J. Westfall

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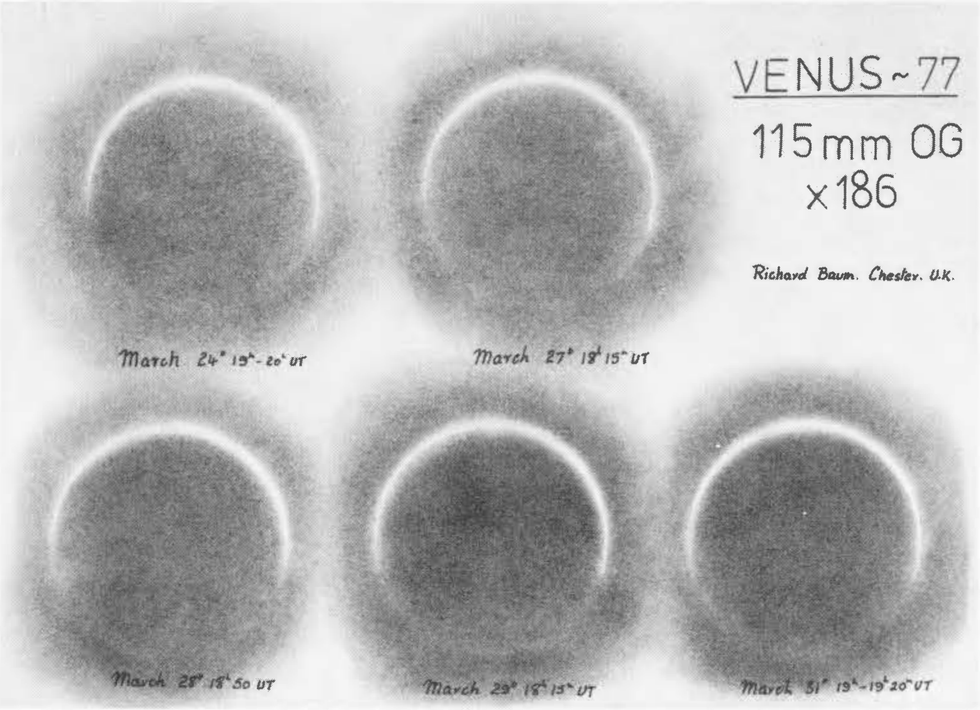

Drawings of Venus by Richard Baum of Chester, England from March 24 to March 31, 1977. 115-mm. refractor at 186X. No filter. Seeing fair, transparency good. The planet was approaching the Inferior Conjunction of April 6, 1977. The north and south cusps showed faint extensions, while the unilluminated hemisphere was the same as the background sky. See also Venus Report on pages 240-251.

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IN THIS ISSUE

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JUPITER IN 1975 - 76: ROTATION PERIODS

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

This apparition will long be remembered as one of the most eventful in the history of Jovian observations. The "Highlights" of the 1975 - 76 apparition were: the observations of a Triple South Equatorial Belt Disturbance; a North Tropical Disturbance; a South Tropical Zone Disturbance; the return of the jet stream along the south edge of the NTB (North Temperate Current C); the lengthening of the rotation period of the Great Red Spot; and the continued observation of the slow and fast currents of the North Equatorial Current.

Some data pertinent to the apparition follow:

Date of Opposition: 1975, October 13.
Dates of Quadrature: 1975, August 15 and December 11.
Equatorial Diameter: 49.78 seconds (at opposition).
Stellar Magnitude of Jupiter: -2.5 (at opposition).
Conjunction with the Sun: 1975, March 22.

This report is based on 2557 visual central meridian transit observations submitted by 24 observers of the A.L.P.O. When plotted on graph paper, 2164 transits form usable drifts for 113 Jovian spots distributed in 17 different atmospheric currents. The contributing observers are listed below by name and number of transits submitted, along with the station of observation and telescope(s) employed.

Allen, David, Richmond, Va., 6-in. refl. and 7-in. refr. *21.
Barnett, John, Richmond, Va., 8-in. refl., 3-in. & 7-in. refrs. *20 & strip sketches.
Blech, Ulrich, Berlin, W. Germany, 6-in. refl., 8.
Budine, Phillip W., Walton, N.Y. 3½-in. cat. & 4-in. refr., 1150 & strip sketches.
Calia, Laird, Lancaster, Pa., 6-in. refl., 3 & strip sketch.

Costanzo, Daniel, Arlington, Va., 6-in. & 8-in. refls., 8.
Curtis, John, Richmond, Va., 6-in. refl., 23 & strip sketches.
Davis, Darryl J., Fresno, Ca., 10-in. refl., 19.
Dickinson, Bill, Norfolk, Va., 5-in. refr. & 8-in refl., 67 & strip sketches.
Doel, Ron, Evanston, Ill., 18½-in. refr. ** 20 & strip sketches.

Gordon, Rodger W., Nazareth, Pa., 3½-in. cat., 65.
Heath, Alan W., Nottingham, England, 12-in. refl., 52.
Horvath, Evelyn, Buchanan, Mi., 10-in. refl. & 2½-in. refr., satellite observations.
Horvath, Joe, Buchanan, Mi., 10-in. refl. & 2½-in. refr., satellite observations.
Hull, Richard, Richmond, Va., 7-in refr.*, 12-in. refl., 337 & strip sketches.

Neve, Chris, Richmond, Va., 7-in. refr. * & 12-in. refl., 36 & strip sketches.
O'Meara, Stephen J., Cambridge, Mass., 9-in. refr.*** strip sketches.
Patton, Chet, Buchanan, Mi., 6-in. refl. & 2½-in. refr., satellite observations.
Prideaux, Jean, Richmond, Va., 12-in. refl., 2.
Rouse, Jim, Naples, Fl., 8-in. refl., photographs.

Sherrod, Clay & Cox, Morris, N. Little Rock, Ark., 5-in. refr. & 8-in. refl., 180.
Smith, J. Russell, Waco, Texas, 16-in. refl.**** 4 & strip sketches.
Tatum, Randy, Richmond, Va., 6-in refl. & 7-in. refr., 468 & strip sketches.
Westfall, John, San Francisco, Ca., 10-in. refl., 52 & latitude measures.
Winkler, William, Bowie, Md., 8-in. refl., 26.

* Richmond Astronomical Society Observatory.
** Lindheimer Astronomical Research Center.
*** Harvard College Observatory.
**** Skyview Observatory.

The distribution of transit observations by months is as follows:

1975, June 46	September 195	December 425
July 74	October 1086	1976, January 20
August 21	November 677	February 13

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, the longitude at opposition, October 13, 1975. The sixth column gives the number of observed transits. The seventh column indicates the number of degrees in longitude which 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.

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

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
D	Wp	Jun. 7 - Dec.29	260° - 139°	185°	41	-17°.79	9:55:16
1	Wc	Jun. 7 - Dec.29	265 - 146	191	50	-17.50	9:55:17
E	Wf	Jun. 7 - Dec.29	271 - 153	196	40	-17.35	9:55:17
2	Wc	Jun.14 - Jan.12	337 - 171	253	29	-23.38	9:55:09
F	Wp	Jun. 9 - Dec.18	69 - 319	1	21	-17.19	9:55:17
3	Wc	Jun. 9 - Dec.18	76 - 326	8	22	-17.19	9:55:17
A	Wf	Jun. 9 - Dec.18	82 - 334	15	19	-16.88	9:55:18
B	Wp	Jun. 7 - Dec.29	125 - 5	51	29	-17.65	9:55:17
4	Wc	Jun. 7 - Dec.29	131 - 11	57	39	-17.65	9:55:17
C	Wf	Jun. 7 - Dec.29	138 - 17	63	37	-17.65	9:55:17
				Mean Rotation Period (without No.2)			9:55:16

The long-enduring white ovals of the STeZ_n continued to be observed well by A.L.P.O. observers. During the early part of the apparition the mean lengths of the ovals were: DE - 11°, FA - 13°, and BC - 13°. By the end of the apparition their lengths were: DE - 14°, FA - 15°, and BC - 12°.

Oval FA was in conjunction with the Great Red Spot on August 5 at a longitude of 39° (II). The center of BC was in conjunction with the Red Spot on October 25,1975 at 44°. Nine transits of the center of FA from July 22 to August 5, 1975 indicate that the oval was repelled as it approached conjunction with the Red Spot. The drift was -4° per 30 days for the dates indicated with a period of 9:55:35 during the interaction. A similar behavior was noted in the 1974 - 75 apparition with the oval DE.

Oval No.2 may be a permanent addition to the category of long-enduring ovals of the South Temperate Current. First seen on June 1st, 1974, it continued to be observed during the 1975 - 76 apparition. In 1974 - 75 it had a period of 9:55:15. It has accelerated now to a period of 9:55:09. The length of the new prominent oval was 6° during the early part of the apparition, but had increased to 8° by the end of the apparition.

Great Red Spot. System II.

Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
RSp	Jun. 9 - Feb. 9	30° - 45°	32°	118	+1°.83	9:55:43
RSc	Jun. 9 - Feb. 9	41 - 57	42	124	+1.95	9:55:43
RSf	Jun. 9 - Feb. 9	52 - 69	55	106	+2.07	9:55:44
			Mean Rotation Period			9:55:43

During the early part of the apparition the Great Red Spot was dark and prominent, as it had been in 1974 - 75. However, by December 5th the Red Spot had faded; and the northern portion was white. By January 15th, 1976, the Red Spot Hollow was developing and was becoming very prominent.

The RS had a length of 22° at the beginning of the apparition, and its mean length increased to 24° by the end of the apparition.

The Red Spot was accelerated during the period of July 18 - August 1, 1975, when the preceding end of the SEB Disturbance No. 1 was passing the RS. The Red Spot

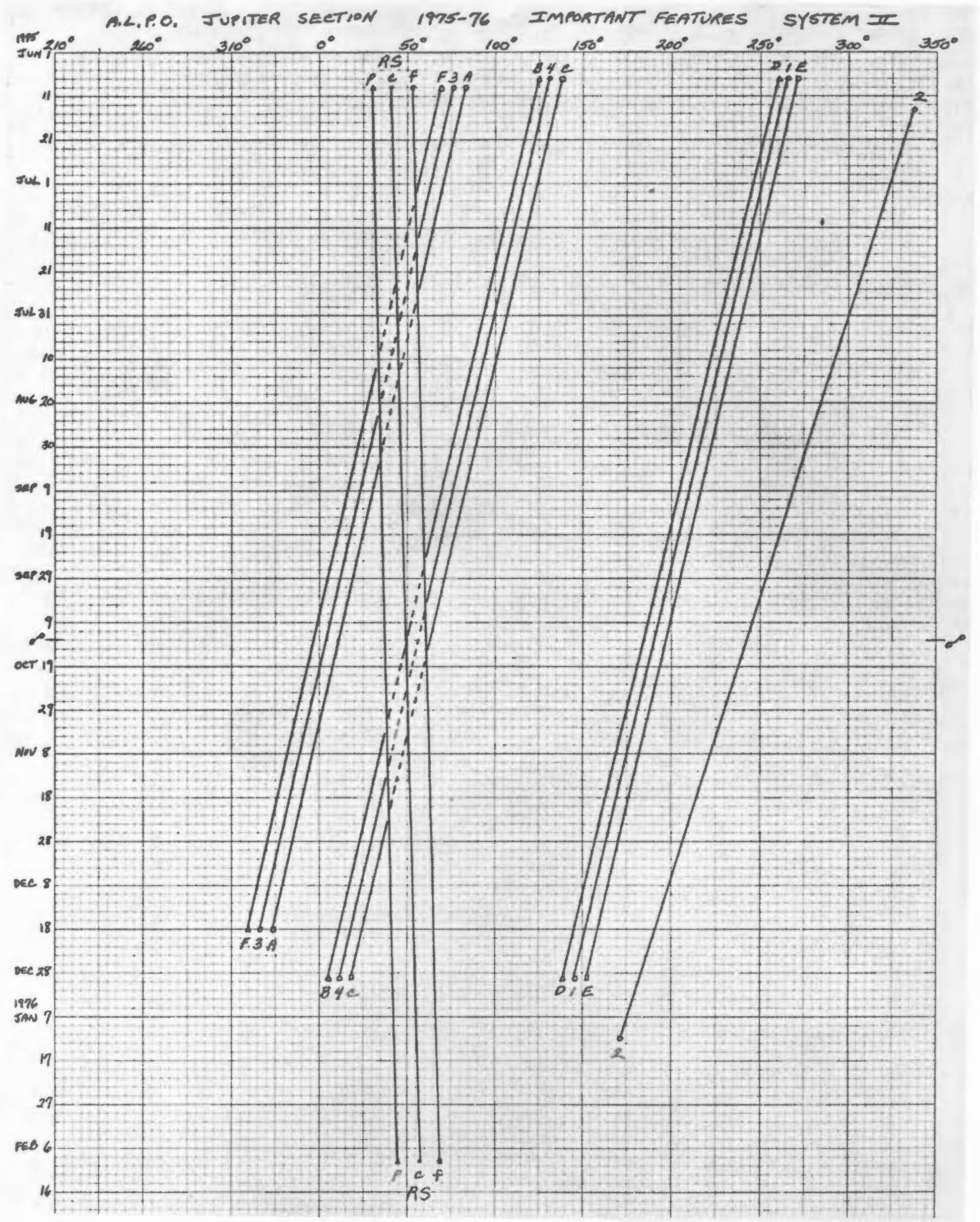

Figure 1. Graph showing longitude in System II vs. time for selected features on Jupiter, namely the Great Red Spot and ovals in the South Temperate Zone. Based on observations by members of the A.L.P.O. Jupiter Section during the 1975 - 76 apparition. Prepared and contributed by Phillip W. Budine. See also text of Mr. Budine's Jupiter Report.

