sun under a clear sky. Note the notch in the hood just to the north. By 5:00 U.T. on the same day the left (northernmost) lobe of the polar hood had broken away from the cooler morning limb region and then covered the desert between Tanais and Mare Boreum.

(Sketch 10) June 29, 1969, 3:30 U.T. A vast portion of Mare Acidalium is under the cloudy cap as morning breaks there.

(Sketch 11) July 1, 1969, 4:10 U.T. Mare Acidalium is totally covered now. Ninety minutes prior to this observation this huge off-the-pole hood was behind the limb; and an enormous white haze, probably a part of the cloudy cap, covered the entire N. quarter of the disk -- from Ismenius Lacus to the N. limb.

(Sketch 12) July 27, 1969, 1:40 U.T. Tanais and Mare Boreum covered; Mare Acidalium clear. Compare Sketches 7-9, especially.

(Sketch 13) August 1, 1969, 1:40 U.T. From Niliacus Lacus to the N. limb a huge cloudy cap covers the N. part of Mars. A bit of Mare Acidulium shows through the cloud cover. It is translucent now and is about half as bright as the opposite (south) polar cap.

Drawings 14 and 15 portray the major changes I observed over a five-week period in Dioscuria-Cecropia.

(Sketch 14) July 5, 1969, 2:00 U.T. The shroud is spread now over a region just N. of Protonilus. It is not opaque tonight, for I can see something of Boreosyrtis beneath it. By an hour and forty minutes after this drawing was made, the Sun had burned off the hood in this part of Mars.

(Sketch 15) August 12, 1969, 1:30 U.T. Now we have another detached mass of the hood -- this time a band stretching almost half way across the N. portion of the gibbous disk.

These observations were a part of the bi-annual Martian studies I have conducted since 1965. I used an f/9.3 12½-inch reflector with no filters at powers of 450X -- 525X. Seeing for the 15 drawings averaged 7 on a 0 -- 10 scale (10 best). Those who are interested can find a photographic record of similar, rapid, night-to-night changes of the N. polar hood in E. C. Slipher's book, Mars -- The Photographic Story, page 95.

SKY COLOR AND DARKNESS AT THE TOTAL SOLAR ECLIPSE OF MARCH 7, 1970

By: William H. Glenn

The exceptionally clear skies experienced at some locations during the March 7th eclipse provided an unusual opportunity for observations to be made of sky color and darkness during the total phase of a solar eclipse occurring when the Sun was relatively high above the horizon. In particular, the eclipse provided an opportunity to study the changing pattern of light and darkness in the sky as the Moon's shadow passed over the observer's location.

Of 19 reports received from observers, 15 were made under clear skies in the Norfolk-Virginia Beach area. Other reports were received from Williamston, North Carolina (clear skies), Marion, South Carolina (high cirrocumulus), and Valdosta, Georgia (total overcast). An observation of the partial eclipse from Jersey City, New Jersey was also received. A list of the observers who submitted reports follows:

Virginia Beach and Vicinity

1. Mildred Bank
2. Barbara Bortle
3. John Bortle
4. Robert J. Grist
5. Florence Glenn
6. William H. Glenn
7. Joseph Kammel
8. Michael Kudish
9. Beverly Liblick
10. George Lovi
11. Edward Oravec
12. Antoinette Pridmore
13. La Savona
14. Mary Schiffmann
15. David Schmidling

Other Locations

16. Regina Cohen (Valdosta, Georgia)
17. John Pazmino (Marion, South Carolina)
18. Steven B. Shelton (Jersey City, New Jersey)
19. Vincent J. Tortorelli (Williamston, North Carolina)

The task of organizing a large body of diverse qualitative descriptions of the appearance of the sky was complicated by several factors. The phenomena observed were very evanescent. Most observers had only a few moments to observe the sky while they were busy conducting other programs and therefore were not able to observe all the phenomena that occurred. Individual observer tension was extremely high during the all-too-short period of totality, and for some observers this was a first total eclipse. In spite of the difficulties the reports received were, for the most part, of high quality; and it was possible to attempt to reconstruct sky phenomena as they were seen just prior to, during, and after totality.

In preparing this report statements attributable to certain specific observers have been indicated by numbers referring to their names in the above list. This choice does not imply that other observations were excluded from consideration, but rather that the

THE MARTIAN POLAR HOOD IN 1969 -- SALMON OBSERVATORY

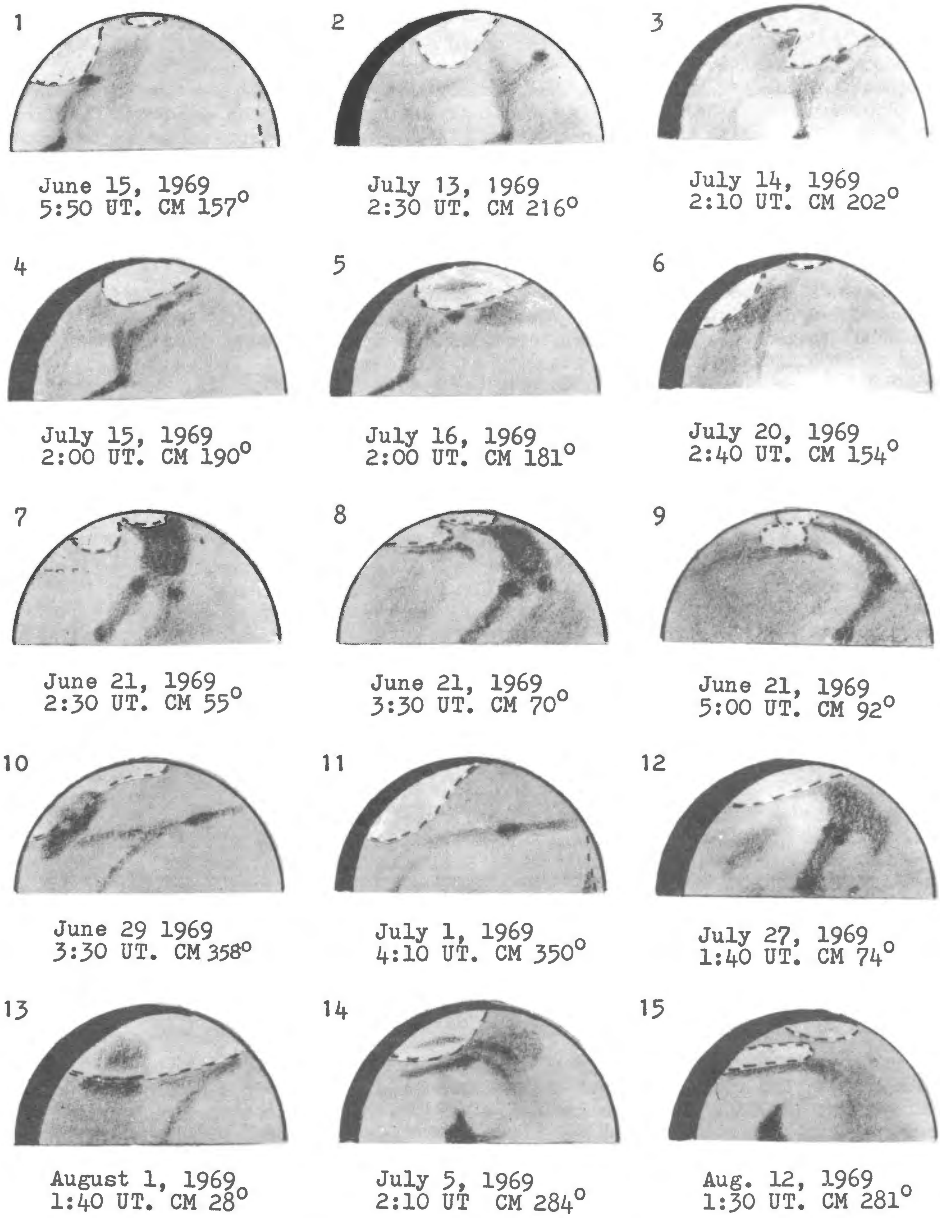

Figure 3. Selected drawings of north polar region of Mars in 1969 by Mr. Bruce Salmon. 12.5-inch reflector at 450X-525X, no filter. North at top, west (as a direction in Earth's sky) at right. See also discussion by Mr. Salmon in his text on pages 91 and 92.

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quoted observations were considered more complete or detailed, or more typical, on certain points than others. It is also recognized that the compilation presented here will probably not satisfy any one individual who submitted a report, precisely for the reason that this is a compilation; and therefore generalizations which appear to fit the greatest bulk of data or the most complete or detailed observations have been given precedence.

Weather conditions at Virginia Beach were near-perfect prior to, during, and after the eclipse. A low haze was seen over the ocean horizon up to an elevation of about 4° in the east and northeast (6), but otherwise the sky was perfectly clear throughout the entire event. It is for this reason that the following compilation has been based on those 16 observations received from the clear-sky region of Virginia and North Carolina. Reference will be made to the South Carolina and Georgia observations later in the report.

Sky Changes Prior to Totality

Most observers did not report on this phase of the eclipse. The writer, standing on a beach dune about one mile north of downtown Virginia Beach, noted the following:

1:05 P.M., EST. (30 minutes before totality): A drop in light was noticed visually at this time. Verification is contained in the report of Michael Kudish, who reports that there was a noticeable absence of glare on white buildings, sand, and concrete at this time.

1:13 P.M. (22 minutes before totality): The sand had now taken on a grayish-yellow tinge. The low bank of haze on the eastern horizon over the sea appeared grayer than earlier, and was tinged with purple-red.

1:20 P.M. (15 minutes before totality): The sand appeared grayish-yellow now.

1:24 P.M. (11 minutes before totality): The haze layer around the eastern and north-eastern horizon had taken on a purple to orange-red coloration, and appeared similar to the twilight bow. The sky was an intense dark blue.

Sky Changes During Totality

One or two minutes before totality the sky in the western and southwestern quadrants became grayish in color (6). The incoming shadow was very diffuse. A few seconds before totality a vague darkening occurred in the direction of the Sun (10), and the shadow seemed to "sit down" over the observers rather than come in from the southwest (6).

The sky during totality was a transparent deep blue color such as is seen overhead at civil twilight (10). At the beginning of totality a suggestion of the V-shaped shadow cone was seen, the base being extremely wide, extending from about the south-southwest to west-southwest points on the horizon, with the edges extending almost parallel to the eastern and western horizons so that they were only about 5° above the horizon at the east and west points (6). See Figure 4.

The color of the eastern horizon below the shadow edge was reported as pale yellow-orange above the grayish-purple haze layer that sat over the sea horizon. The western horizon had the same appearance, with the haze layer lacking (6).

Reports of specific sky brightness and coloration later in totality vary with different observers, but it appears that all but about the lowest 5-15 degrees (6, 3) of the celestial sphere was dark blue in color and was fairly well demarked from a brighter zone that extended completely around the horizon at all times (2). Descriptions of this brighter band vary from yellow (11), through orange (6), to light pink (5, 13). One report (2) specifies a yellow color along the horizon with some red higher up. A haze layer described as purple (6) to gray (11) lay at the base of this zone along the sea horizon to the east. The light changed hardly at all during totality (3, 10) except for a definite shift of the darker parts of the sky from the southwest to the northeast (10). This shift is confirmed by photographs taken by the writer with a "fish-eye" 180° field-of-view lens. See Figure 5.

One observer (8) has reported that, for about the last 30 seconds of totality, the western sky became much brighter. A second observer (6) relates that, as the end of totality neared, a bright pale yellow-orange area was seen rising in the southwestern sky. To the north, within five seconds after totality ended, the shadow was seen to lift rapidly into the sky at an angle of about 45°. See Figure 6. The entire shadow lifted in several seconds (3). After this, a pronounced darkness remained in the northeastern quadrant of the sky for several minutes (2, 3).

One other observer (14) reports that perhaps the vague shadow was seen going off to the northeast. That this phenomenon must have been very evanescent is attested to by other reports, one of which states that nothing was seen and that the sky became very light after third contact (11), and another of which states that all traces of the shadow disappeared within 10-15 seconds after third contact and that it was difficult to detect an even slightly darker area after this time to the northeast (10).

Sky and Ground Darkness

Observations received concerning the visibility of stars and planets indicate that Venus (magnitude -3.4) was seen as long as six minutes before totality (11) and remained visible for ten minutes after totality (13). Mercury (magnitude -0.5) also was easily seen by most observers during totality. Only one report that other objects were seen has been received (10). These objects were Saturn (magnitude +0.6), Vega, Capella, Alpha Andromedae, and Alpha, Beta, and Gamma Cassiopeiae. One report (6) states that although only Mercury and Venus were observed, the sky appeared dark enough probably to allow first, and maybe second, magnitude stars to be located.

All reports except one agree that newsprint, camera settings, and hour and minute hands of watches could be read during totality. Sky darkness was estimated as being equal to that at 20-30 minutes after sunset (8), to deep twilight (6), and to the end of civil twilight (10).

Color of the Moon's Disc

Because of the possibility that earthshine, which would be strongest on the Moon's disc at New Moon, would cause it to appear something less than jet black at totality, observations of the color of the Moon's disc were requested. Of 13 observers who reported the color of the Moon's disc, 12 indicated that it was black. One observer (11), for instance, took very careful note of the appearance of the Moon's disc and reported it as jet black with both the naked eye and 12 x 40 binoculars. He also commented that the Moon's disc was much darker than the sky a few degrees from the Sun. The only dissenting report described the disc color as "very dark gray, actually off-black" (10).

Reports From Other Areas

Reports from observers who experienced less than ideal weather conditions were excluded from the above compilation. These are described below. At Marion, South Carolina (17), a high tenuous veil of cirrocumulus covered the entire sky; and a front of altostratus and stratus clouds lay along the western horizon. Observations at this locality agree substantially with those presented above; but Venus was the only star or planet seen, and the Moon's disc was reported as "extremely dark bluish-black, like a spot of blue-black ink". Also, no swath of darkness was seen to move across the sky at any time.