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period was decreased from 9:55:43 to 9:55:13 with a drift of - 20°.4 per 30 days until July 26; after this date the drift was in the direction of increasing longitude at a rate of +14°.6 and a period of 9:56:01 until August 1. After August 1st the period of 9:55:43 resumed until September 14, 1975, when the preceding end of SEB Disturbance

No. 3 was passing the RS. The Red Spot was again accelerated but not to the degree that it had been with Disturbance No. 1. During the period of September 14 to September 25, 1975, the drift of the RS was -7.°4 with a period of 9:55:31. From September 26 to September 29 the RS was moving in the direction of increasing longitude at a rate of +9.°0 and a period of 9:55:53. After September 29 the period of 9:55:43 returned.

The South Tropical Zone Disturbance was passing the Red Spot during the period of September 19 to September 29 and also contributed significantly to the RS acceleration.

South Tropical Zone Disturbance. System II.

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Wc	Aug.18 - Nov.24	101° - 6°	38°	15	-29.°05	9:55:01
2	Wp	Oct.17 - Dec. 6	217 - 212	-	22	- 1.85	9:55:38
3	Wf	Oct.17 - Dec. 6	246 - 240	-	14	- 2.22	9:55:38
				Mean Rotation Period			9:55:26

No. 1 was a very bright oval associated with the STrZ Disturbance. It was most prominent when observed on the preceding end of the Red Spot. During the period of October 23 to November 8 the oval was in this position and had a period of 9:55:41. This oval was in conjunction with the RS on September 28, 43° in System II. Nos. 2 and 3 represent the preceding and following ends of the South Tropical Disturbance. Both ends were best marked by the bright ovals in the South Tropical Zone. The preceding end had a period of 9:55:25, and the following end had a period of 9:55:34. In mid-October the Disturbance had a length of 29°; by early December this length was 28°.

South Equatorial Belt Disturbance No.1.
SEB$_n$ Branch (SEB Z, S-SEB$_n$). System II.

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Dp	Jul. 4 - Dec.28	53° - 254°	321°	29	-26.°95	9:55:04
2	Dc	Jul. 8 - Oct.19	57 - 328	333	26	-25.65	9:55:05
3	Wc	Jul. 8 - Aug.23	59 - 29	-	35	-19.60	9:55:14
4	Wc	Jul. 8 - Nov.17	62 - 319	356	42	-23.40	9:55:09
5	Wc	Aug.18 - Sep. 3	46 - 35	-	7	-20.75	9:55:12
6	Df	Jul. 4 - Aug.19	57 - 57	-	15	0.00	9:55:41
				Mean Rotation Period (without No. 6)			9:55:09

SEB$_s$ Branch. System II.

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Dc	Jul. 9 - Aug.24	60° - 156°	-	9	+62.°75	9:57:07
2	Dc	Jul.13 - Aug.26	55 - 94	-	4	+30.00	9:56:22
3	Dc	Jul.21 - Aug.26	60 - 141	-	7	+67.50	9:57:13
4	Dc	Sep.14 - Sep.28	60 - 99	-	5	+30.00	9:56:22
5	Dc	Oct.23 - Nov. 9	60 - 85	-	8	+43.86	9:56:41
6	Dc	Oct.23 - Nov.29	56 - 103	-	6	+38.21	9:56:33
				Mean Rotation Period			9:56:56

South Equatorial Belt Disturbance No. 1 was observed as a thin festoon by W.E.Fox of England (the B.A.A. Jupiter Recorder) at longitude 53° in System II on July 4, 1975. On July 5 Elmer J. Reese spotted it on a photograph taken at New Mexico State University Observatory at 58° in System II. It was then a small dark spot on the SEB$_s$ with a small oval in the SEB Z and a thin festoon. Budine observed it on July 8 at 58°, and Randy Tatum of the R.A.S. observed it on July 10, 1975 at 58°. The above observations are the earliest ones reported to the A.L.P.O. By July 20th Richard Hull had a beautiful view with a 12-in. reflector. The main festoon was then very dark with the SEB$_s$ dark with material in the SEB$_s$ Branch. Two preceding bright ovals were leading the SEB$_n$ Branch under the north edge of the Red Spot. Tatum on the same date recorded the dark leading SEB$_n$ spots of the SEB$_n$ Branch of the Disturbance.

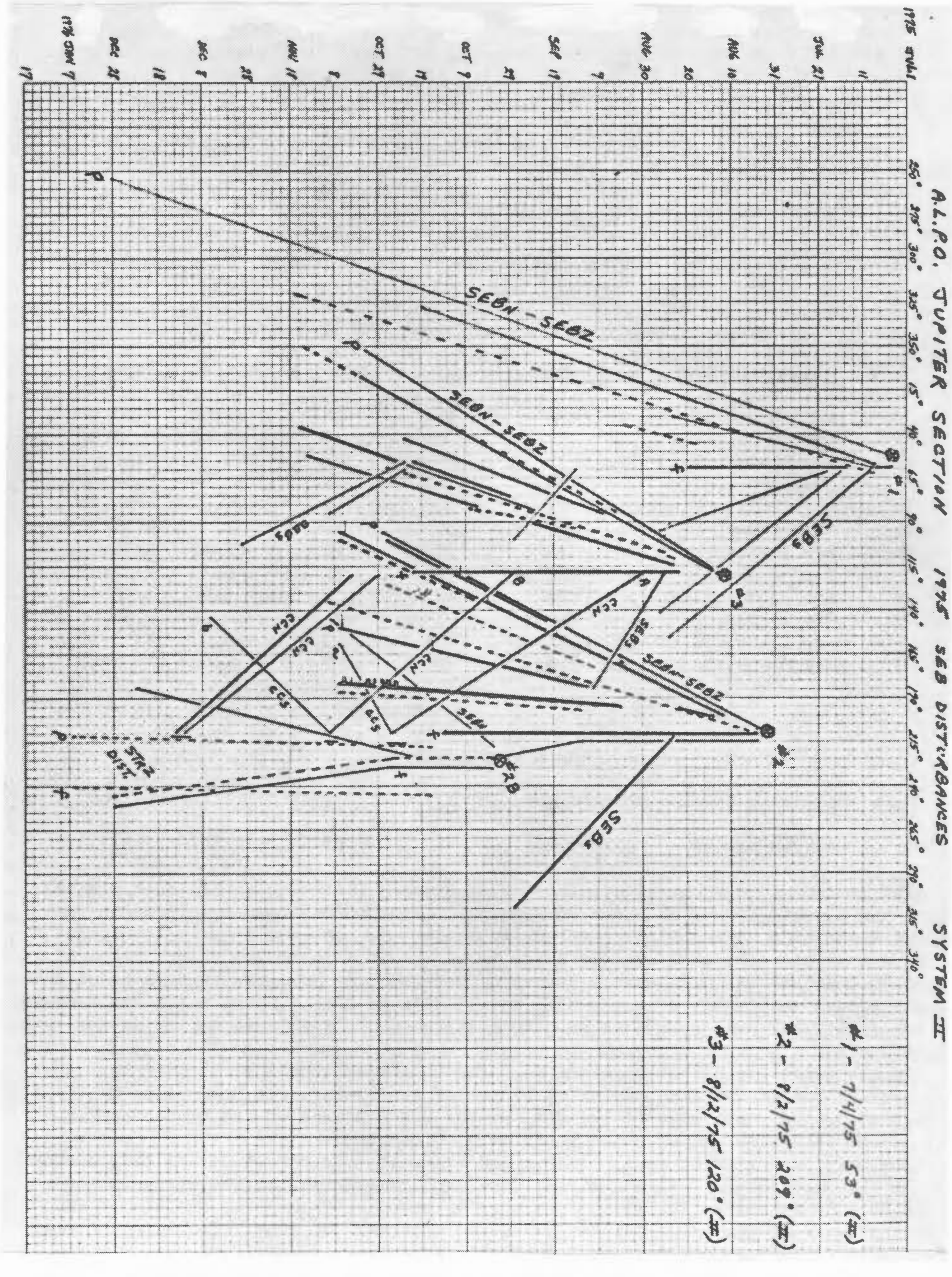

Figure 2. Graph showing longitude in System II vs. time for the three major South Equatorial Belt Disturbances and related features in the South Tropical Zone. Based on observations by members of the A.L.P.O. Jupiter Section during the 1975 - 76 apparition. Prepared and contributed by Phillip W. Budine. The reader may wish to study the drift-lines on this chart carefully in conjunction with the tables and text in Mr. Budine's Jupiter Report.

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The preceding end of the SEB_n Branch of the Disturbance was in conjunction with the Red Spot on July 22 at 36°, System II. Referring to the table of SEB Disturbance No.1, SEB_n Branch (SEB Z, S-SEB_n), one should note: No.1 of the table is the preceding end of the advancing SEB$_n$ Branch, which is moving in a direction of decreasing longitude. No.2 is a very dark spot on the south edge of the SEB$_n$. Nos.3-5 are bright ovals in the SEB Z and are moving with the SEB Z Branch of the Disturbance. No.6 is the following end of the SEB Disturbance No.1. The region was marked by a dark festoon which remained stationary relative to System II and was at a constant longitude of 57° in System II.

The second table is the retrograding spots of the SEB$_s$ Branch of the Disturbance. These spots are moving rapidly in the direction of increasing longitude. All the objects are dark spots moving along the south edge of the SEB$_s$. The retrograding dark spots on the south edge of the SEB$_s$ reached the preceding end of the Red Spot on November 5, 1975. The leading retrograding spot was in conjunction with the RS on November 15, and reached the following end of the RS on December 1, 1975.

South Equatorial Belt Disturbance No.2
SEB$_n$ Branch (SEB Z,S-SEB$_n$).System II.

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Dp	Aug. 2-Oct.28	209°- 96°	113°	24	-38°97	9:54:47
2	Wc	Aug. 4-Oct. 4	207 -128	-	29	-88.18	9:53:40
3	Wc	Aug. 4-Nov. 7	211 -137	160	32	-23.34	9:55:09
4	Dc	Aug.12-Oct.27	196 -100	119	15	-37.94	9:54:49
5	Dc	Aug.12-Nov. 7	200 - 95	122	18	-36.21	9:54:51
6	Dc	Aug.14-Nov. 7	202 -150	164	29	-18.37	9:55:16
7	Dc	Aug.14-Nov. 9	200 -135	153	24	-22.41	9:55:10
8	Dc	Sep. 4-Nov. 7	196 -183	189	18	- 6.10	9:55:32
9	Wc	Sep.10-Oct.27	173 -126	137	7	-29.94	9:55:00
10	Wc	Sep.10-Nov. 7	164 -100	124	11	-33.16	9:54:55
11	Wc	Sep.13-Nov. 7	198 -187	194	15	- 6.01	9:55:32
12	Df	Aug. 4-Oct.14	210 -210	210	19	0.00	9:55:41
				Mean Rotation Period (without No. 12)			9:55:16

SEB$_s$ Branch. System II.

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Dc	Aug.23-Sep.28	212°-310°	-	12	+81°67	9:57:33

The second major upheaval or outbreak of a major South Equatorial Belt Disturbance on the planet Jupiter occurred on August 2, 1975 and was reported first by Gomez from the Agrupación Astronómica de Sabadell, Spain. He observed it at a longitude of 208° in System II. The same evening Randy Tatum observed it at 209°. Mr. Tatum of the R.A.S. observed the Disturbance preceding oval DE. He comments that "a faded festoon was rising vertically from the SEB$_n$ to the SEB$_s$ at 209°. There was a small white oval beside it, the oval seemed to be getting brighter." Randy was employing a 6-inch, F/10 reflector.

In the table for SEB Disturbance No.2 the following should be noted. No.1 is the preceding end of the SEB$_n$ advancing branch of the Disturbance. Markings Nos.2-11 are located on the south edge of the SEB$_n$ or the SEB Z Branch of the Disturbance. No.12 is the following end of this second major Disturbance.

The only retrograding spot observed and timed is object No.1 of the SEB$_s$ Branch table of the Disturbance. It was moving very rapidly and reached the preceding end of the Red Spot on September 30, 1975. One very interesting phenomenon of this second SEB Disturbance was the triggering of a "second outbreak" at longitude 214° in System II on August 4, 1975. Good data were available to follow the drift of features involved in this secondary outbreak of a major SEB Disturbance. The table below gives the data for this secondary outbreak.

South Equatorial Belt Disturbance No.2
"Secondary Outbreak"
SEB$_n$ Branch (SEB Z,S-SEB$_n$). System II.