At Valdosta, Georgia (16), the completely overcast sky appeared to "ripple" with dark grayish-black color as the shadow arrived, and again as the shadow left at the end of totality. The sky color during totality was described as dark gray, almost blue-black, with a slight red sunset effect seen on the clouds for 360° around the horizon. The hands of a watch could not be read at totality, but camera settings could be read with difficulty.

A verbal report from Charles Scovil indicates that at Perry, Florida, also totally overcast, the shadow was also seen to approach and leave on the clouds.

Quantitative Measurements

The average photographic light meter is incapable of registering the low light levels present during the total phase of a solar eclipse, and each make of meter is generally calibrated in arbitrary units which are difficult to convert to foot-candles or to compare to meters of other makes. These drawbacks make it difficult for meaningful quantitative observations of eclipse light levels to be obtained. A graph of zenith sky illumination levels made by Joseph Kammel (7) before and after totality suffers from both of these instrumental difficulties, as does also one prepared by the writer from his own observations. Neither graph shows a reading at totality. Both light curves show asymmetry, however, there being a lower level of zenith light intensity after totality as compared to an equal

Figure 4. Appearance of the southwestern quadrant of the horizon at the beginning of totality, Virginia Beach, Va., during the total solar eclipse of March 7, 1970. Drawn and contributed by William H. Glenn. See also text of his article.

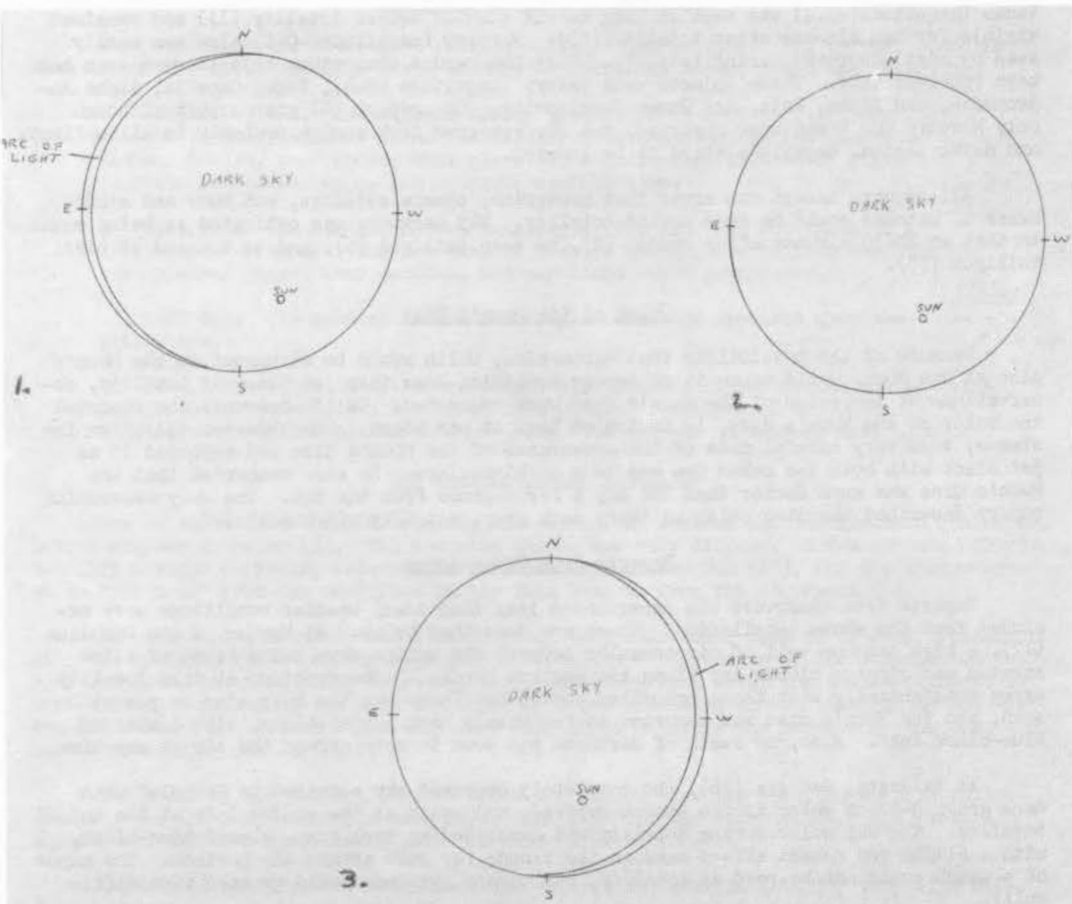

Figure 5. The sky during totality on March 7, 1970: 1. Just after 2nd contact; 2. At mid-eclipse; 3. Just prior to 3rd contact. Sketched from photographs by William H. Glenn made with an F:5.6 "fish-eye" 180° field-of-view lens. Original slides, taken at 1/8 sec. on Anscochrome 200 film, were too greatly underexposed for successful reproduction here. See also text.

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length of time before totality. This asymmetry is probably due to the greater distance of the Sun from the zenith later in the afternoon.

The writer also noted that the incident light readings of the zenith sky brightness dropped five stops from first contact to three minutes prior to totality. The drop continued sharply from this point into totality, but no further observations were made. A verbal report from Fred Goldsmith indicates, however, that his attempts at photography of

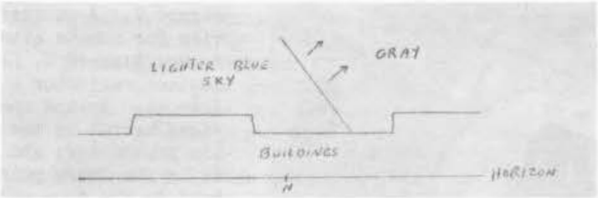

Figure 6. The Moon's shadow lifting into the sky at the end of totality, March 7, 1970, as observed by John Bortle from a site southwest of Virginia Beach. See also text.

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nearby landscapes at Virginia Beach required a 12-stop greater opening at mid-totality than before the partial phases (F-4 at ¼ second opposed to F-16 at 1/1000 second, film not specified).

A series of zenith light meter readings made by Steven B. Shelton (18) in a partly cloudy sky during the 96 per cent partial eclipse seen at Jersey City, New Jersey, was also received. A five-stop drop in light occurred from before first contact to maximum eclipse, and the light returned to its original level well before fourth contact. Cloudiness may have affected these observations somewhat. Shelton also observed Venus from 1:42 to 1:48 P.M., E.S.T., thus around the time of maximum eclipse. The five-stop decrease in light was enough to make Venus visible.

A SIMPLE MICROMETER MICROSCOPE FOR OFF-AXIS GUIDING IN COMET PHOTOGRAPHY*

By: Richard D. Lines, Phoenix, Arizona

In order to make guided exposures on comets with my 16-inch telescope, I constructed a micrometer microscope to replace the regular guiding microscope on the Kreimer cold camera (Sky and Telescope, Aug., 1966). This micrometer was used to obtain color photographs of Comet Bennett in 1970 and proved satisfactory.

The micrometer microscope consists of a 1½-inch diameter tube about 5 inches long with a 35-mm. focal length objective mounted in one end and an 18-mm. focal length eyepiece in the other. At the focal plane of the eyepiece are cross wires attached to a light metal frame, which slides in notched sheet metal guides. The frame is moved by a No. 1-72 thread screw bearing against one end of the frame and is returned by a light compression spring pushing against the other end. The screw is fitted with a small 10-tooth gear which runs against a flat spring, causing a click each one-tenth rotation of the screw. A flexible wire, 4 inches long, with a knob on the end is attached to the screw to reduce the vibration transmitted to the telescope when the knob is turned by hand. The position angle circle is made from a plastic protractor fitted with a hub that slips over the microscope tube and can be rotated in relation to the tube for zero adjustment. The circle is graduated in degrees, numbered each 10 degrees from 0 to 360 in a clockwise direction. The index for the circle is a rod supporting a pointer held in place on the telescope tube by a magnet. The assembly can be moved to any convenient location on the tube as the camera is rotated. This index is removed from the tube after the position angle has been set and does not interfere with attachment of the vacuum hose or capillary tube to the camera.

In order to calibrate the micrometer, I clamped it in a vise and focused on a machinist's scale. The screw was turned clockwise several turns while counting the clicks to determine the number of clicks required to move the cross wire a certain number of divisions of the scale. The distance traversed was divided by the number of clicks, giving the value of one click in inches in the focal plane. This value was converted to seconds of arc by multiplying by 206, 265 and then by dividing by the focal length of the telescope in inches. One click of the micrometer screw is 1.08 seconds of arc when on my 16-inch telescope of 127 inches focal length.

At the intersection of the cross wires is cemented a tiny disc 0.015 inches in diameter, corresponding to about 12 seconds of arc. When the guide star is occulted by this disc, a movement of one-quarter disc diameter is easily detected. This disc is larger than that used for our deep sky photography but is fine enough for photographing comets near the horizon. A smaller disc is desirable for stars fainter than 6.0 mag. The cross wires are illuminated for centering the guide star but not while guiding.

The micrometer microscope was constructed by Evered Kreimer and Richard Lines. It can be used on a separate guide telescope.

*Contributed by Dennis Milon, ALPO Comets Recorder.

Figure 7. A guiding device for comets attached to Mr. Richard D. Lines' 16-inch reflector at Mayer, Arizona. Around the eyepiece barrel is the plastic protractor; and below it is the index pointer, held to the tube with a magnet. See also text on page 97. Mr. Lines' address is 6030 N. 17th Pl., Phoenix, Arizona 85016.

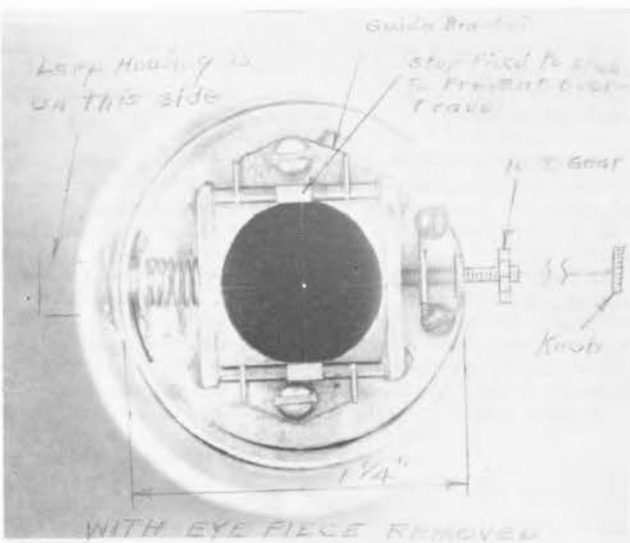

Figure 8. View of micrometer microscope constructed by Mr. Richard D. Lines, as described by him on page 97. Here the eyepiece has been removed from the guider in order to show the cross wires on a metal frame. The frame is spring loaded at the left and is adjusted by a screw and a 10-tooth gear at the right. The bracket has stops next to the screws to prevent overtravel. The entire device is contained within a 1¼-inch tube.

HOW TO USE A MICROMETER MICROSCOPE TO GUIDE FOR COMET PHOTOGRAPHY*

By: Richard D. Lines, Phoenix, Arizona

First, determine the position angle and rate of motion of the comet from an ephemeris of predicted positions. Find the position of the comet for two dates, the one just before and the other just following the date on which the comet is to be photographed. Determine the average rate of change in right ascension and declination by dividing the difference in position for the two dates in seconds of arc by the number of minutes of time between the two dates. Convert seconds of time in right ascension to seconds of arc by multiplying by 15 times the cosine of the mean declination of the comet.

If greater accuracy is desired, take positions from the ephemeris for four dates. On graph paper plot right ascension and declination independently by days. Draw smooth curves through the points and interpolate positions for 12 hours on either side of the time planned for taking the photograph. Use these positions to calculate the rate of change as above.

*Contributed by Dennis Milon, ALPO Comets Recorder.

Next, calculate the position angle of the comet motion, P, as follows:

If the motion is north and east, $P = \theta$
If the motion is south and east, $P = 180° - \theta$
If the motion is south and west, $P = 180° + \theta$
If the motion is north and west, $P = 360° - \theta$

Here tangent θ is the numerical change in right ascension per unit of time divided by the numerical change in declination, thus:

$$\tan \theta = \frac{\Delta \alpha}{\Delta \delta}.$$

The rate of motion of the comet, R, is the square root of the sum of the squares of the changes in right ascension and in declination, thus:

$$R = \sqrt{\Delta \alpha^2 + \Delta \delta^2}.$$

Now determine the number of lapsed seconds between clicks of the micrometer screw in order to obtain the required rate. This value will be the number of seconds of arc per click of the micrometer screw, C, multiplied by 60 and divided by the rate of motion of the comet in seconds of arc per minute, or:

$$t = \frac{60\ C}{R}.$$

To set the micrometer to the proper position angle, first rotate the micrometer, pointing the screw knob to the south relative to the telescope field; and adjust until a star follows a cross wire when the telescope is moved in right ascension or in declination. Then rotate the position angle circle independently of the micrometer until zero degrees is opposite the index mark. Set off the position angle by turning the micrometer until the desired position angle is read on the circle opposite the index mark. This will set up the micrometer for operation by turning the micrometer screw clockwise for corrections. Keep in mind that the field of the microscope is inverted relative to the field of the telescope.

To guide, the guide star is kept on the cross wires, the micrometer being turned one click clockwise at intervals equal to the number of seconds as determined above. The time intervals may be determined directly from WWV broadcast time signals, or an assistant may call clicks by counting seconds while watching a watch sweep hand.

To account for fractional seconds, one adds or subtracts a whole second at suitable intervals to prevent accumulative error.

A 1969 PHOTOVISUAL CHART OF MARS - ALPO REPORT III

By: C. F. Capen, A.L.P.O. Mars Recorder

Figure 10 is a photovisual chart of Mars for 1969 which depicts all of the surface features and seasonal whitened areas photograhically and visually recorded during the apparition by the 31 ALPO observers listed in the "Mars 1969 Apparition - ALPO Report I" (Ref. 1). The Lowell Observatory 1969 photographic Mercator projection map of Mars (Ref. 2) was used as the initial base chart upon which fine photographic and visual details were added from over 200 individual observations made in green, orange, and red light during the Martian northern summer and autumn seasons (110°-270° L_s). This chart is here presented for reference with Mars 1967, 1969, and 1971 ALPO Reports and for comparison with Mariner VI and VII far-encounter photography.

The chart favors the equator and the northern hemisphere because of the axial tilt in 1969 of the Martian globe. Small telescopes with apertures up to ten inches added gross, delicate contrast shadings and verified features recorded on photographs. Twelve-inch and larger instruments obtained the fine detail. During the period near opposition it was possible with excellent seeing to achieve the resolution of 132 kms. with a 12-inch, 101 kms. with a 16-inch, 66 kms. with a 24-inch, and 52 kms. with a 30-inch telescope. Very high resolution of 19 kms. to 25 kms. was achieved close to opposition by C. Capen with the 82-inch McDonald Observatory reflector, when at times the seeing blur was only 0.1 arc second (Refs. 3& 4). Many fine-detailed photos and visual drawings were secured. This ultra-detail was recorded on the map in the vicinity of the Syrtis Major-Sabaeus Sinus within the 220° westward to 30° longitudes. The oases appeared to be com-

Figure 9. Richard and Helen Lines with the 16-inch, f/8 Newtonian reflector of the Lines Observatory at Mayer, Arizona. The observatory is described in Sky and Telescope for September, 1968.

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posed of small triangular and circular objects. Internally, the maria were composed of various geometric shadings. The canal-type structures broke up into dark gray, irregular, circular, and parallel filaments which were aligned with the axes of the canal-like features. Much subtle detail was added to both sides of the Syrtis in the Aeria-Arabia region, along the northern border of Sabaeus within the Hammonis Cornu and Edom areas, and contiguous to the Meridiani Sinus (Ref. 4). Note on Figure 10 that the Coloe Pons (longitude 304°; latitude +38°) appeared as a separate entity from the Umbra. The intense contrast of Meridiani's third prom (10°; 00°), known as Argus (Fournier) or as Brangaena (Ebisawa), was exceptional in red- and magenta-light photographs.

According to the observations of J. Bartlett, D. Cave, E. Cross, K. Delano, W. Haas, A. Heath, R. and H. Lines, E. Mayer, R. McClowry, J. Mitchell, T. Osawa, R. Rhoads, K. Simmons, and others, seasonal changes were particularly evident in the Trivium-Elysium, Isidis-Syrtis-Aeria, Deucalionis R.-Pandorae F.-Noachis, Solis L.-Thaumasia, and Nilokeras-Lunae L. regions. T. Cave recorded delicate detail in the Meroe area just north of the north tip of Syrtis Major. The Mare Acidalium and Tempe-Tharsis-Arcadia-Amazonis regions were especially well observed and were mapped by Osawa and Salmon. C. Capen and T. Osawa recorded a vast seasonal darkening in the Tempe Desert late in the apparition during August and September, 1969. This broad streak can be seen joining the Ascuris L. (longitude 95°; latitude +53°) with the Lunae L. (71°; +15°). It runs parallel to, and is similar in appearance to, the secular streak known as Tempes (63°; +47°) which was photographed by the author with a 16-inch Cass. in 1963.

Three distinct areas exhibited secular changes. The Nodus Laocoöntis complex (250°; +30°) continued its changing appearance, which became so evident in 1954. The Laocoöntis, Nubis L., and Thoana Palus have been fading during the past fifteen years, leaving the small but dark Laocoöntis isolated at 245°; +15°. This fading out of the gross 1954-56 features gives the pseudo-effect that the Laocoöntis has been moving its center-of-area eastward. Indeed, the 1969 chart shows that it has only expanded southward along Amenthes towards Tritonis S. The second secular change appeared as a darkening in the Chryse Desert along the Margaritifer NW border. The author has called this the "Hydrae darkening". The Eye-of-Mars was the third secularly affected region. The Solis L. had darkened completely, and had enlarged its east portion since its appearance in 1967 (Ref. 5). The Nectar was strong and broad and was hooked at its E. end where it joined M. Erythraeum. This aspect may be caused by an enlargement of the Nectar Fons.

The ALPO Mars Section has produced apparitional charts in the tradition of Antoniadi and De Mottoni. Charts produced during each apparition are useful for comparison of changes with the preceding and following apparition because there is about a one Martian

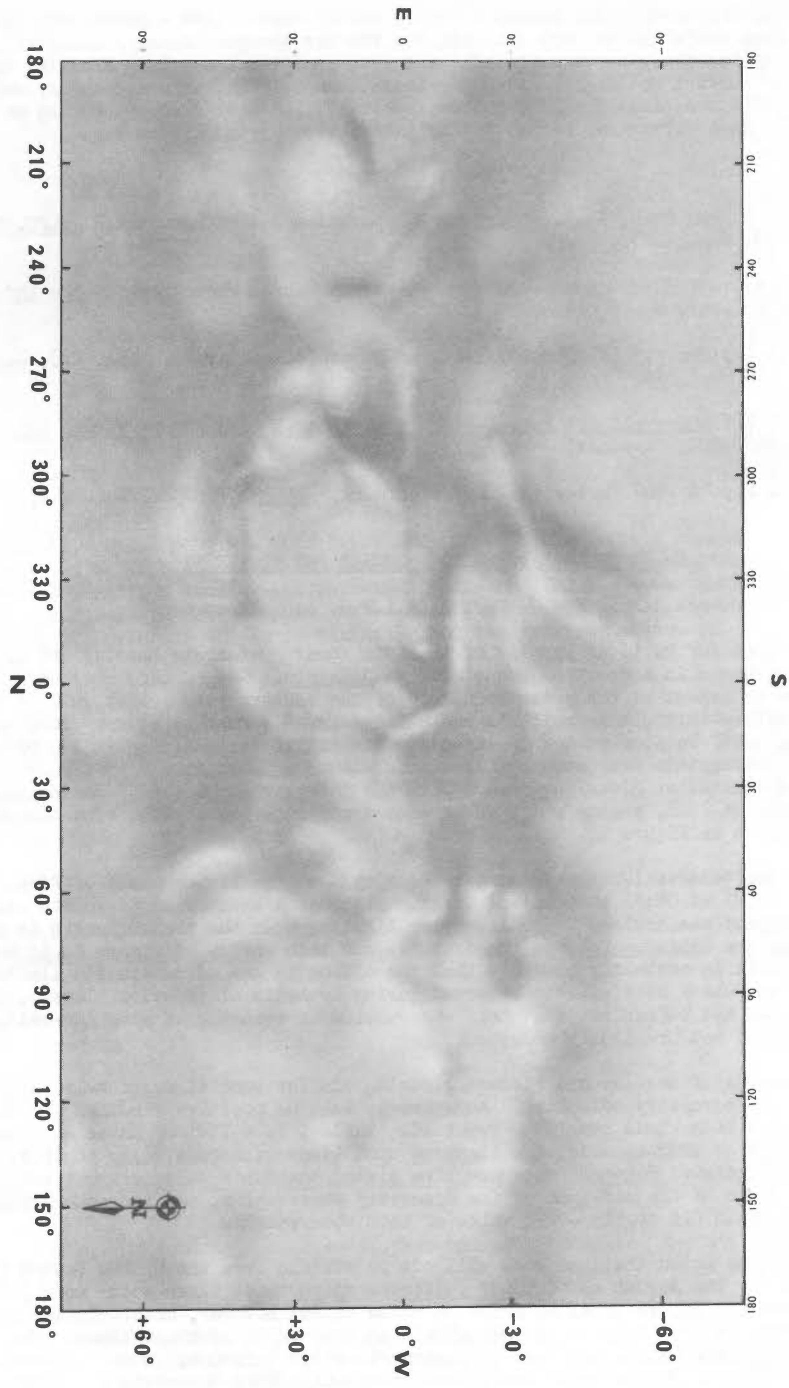

Figure 10. A 1969 photovisual chart of Mars - ALPO. Constructed by C. F. Capen on the basis of more than 200 visual and photographic observations by the A.L.P.O. Mars Section observers. Martian season summer and autumn in the northern hemisphere. See also discussion in text on page 99 <u>et seq</u>.

season overlap and about a one season advance between consecutive apparitions. Such charts are also useful to compare seasonal and secular changes during similar seasons in the 15-year cycle; e.g., between the 1969 and 1954 apparition charts. Finally, the charts are of current use for plotting the positions of local surface changes, whitened areas, and cloud positions. All of the definitive disk detail recorded during an entire apparition by an observer may be plotted on a current apparition base map.

References

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3. Capen, C. F.; "Mars," IAU Central Telegram Bureau, Circular No. 2154, SAO, Cambridge, Mass., 1969.

4. Capen, C. F.; Observational Patrol of Mars in Support of Mariners VI and VII; TR. 32-1492, NASA-JPL, Pasadena, June, 1970.

5. Capen, C. F.; "A 1967 Photovisual Chart of Mars," JALPO, Vol. 22, Nos. 7-8, Aug., 1970.

UNUSUAL ASPECT OF MESSIER AND PICKERING

By: Roy C. Parish, A.L.P.O. Lunar Recorder

The project for vertical studies of the twin lunar craterlets Messier and W. H. Pickering was announced in a previous issue of this Journal[1]. One of that project's observers has reported an aspect of the exterior shadow of the eastern (IAU sense) wall of Pickering under late afternoon lighting which is unusual and invites further study. Todd Hansen, NAS Lemoore, California, reports[2] an extended observation of 1972, August 27, 08:51 to 09:21 U.T. (Colongitude 126°4 to 126°7), during which he observed a thin thread of shadow connecting the exterior Pickering shadow with the interior of Messier. Hansen used a 6-inch reflector at 200X, seeing and transparency conditions not stated. The observer's drawing is shown in Figure 11.

During the observation the local solar altitude at the eastern wall of Pickering ranged from 6°22' at 08:51 to 6°04' at 09:21. Although a broad band of shadow can be expected to connect the craters under low solar lighting when the shadow length is sufficient to span the distance between the craters, the thin shadow of Figure 11 is most unusual. While it is certainly possible that the effect is one of resolution limitations, similar to the "black drop effect" observed during transits of inferior planets, the possibility should not be ignored that this observation is evidence of some low-relief feature of the wall not previously detected.

Observations of Messier and Pickering during similar conditions of solar altitude and azimuth are earnestly solicited. Negative as well as positive findings are of equal usefulness, and both kinds should be reported. Table I is a list of dates and times through the end of 1973 at which the lighting conditions will be similar to those of Hansen's observation. For each date and time listed the Sun's selenographic colongitude is near the 126°6 of the mid-time of the discovery observation, and its selenographic latitude is within 0°5 of the -0°97 value of that observation.

It should be noted that the Moon will not be visible from the United States at the times listed for the August and October lunations since these times occur during local daylight hours and before local moonrise on those dates; however, observers in western Europe can observe the newly risen Moon within an hour or so of these times. The coincidence of the desired colongitude and selenographic solar latitude, which together define local solar altitude and azimuth, occurs so infrequently that observations should be attempted even under poor conditions or when exact times can only be approximated within an hour or so.

Here is another instance of a single report of an observed effect by a competent lunar observer, and it is expected that efforts to duplicate the observation will be rewarding.

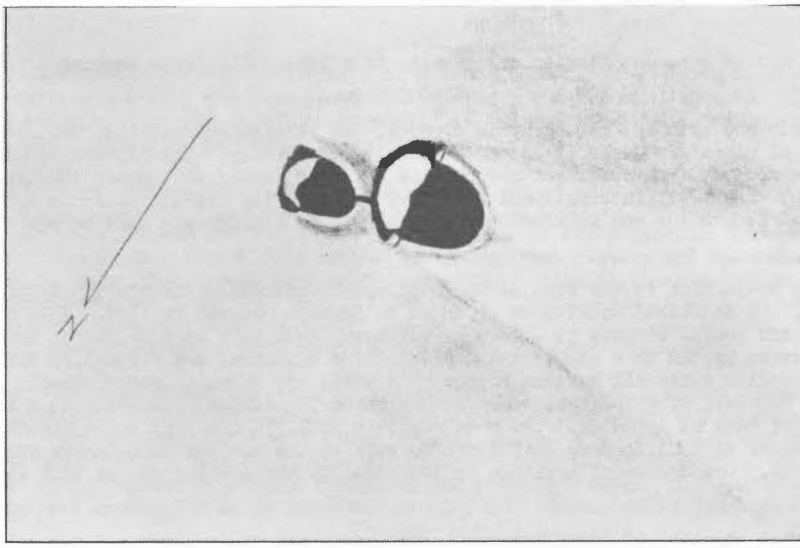

Figure 11. Drawing by Mr. Todd Hansen of the lunar craterlets Messier (left) and W. H. Pickering on August 27, 1972, 8^h51^m to 9^h21^m, Universal Time. Colongitude 126°.4—126°.7. 6-inch reflector, 200X. Lunar south at top, lunar east in IAU sense at left. Note the thin thread of shadow joining the exterior shadow of Pickering and the interior shadow of Messier.

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For those not familiar with the Messier-Pickering program of vertical studies, the writer will be glad to provide details of the objectives and methods of the project and to furnish a supply of report forms free of charge. Please address all inquiries and observations to:

Roy C. Parish, Jr.
208 Birch Street
Milton, Florida 32570

Table I. Preferred Times for Future Observations of Messier and Pickering.

Universal Date and Time (to nearest half hour)		The Sun's Selenographic Colongitude	The Sun's Selenographic Latitude
1973, July 18	$07^h.5$	126°.7	-0°.49
Aug. 16	18.5	126.7	-1.16
Oct. 14	18.5	126.5	-1.44
Nov. 13	08.0	126.5	-0.97

References

1. Parish, Roy C., and Jamieson, Harry D., "Progress Report on a Study of Messier and Pickering", Journal of the Association of Lunar and Planetary Observers, 23:181-182 (1972).