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1A	Wc	Aug. 4-Sep.13	214°-214°	-	12	0°00	9:55:41
1B	Wc	Sep.13-Oct. 3	214 -225	-	9	+16.42	9:56:03
1C	Wc	Oct. 3-Oct.26	225 -225	225°	6	0.00	9:55:41

"Secondary Outbreak" (Continued)

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1D	Wc	Oct.26-Dec.28	225°-246°	-	13	+10°.00	9:55:54
2	Dp	Oct. 3-Nov. 9	217 -144	203°	11	-59.35	9:54:20
3	Dp	Oct.20-Dec.23	225 -184	-	15	-19.25	9:55:14
4A	Dc	Oct. 3-Oct.26	231 -230	231	9	- 1.30	9:55:39
4B	Dc	Oct.26-Dec.28	230 -252	-	21	+10.48	9:55:55
				Mean Rotation Period			9:55:33

Marking Nos. 1A - 1D is the bright oval in the SEB Z which was the initial secondary outbreak source. At position 1C the bright oval was in conjunction with the preceding end of the STrZ Disturbance, on October 17, 1975. Object No.2 was the preceding end of the secondary SEB Disturbance. No.3 was a dark elongated spot on the south edge of the SEB$_n$. Nos. 4A and 4B was a dark spot in the SEB$_n$. While SEB$_s$ spots were observed, no timings were available of retrograding dark spots needed to establish rotation periods for this "secondary outbreak."

South Equatorial Belt Disturbance No.3.
SEB$_n$ Branch (SEB Z, S-SEB$_n$), System II.

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Dp	Aug.12-Nov. 1	120°- 353°	29°	21	-47°.04	9:54:36
2	Dc	Aug.13-Nov. 3	118 - 7	35	19	-41.11	9:54:44
3	Dc	Aug.24-Oct.29	91 - 18	37	20	-33.18	9:54:55
4	Wc	Aug.23-Nov.15	102 - 350	47	15	-40.00	9:54:46
5	Dc	Aug.25-Oct.23	97 - 43	55	12	-27.41	9:55:03
6	Dc	Sep.29-Oct.21	76 - 56	63	9	-27.40	9:55:03
7	Wc	Aug.25-Oct.27	107 - 59	68	13	-22.86	9:55:09
8	Wc	Sep.14-Oct. 8	93 - 82	-	7	-13.75	9:55:22
9	Dc	Aug.23-Nov.16	111 - 36	73	15	-26.50	9:55:04
10	Dc	Aug.23-Nov.14	114 - 53	75	20	-22.02	9:55:11
11	Df	Aug.22-Oct.21	118 - 118	118	17	0.00	9:55:41
				Mean Rotation Period (without No. 11)			9:54:59

South Equatorial Belt Disturbance No.3 was first observed by M. Cortes of Agrupación Astronómica de Sabadell, Spain on August 12 at longitude 120°, System II. On August 14, 1975 Randy Tatum of the R.A.S. observed the third disturbance. Early views were also secured on August 17 by Richard Hull and Davis Allen of the R.A.S. (Richmond Astronomical Society).

No.1 is the preceding dark spot of the SEB$_n$ Branch. Nos. 2,3,5,6,9, and 10 were located on the south edge of the SEB$_n$. Nos. 4,7, and 8 were bright spots in the SEB Z Branch. No.11 is the following end of the Disturbance. It is interesting to note that the initial eruption of Disturbance No.3 occurred when the preceding retrograding dark spot of the SEB$_s$ of Disturbance No.1 reached the source longitude of No.3 (see Figure 2).

SEB$_s$ Branch, System II.

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Dc	Aug.25-Sep.10	118°-184°	-	7	+124°.53	9:58:32

The dark spot No.1 above is one of the rapid-moving retrograding dark spots of the SEB$_s$. There were four others timed, which are in the table below of the "Circulating Current."

Circulating Current - South Branch
STB North Edge, System II.

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Dc	Oct.26-Nov. 7	210°-159°	-	7	-127°.50	9:52:47
2	Dc	Nov. 9-Dec. 6	210 -144	-	8	- 73.33	9:54:01
				Mean Rotation Period:			9:53:24

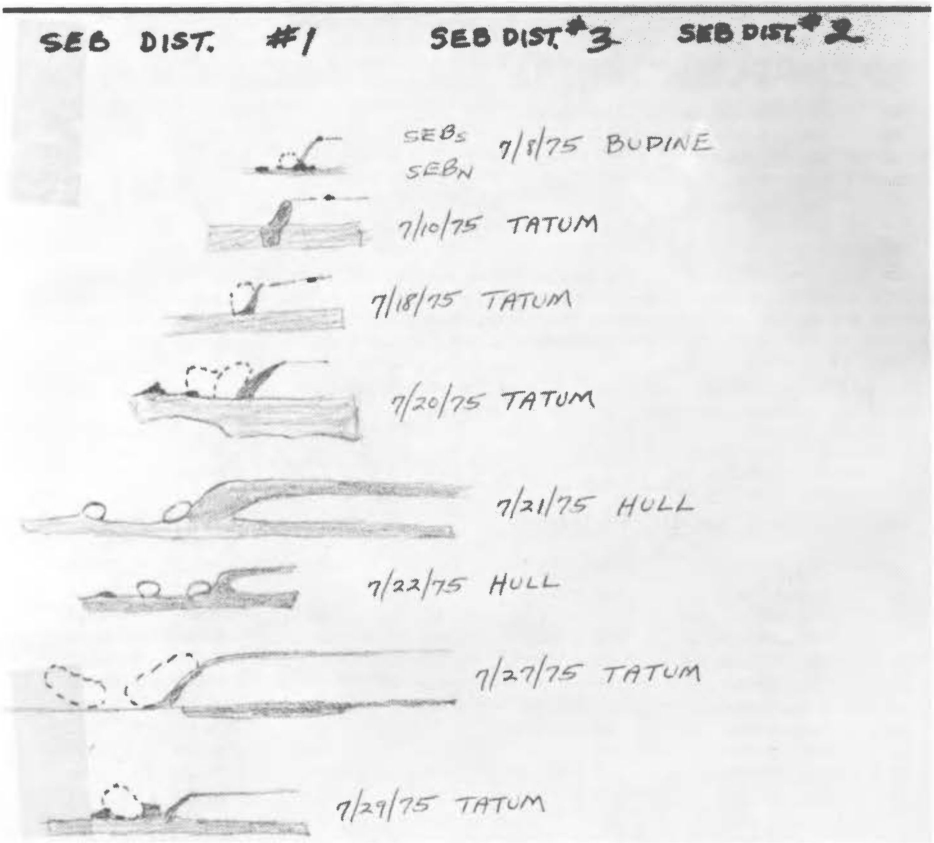

Figure 3. Strip sketches of South Equatorial Belt Disturbance No.1 in its early development. This series of sketches is continued in time on Figures 5 and 6. The sketches in Figures 3-10 were all arranged by Jupiter Recorder Phillip W. Budine.

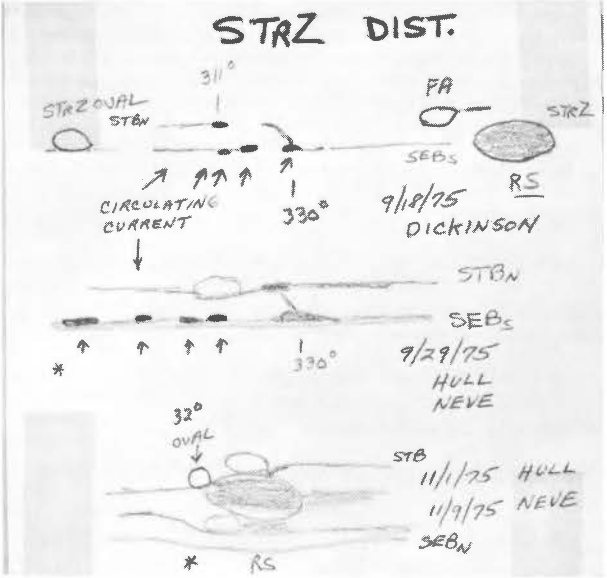

Figure 4. Strip sketches of South Tropical Zone Disturbance by various A.L.P.O. observers. See also text of Mr. Budine's Jupiter Report.

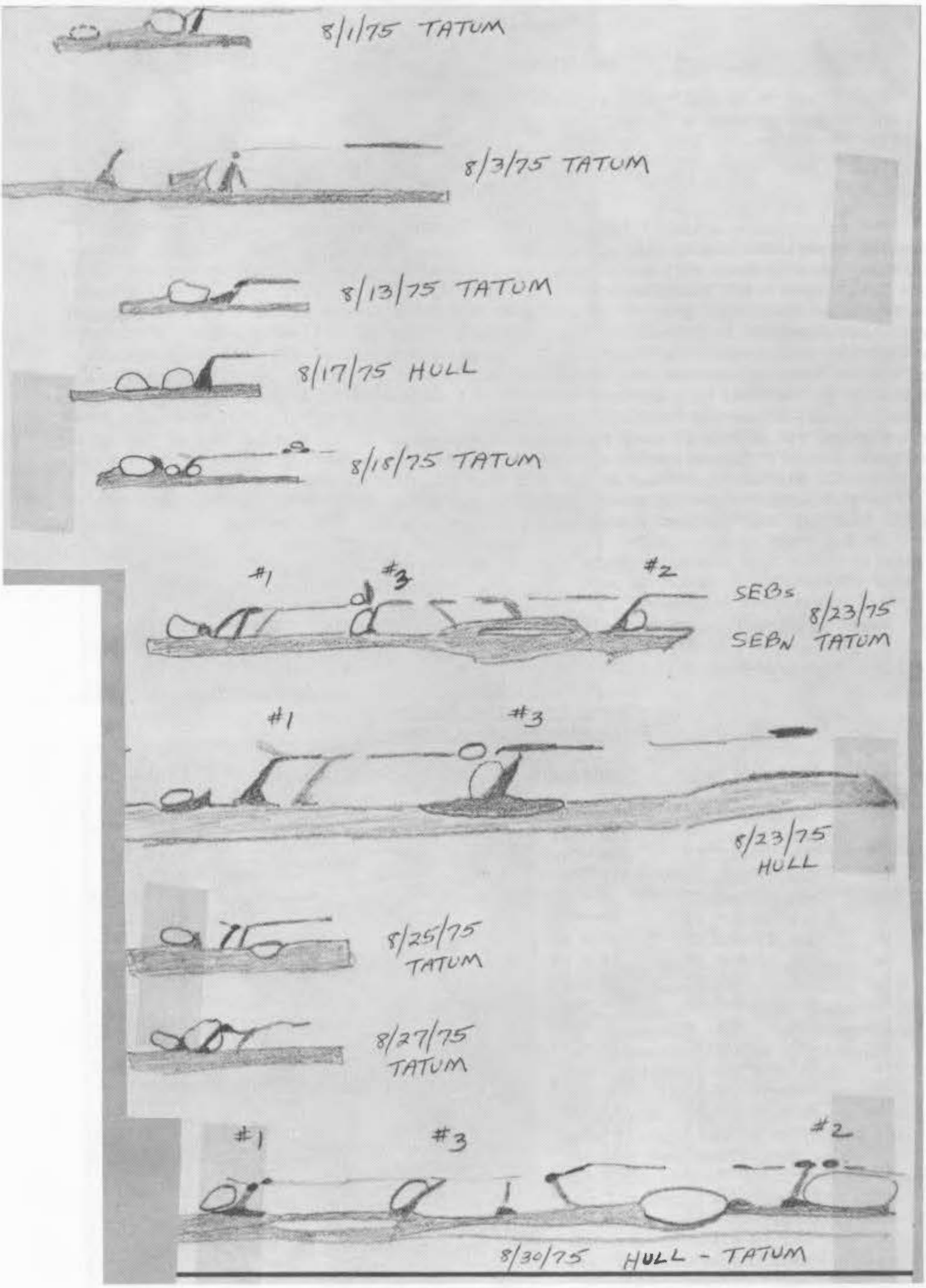

Figure 5. Strip sketches by various observers of South Equatorial Belt Disturbances No.1, No.2, and No.3. Note headings at top of Figure 3. The sketches in Figure 5 are a continuation in time of those in Figure 3.

Circulating Current - North Branch
SEB_s, System II.

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Dc	Aug.30-Oct.26	118°-210°	185°	15	+48°42	9:56:47
2	Dc	Sep.28-Nov. 9	117 -210	150	13	+66.43	9:57:12
3	Dc	Oct.29-Dec.12	120 -210	-	12	+61.22	9:57:05
4	Dc	Nov. 4-Dec.14	120 -210	-	16	+67.67	9:57:14
				Mean Rotation Period			9:57:04

The return once again of the famous Circulating Current was another rewarding observing experience during the active 1975-76 apparition of Jupiter. Readers may recall that the phenomena of the "Circulating Current" occur on Jupiter when there is a major South Equatorial Belt Disturbance and a South Tropical Disturbance. The phenomena occur in the bright portion of the STrZ, which is devoid of the STrZ Disturbance. The Disturbance itself is dusky with concave preceding and following ends. When retrograding SEB_s spots reach the longitude of the preceding end of the STrZ Disturbance, they are deflected southward and cross the latitude of the STrZ; when they reach the north edge of the STB, they proceed to move in a direction of decreasing longitude or in the opposite direction from which they were originally moving. They move along the north edge of the STB until they reach the longitude of the following end of the STrZ Disturbance, where they either dissipate or are deflected northward where they resume the cycle all over again. Thus we get the name of "Circulating Current."

In the tables above the south branch is the SEB_s spots moving along the north edge of the STB, and the north branch is the retrograding SEB_s spots.