2. Hansen, Todd, NAS Lemoore, California, personal communication, August, 1972.

B O O K   R E V I E W S

The National Geographic Society's The Red Planet Mars chart is available on heavy chart paper or plastic, rolled, from the National Geographic Society, Washington, D.C., 20036. Price: heavy paper $2.00, plastic $3.00.

Reviewed by Charles F. Capen, ALPO Mars Section

A new full color Mars chart which depicts the telescopic photographed albedo features (light and dark areas) over the Mariner IX topographic details has been published by the National Geographic Society. The chart first appeared with Mr. K. F. Weaver's article, "Journey to Mars," in the February, 1973 National Geographic. This new chart is the first of its kind, and it advances Martian cartography to a level with lunar mapping in the early 1960's.

The basic map artwork, cartographic control, and Martian nomenclature were the responsibility of planetary authorities of the Lowell Observatory. The telescopic albedo features were derived from red-light photographs obtained during the recent 1969 and 1971 apparitions by the Lowell International Planetary Patrol. The overall color is good and was determined from color and multicolor photographs. No attempt was made to add local area colors.

The map projection is the same as the National Geographic Society's The Earth's Moon, namely, the Azimuthal Equal-Area which J. A. Lambert created in 1772. This projection is neat and useful because it allows all of Mars, from pole to pole, to be seen in a single projection system on a single chart sheet. The Azimuthal E-A projection assists statistical studies since all Martian topographic areas are shown in their correct relative sizes. However, it gives the pseudo-orthographic impression of looking at a telescopic image of Mars at infinity. The mean scale is 1:31.770 million, which yields a Mars map diameter of 13.1 inches, sufficient to read to the Mariner IX A-camera photomosaics resolution. One degree of latitude or longitude on the equator equals 59.1 kms. or 36.7 miles.

The layout consists of three ocher-colored equatorial hemispheres and two polar maps based on the same projection and drawn to the same scale and presented on an attractive dark-blue background with an appropriate border. The three equatorial views have central meridians of 0°, 120°, and 240° longitude. Each map overlaps the next one by 60° for excellent continuity, but most accuracy lies within the region of 60° on either side of the CM.

The white North Polar Cap is shown with its Martian July (110° - 120° L_s) summer aspect just prior to its minimum static diameter as determined from telescopic studies. The South Polar Cap remnant is shown at its minimum static diameter as photographed by Mariner IX. The caps' rift details are indeed interesting.

The remaining unfilled face of the chart is cluttered with short paragraphs and useful colored figures explaining the Martian orbital aspects and physical characteristics. Comments regarding areographic features and surface structures are shown in red print over the map, which negated some of the topographic relief. This pertinent information was injurious to the aesthetic balance of the chart and confused the cartography. These data could have been better presented and organized on the reverse side of the chart in place of the gross, fictitious painting of a Martian dust cloud.

The standard Schiaparellian system of feature names is used and is indicated in proper position. The usual high standard and variety of the National Geographic Society's print type styles are employed to differentiate between light and dark albedo features and the new Mariner IX topographic detail. The tastefully chosen typographic design gives the five circular maps that "Old World" flavor. An index of 224 traditional names is listed with maps reference numbers, and is inconveniently placed on the reverse side of the chart. Improper usages of names are few: The Coprates Canal (longitude 83°; latitude -07°) extends east past Melas L. to improperly replace Agathodaemon (65°; -12°); Trinacria is used instead of Ausonia Borealis (270°; -20°); and Rasena (190°; -22°) replaces Symplegades, probably because it is easier to pronounce. The nomenclature of the polar regions is most useful because it is rather lacking on modern maps. The quantity of names used is quite adequate for dead-reckoning oneself about the globe of Mars while not cluttering the map faces. It is unfortunate that this useful reference index was not placed next to the maps on the front of the chart.

The quality artistic workmanship, positional accuracy, attractive colors, planetary data, and a standard reliable nomenclature combine to make this chart a valuable reference tool for office, classroom, or observing wall. "The Red Planet Mars Chart" is definitely a worthy companion for the National Geographic Society's "The Earth's Moon Chart" and is a must for the student of Mars.

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New Horizons in Astronomy, John C. Brandt and Stephen P. Maran, W. H. Freemen and Company, San Francisco, 1972. 496 pages. Price: $12.50.

Reviewed by Ken Thomson

Capturing and retaining the interest and respect of the nonscience major who undertakes a one-semester course in astronomy is often difficult; and few texts exist which combine these goals with the presentation of abundant timely, authoritative information not only on astronomy, but also on necessarily allied subjects which may be new to the reader. New Horizons in Astronomy is admirably suited to this task.

No previous exposure to the physical sciences or to mathematics (except for powers-of-ten notation, which is explained in an appendix) is supposed. Therefore, of necessity, the authors must digress frequently into descriptions of basic physical processes and phenomena. The book begins with a section on terrestrial history and the evolution of life, and it is not until page 61 that the astronomy begins in earnest with a chapter bearing the whimsical title "Sky and No Telescopes". The reader is edified by a chapter on matter, heat, and light before a discussion of telescopes and observatories is presented; here equal space is given to optical and to radio instruments.

The Solar System and the discoveries of the outer planets are next summarized in brief; there then follows an excellent in-depth chapter on the individual planets - appearances, compositions, and atmospheres. Comets are not neglected; this is the best elementary treatment of cometary structure this reviewer has seen. The Sun is next studied; then four chapters on stellar evolution and cosmology ensue. A description of the results of the space program provides the setting for a comprehensive discussion of the Moon.

The text closes with a resumé of problems in modern astronomy - pulsars, quasars, and the like - with suggested methods of attack. Appendices are provided on units, powers of ten, basic astronomical equations (even the simplest algebra is avoided in the main text), and the usual tables of Solar-System data. The work is liberally provided with excellent illustrations, diagrams, and photographs, with a center section of eleven color plates.

The suthors acknowledge that certain standard topics have had to be omitted due to space limitations. Whereas the traditional nearly useless embellishments such as too small star charts have been refreshingly neglected, there is little information on observational astronomy for the individual; and the section on telescopes is woefully brief. It might have been hoped that the bibliography would be of help here; unfortunately, it leans heavily toward astrophysics and cosmology and is disappointingly short.

In order to provide an easily-read text and to avoid alienating the neophyte reader, most of the subjects are first introduced as overviews, with finer and more profound details introduced later, usually with irrelevant material in between. This dispersal makes retrospective fact-gleaning quite difficult, despite the eight-page index; this circumstance is probably the greatest weakness of the book.

The authors, both affiliated with NASA-Goddard Space Flight Center, are to be commended for not overemphasizing the contributions of the space program. They are also realists; they acknowledge the fact that today's young person is vitally concerned with the relevance and cost of astronomical research. The following quote (page 440) is illustrative: "We believe that research in astronomy and the exploration of space are related, desirable, and important activities that transcend national boundaries and express much of the best in man. They challenge thought and open new horizons for us today as they did for men in Galileo's time."

In summary, here is an excellent book for the beginner, highly readable, interesting, and useful. Educators might well choose this book as an introduction to the physical sciences in general, and it would be a welcome addition to the shelves of any library.

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Man and His Universe, by Zdenek Kopal. William Morrow and Company, Inc., New York, N. Y., 1971. 313 pages. Price: $7.95.

Reviewed by H. W. Kelsey

This book will provide up to date answers for the more general reader, who desires a convenient means of reference to the results of astronomical research as practiced in the last few years. Thirty-two illustrations, seven line diagrams, and a brief glossary of terms are included as an enhancement of the author's presentation of the facts, theories, and methods of present day astronomy. Man and His Universe is divided into three parts starting with the stars and followed by the major objects of the Solar System, including the Moon, comets, and meteors, and concluding with a discussion of the galaxies as well as of the universe. The nearest star, our Sun, our stellar neighborhood, and the origin and evolution of the stars are surveyed and interpreted.

In the discussion of our planetary system, greater emphasis is directed toward the Earth and Moon system. The Earth's anatomy and composition and the evolution of its surface are discussed in detail, as well as the evolution of Man upon the Earth. The Moon is thoroughly reported upon by utilizing the data acquired in our lunar exploration programs, the most recent being the Apollo 14 Mission. It must not be thought that the other terrestrial planets have been neglected since the author does adequately report on the most recent findings concerning Mercury, Venus, Mars, and Pluto. This section is then concluded with a discussion of the origin and design of the Solar System.

In its conclusion, <u>Man and His Universe</u> provides an interesting consideration of our galaxy, the external galaxies, and the size, expansion, and age of the universe. The author also discusses, somewhat pessimistically, the idea that life with which we could communicate may exist in another part of the universe.

Most of you are aware of the fact that Professor Kopal has written many books and papers on astronomy, some of which you have probably read and have thus been introduced to his entertaining style of writing. This work is no exception.

This interesting and informative contribution to the subject of astronomy is available for your reading through the A.L.P.O. Library.

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<u>The Emerging Universe: Essays on Contemporary Astronomy</u>, W. C. Saslaw and K. C. Jacobs, eds., University Press of Virginia, Charlottesville. Copyright 1972, price $7.95. 195 + ix pages with 23 plates, 19 diagrams, plus 4 tables.

Reviewed by David D. Meisel, SUNY - Geneseo

Interpretation of one's research within the larger context of modern scientific developments has lately become nearly a lost art. Many "popular" reviews suffer either from professional myopia or are so watered down that only clichés remain. The introspective essays in <u>The Emerging Universe</u> are not trite and, therefore, are not light reading. They are, however, provocative, realistic, and thoughtful "progress" reports on ten important topics in modern astronomy. Each essay has a suggested bibliography as an aid to students and laymen who wish to pursue the subject further. Figure captions are clear and self-explanatory.

Since these essays are based on a series of informal lectures at the University of Virginia, the considerable differences in level of presentation are probably unavoidable. Although the average reader may find the mathematics in some essays a bit difficult, in most instances the mathematics is not an impediment to an appreciation of the topics being discussed. With the exception of the essay on Olbers Paradox (which presumably because of its unusual "classical" approach to this famous cosmological problem is presented in full mathematical detail), the accounts are quite apropos and lucid and could be used as supplementary readings in many college-level astronomy courses. A thoughtful reading is recommended for the <u>teacher</u> as well as the student. The table of interstellar molecules should be particularly useful. Only a few editorial improvements can be suggested. First, I feel that the mathematical details of the Olbers Paradox could well have been put in an appendix. While this undoubtedly would have meant a considerable reorganization, it would have made less of a "quantum jump" in level between this essay and the much more understandable essays on either side. Secondly, initial lack of a proper definition of the fundamental physical constant $\hbar = h/2\pi$ (where h is Planck's constant) would be quite distressing to the general reader. In essay five (Kahn, "Life in the Universe") the $\hbar$ is given without definition, but from the context one gathers that it is a rotational quantity. In essay nine (Jacobs, "A Quantum Universe ...") a reference about the rotational significance of $\hbar$ is assigned erroneously to essay one (Mestel, "Why Does the Sun Shine?") when essay five is meant. (In essay one, the symbol $\hbar$ is not used, only $h/2\pi$!) The poor reader must wait until page 161 to find a suitable definition for a symbol used some 90 pages earlier!

The layout of the book is neat and attractive and, except for the minor irritations cited above, should be stimulating and informative to all who are trying to put modern astronomy into its proper perspective. The volume would probably make a fitting gift to an advanced amateur astronomer or student who has read the standard (and perhaps somewhat milk-toasty) elementary texts and is ready for something with a little more meat in it.

A MODIFIED FISSION PROCESS FOR THE FORMATION OF THE MOON

By: Curtis C. Mason*, Associates for Planetary Research

(Paper presented at the 53rd Annual Meeting, American Geophysical Union, April 17, 1972)

Abstract

Data from the returned lunar samples indicate that the lunar maria are composed of high density material (3.36 gm/cc) of essentially the same age overlying a lower density material (3.0 gm/cc). If a layer of material 34 km in thickness with surface area equal to 70% of the primitive earth's surface were removed from the earth, a quantity of material nearly equal to that of the moon would result. A mechanism that would cause 70% of the primitive earth's crust to collect at one end of an ellipsoidal earth would cause the ellipsoid to go into a pear-shaped configuration and would result in fission of this primitive crustal material, thus forming the moon. Some material from below the primitive Mohorovičić discontinuity would cling to the surface, forming the maria. A phase change between 80 and 200 km lunar depth would increase the 3.0 g/cc material to 3.4 g/cc resulting in a moon with the correct moment of inertia and density. A mathematical investigation of the orbit of the moon after such fission from the earth shows that rather than going into orbit about the earth, the newly formed moon would go into orbit about the sun. However, the moon would be in an orbit ideally suited for capture by the earth.

Introduction

A large volume of data has been published on the nature of the lunar material in the vicinity of the Apollo 11, 12, 14, and 15 landing sites. Data particularly important in relation to the origin of the moon are density and maximum age of the crystalline rocks. These data when considered along with the lunar mass concentrations in the circular maria, the volume and average density of the moon, and Jeans' (1919) mathematical investigations into the requirements for fission of a rotating fluid body indicate a modified fission process for the formation of the moon.

The Density Reversal Beneath the Maria

In a previous paper (Mason, 1972a) the author has shown that there is a density reversal beneath the maria and Oceanus Procellarum. Density of the mare basalt returned by the Apollo 11, 12, 14, and 15 missions is about 3.36 g/cc. Since the average density of the moon is 3.34 g/cc, this mare basalt is too dense to be average lunar material. Highland material has a density of 3.0 g/cc. If the bulk composition of the moon is similar to highland material, a phase change starting at 80 km depth and ending at 200 km depth would result in a quartz and kyanite bearing eclogite with a density of 3.40 g/cc. Another phase change at 1000 km depth results in the quartz going to coesite with density increasing to 3.46 g/cc (Mason, 1972b). A moon with composition similar to highland material would have the correct density (3.34 g/cc). Its moment of inertia expressed as I/MR^2 would be 0.393. This value is within the uncertainty range of the measured value for the moon. In the maria areas the layering would be as shown in Figure 12. There would be a 24 - km thickness of mare material, density = 3.36 g/cc, overlying a 3.0 g/cc highland type material, which in turn undergoes two phase changes, one at from 80 to 200 km lunar depth where the density increases to 3.40 g/cc, and the other at 1000 km depth where the density increases to 3.46 g/cc.

Age of the Maria and Adjacent Areas

Wasserburg (1972) has shown that igneous activity on the moon appeared to start at about 4.0 AE (10^9 years) and continued to 3.16 AE as illustrated in Figure 13. The author in examining the ages of lunar material published in the literature has come to a somewhat different conclusion. There can be no doubt that there has been a period of igneous activity on the moon lasting about one billion years; however, as the data in table 1 show, each of the areas visited by Apollo spacecraft has yielded a few crystalline samples with

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maximum ages of 4.2 ± 0.1 AE. Examination of the Pb/U concordia diagram shown in Figure 14 reveals that the <u>maria</u> and adjacent areas originally crystallized about 4.2 AE. The field of the Apollo 11 samples crosses concordia in the 4.13-4.24 region; Apollo 14 samples 14073 and 14310 lie near concordia at about 4.24 AE; and although the Apollo 12 samples lie below concordia, a line drawn through the 3.3 AE point (Rb/Sr age of the Apollo 12 samples) and the middle of the Apollo 12 field intersects concordia at about 4.24 AE. It is apparent from the maximum ages of the crystalline rocks returned by the Apollo missions and the Pb/U concordia diagram that there was some widespread event that occurred at 4.2 ± 0.1 AE. This event effectively set the radioactive "clocks" in the <u>maria</u> and adjacent areas. Subsequent activity reset some of the "clocks" in the crystalline rocks, but this activity has not been sufficient to destroy the evidence of the earlier event at 4.2 ± 0.1 AE.

Data Indicating How the Moon was Formed

The data presented above indicate that the lunar <u>maria</u> are anomalous areas of high density material (3.36 g/cc) which overlie a lower density material (3.0 g/cc). The <u>maria</u> and adjacent areas were formed at essentially the same time. These <u>maria</u> are concentrated in an area of the moon approximately 4800 km east-west and 2200 km north-south. Any theory on the formation of the moon must explain these data.

There is one piece of circumstantial evidence which may relate to the formation of the earth-moon system. If material with a thickness of 34 km, with an areal extent equal to that of all the earth's oceans, and with a density equal to 3.0 grams per cc were removed from the earth, a quantity of material equivalent to the volume of the moon would result. That is to say, a portion of the earth may be missing; and there is an equivalent body of material in the proximity of the earth.

A modification of Darwin's fission hypothesis for the origin of the moon can satisfy this evidence, and in addition it can fulfill one enigmatic requirement established by Jeans (1919) as a necessary condition for a fission process to go to completion.

Configurations of Equilibrium of a Rotating Fluid

Configurations of equilibrium of a rotating fluid have been the subject of a large body of mathematical studies starting with Newton in the seventeenth century and continuing on into the twentieth century. Jeans (1919) presented a comprehensive summary of this work in addition to his own analysis on the stability of the pear-shaped figure. In brief, a stable rotating gravitating homogeneous fluid body as its density increases (it contracts, causing a decrease in its moment of inertia) follows the configuration path diagramed in Figure 15 with the only requirements placed on the body being that its angular momentum and total mass remain constant. The first figures of equilibrium are the Maclaurin spheroids. They are a series of oblate spheroids that become increasingly flat as the density increases. At first the rate of rotation expressed as $\omega^2/2\pi\Phi$ (where Φ is the product of the density times the gravitational constant) increases as the spheroid flattens. When $\omega^2/2\pi\Phi = 0.18712$, a bifurcation point is reached where a second series of configurations of equilibrium meets the Maclaurin spheroids. The second configuration is the Jacobian ellipsoids. Stability will pass to this family; and as the material contracts the value of $\omega^2/2\pi\Phi$, rather than increasing, will decrease; for the rate of elongation of the ellipsoid will cause the moment of inertia to increase more rapidly than contraction will cause it to decrease. As these configurations of equilibrium proceed along their path, a second bifurcation point is reached where a pear-shaped configuration of equilibrium meets the path of these ellipsoids. Jeans (1919) has shown that, unlike the previous bifurcation point, the configuration of equilibrium for a homogeneous body will not take the "pear-shaped" path unless either angular momentum is lost or else the volume increases. If the configuration of equilibrium continues along the path of the Jacobian ellipsoids, the figure will remain stable; and the centrifugal force on the equator will never exceed the gravitational forces. Jeans has shown by analogy with the two-dimensional case for the pear-shaped equilibrium figure that should some mechanism cause the equilibrium configuration to take the pear-shaped path, this figure will become unstable as the density or angular momentum increases with the final result being the separation of a satellite from the small end of the parent mass.

Formation of the Moon

The process hypothesized by the author for formation of the moon starts with a body with a density less than 5.52 g/cc and a total mass and chemical composition equal to that of the earth-moon system. This body was rotating with sufficient momentum to carry it to the point of separation of the pear-shaped configuration.

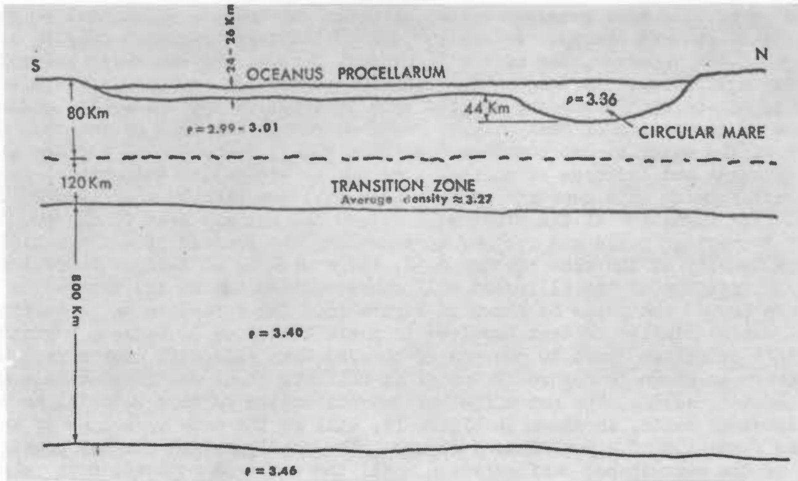

Figure 12 (above). Schematic diagram of layering in <u>maria</u> areas of Moon. See also text of Curtis C. Mason's article in this issue.

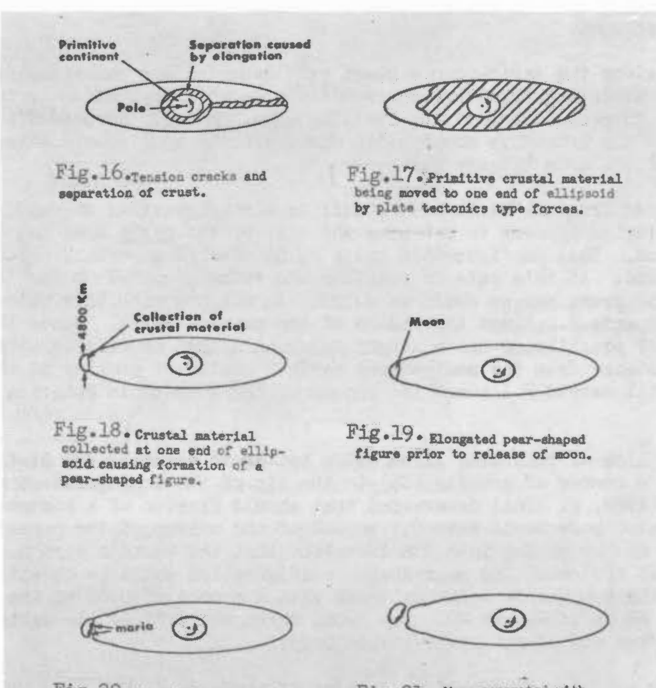

Fig.16. Tension cracks and separation of crust.

Fig.17. Primitive crustal material being moved to one end of ellipsoid by plate tectonics type forces.

Fig.18. Crustal material collected at one end of ellipsoid causing formation of a pear-shaped figure.

Fig.19. Elongated pear-shaped figure prior to release of moon.

Fig.20. Moon being separated from pear-shaped earth.

Fig.21. Moon separated with sufficient velocity to go into orbit about the sun.

Sequential series of diagrams to illustrate progressive fission of Moon from Earth in theory discussed by Dr. Curtis Mason in this issue. See also text.

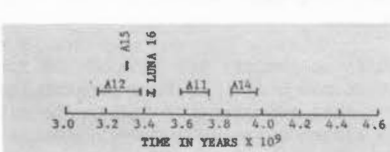

Figure 13 (left). Period of igneous activity on Moon. After Wasserburg, 1972.

Contraction of this mass requires a loss of potential energy, which must be dissipated in the form of radiant energy. As contraction of the mass proceeds, causing an apparent angular momentum increase, the mass will proceed through the Maclaurin spheroids into the Jacobian ellipsoids. As long as the mass is contracting rapidly, convection will be vigorous, keeping the body homogeneous. But when contraction approaches its maximum amount, the rate of generation of heat will be reduced, convection will be reduced, and differentiation of the material can commence. At some point, reduction of surface area due to volume decrease and increase of surface area due to elongation will cancel each other; and a crust forming with constant surface area will not then be subjected to disruptive forces. The formation of the crust will retard the outward heat flow, reducing the velocity of convection cells and further accelerating the process of differentiation. Once the average density of the mass reaches 5.52, there will be no further reduction in volume; and any elongation of the ellipsoid will cause tension cracks and separation of the crust to form around the poles as shown in Figure 16. The formation of these cracks will allow a mechanism similar to that involved in plate tectonics to cause a migration of 70% of the earth's primitive crust to one end of the Jacobian ellipsoid over a period of about 4×10^8 years as shown in Figure 17, until it collects in an ellipsoidal mass at one end of the ellipsoidal earth. The net effect of the collection of this material on the end of the ellipsoidal earth, as shown in Figure 18, will be the same as a loss of angular momentum and the formation of a pear-shaped figure. The configuration can now proceed along the path of the pear-shaped configuration until the point of separation is reached (Figure 19). However, instead of being gently released by "pinching" off the point of attachment, as would be the case with a homogeneous fluid configuration, release would be, as shown in Figure 20, by first detaching the leading edge of the moon, which by allowing a portion of the body to move away from the center of gravity causes an increase in the moment of inertia of the entire configuration. This fact will cause shear forces to be set up at the point of attachment.

These shear forces along the earth-moon contact will cause either recrystallization or melting of the material along the primitive Mohorovičić discontinuity, which in turn allows release of the moon to proceed toward the trailing edge. A small amount of high density material from below the primitive Mohorovičić discontinuity will remain attached to the earth-facing side of the moon (Figure 21).

The moon when released from the earth must itself be a configuration of equilibrium. The configuration of equilibrium closest to matching the size of the <u>maria</u> area has axes of 4,800 x 2,200 x 3,200 kms. This configuration has a value of $\omega^2/2\pi\phi = 0.17$ or $\omega = 4.8 \times 10^{-4}$ radians per second. At this rate of rotation the value of $\omega^2/2\pi\phi$ for the earth with a density of 5.52 grams per cc would be 0.105. An ellipse with this value of $\omega^2/2\pi\phi$ would have a major axis 2.4 times the radius of the present earth. Since the pear-shaped configuration of equilibrium has a longer major axis than an ellipse with the same rotation rate, the distance from the pear-shaped earth's center of gravity to the moon's center of gravity will exceed 2.4 times the radius of the comparable spherical earth.

The author used the line of reasoning given below better to estimate the distance from the pear-shaped earth's center of gravity (CG) to the tip of the configuration at the time of fission. O'Keefe (1969, p. 2764) determined that should fission of a homogeneous body take place, the separated body would have 0.1 to 0.2 of the volume of the parent body. By using the smaller value and by taking into consideration that the earth's core had already formed, one finds that the resulting pear-shaped configuration would be an ellipsoid with major axis 2.4 times the comparable spherical mass with a sphere of 0.06 of the earth's mass on the end as shown in Figure 22. The moon, which has 0.01 of the earth's mass, would be attached to the end of this pear-shaped body.

The pear-shaped body was simulated by five spheres as shown in Figure 23. The mass of the two largest spheres has been adjusted to take the earth's core into consideration. The CG of the five spheres was 2.91 earth radii from the tip of the configuration. Calculations show that when $\omega = 4.74 \times 10^{-4}$ radians per second (velocity = 8.8 km/sec), the centrifugal force on the end of the configuration equaled the gravitational force. This value compares favorably with the 4.8×10^{-4} radians per second determined previously from the assumed shape of the moon at the time of separation.

A program was written for the Wang 700 computer to compute the path of the moon after fission had taken place from the simulated pear-shaped body. In this program the fissioned moon was given a 1% velocity increase over that required for fission to take place by increasing the distance from the CG of the system by an amount equivalent to a 6° angle between the moon and the tangent to the earth's surface at the moment of release.

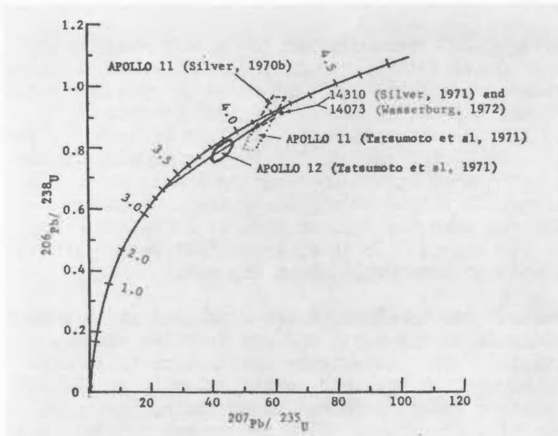

Figure 14 (above). Pb/U concordia diagram for Apollo 11, 12, and 14 lunar samples. See also text.