South Equatorial Current
N.edge SEB_n, EZ_s, System I.

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Dc	Oct.24-Nov. 7	201°-197°	-	4	-8°00	9:50:19

North Equatorial Current
South edge NEB,EZ_n, System I.

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Wc	Oct.16-Nov.16	305°-300°	-	10	- 5°00	9:50:23
2	Wc	Jun.27-Jul. 4	320 -321	-	4	+ 5.00	9:50:37
3	Wc	Jun.27-Jul.23	339 -341	-	6	+ 2.20	9:50:33
4	Wc	Jun.27-Aug.26	357 -337	-	9	-10.00	9:50:17
5	Wp	Oct.15-Oct.25	0 -352	-	5	-26.67	9:49:54
6	Wc	Oct.14-Oct.22	23 - 19	-	3	-13.33	9:50:12
7	Wc	Oct.13-Oct.22	46 - 40	-	4	-20.00	9:50:03
8	Dc	Oct.28-Nov.20	23 - 73	-	7	+62.50	9:51:54
9	Dc	Oct.28-Nov.18	30 - 75	-	6	+64.29	9:51:57
10	Wc	Nov.19-Nov.28	356 -347	-	3	-30.00	9:49:50
11	Dp	Oct.28-Nov. 6	68 - 55	-	4	-43.33	9:49:32
12	Wc	Jul. 7-Sep.10	153 - 93	-	11	-27.27	9:49:53
13	Wc	Jul.26-Sep.10	158 -133	-	7	-16.67	9:50:08
14	Wp	Sep.29-Nov.15	134 - 97	124°	9	-23.13	9:49:59
15	Wc	Sep.29-Nov.15	143 -104	131	9	-24.38	9:49:57
16	Wf	Sep.29-Nov.15	148 -111	138	11	-23.13	9:49:59
17	Wc	Jun. 8-Aug. 2	243 -208	-	8	-19.44	9:50:04
18	Dc	Jul. 8-Aug. 3	238 -223	-	6	-16.67	9:50:08
19	Dc	Sep.18-Oct.15	274 -283	282	6	+10.00	9:50:43
20	Wc	Oct.22-Nov.10	296 -296	-	6	0.00	9:50:30
				Mean Rotation Period			9:50:20

North Tropical Current A
North edge NEB,NTrZ. System II.

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Wc	Jun.16-Nov.27	342°-291°	311°	55	- 9°30	9:55:28
2	Wc	Jun. 9-Dec.19	73 -310	352	67	-18.90	9:55:15

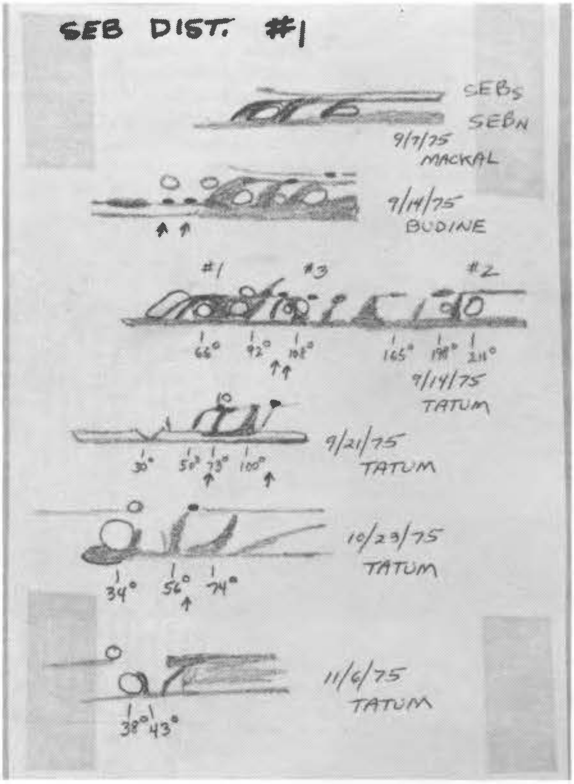

Figure 6. Strip sketches of South Equatorial Belt Disturbances No.1, No.2, and No.3. Note headings at top of Figure 3. These sketches continue in time those in Figures 3 and 5.

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[Editorial Ramblings. How accurate is a visual central meridian transit of a feature on Jupiter? A reasonable guess for an experienced observer would be a standard deviation of around two minutes, with perhaps a larger "personal equation." Yet this degree of accuracy is often very sufficient to determine periods of rotation to within one or two seconds of time. However, it is probably safe to assert that the random and systematic errors in visual C.M. transits have never been adequately investigated. (Now go to below caption of Figure 7.)]

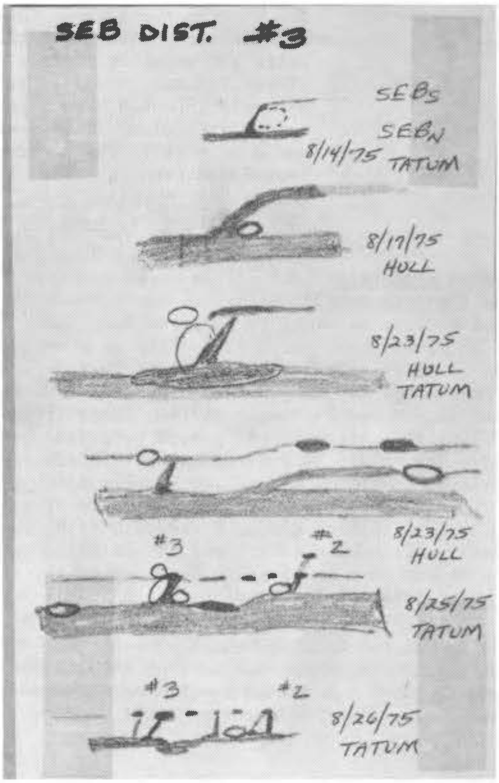

Figure 7. Some strip sketches to show the early development of South Equatorial Belt Disturbance No.3.

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[Further Editorial Ramblings. Several methods can be used: (1) Longitudes from visual transits can be compared to longitudes measured on photographs taken on the same date and near the same time. (2) The transit times of different observers for the same feature at the same transit can be compared, and perhaps Recorder Budine could schedule several special simultaneous observing programs with this specific goal. (3) Observations of the C.M. transits of the four Galilean satellites and their shadows can be compared to computed values based on A.E.N.A. data, although the satellite and shadow ingress and egress times in A.E.N.A. are not really intended to allow a comparison of observation and theory.]

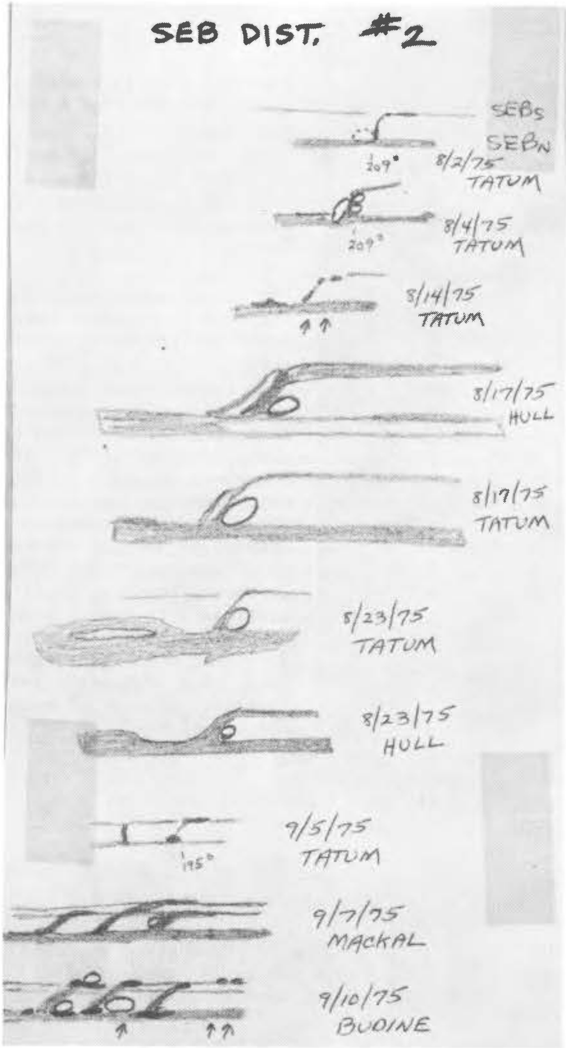

Figure 8. Strip sketches to show the development of South Equatorial Belt Disturbance No.2 on Jupiter during the 1975-76 apparition. This series of sketches is continued in Figure 9 on the facing page.

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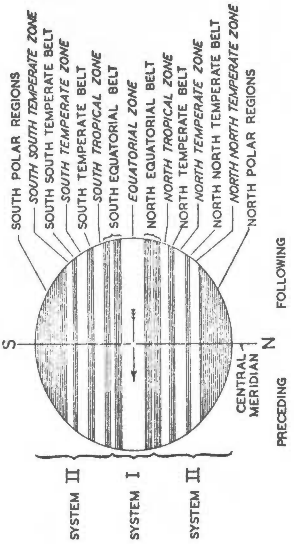

The diagram above shows the standard nomenclature of the belts and zones of Jupiter employed in this journal. It is a simply inverted view with labelled directions (S is south, and N is north). The diagram is reproduced from pg. 18 of The British Astronomical Association, Its Nature, Aims and Methods, 1944.

North Tropical Current A
North edge NEB,NTrZ. System II.
(Continued)

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
3	Wc	Jun.19-Oct.12	125°- 59°	-	19	-17°.40	9:55:17
4	Wc	Oct.12-Nov. 9	64 - 60	64°	16	- 4.30	9:55:35
5	Wc	Jul. 6-Aug.23	125 -110	-	7	- 9.40	9:55:28
6	Wc	Oct.26-Nov. 7	191 -191	-	9	0.00	9:55:41
7	Dc	Oct.26-Nov.19	237 -235	-	7	- 2.40	9:55:37
8	Wc	Jun.25-Nov.27	277 -236	245	27	- 7.90	9:55:30
9	Wc	Jun.25-Oct.19	307 -277	282	19	- 7.70	9:55:30
10	Dc	Nov. 7-Nov. 9	91 - 91	-	3	0. 0	9:55:41
				Mean Rotation Period			9:55:30

[Note by Editor. The reader who is interested in how observed times of central meridian transits are converted into rotation periods can do no better than to read and study B.M.Peek's excellent book, The Planet Jupiter, published by the Macmillan Company in 1958. The book contains a tremendous wealth of information about Jupiter and is available for loan in the A.L.P.O. Library.]

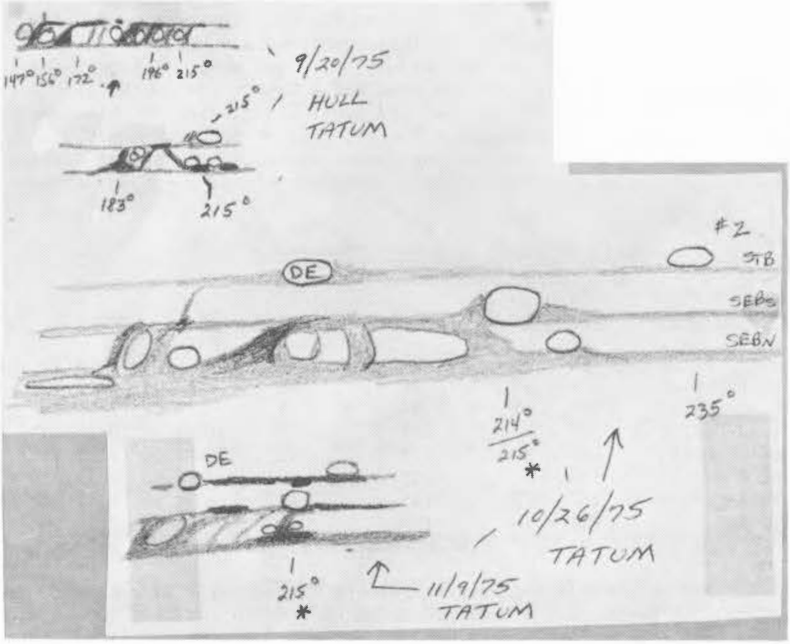

Figure 9. Strip sketches of South Equatorial Belt Disturbance No.2. These are a continuation in time of those in Figure 8.

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North Tropical Current B
North edge NEB,NTrZ. System II.

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Wc	Jun.29-Jul.26	198°-175°	-	9	-24°70	9:55:07
2	Wc	Aug.17-Sep.10	198 -170	-	7	-32.90	9:54:56
3	Dc	Nov. 7-Dec. 1	185 -141	-	11	-51.80	9:54:30
4	Wc	Oct.23-Nov. 9	83 -100	-	12	+28.30	9:56:19
				Mean Rotation Period			9:55:13

During the early part of the apparition the North Tropical Zone was narrower than in 1974 and much brighter. As a matter of fact, this zone was the brightest zone on the planet in 1975.

Activity began in the NTrZ with large bright ovals appearing along the north edge of the NEB and spreading in area across the southern and central parts of the NTrZ. The first bright oval appeared at 73°, System II, on June 9. The second oval was observed at 342° on June 16; the third, on June 19 at a longitude of 125°; the fourth, at 277° on June 25; and the fifth, at 307° on June 25. Other NTrZ ovals were observed in late June at 198°, in July at 125°, and in October at 64°, 83°, and 191°, System II. Oval No.1 in Current A was one of the brightest of the NTrZ ovals. It was the longest lived, being observed the earliest on June 9 and being last recorded on Dec. 19, 1975. It had a drift of -18°9 with a period of 9:55:15. Two bright ovals of the NTrZ had very linear drifts and remained almost stationary relative to System II. The first oval was drifting slowly in a direction of decreasing longitude and was from October 12 to November 9 moving from 64° to 60° with a drift of -4°3 and a period of 9:55:35. The second oval was observed from October 26 to November 7 and had a rotation period of 9:55:41. The first oval was in conjunction with the North Tropical Zone Disturbance on October 23 at a longitude of 65°, System II.

Among the more interesting features observed on the north edge of the North Equatorial Belt and projecting into the southern part of the North Tropical Zone were two objects similar in shape and structure to the Red Spot. The first "little Red Spot" was observed over October 26 - November 19 as a feature on the north edge of the

NEB at longitude 237° and had drifted to 235° by November 19. It had a period of 9:55:37. The other "Red Spot" was larger (18° in length) and was observed in the extreme southern portion of the NTrZ. The feature was the exact shape of its famous twin and was similar in interior structure and also had a bay in the north edge of the NEB, which surrounded the southern edge of the "Red Spot." The color of this feature was red-orange. It was observed from November 7 to 9, 1975 at 91° with a period of 9:55:41, near that of the Great Red Spot. During recent apparitions features similar to the Great Red Spot have been observed visually, photographically, and by Pioneers 10 and 11.

North Tropical Zone Disturbance
NTrZ. System II.

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Dp	Oct. 4-Oct.23	118°- 48°	83°	12	-111°.10	9:53:09
2	Dc	Oct. 4-Oct.23	134 - 54	94	10	-127.00	9:52:48
3	Dc	Oct. 4-Oct.23	141 - 57	99	7	-133.30	9:52:39
4	Dc	Oct. 4-Oct.23	145 - 73	109	5	-114.30	9:53:05
5	Dc	Oct. 4-Oct.23	155 - 80	118	11	-127.00	9:52:48
6	Wc	Oct. 4-Oct.23	158 - 84	121	9	-117.50	9:53:01
7	Dc	Oct. 4-Oct.23	187 -102	145	11	-134.90	9:52:37
8	Df	Oct. 4-Oct.23	200 -110	155	14	-142.90	9:52:26
				Mean Rotation Period			9:52:49

On October 4, 1975 an outstanding complex feature was recorded in the North Tropical Zone of Jupiter. It began with a dark preceding end, which was just following a North Tropical Zone oval and the jet-stream oval of October 3 described below. This NTrZ feature was a dark streak at its northern extreme with dark preceding and following ends; the interior was marked with bright areas, ovals, and dark festoons which connected to the south edge of the NTB and bent in the direction of decreasing longitude and hooked themselves to the north edge of the North Equatorial Belt. The mean length of this feature was about 82° on October 4 and 62° on October 23, 1975. The structure of this feature and its rapid motion in the direction of decreasing longitude has led your Recorder to define this feature as a true North Tropical Zone Disturbance. The Disturbance was observed from October 4 to 23, 1975; and its preceding end was drifting at -111°.1 and moved from 118° to 48°, System II. The following end was first observed at 200° and was last observed at 110°. Their periods were 9:53:09 and 9:52:26 respectively. The NTrZ Disturbance marks a new record for the NTrZ Current B. The previous record was set in 1973 with a period of 9:54:48.

North Temperate Current C
South edge NTB. System I.

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
1	Wc	Sep.14-Sep.30	0°-285°	-	8	-141°.50	9:47:21
2	Wc	Oct. 3-Oct.20	115 -336	5°	19	-262.30	9:44:41
3	Wc	Oct.24-Nov.28	214 - 34	-	12	-163.60	9:46:51
				Mean Rotation Period			9:46:18

On September 14, 1975 a very bright spot (the first of three) appeared at longitude 0° in the infrequently-active jet stream along the south edge of the North Temperate Belt and projected into the northern part of the North Tropical Zone. This intensely brilliant spot was moving very rapidly in a direction of decreasing longitude and soon caught up with oval No.2 of the NTrZ. It was in conjunction with oval No.2 on September 22, 1975. The NTB_s spot was drifting at a rate of -141°.5 with a period of 9:47:21 in System I. It was last observed on September 30, 1975 at 285°. The next event was the development of another brilliant jet-stream oval along the south edge of the NTB, this time at a longitude of 115°, System I on October 3, 1975. This oval was moving with almost twice the relative velocity of the first oval and had a remarkable drift of -262°.3 with a period of 9:44:41, a new record for the jet-stream current which is more commonly known as the North Temperate Current C. The last of the brilliant small white ovals of the jet-stream current was discovered on October 24 at 214°. It was drifting at -163°.6 and was last seen at 34° on November 28, 1975. The period for this spot was 9:46:51! All of the rapid-moving spots on the south edge of the NTB were moving in the North Temperate Current C.

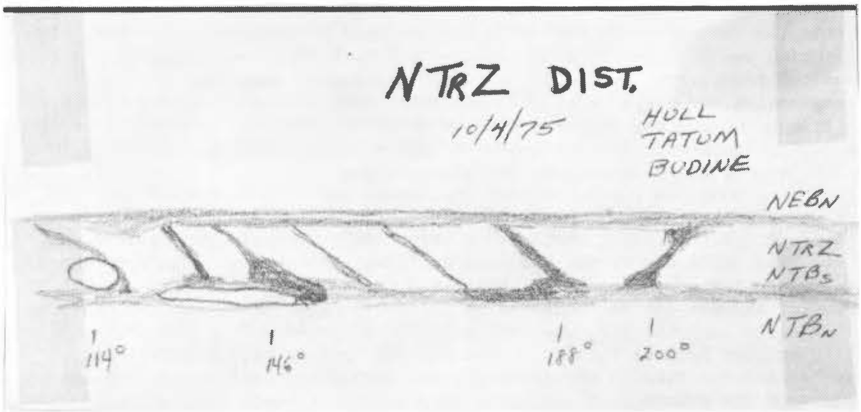

Figure 10. Strip sketch of North Tropical Zone Disturbance at its discovery on October 4, 1975. See also table and text on page 230.

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Comparison of NTrZ Features and South Hemisphere Features

When your Recorder compared and overlaid the drift charts of the NTrZ activity with the features in other latitudes and in the southern hemisphere, the following interesting comparisons were revealed:

1. NTrZ oval No.1 coincided almost exactly with the drift and position of long-enduring STeZ$_n$ oval FA in the southern hemisphere.
2. NTrZ oval No.2 matched closely with oval No.2 of the STeZ$_n$.
3. NTrZ oval No.3 had very nearly the same motion and location as long-enduring oval BC in the STeZ$_n$.
4. NTrZ oval No.1 was first observed in the same longitude as SEB Disturbance No.1.
5. The NTrZ Disturbance originated and was first observed near the longitude of eruption of SEB Disturbance No.3.
6. Jet-stream NTB$_s$ oval No.2 was first observed at the longitude of the eruption of SEB Disturbance No.3.
7. The "New Red Spot" observed from November 7 to 9 was at the longitude where the North Tropical Zone Disturbance was last observed.

Again in 1975 - 76 we find evidence of events and changes which are happening on a scale which encompasses the entire planet. We find eruptions in one hemisphere triggering events in the other hemisphere and matching longitudes from one latitude to another having changes and events which coincide. The unusual events of 1975 - 76 only continue to support the phenomena of Jovian activity on a very large scale and are causing us to study and to scrutinize the Giant Planet with a new perspective and an open mind to seek an explanation.

MEASURED PHOTOGRAPHIC LATITUDES ON JUPITER IN 1975-76

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

Two sets of latitude measures on photographs are available for the 1975-76 apparition.

Latitudes were measured by the Richmond Astronomical Society Jupiter Section on 22 good, clear photographs taken by Richard L. Hull, James K. Rouse, and Jean Prideaux between July 20, 1975 and January 2, 1976. All photographs were black and white with a disc diameter on the prints of 1.5 inches or greater. North and south pole points were determined, and a series of measures was made with a micrometric measuring engine constructed by R. L. Hull and accurate to 0.001 inches. A total of 506 measures was taken, and these were reduced to <u>zenographic</u> latitudes.

The positioning of the north and south pole points is of critical importance in all photographic latitude work. Special prints with low contrast were made for this purpose so that the extreme north and south points could be located accurately. Intense backlighting was used to shine through the print, further assisting in the location of these two points.

The examination and graphing of all belt latitudes, in order, showed no continued or definite change in latitude of any feature within the limits of confidence of the data. Therefore, it was considered to be permissible to give average latitudes in all longitudes and for the whole apparition in Table I below.

The two NTB components persisted over the latter part of the apparition, and the latitudes of the pair are given. The primary or southern component is here given the designation NTB #1. Both a faint NNNTB and a faint SSSTB were seen in 1975-76, contrary to 1974. The SSSTB was barely recorded on film. Measures were made on three photographs, mainly taken by Rouse. The NNNTB was recorded visually by Hull with a 12-inch reflector but was not photographed so that we lack accurate latitude data on this belt. In early July the SEB_s was very thin and measured only 2-3 degrees of latitude in thickness, but by late October it had swollen to 6 or more degrees wide.

Since the sine function is not linear, large deviations in far northern and southern latitudes are common.

Table I. Measured Jovian Latitudes in 1975-76 by R.A.S.

Position	Average Zenographic Latitude	Standard Deviation
South Polar Region, N edge	-56°.8	2°.6
South South South Temperate Belt, S edge	-51.7	- (1 observation)
South South South Temperate Belt, N edge	-47.0	0.72
South South Temperate Belt, S edge	-44.8	2.9
South South Temperate Belt, N edge	-40.5	3.1
South Temperate Belt, S edge	-35.0	3.1
South Temperate Belt, N edge	-30.3	2.7
Great Red Spot, S edge	-29.1	2.6
Great Red Spot, center	-22.0	3.0
Great Red Spot, N edge	-15.0	1.7
South Equatorial Belt South, S edge	-22.4	2.1
South Equatorial Belt South, N edge	-17.4	1.6
South Equatorial Belt North, S edge	-10.9	1.6
South Equatorial Belt North, N edge	+ 0.5	1.5
North Equatorial Belt, S edge	+ 7.9	1.8
North Equatorial Belt, N edge	+18.7	1.3
North Temperate Belt #1, S edge	+25.9	2.6
North Temperate Belt #1, N edge	+30.4	2.5
North Temperate Belt #2, S edge	+31.7	3.5
North Temperate Belt #2, N edge	+34.5	3.7
North North Temperate Belt, S edge	+42.4	3.1
North North Temperate Belt, N edge	+46.5	2.3
North Polar Region, S edge	+60.1	4.4

The second set of latitudes was obtained by Dr. John E. Westfall of San Francisco. He measured seven of his own color positive photographs, six on Kodachrome 64 and one on Agfachrome 64, taken from September 25 to December 1, 1975 with a 10-inch Cave Cassegrain. Eyepiece projection (approximately effective f/47) gave polar diameters from 2.533 to 2.720 mm. The exposure times varied from 2½ to four seconds. Dr. Westfall made the measures using a 12X magnifier with a reticle graduated to 0.1 mm., estimated to 0.01 mm., taking three measurements of each feature on each photograph.

The means of all photographs measured for each feature are given in Table II below, together with the probable error (50 per cent confidence limit) of the mean, this last being a formal statistical error and not including any systematic effects. The possible effect of limb darkening was ignored; this limb darkening was probably present but with a greater effect along the equatorial diameter of Jupiter than along the polar diameter, for the measured polar flattening ranged from 1/28.04 to 1/16.90 with a mean of 1/19.81.

Table II. Measured Jovian Latitudes in 1975-76 by John E. Westfall

Position	No. of Photographs Measured	Average Zenographic Latitude and Probable Error
South Temperate Belt, S edge	5	-36°.2 ± 0°.1
South Temperate Belt, N edge	2	-31.5 ± 0.4
South Equatorial Belt South, S edge	6	-23.2 ± 0.3
South Equatorial Belt South, center	1	-20.5
South Equatorial Belt South, N edge	6	-18.9 ± 0.4
South Equatorial Belt North, S edge	7	-11.2 ± 0.5
South Equatorial Belt North, N edge	7	- 2.7 ± 0.4
North Equatorial Belt, S edge	7	+ 9.8 ± 0.2
North Equatorial Belt, N edge	7	+16.9 ± 0.2
North Temperate Belt, S edge	4	+26.1 ± 0.5
North Temperate Belt, N edge	4	+30.0 ± 0.4
North North North Temperate Belt, center	4	+45.3 ± 0.7

Dr. Westfall's NTB is evidently the NTB #1 of the Richmond Astronomical Society.

The critical reader will note that a number of latitudinal positions appear in both Table I and Table II; a comparison of the two <u>independent</u> determinations of latitude may prove instructive.

AN AMATEUR PROGRAM: TIMING ECLIPSES OF JOVIAN SATELLITES

By: Joseph Ashbrook, A.L.P.O. Assistant Jupiter Recorder

1. A careful visual observer, using a small telescope to watch the fading of Jupiter's satellite I as it enters the planet's shadow can (under favorable conditions) clock the disappearance of the last visible speck of light to about ± 10 seconds. In 10 seconds this satellite travels 0°.02 along its orbit. Hence, in principle, very simple amateur observations can fix the orbital position of the satellite rather accurately.