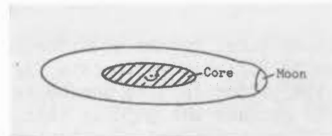

Figure 22 (above). Schematic diagram of Earth-Moon body just prior to its fission.

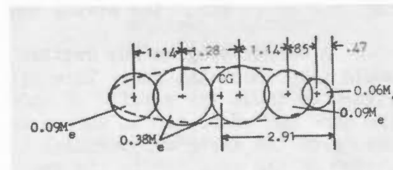

Figure 23 (above). Five spheres used to simulate pear-shaped Earth. Distances are in Earth radii. M_e = mass of Earth.

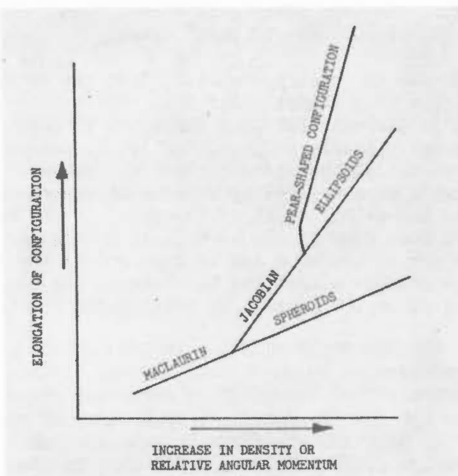

Figure 15 (above). Schematic diagram of paths taken by configurations of equilibrium.

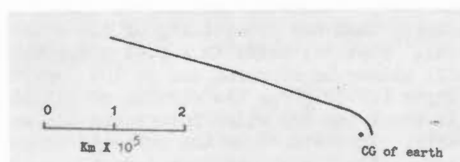

Figure 25 (above). Path taken by Moon during the first 64,000 seconds after fission. CG is center of gravity.

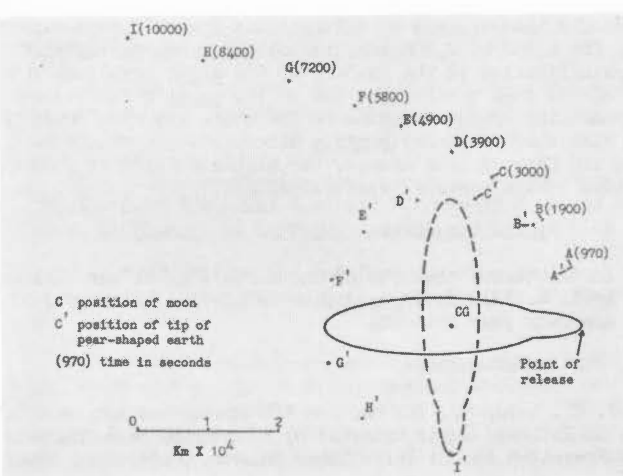

Figure 24 (left). Path taken by Moon during first 10,000 seconds after fission. See discussion in text of Dr. Curtis C. Mason's article.

The path taken by the moon during the first 10,000 seconds after the moon's release is shown in Figure 24. In this figure, the ordinary letters denote the position of the moon; and the primed letters denote the comparable position of the tip of the pear-shaped earth. At 970 seconds the moon is still close to the tip of the earth. At 1900 seconds it has receded a little and has started to lag a little behind the tip. At 3000 seconds the separation and lagging behind have increased. At 10,000 seconds the moon is rapidly receding from the earth. Figure 25 shows the path taken by the moon during the first 64,000 seconds after separation. From 10,000 to 64,000 seconds the path of the moon is essentially a straight line. At 64,000 seconds the moon was 384,000 kms. from the earth and was still receding, at a rate of 5.9 kms. per second. It is apparent thet rather than going into orbit about the earth, the moon will go into orbit about the sun.

A second program was written to evaluate the orbit which the fissioned earth's moon would take about the sun. This program considered the earth and sun as point masses. Figure 26 shows the results of this evaluation. The two extreme orbits were those when the moon was separated in such a manner that the 5.9 kms. per second velocity at 384,000 kms. from the earth was parallel to the earth's velocity vector about the sun and was either in the same, or in the exactly opposite, direction. With the moon's velocity vector in the same direction as the earth's, perihelion was tangent to the earth's orbit; and aphelion was at 355,000,000 kms. from the sun. With the moon's velocity vector in the opposite direction from the earth's, aphelion was tangent to the earth's orbit; and perihelion was at 70,000,000 kms. from the sun. With release so that the moon's velocity vector was $\pm 16°$ from the earth's velocity vector, the moon never gets closer than 2,000,000 kms. to Venus' orbit or closer than 20,000,000 kms. to Mars' orbit.

If it is considered that any angle of release is equally probable, then the probability of the moon's orbit intersecting the orbit of a planet other than the earth is less than 64/360 or about 0.18. If it is further assumed that when the orbit intersects that of two planets, the fate of the moon is equally likely to be controlled by either planet, then the probability of the moon's eventual fate being controlled by the earth is 0.91. That is, there is a 0.91 probability that a moon derived by fission of the earth will either be captured and go into orbit about the earth, or it will crash into the earth. Singer (1970) gives the results of calculations that show if the moon is in a prograde orbit about the sun which intersects the earth's orbit, the moon can be captured by the earth. The results of the author's computer program show that the mechanism which would lead to fission of the moon from the earth will place the moon in an orbit about the sun that is ideal for recapture by the earth.

Conclusions

The maria and adjacent areas are the same age and are underlain by a layer of material having a density lower than the average lunar density. This can be explained if the moon came from the earth in such a way that a bulge 4,800 x 2,200 x 3,200 kms. in dimensions formed slowly on the surface of the earth and then remelted or recrystallized along the primitive Mohorovičić discontinuity, allowing it to be released with fragments of material from below the primitive Mohorovičić discontinuity clinging to its surface to form the maria.

This mechanism will account for the presence of intermittent areas of high-density material (3.36 gr/cm^3) extending for 4,800 by 2,200 kms. across the earth-facing surface of the moon. Remelting or recrystallization of the surface of the maria would account for the relatively fine texture of the rock and for the age of the maria and adjacent areas. There could be limited remelting in the interior of the moon; but this remelting would not reach the surface, or else the high-density maria material would settle to the center of the moon. If the moon did form in this manner, the highland material should have a chemical composition similar to the earth's primitive crust.

Acknowledgement

The author was introduced to the theory that 75% of the earth's crust was fissioned from the earth to form the moon by R. L. Folk during a debate before the University of Texas Geological Society in the academic year 1955-56.

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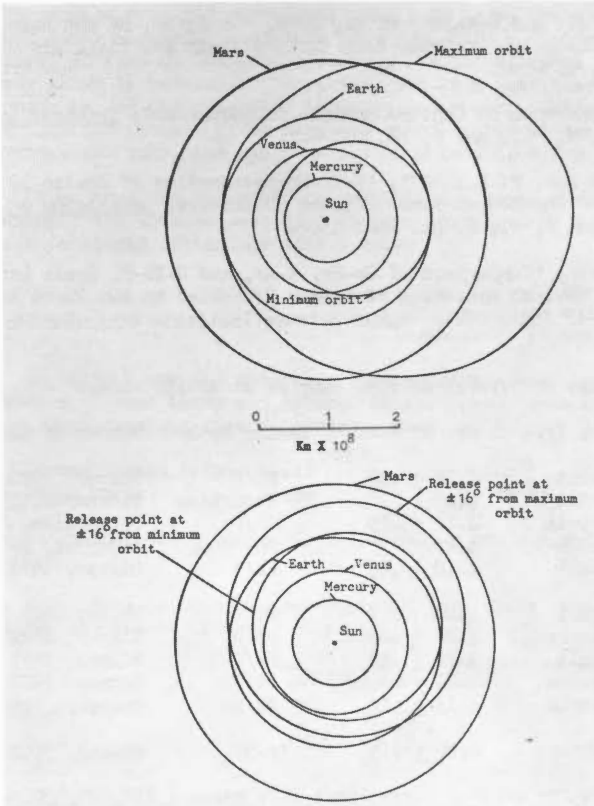

Figure 26 (above). Orbits about the Sun taken by the Moon for various conditions of release in the fission theory discussed by Dr. Mason in his paper.

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Table 1. Maximum age of crystaline rock samples at Apollo sites.

Apollo Site	Rock Number	Rock Type	Age of Rock	Dating Method	Source of Data
11	Older Group	Basalt	4.22 ± .01	Pb/U	Silver, 1970
11	All Basalt	Basalt	4.2	Pb Evolution	Tatsumoto, 1971
12	12013	Breccia	4.12 ± .18	Rb/Sr	Schnetzler, 1970
12	12013	Zircon	4.25	$^{207}Pb/^{206}Pb$	Andersen, 1972
12	12018	Basalt	4.18 ± .05	Pb/U	Silver, 1970
14	14073	Basalt	4.23	Pb/U	Wasserburg, 1972
14	14303	Breccia	4.20 ± .03	Pb/U	Silver, 1972
14	14310	Basalt	4.27 ± .03	Pb/U	Silver, 1972
14	14321	Breccia	4.18	Rb/Sr	Barnes, 1972
14	14321	Breccia	4.15 ± .10	Rb/Sr	Compston, 1972
15	15415	Anorth.	4.09 ± .19	$^{40}Ar/^{39}Ar$	Husain, 1972

The unit on age in Table 1 is one billion years; thus 4.22 means 4,220,000,000 years ago.

LUNAR NOTES

By: Harry D. Jamieson and Christopher Vaucher, A.L.P.O. Lunar Recorders

A Summary of Findings by the Bright and Banded Craters Program

(Harry D. Jamieson)

A number of months ago, this writer undertook what was to be a short-term program to investigate possible relationships between lunar craters which appear bright under high-sun conditions and those possessing dark radial bands within their walls. This report is based on nearly 1,500 observations by 8 observers of 96 craters. These observers were:

Inez N. Beck	Wadsworth, Ohio	6" reflector
Kenneth J. Delano	Taunton, Massachusetts	12½" reflector
Eugene Lonak	Chicago, Illinois	10" reflector
Roy C. Parish	Milton, Florida	8" reflector
Paul D. Reddick	Valdosta, Georgia	6" reflector
Charles L. Ricker	Marquette, Michigan	10" reflector
B. R. Webb	Redondo Beach, California	6" reflector
Richard J. Wessling	Milford, Ohio	12½" reflector

Of special merit was the work of Inez Beck, who submitted over 1,300 of the observations described above. It goes without saying that this report would not have been possible without her work.

Before we go into the actual results of the program, certain important factors need to be stressed. First of all, 96 craters represent a very tiny sample of the total present on the Moon. A sample twenty times larger would have given results far more reliable than those to be presented here. Also, observational selection was not completely random.

Observers were told to concentrate mainly on those craters which appeared fairly bright to them under high-sun conditions (as opposed to a crater such as Eratosthenes, which is difficult to find at local noon), and a few concentrated largely on craters which were already known to be banded. Moreover, the fact that some 87 per cent of the observations were made by one observer also tends to color our results. It should therefore be understood that the results given here are based on the 96 crater sample obtained by the program discussed only, and may possibly only hold true for it.

Other than the observational selection already discussed, the sample was gathered at random. The craters were divided into three groups according to their diameters, and their populations within the sample were:

Small (3-20 kms.):	51 craters (53.1%)
Medium (20-40 kms.):	29 craters (30.2%)
Large (over 40 kms.):	16 craters (16.7%)

On their forms the observers were asked to note (among other things) the presence or absence of dark bands and central peaks. When these categories are checked against the entire sample without regard to crater size, we have:

Central peaks only:	10.4%	Both:	16.7%
Bands only:	22.9%	Neither:	50.0%

Altogether, 27.1 per cent of the sample had central peaks, and 39.6 per cent had dark bands.

When these categories are separated into their various size groups, however, some relationships become obvious, thus:

	Central Peaks Only	Bands Only	Both	Neither
Small	02.0%	19.6%	03.9%	74.5%
Medium	13.8%	37.9%	20.7%	27.6%
Large	31.2%	06.3%	50.0%	12.5%

Under the central peaks heading, it becomes obvious that these features tend to be more common as crater size increases. A total of 81.2 per cent of the large craters had central peaks, as opposed to 34.5 per cent of the medium sample and only 05.9 per cent of the small craters. For bands, no such clear relationship could be found. Here 23.5 per cent of the small craters were found to have them, while some 58.6 per cent of the medium sample and 56.3 per cent of the large group were noted to possess them. It would appear that bands tend to be about twice as common in craters larger than 20 kms. in diameter. In fact, the only difference that can be found between the medium and large groups in this respect is that bands in craters without central peaks are about six times more common in the medium group.

Some additional interrelationships among bands, crater size, and central peak population were also noted. In the sample containing 51 small craters, only <u>one</u> crater was found to have a central peak without <u>also</u> having one or more dark bands (though only 03.9 per cent had both). In contrast, 13.8 per cent of the medium-crater sample and 31.2 per cent of the large-crater sample possessed central peaks but were devoid of bands. We are thus faced with the problem of the relationship between bands and central peaks. While the probability that a crater will have both features increases with size, small and medium craters are more likely to have bands <u>only</u> while craters in the large group are more likely to have central peaks only. Thus, no relationship between bands and central peaks can be clearly established (unless it is a negative one), and one must consider the increased likelihood that larger craters have both to be a simple function of the larger areas involved. Larger craters should tend to have more features of all types in them, though it would appear odd that this assumption does not hold true for bands appearing without central peaks.

Observers were also asked to note the relative positions and intensities of any bands found within a crater. A number of craters were found to have a parallel or common orientation of their bands when taken in "local groups" (especially in one region east of Mare Tranquillitatis); but the data were not sufficient for general, much less specific, conclusions.

One area of fair certainty was in the orientation of dark bands within individual craters. Those with central peaks appeared more likely to be displayed in a "spoke pattern", while those without central peaks often had their bands in a transverse pattern, crossing the floor in straight and often parallel lines from wall to wall. The vast majority of these bands were aligned from east to west.