Until very recently, American amateurs have largely neglected the timing of Jupiter's satellite eclipses, even though the observations are easily made with instruments as small as 2.4-inch and 3-inch refractors. It would be very desirable if many amateurs would conduct such observations regularly, on a year after year basis. The present article is intended to provide some practical guidelines for such work.

2. <u>Timing an eclipse</u>. Because all four of Jupiter's Galilean satellites have disks about one arc second in diameter, the entrance of a satellite into the planet's shadow is a gradual affair, taking several minutes. At an eclipse disappearance, the observer should watch the fading satellite continuously, and record to the nearest second when the last speck of light vanishes.

Similarly, to observe a reappearance, an amateur should be watching beforehand, ready to catch the first very faint speck of light as the satellite brightens into view. If when the satellite is first caught, it is already easily seen, the observation is too late, and should not be reported. The observer can tell just where to expect the satellite to reappear with the aid of the diagrams printed in the <u>American Ephemeris and Nautical Almanac</u> and in <u>Sky and Telescope</u>, at the foot of each month's chart of Jupiter satellite configurations.

Experience shows that excellent observations can be made with telescopes of any aperture down to a 2-inch or 3-inch, armed with a power of not less than about 100. With large telescopes, moderate rather than high powers appear to be best. No other equipment is essential except a radio receiver for WWV or CHU time signals, or an equivalent means of timekeeping to one-second accuracy.

Obviously, if observers side by side with 10-inch and 3-inch telescopes watch the same disappearance, the larger instrument will hold the dwindling satellite longer in view; similarly, at a reappearance it will catch the first speck earlier. Likewise, hazy or moonlit skies will cause disappearances to be clocked too early and reappearances too late.

Hence, the record of each satellite eclipse timing should include the telescope aperture and magnification, together with details of sky conditions. In particular, note should be made of any of the following factors that can influence a timing:

a) clouds or haze near Jupiter.
b) moonlight (age of Moon and distance from Jupiter).
c) artificial lights.
d) low altitude of Jupiter.
e) proximity of satellite being observed to Jupiter's disk or to another satellite.

When detailed information of this sort is provided, observations can be graded as good, fair, and poor, for purposes of analysis. If conditions are very unfavorable, it is better not to record the observation.

Eclipses of satellites III and IV are slower phenomena than for I or II; hence their timings are inherently less accurate.

3. Events of 1977-78. Jupiter comes to opposition on December 23, 1977. Before that date, the planet's shadow cone is on the western side of the disk, by an amount which decreases until opposition, when the shadow lies behind the disk. After opposition, the shadow cone lies increasingly farther to the east of the planet. Hence, before opposition, the following eclipse phenomena await the observer.

Satellite I. Disappearance (D) can be seen, west of the disk; reappearance (R) is unobservable, because it occurs when the satellite is hidden behind Jupiter's disk.

Satellite II. As with I, D can be seen but not R. However, for a few days around the date of Jupiter's morning quadrature point (September 27, 1977), R is observable very close to Jupiter's west limb, a very few minutes before this satellite is occulted.

Satellite III. Both D and R can be observed to the west of Jupiter until mid-November, after which only D occurs, because the end of the eclipse takes place behind the planet.

Satellite IV. No eclipses occur before opposition because IV currently misses the shadow cone, passing north of it.

After opposition, the pattern of eclipse events has changed to the following:

Satellite I. R is observable, east of the planet, but D is invisible.

Satellite II. R is observable, but not D, except for a short while around Jupiter's evening quadrature point (March 18 , 1978). At that time D may be a visible event, close to Jupiter's east limb immediately after II has emerged from occultation behind the planet.

Satellite III. R occurs east of the planet. From January 28, 1978 on, D will also be observable, likewise east of Jupiter.

Satellite IV. No eclipses occur until February 12, 1978; after that, both D and R will be observable, well to the east of Jupiter.

4. Aperture effect. As already mentioned, the gradualness of a satellite's brightness changes at an eclipse means that large telescopes show the last speck later than small telescopes do, and the first speck earlier. For satellite I, the time differences among the various-sized telescopes in amateur use can amount to a large fraction of a minute; for slower-moving III and IV, they can be several minutes.

Hence, to realize the full usefulness of eclipse timings, it will be necessary to determine for each satellite the corrections required to reduce all observed times to those for a selected standard aperture. The A.L.P.O. timings should be valuable material for determining these aperture corrections, if many events can each be timed by several telescopes of various sizes.

As a rough illustration of the aperture effect, here are approximate corrections to reduce disappearance times of I to those for an 8-inch telescope. They have been deduced from the eclipse observations tabulated in Sky and Telescope for March and August, 1977. Listed for each aperture A in inches is the correction in seconds of time:

A	2.4	3	5	6	8	10
Corr'n	+38	+26	+16	+14	0	-1

The above numbers are only for purposes of illustration; they should not be applied by observers.

5. Correction to predictions. Each year, The American Ephemeris and Nautical Almanac (AENA) publishes predicted times for Jovian satellite phenomena, rounded to the minute. (These predictions are also conveniently available in The Observer's Handbook of the Royal Astronomical Society of Canada and in the Handbook of the British Astronomical Association.) These listings are really intended only to enable the observer to be ready at the telescope, not for a comparison of observation and theory. The predicted times refer not to first or last speck, but to when the center of the satellite disk enters or leaves the umbra. The following corrections can be added to

the AENA predictions for 1977-78 to give approximate first and last speck times for 6 to 8-inch telescopes.

Table 1. Corrections to AENA Predictions of Satellite Eclipses

Event	minutes	Event	minutes
I D	0	I R	-3
II D	0	II R	-3
III D	+4	III R	-9

These numbers should be valid for 1977-78. The corrections for IV are unknown and may amount to many minutes, since this satellite will enter the shadow very grazingly when its new series of eclipses begins in 1978. The first eclipse predicted in the AENA for IV is February 12, D 4:49 UT, R 5:53 UT. This event is worth watching because it might possibly be a partial eclipse of IV, a rarely seen event. It is also possible that a partial eclipse might occur at the previous superior conjunction of IV (January 26, 3:28 UT).*

6. Reporting observations. Readers of this Journal are requested to report their observations of Jovian satellite eclipses to Joseph Ashbrook, 16 Summer St., Weston, Mass. 02193, for analysis and publication in the Journal. Your report should indicate for each observation the instrument, magnification, and observing conditions as explained above. Observers who may have made unpublished eclipse timings in earlier years are asked to report them. Queries and suggestions are welcome. Please note that only satellite eclipse observations should go to the author at this address; anything concerning Jupiter itself or other aspects of satellite observing should continue to be sent to the regular Jupiter Recorders.

LUNAR HEIGHT MEASUREMENTS MADE EASY

By: Harry D. Jamieson, former A.L.P.O. Lunar Recorder

The determination of heights and depths on the Moon has been a worthwhile and fascinating pastime since Galileo made the first attempts in 1609-10. And yet, the task has always been a tedious one involving the looking up and manipulation of numerous trigonometric values. One might easily spend a good deal of time and effort computing and checking the results of each measurement manually, only to find an error and have to begin all over again. As small hand calculators recently became popular, though, the process became much easier. At most, one need only go through the looking up phase and key in his table values. With the introduction of calculators with preprogrammed trig functions, even tables became a thing of the past.

Today, however, it has become possible to refine the task one step further. The answer lies with the new generation of highly flexible programmable calculators now on the market at a reasonable price. With this type of machine, one need only key in a program once in order to run as many calculations of a certain type as desired. The more advanced models even allow one to store his programs on cards, and thus to avoid program key-in when it is desired to do something different.

The main purpose of this paper is to show how one might make use of such a machine as an aid in lunar vertical profile studies. The specific calculator used in the following example was a Texas Instruments SR-56 programmable slide-rule model, recently purchased by the writer. The cost, which has just gone down slightly, was $89.95. The lunar feature used in the example was the mountain Piton. The source for shadow length and positional data was Plate D2-a of the Orthographic Lunar Atlas (OLA), exposed on September 15th, 1919 at 13^h 23^m U.T. All other variables are directly from the 1919 edition of the American Ephemeris and Nautical Almanac, except those values for F and A, which are based on data from the aforementioned source.

The first step was, of course, to determine manually the height of Piton using the "Classical Method" outlined below. After this was done and checked, it then became time to reduce the steps used in the manual method to SR-56 program steps so that the machine could take over much of the work that I had just gone through. At first, the program that I came up with was too large for the machine's capacity, and I had to do some trimming. But this was accomplished without too much trouble, and the final version is shown later in this paper.

Anyone interested in undertaking a program of lunar vertical studies with the aid of a programmable calculator need only follow these steps:

---

*Of course, there is nothing that can be timed at a partial eclipse of IV; what an observer can do is to note whether any fading has occurred, and perhaps estimate its amount. The writer has never heard of any photoelectric light curve of a partial eclipse of IV.

1. Obtain shadow length measurements for those peaks which you wish to compute heights for. These may come from either of two sources:

A. Visual Observations. There are numerous techniques for those wishing to obtain their measurements visually, and some of them can be made to yield accurate results.

a. Simple Visual Estimates. Here. one merely notes that a shadow length is a stated fraction of the unforeshortened diameter of a comparison crater of known size. Accuracy should be improved by making a number of estimates for the same shadow, using different craters and computing an average. Magnifications as high as your telescope and seeing will permit should be employed.

b. Drift Timing Method. This is a direct method using a north-south cross-hair at the focus of an eyepiece, a stop watch, and a good clock drive. At the beginning of a night's observations, the amount of time needed for the Moon to "drift" across the cross-hair from one reference point to another must be measured several times (with the drive on) and averaged. The Moon's own orbital motion will cause features to "drift" by the cross-hair at the rate of less than 1 km. per second. It then becomes a matter of using the Xi coördinates of the reference points to determine how much time it would have taken for one lunar radius to transit the cross-hair. Once this has been accomplished, one need only time the tip-to-base transit "drift" for any shadow and convert that time into shadow length in lunar radii. Again, the highest practical magnifications should be used; and several timings should be made for each shadow, and an average taken. The clock drive should remain on during all observations, and the telescope's alignment should remain stable.

B. Photographic Measurements. Photographs are measured directly using a finely divided ruler. However, the scale of the photograph, as well as the exact time when it was taken, must be known with precision. Also, very small scale photographs are useless, as are photographs which have been enlarged to the point where one has trouble telling the shadow tip from the grain. The highest possible quality amateur or professional photographs must always be used if accurate results are to be expected. To be preferred are photographs from the better professional atlases, such as the O.L.A. Orbiter photographs are, of course, the ultimate. However, the equations discussed in this paper will not work for them; and their treatment will have to await a future opportunity. Anyone reducing the necessary equations to calculator program steps would be doing a great service,

2. Obtain the feature's position from an accurate chart. The O.L.A. or Air Forces's A.C.I.C. Charts are to be preferred; but if the latter are used, the feature's longitude and latitude will have to be converted into Xi and Eta coördinates, using the following equations:

a. Eta = Sin B

b. Xi = Sin L Cos B,

where B is the object's latitude and L is its longitude. Coördinates should be accurate to 0.001 lunar radii or better, and a finely divided ruler should be used to measure the coördinates.

3. Obtain data for all of the variables listed at the beginning of the classical example from the American Ephemeris and Nautical Almanac.

4. Key the program given below into your calculator. Should you have a machine not made by Texas Instruments, your program may have to be a little different; but the one given should still serve as a guide to the ready development of a program suitable to your particular machine.

5. Key the variables into your machine as shown below. The amounts to be entered are on the left, followed by the key tops to be depressed, followed by the resulting display for each step.

Vertical studies are one of the few remaining areas left open for the lunar observer who wants to make a really worthwhile contribution to our knowledge of the Moon's topography. There are literally thousands of peaks as yet unmeasured, and these measurements can now be made easily and in quantity by almost anyone. Nor are peaks the only features measurable in this manner. The height or depth of any feature having a vertical profile can be obtained in this way. Also, since the heights found are relative heights (that is, the difference between the summit and the ground upon which the shadow tip falls), it can be seen that it should not be too difficult to obtain the vertical profile of the ground directly east or west of any elevation when several measurements are made under various solar altitudes, and the results are plotted on a graph.

Interested persons having calculators manufactured by companies other than Texas Instruments are invited to develop and to make available their own versions of the program given here, and anyone having questions about the program itself or the general method used for height determination should feel free to contact the writer at the address given below. The program given here is certainly not the only one possible, and suggestions for its refinement would be welcomed. It should also be remembered that this is only one of many possible applications for programmable calculators in astronomy, and that these will increase in number as the available hardware becomes more and more advanced. The time to begin thinking of new ways to make this explosion of personal computing power benefit astronomy is now.

The writer's address is P.O. Box 30163, Middleburg Heights, OH 44130.

References

1. Ashbrook, Joseph, "Finding the Height of a Lunar Mountain." <u>JALPO</u>, <u>16</u>, Nos.9-10, pp. 214-217.
2. Westfall, John E., personal correspondence.

<u>Example of the Classical Solution to the Mountain Height Problem: Piton</u>

Variables:

F = Angle between the Earth and the Sun, as seen from the center of the Moon. Calculated below.
A = Height of the Sun, in degrees, over the mountain. Calculated below.
L'= Earth's selenographic longitude. (See Note 2.)
B'= Earth's selenographic latitude. (See Note 2.)
C = Sun's selenographic co-longitude.
B''= Sun's selenographic latitude.
L = Mountain's selenographic longitude. Measured from an accurate chart.
B = Mountain's selenographic latitude. Measured from an accurate chart.
D = Shadow length in lunar radii. Obtained from photograph or visual observation.

The source of positional and shadow length measurements was <u>QLA</u> Plate D2-a, exposed on 9-15-19 at 13:23 U.T. At that time, the following variables had the values given below:

$L' = +\ 3\overset{\circ}{.}22$
$B' = +\ 2\overset{\circ}{.}35$
$C = 172\overset{\circ}{.}13$
$B'' = -\ 1\overset{\circ}{.}37$

Piton is located at the following co-ordinates:

Xi = -.01002
Eta = +.65309

These must be converted into lunar longitude and latitude for later use:

Latitude = Sin^{-1} Eta = $+40\overset{\circ}{.}77498181$ = B.
Sine Longitude = (Xi/Cos latitude) = -.01002/.7572802994 = -.0132315604;
$-0\overset{\circ}{.}7581346884$ = L.

From close measurement on Plate D2-a, the longest length of shadow cast by Piton was 0.0136 lunar radii. This quantity, <u>D</u>, will be used in the final height equation.

From the commonly used equation given below, the height of the Sun in degrees over Piton is now calculated:

$\text{Sin } A = \text{Sin } B \ \text{Sin } B'' + \text{Cos } B \ \text{Cos } B'' \ \text{Sin } (C + L) = 0.0979608028.$
Then $5\overset{\circ}{.}621756488$ = A.

We now need to compute <u>F</u>, which is the angle between the Earth and the Sun as seen from the center of the Moon. The equation is given below:

$\text{Cos } F = \text{Sin } B' \ \text{Sin } B'' + \text{Cos } B' \ \text{Cos } B'' \ \text{Sin } (C + L') = 0.0799970661.$
Then $85\overset{\circ}{.}4116029$ = F.

The actual height of the mountain may now be calculated using the equation below:

$H = D \ \text{Sin } A \ \text{Csc } F - 0.5 \ D^2 \ \text{Csc}^2 \ F \ \text{Cos}^2 \ A = 0.001244368$ = height in lunar radii.

This value converts to 2162.711537 meters, which may <u>certainly</u> be rounded to 2160 meters or 7090 feet.

Example of Computerized Solution to Mountain Height Problem: Piton

Enter	Depress	Display	Comments
	*CMs RST	0	Clear memories and reset program to beginning.
172.13	STO 0	172.13	Store co-longitude (C).
- 1.37	STO 1	- 1.37	Store sun's selenographic latitude (B").
+ 0.65309	STO 3	+ 0.65309	Store mountain's Eta co-ordinate.
1,738,000	STO 4	1,738,000	Store lunar radius (in degrees).
0.0136	STO 5	0.0136	Store shadow length (D).
+ 2.35	STO 6	+ 2.35	**Store Earth's selenographic latitude (B').
+ 3.22	STO 7	+ 3.22	**Store Earth's selenographic longitude (L').
- 0.01002	R/S	- 0.01002	Enter mountain's Xi co-ordinate and start program.
		2162.711537	After calculations, machine displays height in meters.

Note 1: Keys preceded by an '' are second function keys.

**Note 2: Slightly greater accuracy may be obtained by converting these geocentric librations into topocentric ones. See appropriate appendix in your current edition of the A.E.N.A. Geocentric librations are not seriously in error except during New and Full phases, when little height work is done in any case.

```
Location     Code   Key      Comments

   -                         PROGRAM LISTING FOR SR-56 LUNAR HEIGHT MEASUREMENT
   -                         APPLICATION.  AUTHOR:  HARRY D. JAMIESON
   -
   00         54    ÷        DIVIDE XI COORDINATE BY COSINE OF MOUNTAIN'S LAT-
   01         57    *subr    ITUDE TO OBTAIN MOUNTAIN'S LONGITUDE.  (LATITUDE =
   02         07    7        VARIABLE B).
   03         09    9
   04         94    =
   05         12    INV      CONVERT SINE OF LONGITUDE INTO DEGREES.  (VARIABLE
   06         23    SIN      L).
   07         32    X><T     STORE LONGITUDE IN "T" REGISTER FOR LATER USE.
   -
   -                         BEGIN NOW TO CALCULATE THE SUN'S ALTITUDE IN DEGREES
   -                         OVER THE MOUNTAIN (VARIABLE A) USING THE EQUATION:
   -
   -                         SIN A = SIN B  SIN B"  +  COS B  COS B"  SIN(C + L),
   -
   -                         WHERE THE VARIABLES ARE AS FOR THE LIST GIVEN IN THE
   -                         CLASSICAL EXAMPLE.
   -
   08         57    *subr    SIN B" TIMES
   09         07    7
   10         04    4

   11         34    RCL      RECALL SIN LAT. (VARIABLE B).
   12         03    3
   13         84    +
   14         57    *subr    COSINE LATITUDE (VARIABLE B).
   15         07    7
   16         09    9
   17         57    *subr    TIMES COS B" TIMES SIN (C + L) =  SIN A
   18         08    8
   19         06    6
   20         33    STO      STORE ALTITUDE IN MEMORY 8 FOR LATER USE.

   21         08    8        BEGIN NOW TO CALCULATE VARIABLE F, THE ANGLE BETWEEN
   -                         THE EARTH & THE SUN AS SEEN FROM THE CENTER OF THE
   -                         MOON, USING THE EQUATION:
```

Example of Computerized Solution to Mountain Height Problem: Piton (continued)

Location	Code	Key	Comments
-			COS F = SIN B' SIN B" + COS B' COS B" SIN(C + L'),
-			
-			WHERE THE VARIABLES ARE AS FOR THE LIST GIVEN IN THE
-			CLASSICAL EXAMPLE.
-			
-			
22	34	RCL	GET VARIABLE L', EARTH'S SELENOGRAPHIC LONGITUDE.
23	07	7	
24	32	X>< T	STORE L' IN "T" REGISTER AND RELEASE L, WHICH IS NO
-			LONGER NEEDED.
25	57	*subr	SIN B" TIMES
26	07	7	
27	04	4	
28	34	RCL	GET B' (EARTH'S SELENOGRAPHIC LATITUDE).
29	06	6	
30	23	SIN	CONVERT INTO SIN B'.
31	84	+	
32	34	RCL	GET B' AGAIN.
33	06	6	
34	57	*subr	COS B' TIMES COS B" TIMES SIN (C + L') = COS F
35	08	8	
36	05	5	
37	12	INV	MAKE VARIABLE F DEGREES.
38	24	COS	
39	23	SIN	GET SINE VALUE OF F.
40	20	*1/x	RECIPROCAL OF SINE = COSEC OF F.
41	33	STO	STORE IN MEMORY 9 FOR LATER USE. BEGIN ACTUAL HEIGHT
42	09	9	CALCULATION HERE. COSEC F IS MULTIPLIED
43	64	X	TIMES SOLAR ALTITUDE (VARIABLE A).
44	34	RCL	
45	08	8	
46	64	X	TIMES SHADOW LENGTH (VARIABLE D).
47	34	RCL	
48	05	5	
49	74	-	MINUS
50	92	.	
51	05	5	.5
52	64	X	TIMES SHADOW LENGTH (D) SQUARED.
53	34	RCL	
54	05	5	
55	43	X^2	
56	64	X	TIMES COSEC F SQUARED.
57	34	RCL	
58	09	9	
59	43	X^2	
60	64	X	TIMES COSINE OF SOLAR ALTITUDE (VARIABLE A) SQUARED.
61	34	RCL	
62	08	8	
63	12	INV	CONVERT TO DEGREES.
64	23	SIN	
65	24	COS	GET COSINE
66	43	X^2	
67	94	=	EQUALS HEIGHT IN LUNAR RADII.
68	64	X	TIMES LUNAR RADIUS IN FEET OR METERS.
69	34	RCL	
70	04	4	
71	94	=	EQUALS HEIGHT IN FEET OR METERS.
72	41	R/S	STOP - END OF JOB!!

Example of Computerized Solution to Mountain Height Problem: Piton (continued)

```
Location        Code   Key     Comments

   73            42    RST     RESET PROGRAM LOCATION COUNTER TO TOP OF PROGRAM.
   -                           **** SUBROUTINES
   -                           **** SUBROUTINES
   -
   -                           PROGRAM SUBROUTINES THAT UTILIZE PARTS OF THE
   -                           EQUATIONS GIVEN THAT ARE SIMILAR TO EACH OTHER.
   -
   74            34    RCL     SUBROUTINE GETS SIN B" AND MULTIPLIES QUANTITY
   75            01    1       TIMES AMOUNT CALLED UP WHEN PROGRAM RETURNS TO
   76            23    SIN     MAINLINE.
   77            64    X
   78            58    *rtn    RETURN TO MAINLINE.
   -
   79            34    RCL     SUBROUTINE GETS VARIABLE B (MOUNTAIN'S LATITUDE),
   80            03    3       COMPUTES ITS COSINE, AND RETURNS.

   81            12    INV
   82            23    SIN
   83            24    COS
   84            58    *rtn    RETURN TO MAINLINE.
   -
   85            24    COS     SUBROUTINE COMPUTES THE COSINE OF QUANTITY CALLED
   86            64    X       UP BEFORE *subr AND MULTIPLIES THIS TIMES COSINE
   87            34    RCL     B" (SUN'S SELENOGRAPHIC LATITUDE) TIMES SIN (C +
   88            01    1       THE CONTENTS OF THE "T" REGISTER);  THE LATTER WILL
   89            24    COS     BE EITHER L OR L'.
   90            64    X

   91            52    (
   92            34    RCL
   93            00    0       GET C (COLONGITUDE)
   94            84    +
   95            32    X><T    GET CONTENTS OF "T" REGISTER.
   96            53    )
   97            23    SIN
   98            94    =
   99            58    *rtn    RETURN TO MAINLINE.
```

THE 1976-77 EASTERN (EVENING) APPARITION OF THE PLANET VENUS: VISUAL AND PHOTOGRAPHIC INVESTIGATIONS

By: Julius L. Benton, Jr., A.L.P.O. Venus Recorder

Abstract

Visual and photographic observations of the planet Venus during the 1976-77 eastern (evening) apparition are examined and discussed. The source of the data and the instrumentation which was utilized to gather the information are described in the report. A statistical investigation of the kinds and types of surface markings seen on Venus' apparent surface at visual wavelengths is presented, including also information on the cusps, cusp-caps, cusp-bands, cusp-extensions, the bright limb band, terminator irregularities, dark side phenomena and the Ashen Light, phase and dichotomy estimates, etc. Comparisons are made between the results of various observers and between visual and photographic data. Accompanying illustrations serve to enhance the value of, and one's appreciation of, the accumulated data during 1976-77 on Venus.

Introduction

The report which follows deals with accumulated data, both visual and photographic, on the planet Venus throughout the 1976-77 eastern (evening) apparition of the planet; the following geocentric phenomena in Universal Time (U.T.) are presented for the convenience of the reader:[1,2]

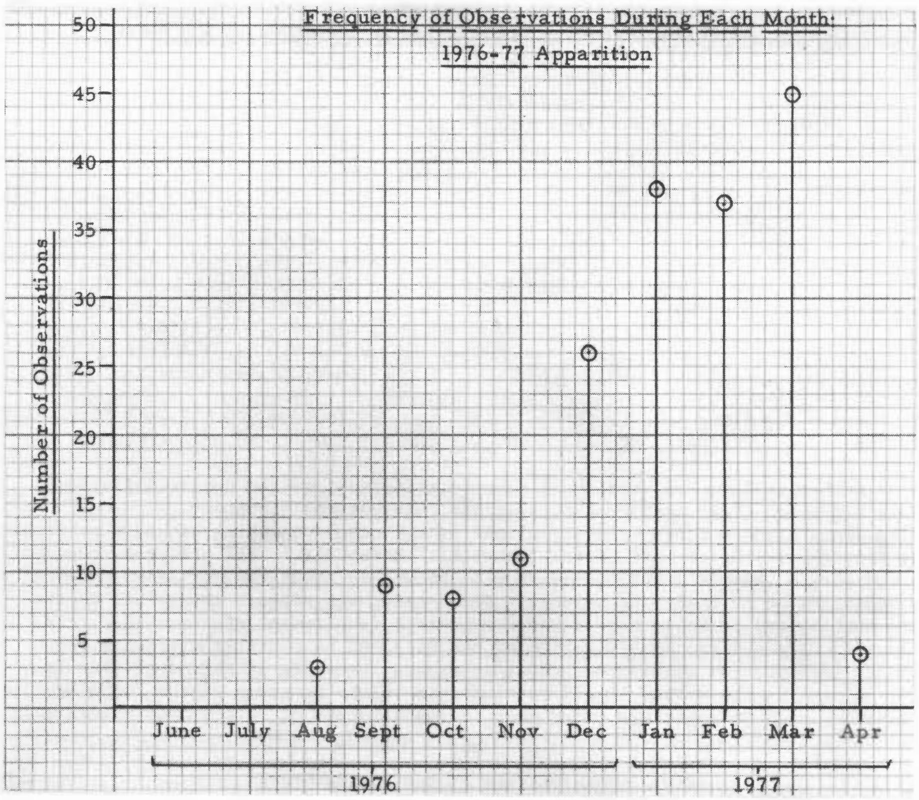

Figure 11. Histogram to show monthly frequency of observations by members of the A.L.P.O. Venus Section during the 1976-77 evening apparition.