Though the program was primarily concerned with dark bands, many observers reported bright bands as well. These features resembled ordinary rays in many ways; and in fact not a few of them were obvious ray fragments, or disconnected portions of larger ray systems from Tycho, Copernicus, and elsewhere. As such, all were displayed in transverse rather than spoke patterns regardless of whether or not the crater possessed a central peak. Many bright bands were found to run alongside the dark bands actually under study, though; and the vast majority of these appeared to have a common origin with the dark bands that they were associated with.

Some attempt was also made to determine whether or not crater brightness (under local noon or near noon conditions) had any relationship with the presence of bands, central peaks, or both. Other than a general relationship between craters which appear bright under a high sun and dark radial bands, nothing specific could be determined. Observational selection and the small amount of data gathered made even the general relationship mentioned tentative and uncertain, and this writer would not have mentioned it at all were it not for the fact that previous studies lend support to it.[1,2,3]

In conclusion, readers are once again reminded that the results above are based on what can only be called inadequate data which were hardly selected with complete randomness. To base a report such as this primarily on the work of one observer is risky at best, and this difficulty accounts in part for the length of time that it took this report to appear. This writer will be happy to resume work with this program if a sufficient number of observers write to him and express an interest in observing for it. Some changes would be made in the original format of the program, and these would - hopefully - correct some of the difficulties encountered with the preparation of this report. One such would be the selection of specific areas on the Moon to which to confine our studies. These would probably be squares 10° of longitude and latitude on a side, and chosen at random. Readers interested in advancing this lunar study are invited to contact the Recorder.

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3. Robinson, L. J., "Contributions to Selenography: Part III.", JALPO, Vol. 16, Nos. 9-10, pp. 217-222.

Additional good references are to be found at the conclusions of all three of the above papers.

APPENDIX I. CRATERS USED BY THE PROGRAM.

Crater	Size	Central Peak	Bands
Abulfeda E	S	N	N
Adams B	M	Y	Y
Agatharchides A	M	N	Y
Alfraganus	M	N	N
Alfraganus C	S	N	N
Alpetragius B	S	N	N
Apollonius G	S	N	N
Archimedes	L	N	Y (Bright)
Archimedes A	S	N	N
Archimedes C	S	N	N
Aristarchus	M	Y	Y
Aristillus	L	Y	Y
Autolycus	M	N	N
Banachiewicz B	S	N	Y
Beaumont B	S	N	N

Crater	Size	Central Peak	Bands
Beer	S	N	N
Bellot	M	N	Y
Bessarion	S	N	Y
Birt	M	N	Y
Bohnenberger	M	Y	N
Brayley	S	N	Y
Burg	L	Y	Y
Caramuel	L	Y	Y
Cassini	L	N	N
Cavendish E	M	N	Y
Cayley	S	N	N
Censorinus	S	N	N
Colombo H	S	Y	Y
Conon	M	N	Y
Copernicus	L	Y	N
Cyrillus A	S	N	N
Darney	S	N	N
Darney C	S	N	Y
Dawes	M	N	Y
De Morgan	S	N	N
Dionysius	M	N	Y
Dollond E	S	N	N
Dunthrone	S	N	N
Eratosthenes	L	Y	Y
Euclides	S	N	N
Feuillée	S	N	N
Gambart A	S	N	N
Gassendi E	S	N	N
Goclenius	L	Y	N
Godin	L	Y	N
Guerické C	S	N	N
Guerické D	S	N	N
Guerické H	S	N	N
Gutenberg A	S	N	N
Hind	M	N	Y
Hipparchus C	S	N	N
Humboldt, W.	L	Y	N
Kant	M	Y	N
Kepler	M	Y	Y
Kircher	L	N	Y
Langrenus	L	Y	N
Langrenus X	M	N	Y
Lassell C	S	N	N
Lenham	S	N	Y
Lichtenberg	S	Y	Y
Liebig	M	N	Y
Macrobius A	M	N	Y
Manilius	M	Y	N
Marinus A	S	N	Y
Marth	S	N	N
Menelaus	M	Y	Y
Mercator A	S	N	N
Mersenius C	S	N	N
Messier	S	N	Y
Messier A	S	N	Y

Crater	Size	Central Peak	Bands
Moltke	S	N	N
Mösting A	S	N	N
Petavius B	M	Y	Y
Plinius	L	Y	Y
Polybius A	S	N	N
Polybius B	S	N	N
Proclus	M	N	N
Ptolemaeus A	S	N	N
Pytheas	S	N	Y
Ramsden	M	N	N
Römer	L	Y	Y
Römer P	S	N	Y
Ross	M	N	N
Rosse	S	N	N
Silberschlag	S	N	N
Taruntius	L	Y	Y
Taruntius G	S	N	N
Theaetetus	M	Y	Y
Theon Jr.	M	N	N
Theon Sr.	M	N	N
Theon Sr. C	S	N	N
Theophilus B	S	N	N
Tobias Mayer A	S	Y	N
Triesnecker	M	Y	N
Vitello	L	Y	Y
Wallace	M	N	N

Under the column for "Size", S stands for small, M for medium, and L for large as outlined in the text. In the other two columns, N stands for 'no', and Y stands for 'yes'.

The Selected Areas Program: Endymion, Gassendi, Piton, and Aristillus

(Christopher Vaucher)

Since the last "Lunar Notes", observations have been received from the following observers: Frank Des Lauriers, Michael Fornarucci, Lothar Stadler, John West, and André La Clair. From their reports, the following interesting events have been selected for mention.

Frank Des Lauriers has been concentrating his efforts on Endymion and Gassendi, observing these craters every night the weather is clear. In Endymion, he has almost consistently reported seeing a bright ray extending across the width of the crater, from east to west. This ray appears to be always present, no matter what the colongitude; but its intensity can range anywhere from 3.5 to 6. Lunar Orbiter IV photos of Endymion do not confirm or deny the ray's existence, so yet more observations by more observers are needed. Mr. Des Lauriers has also sent meaningful observations of Gassendi, revealing several interesting facets of the crater.

Lothar Stadler has been working for a long time on Atlas, and has recently also been observing Gassendi. The incredibly detailed work he does with his 3" refractor should serve as a model for those who have larger telescopes. Mr. Stadler's reports on Atlas have enabled the Recorder now to get a fair idea of the general appearances and intensities of different features in the crater; however, due to the small aperture of the telescope, no recent reports of rilles in the crater have arrived. An appeal for more observations of this crater should be made (now being under-observed) in order to determine more precise locations of the Atlas rilles. Mr. Stadler, as well as Mr. Des Lauriers, has also contributed greatly in determining the nature of a long but narrow band, extending from the central peaks of Gassendi to the south-west (I.A.U.) rim of Gassendi A. It was originally thought from photographic data that this band might be a deep valley; recently, however, as a result of the careful observations of two men (independently made), it is now fairly certain that this feature is a long ridge system, with steep slopes.

The shadow of this ridge has been seen as late as nearly local noon at Gassendi.

Michael Fornarucci, with his extensive work on the peak Piton, has recorded an unusual double shadow anomaly. His observation of September 16, 1972 not only shows the usual shadow cast by Piton, running westward from the peak -- but also a second shadow (see Figure 27) extending from the base of the peak, running south-east. This observation remained a mystery until just recently when, after long hours of searching and comparing other observers' reports of Piton, the Recorder finally came up with an observation made by Richard J. Wessling on October 27, 1971. This observation, made with a 12½" reflector (as opposed to the 6" reflector Mr. Fornarucci possesses), clearly shows that the cause (see Figure 28) of the second shadow is a ridge running south-east from the crater. Other anomalies of this crater and Pico have not been solved yet, and much more research has to be done to find out what some of them are.

In the last few months John West has been sending a new series of observations of Aristillus, revealing several dark bands emanating from the center of the crater and extending out past the walls. One band in particular is interesting; for it runs north-eastward from the central peaks and divides into two, sometimes three, sub-sections just outside the walls of Aristillus. Mr. West usually records this band as 3.5 to 4.2 intensity, depending upon the colongitude at the time. The band phenomena of Aristillus are just now under study; hopefully more observers will get interested in this unusual crater so that more extensive work can be done.

André La Clair has also done work on Aristillus. His results confirm Mr. West's almost exactly, with the exception that he usually observes more radiating bands on any given occasion.

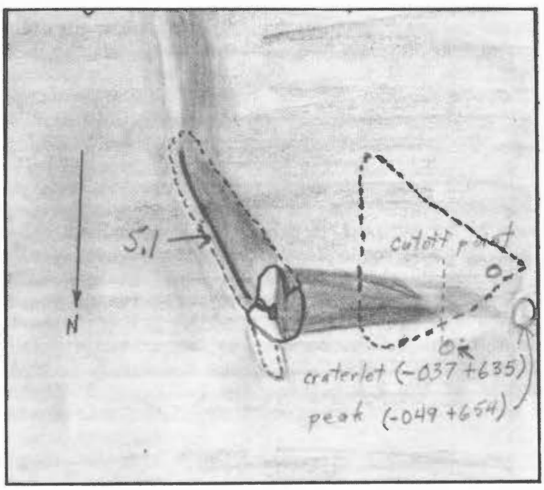

Figure 27. Drawing of the lunar mountain Piton by Michael Fornarucci on September 16, 1972, $0^h 15^m$-$0^h 30^m$, U.T. 6-inch reflector, 175X. Seeing 3 (poor), transparency 4 (limiting stellar magnitude). Colongitude 6°.5. Lunar south at top, lunar east in IAU sense at left. Compare to Figure 28 on page 121, and note text of second paragraph on page 119.

A REQUEST FOR OBSERVATIONS OF SPOTS IN JUPITER'S EQUATORIAL ZONE

By: Elmer J. Reese, former A.L.P.O. Jupiter Recorder

Certain theoretical considerations suggest that Jupiter's Equatorial Zone rotates more rapidly along its north and south edges than near the equator. Visual central meridian transit observations of spots in the equatorial currents may be useful in confirming or refuting a center-to-edge sheer in the rotational velocity of the equatorial jet. It is suggested that observers make a special effort to observe the transit times of spots near the middle of the Equatorial Zone as well as along the south edge of the North Equatorial Belt and along the north edge of the South Equatorial Belt. The current apparition may be especially suitable for such a study because of an unusual amount of dark material in the Equatorial Zone.

In a paper soon to be published, Jay L. Inge discusses short-term rotation profiles obtained by measuring the longitudinal positions of features on optically projected photographic images with superimposed orthographic grids. The measurements were made at the Lowell Observatory using blue-light photographs of the planet obtained by the International Planetary Patrol from 1970 to 1972. In 1970 and 1971 Inge found that the rotation periods of several spots near the middle of the Equatorial Zone averaged about twenty seconds longer than the average periods found for spots along the north and south edges of the zone.

Although the measurements reported by Inge are more accurate than visual transit observations, we believe that the visual observer can more than offset this handicap by observing many spots well distributed in time and longitude. Now it is just possible that the sheer in the equatorial jet may show up better in small, short-lived spots than in larger, long-enduring spots. Even if the observed life of a given spot were only 30 days, visual transit observations should be capable of yielding a rotation period accurate to within four or five seconds. The success or failure of this suggested program will depend on the extent of observer response, the presence of suitable spots or other features near the middle of the Equatorial Zone, and the correct identification of features when plotted on longitude-time charts.

Discussion by Paul K. Mackal

As a current A.L.P.O. Jupiter Recorder I should very much like to have all interested observers who specialize in transit observations (in either the Jupiter or the Saturn Sections) co-operate fully with Elmer Reese and Mr. Inge to provide suitable transit material for the sheer regions of the equatorial jet of Jupiter (the $N.E.B._s$ and the $S.E.B._n$). Also, transit material dealing with the Equatorial Zone North (its south edge) and the Equatorial Zone South (its north edge) is needed for purposes of comparison. This summer is a fine time to observe Jupiter.

Elmer Reese is one of the foremost observers of Jupiter in the A.L.P.O., and his projects are considered to be wholly in keeping with our research interests. His personal (as well as professional) dedication as an observer of Jupiter, his long association with successive staffs of the Jupiter Section and his friendly assistance, his work as a former transit recorder on the A.L.P.O. staff from 1958 through 1963, and his subsequent work as a professional scientist analyzing the atmospheric data of Jupiter at New Mexico State University in Las Cruces, New Mexico altogether make Mr. Reese the A.L.P.O.'s most successful astronomer.

In order for you to maximize the overall value of your transit observations, certain specific requests are herewith made: (1) observe as many of the spots in the System I region and flanking sheer regions as appear to be evident in your telescope and visible in their entirety (not obscured by haze, e.g.); (2) note down the transits as accurately as possible, perhaps using the new method recommended by the A.L.P.O. staff (taking the mean of two symmetrical timings); (3) carefully observe and then classify all features, providing descriptions of each, especially if any suspected connection with another feature may be indicated; and (4) assess the features in the E.Z. according to two criteria: (a) a column for spots that are definitely independent of the $N.E.B._s$ and the $S.E.B._n$, or (b), a column for spots that are not independent of the $N.E.B._s$ and the $S.E.B._n$. It is the type (a) spots which would be expected to exhibit the absence of sheer in their motion.

Finally, please send your observations directly to:

Elmer Reese
c/o Walter Haas
Box 3AZ
University Park, N. M. 88003

or to:

Paul K. Mackal
7014 W. Mequon Road, 112 N.
Mequon, Wisconsin 53092

All observations I receive will be sent on to Mr. Reese; and when he is finished with same, as well as those sent directly to him, they will be returned to me and will then be posted to Mr. P. W. Budine, our transit recorder.

It is certainly an honor, as well as an opportunity, to work with Mr. Reese, and the Recorder intends himself to take full advantage of it. I hope many of you will join me in supplying Elmer with the needed observations. Thank you!

PLANETOLOGICAL FRAGMENTS - 9

Iapetus, an Unusual Satellite of Saturn

While observing Saturn with one of those gigantic, long refracting telescopes of his age, the remarkable Italian astronomer, J. D. Cassini, discovered a second satellite,

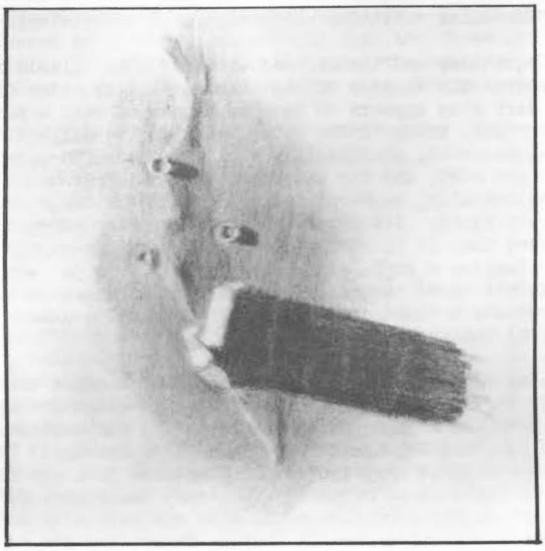

Figure 28. Drawing of the lunar mountain Piton by Richard J. Wessling on October 27, 1971, 0^h24^m-1^h0^m, U.T. 12.5-inch reflector, 450X. Seeing 2-4, transparency 2-3. Colongitude 4°.7. Lunar south at top, lunar east in IAU sense at left. Compare to Figure 27 and text on page 119.

****

Iapetus, in 1671. Titan, the largest satellite of the Saturn system, had been discovered sixteen years before by C. Huygens; and Cassini himself was to discover three more (Rhea in 1672 and Dione and Tethys in 1684). Cassini noted at once that Iapetus varied in brightness over a wide range, and at times was invisible in his primitive telescopes. He found that the satellite circled Saturn with a period of about 80 days, appearing at maximum brightness at western elongation and disappearing near eastern elongation. He believed that one side of the satellite was darker (lower reflecting power, or albedo) than the other, and that Iapetus kept its same face toward Saturn, just as the Moon does to the Earth. William Herschel later verified these opinions.

Subsequent visual and photoelectric photometry showed that Iapetus varies in brightness by more than two magnitudes between eastern and western elongations. A modern discussion of this effect is given with new observations in a paper by T. B. McCord, T. V. Johnson, and J. H. Elias (Astrophysical Journal, 165, 413, 1971). In a detailed technical paper A. F. Cook and F. A. Franklin (Icarus, 13, 282, 1971) attempted to understand how the "leading" hemisphere (the hemisphere facing the direction of the satellite's motion in its orbit) can be darker than the "trailing" hemisphere. They think that meteorite bombardment would be preferentially concentrated on the leading hemisphere and that such bombardment tends to erode the layer of high albedo ice presumed to cover the darker rocks comprising the bulk of the satellite.

In a new approach to the problem of Iapetus, its brightness variations, temperature, and poorly-determined diameter, R. Murphy, D. Cruikshank, and D. Morrison recently obtained radiometric measurements of the satellite with the new 88-inch telescope at 14,000-foot Mauna Kea Observatory on the Island of Hawaii. Mauna Kea, the highest insular peak on this planet, is noted for its very dry atmosphere which permits infrared measurements with greater ease and precision than at most other observatories. The radiometric measurements were made at wavelength 20 microns using a detector cooled to about 2° Kelvin (absolute) with liquid helium. The radiation of a planet or satellite measured at 20 microns is actually a heat flux. Iapetus is relatively small, far away, and very cold (117° Kelvin); and its heat flux measured on the Earth is very weak, amounting to about one-twelfth of the heat flux from Aldeberan, the brightest star in Taurus. Still, with the 88-inch telescope the measurement was possible, using the techniques of modern astronomy.

The heat flux from Iapetus can be used to estimate the albedo of the surface and the diameter of the satellite, as well as the temperature. We know that the visual brightness of an object in the Solar System depends on (1) its distance from the Earth, (2) its distance from the Sun, (3) the albedo, or reflecting power, of its surface materials, and (4) its diameter. The amount of heat flux from an object, assuming that it is in thermal equilibrium with its surroundings (cold, empty space with the Sun shining in the distance), depends on its temperature, and its distance from Earth. The temperature in turn depends on the distance of the object from the Sun, and its bolometric albedo (bolometric albedo means the total amount of radiation - infrared as well as visible - reflected by an object). From all this information we can solve various equations simultaneously and thus determine the radius and albedo of Iapetus if we know the heat flux at 20 microns and the visual brightness of the satellite at the time of the heat flux measurement. We must also assume that the surface albedo is the same as, or some fixed fraction of, the bolometric albedo and that the satellite's surface emits radiation perfectly (unit emissivity).

Within the framework of these equations and the assumed emissivity and albedo relationship, the Hawaii astronomers computed the albedos of the dark and bright sides of Iapetus as well as its radius. The dark side appears to have an albedo of only 4 per cent, making it one of the darkest surfaces known in the Solar System. The darkest spots on the Moon have albedos of about 5-6 per cent, the satellites of Mars measured recently by Mariner 9 have albedos of about 5 per cent, and the asteroid (324) Bamberga has a surface albedo of about 3 per cent. Incidentally, Bamberga is known now to be the fourth largest asteroid even though it is very faint. Its faintness was originally presumed to mean that it was small, but we now know that it is really due to the very low albedo of the surface materials. It's hard to imagine a surface of albedo only 3 or 4 per cent. Pure black carbon is about that dark, but known naturally occurring rocks are somewhat brighter. Clearly, further work is needed to understand surfaces of this low albedo, and we may never find a natural terrestrial analog.

The bright side of Iapetus has an albedo of about 25 per cent, which means that it can be covered with almost anything. The spectra of the bright and dark sides are about the same and contain no features to betray the chemical or mineralogical composition. We only know that the dark side is very dark and the bright side is sort of average. The fact that the dark side is <u>so</u> dark does suggest that the boundary between dark and bright sides is quite sharp. This conclusion comes about because even a very small mixture of material from the bright side with that on the dark side would make the dark side measurably less dark. The consequence of this sharp boundary is that as Saturn and its system of rings and satellites undergo the 30-year cycle of tilt with respect to the Earth we shall see slightly over or under a given pole of Iapetus at various times during the cycle. Since we are presently near maximum southern tilt, we are looking slightly over the south pole. The radiometric measurements were made near maximum tilt, which by the above reasoning would have "mixed" some of the bright side with the dark side, meaning that the true unmixed dark side has an even lower albedo than 4 per cent! I think Richard Hodgson had his finger on the problem of possible variations in the Iapetus visual brightness cycle when he considered the varying polar aspect of the satellite at different tilts of the system of Saturn (<u>Str</u>. <u>A</u>., <u>23</u>, 126, February, 1972).

The diameter of Iapetus determined from the infrared radiometry is 1700 (± 200) kilometers, or about 1050 (± 125) miles, making it the second largest (after Titan) satellite of Saturn. Rhea, which was also measured by the infrared technique, is about 930 (± 125) miles in diameter. These measurements of diameter are assumed to be more accurate than direct visual measurements since both satellites are less than 0.2 seconds of arc in diameter.

Measurements of the infrared heat fluxes from Solar System objects were first made less than a decade ago, and it is now possible to detect these faint satellites of Saturn. Infrared astronomers eagerly await new developments in instrumentation and techniques to permit measurements of even weaker signals, thereby enriching our knowledge of the system of planets of which our Earth is just a small part.

DPC

ANNOUNCEMENTS

<u>Second Annual Tehachapi Mountain Telescope Makers Meeting</u>. Our long-time member, Mr. Phillip D. Wyman of Sacramento, California, calls attention to this meeting on July 28-29, 1973. All ALPO members are welcome. The site is the Antelope Canyon Ranch and Recreational Complex, south of Tehachapi, California. The registration fee is $2.00 per person and $1.00 per night for additional nights or $5.00 per family and $2.50 per night for additional nights. The observing site is high in the Tehachapi Mountains at an elevation of almost 7,500 feet above sea level; the seeing there is often superb. Campout-type facilities are available at the site, and motels can be found in Tehachapi. The purpose of the gathering is "to advance the art and science of telescope making through the exchange of ideas among people who build telescopes." For further information write to: Art Leonard, 740 Elmwood Drive, Davis, California 95616.

<u>Errors in Volume 24, Nos. 1-2 of Journal A.L.P.O.</u> Sergeant Eugene Cross has written from Southeast Asia to tell us that his cover drawing of Saturn in the issue mentioned was made with a 6-inch <u>refractor</u>, not a 6-inch reflector as there stated. The objective, of 102 inches focal length, was made by Mr. Earl Witherspoon of Sumter, South Carolina. In Mr. Cross's opinion this 6-inch refractor has given him more resolution per inch of aperture than any other telescope which he has employed at any length.

Some errors found in Table III on page 33 of Julius Benton's Report on the 1969-70 apparition of Saturn have already been corrected on page 89 of this issue. We have been embarrassed to discover in addition that the three latitudinal positions in Table III measured by Dr. John E. Westfall were erroneously reported. Apparently two of his latitude columns were interchanged! The corrected values are:

Position	Saturnigraphic Latitude	Saturnicentric Latitude	Eccentric Latitude
S. Edge South Equatorial Belt	-28°.2	-24°.4	-26°.5
N. Edge South Equatorial Belt	-22.3	-17.9	-19.5
N. Edge South Polar Region	-64.4	-59.7	-61.3

Free Charts of Minor Planet Paths. The following note will surely be of interest to all observers and would-be observers of minor planets among our readers: "Tracking charts for currently observable asteroids may be obtained free and without obligation by sending a long, self-addressed, stamped envelope to Dr. J. U. Gunter, 1411 N. Mangum St., Durham, North Carolina 27701." A Minor Planets Section in the A.L.P.O. was formed a few months ago under the leadership of Reverend Richard Hodgson at Sioux Center, Iowa; its members may find Dr. Gunter's offer an extremely helpful one. Moreover, readers not actively observing the Moon, the bright planets, or comets might find the study of minor planets very attractive. Dr. Gunter has kindly sent us a sample copy of a bulletin he publishes with the name "Currently Observable Asteroids", giving news notes and charts about asteroids of immediate observational interest.

Sustaining Members and Sponsors. The persons in these special classes of membership as of June 16, 1973 are listed below. Sponsors pay $25 per year; Sustaining Members, $10 per year. The balance above the normal rate is employed to assist the ALPO in suitable ways. We thank all these colleagues for their generous help.

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1973 ALPO Convention at Omaha. Our annual meeting this year will be held jointly with the National Convention of the Astronomical League on August 1-5, 1973 at Omaha, Nebraska. The place will be the campus of Creighton University. General information may be obtained from Mr. Robert D. Allen, 910 Avenue "E", Council Bluffs, Iowa 51501. Readers desiring to present a paper should send a copy to Mr. Allen as soon as possible, especially if inclusion in the Proceedings is desired. The Director of the ALPO would appreciate receiving copies of papers by our members. Exhibit materials - drawings, photographs, charts, etc. - will again be handled for the ALPO by Harry D. Jamieson, Box 30163, Middleburg Heights, Ohio 44130. The participation of qualified members in the program of papers and in the astronomical displays is most cordially invited and has added much to similar gatherings in past years.

Registration is four dollars ($4.00) per person or five dollars ($5.00) per family for advance registration; each charge will be one dollar ($1.00) more at convention time. Checks should be made payable to "1973 National Astronomers Convention" and should be mailed to Mr. Jerry M. Sherlin, 6117 Hillsdale Avenue, Omaha, Nebraska 68117. The program will include addresses by several specially chosen professional astronomers. The University of Nebraska's new 30-inch Cassegrain will be used to view objects selected by the attendees. A restricted field trip will be conducted for those with a legitimate interest in planetarium education. There will be a banquet on Saturday evening and an astronomical "flea-market" for those having items to trade. Both the Astronomical League and the Association of Lunar and Planetary Observers will hold their annual business meetings. Persons wishing to conduct special seminars or symposiums will be given classrooms set aside to such use.

Dormitory rooms and cafeteria meals are conveniently available on the Creighton University campus. Mr. Allen and his committees are making every effort to hold prices to a minimum; and although predictions are difficult in a period of inflation, it is thought that one person can take part in all Convention activities for about forty dollars ($40).

OBSERVATIONS AND COMMENTS

Reverend Kenneth J. Delano, the Lunar Recorder in charge of the Dark-haloed Craters Program, calls attention to the drawing here published as Figure 29. A dark-haloed crater (Xi = +360, Eta = +768) 4 kms. in diameter was surrounded by a dark halo 11 kms. across. The sketch shows a dark spicule extending to the northwest of the crater and its halo, but off-center. Mr. Des Lauriers thought that the spicule might have been a lower lunar area. Lunar Recorder Delano requests that participants in his program take particular note of any dark rays within or extending beyond the dark halos which they observe.

Figure 29. Drawing of a dark-haloed lunar crater southwest (west in IAU sense) of Hercules on September 18, 1972 at 0^h30^m, U.T. by Frank Des Lauriers. 6-inch reflector at 200X. Seeing 6 (fairly good), transparency 5+ (clear). Lunar south at top, lunar west in IAU sense at right. Colongitude 31°0.

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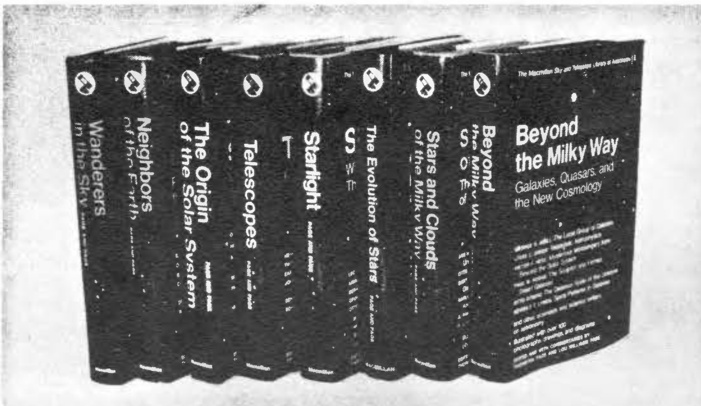

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