* * * * * * * * * * * * * * * * *

1976,	June	18^d 04^h	U.T.	Superior Conjunction
1977,	January	24 12		Greatest Elongation East (47°)
	March	01 02		Greatest Brilliancy (-4.3)
	March	14 19		Stationary Point
	April	06 06		Inferior Conjunction

A total of 181 observations was received by the Section during 1976-77, and Figure 11 will serve to demonstrate how the observational reports were distributed during the apparition by months. Examination of the data presented in the histogram in Figure 11 will reveal an obvious lack of proper observational attention throughout the earliest parts of the apparition, leading up to the month just before elongation occurred. The greatest wealth of visual and photographic data emerged during the period from 1976, December through 1977, March. As Venus neared Inferior Conjunction, in April, observational attention declined.

Numerous drawings and several good photographs were submitted throughout 1976-77, and many of these were exceedingly useful in the analysis. The incidence of simultaneous observations appears more pronounced in 1976-77, although the writer would like to see still more effort in this direction in future apparitions. The need for coincident data on Venus cannot be over-emphasized.

The following individuals contributed observational data for the 1976-77 apparition:

Observer	Location	No. of Observations	Instrumentation
Baum, Richard	Chester, England	11	11.5-cm. (4.5") Refr.
Benton, Julius L.	Clinton, SC	1	8.3-cm. (3.25") Refr.

Observer	Location	No. of Observations	Instrumentation
Deicsics, Leslie	Budapest, Hungary	3	20.0-cm. (8.0") Refr.
Haas, Walter H.	Las Cruces, NM	23	31.0-cm. (12.5") Refl.
Heath, Alan W.	Nottingham, England	24	30.0-cm. (12.0") Refl.
Keszthelyi, Sandor	Budapest, Hungary	2	20.0-cm. (8.0") Refr.
Mizser, Attila	Budapest, Hungary	4	15.0-cm. (6.0") Refl. 20.0-cm. (8.0") Refr.
O'Meara, Stephen J.	Cambridge, MA	27	23.0-cm. (9.0") Refr.
Schaefer, Brad	Cambridge, MA	11	15.0-cm. (6.0") Refl. 13.0-cm. (5.0") Refr. 51.0-cm. (20.0") Refr. 31.0-cm. (12.5") Refl.
Smith, Michael B.	Alamogordo, NM	61	11.0-cm. (4.25") Refl. 5.2-cm. (2.1") Refr. 8.3-cm. (3.25") Refr. 6.0-cm. (2.4") Refr.
Stelzer, Harold J.	River Forest, IL	13	20.0-cm. (8.0") Refl.
Wetsch, John	Killdeer, ND	1	6.0-cm. (2.4") Refr.

The writer is indebted, with much sincere gratitude, to the twelve individuals mentioned above for their continued support and observational interest.

The Venus Section programs are outlined in a concise observing brochure available at cost from the writer as part of the "Venus Kit" materials.[3] All prospective observers should obtain this information and should thoroughly study the pertinent material before embarking on an observing venture. Consistent use, without exception, of the standard methods and forms is considered a mandatory requirement of Venus observers. No truly effective and proper evaluation of the data can be possible without systematic and standardized program objectives. Most observers are aware of this need, but it would be helpful to the writer if all participants in the programs of the Venus Section would conform. All attempts are being made in the interest of better data acquisition and observer utilization.

Visual Observations of Surface Markings

In a much earlier Venus Section report the writer outlined in some detail the conventional methods and techniques of making visual investigations of the somewhat vague and elusive "markings" on the apparent surface of Venus.[4] Study of this material is particularly recommended for the individual who is new to the A.L.P.O. Venus Section.

No ultraviolet photographs of Venus were received by the Section during the 1976-77 period. Thus, the present report deals largely with visual observations and accompanying drawings. Further supplementing the data are photographs at visual wavelengths, which in part were made almost coincidentally with visual drawings. A preliminary evaluation of the observations as a whole suggests a worthwhile incidence of continuity of method and technique.

Following an exhaustive examination and appraisal of the visual and photographic data for 1976-77, it is very clear that nearly all categories of markings discussed in the literature were represented.[3,4] Table I represents a somewhat quantitative treatment of such observational data in the spirit of previous apparition reports, in which an attempt has been made to show the percentage of the 181 total observations which fit into specific categories.

Table I. Frequency of Occurrence of Types of Surface Markings on Venus' Apparent Disc During 1976-77

Marking Type	Percentage of 181 Total Observations
Banded Dusky Markings	18%
Radial Dusky Markings	6
Irregular Dusky Markings	19
Amorphous Dusky Markings	60
Terminator Shading	74
No Markings	36
Bright Spots and Regions (exclusive of the cusps and limb band region)	12

k = 0.978 (1976, July 31) to 0.016 (1977, April 2).[1,2]

Notes

1. Assuming that the bright illuminated hemisphere of Venus (areas devoid of any markings) was typically assigned a numerical relative intensity of 8.0-8.5 during 1976-77 (note that the scale of intensity used is a 0-10 sequence, where 0 is black shadow and 10 is the most brilliant condition), it was noticed that the average assigned intensity for the dusky markings in integrated light was near 7.5 (first five items in Table I above); the last category yielded an average value of 9.0-9.5.
2. Observers failed to utilize the scale of conspicuousness consistently enough in 1976-77 to generate reliable figures, but it is clear from verbal notes by individuals that the dusky features were elusive and vague; bright areas tended to be more pronounced visually than dusky markings, although not significantly so.
3. Seeing conditions, appraised on the A.L.P.O. 0-10 scale (where 0 is impossible and 10 is perfect), on the average were found to be near 5.0. Observations were usually made during twilight or on a bright sky; transparency of the atmosphere was commonly fair to moderately good. In the instances when observations were made against a dark background, the average atmospheric transparency was around 3.5 to 4.0 (faintest star visible to unaided eye).

Several somewhat tentative conclusions might be derived from the data in Table I and the supporting observational reports, even though an obvious level of subjectivity still exists in the limited quantitative notes; these will be the subject of the next few paragraphs.

A reasonable proportion of visual drawings, and virtually all photographs at visual wavelengths, showed Venus' disc as being totally devoid of shadings and markings of any kind. As in the past, both beginning observers and experienced individuals frequently "draw" Venus without any detectable markings. Visual detection of such features, if they exist, is quite a task even for the seasoned visual observer. It is widely recognized that such elusive markings, usually at the visual threshold, seldom lend themselves to detection at visual wavelengths. This is not to suggest that markings depicted on drawings by painstaking observers are merely illusions, but it does serve to stress the necessity for simultaneous attempts by different observers on Venus whenever such work is possible. Even so, there remain variables such as one's contrast perception and sensitivity, instrumental factors, seeing and transparency, and many other peculiarities over which one has little or no control.

The feature on Venus' disc most commonly detected in 1976-77 was the terminator shading, although it is quite possible that such a phenomenon has very little to do with the physical nature of the planet. Observers remarked that the shading along the terminator was graded toward a lighter intensity (toward 10 on the scale introduced earlier in this report) as the distance from the terminator toward the direction of the illuminated limb became greater. This gradation proceeded until no shading was apparent, commonly at a point halfway between the limb and the terminator. Photographs also showed this phenomenon. Dusky features on Venus were sometimes associated with the terminator shading, but the basic connection between the two types of features could not be firmly established.

The roughly parallel banded dusky markings, normal to the terminator, were seen with about the same frequency as the irregular dusky markings. Amorphous dusky markings were by far the rule during 1976-77, having no specific properties or orientation other than their fuzzy outlines, characteristic faintness, and intermittent invisibility, especially during poor seeing.

The radial or "spoke" pattern with regard to the dusky markings was seen only occasionally, and even at those times it was difficult to tell whether such features should be classed among the irregular or amorphous dusky markings or not. The radial pattern is more common on ultraviolet photographs, and the lack of its presence during 1976-77 on drawings was not unexpected.

Bright spots and regions, excluding the cusp regions and the bright limb band, were reported rather infrequently throughout the apparition. It is well to note here that such areas were more clearly defined than were the dusky markings, and it remains difficult to tell what the true cause of such amorphous bright areas can be (contrast effects?) None were apparent on photographs examined by this writer in visual wavelengths.

Filter observations using a Wratten 25 (red) and a Wratten 47 (blue) filter yielded results similar to those above which were made in integrated light (no filter). Polaroid filters were employed by several observers in order to reduce glare, as was an apodizing screen. There was too much inconsistency among these filter observations to afford much information for analysis, and individuals must concentrate in the future on obtaining and using standardized color filters of known transmissions; one can do no better than to secure the Eastman Kodak Wratten glass filters.

Accompanying the discussion here are several drawings and photographs, some of which are very nearly simultaneous. Comparing the illustrations with the foregoing text material should prove instructive, lending some idea of the multitudinous variety of vague, dusky features on Venus, not to exclude the occasional bright spots seen on the planet.

One should begin to appreciate from all this discussion the need for more painstaking, confirmatory observations of Venus by numerous individuals. If there is ever to be any hope of deriving something really significant from the emerging patterns of features seen on Venus' disc, every effort to accumulate objective data must be made.

Cusps, Cusp-Caps, and Cusp-Bands

Past observational records suggest that the most prominent and contrasty features on the planet Venus appear near or at the cusps; and when the numerical phase of Venus is between k = 0.8 and k = 0.1 (where k is the ratio of the illuminated disc to the whole disc regarded as circular), the so-called "cusp-caps" show up from time to time.[1,2,3] The cusp-caps are sometimes accompanied by dark "cusp-bands," as observations during the 1976-77 apparition support.[3]

During the 1976-77 apparition, as in previous observing seasons, cusp-caps and cusp-bands were often seen on Venus. Table II presents a statistical inquiry into the visibility of these features and their frequency of occurrence in the available observational sample.

Table II. Cusp-Cap and Cusp-Band Statistics: 1976-77 Apparition of Venus

Condition	Percentage of 181 Total Observations
South Cap Alone Visible	3.3%
Both Caps Visible	35.0
North Cap Alone Visible	4.4
Neither Cap Visible	53.0
South Cap Larger	2.7
Both Caps of Equal Size	23.0
North Cap Larger	12.0
South Cap Brighter	11.0
Caps of Equal Brightness	22.0
North Cap Brighter	3.8
South Cusp-Band Alone Visible	1.6
Both Cusp-Bands Visible	15.0
North Cusp-Band Alone Visible	2.3
Neither Cusp-Band Visible	78.0

Notes

1. Assuming that the bright illuminated hemisphere of Venus, as in Table I, was typically of an intensity somewhere between 8.0 and 8.5 in 1976-77, it was found that the average numerical relative intensity of the cusp-caps was about 9.5; the value for the cusp-bands was about 7.3 during 1976-77.
2. The seeing and transparency conditions were as stated in the "Notes" following Table I.

Although the data in Table II are perhaps slightly ambiguous at times, the following results might be offered:

1. Over half of the observations received during 1976-77 showed no hints of the cusp-caps of Venus. When the northern and southern cusp-caps were detected, it was more usual for individuals to record them simultaneously rather than singularly. At times when the cusp-caps were reported, it was common for them to be equal in size and in brightness; yet, there were some instances when differences existed between the northern and southern cusp-caps with respect to overall comparative size and intensity. If there was a reported difference between the two cusp-caps, it was likely for the northern one to be the larger and the southern one the brighter.

(Text continued on page 248)

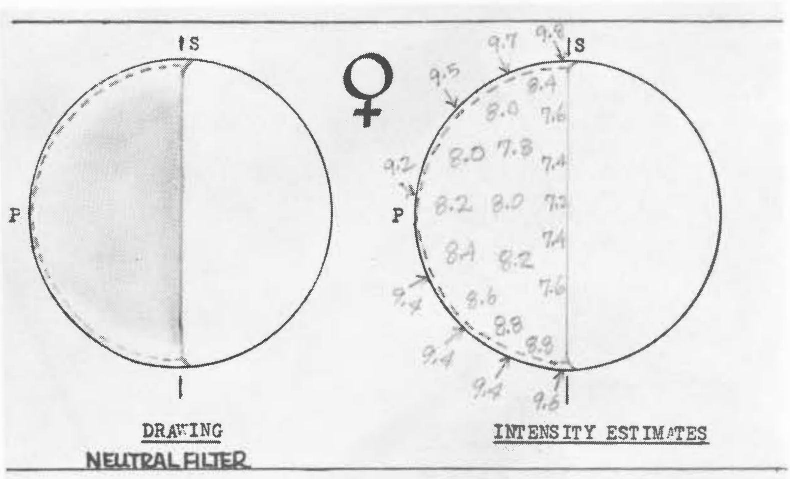

Figure 12. Drawing of Venus by Michael B. Smith on January 22, 1977, $23^h 15^m$ - $23^h 50^m$, U.T. 10.6-cm. refl., 115X to 173X. Seeing 9-10 (on a scale of 0 to 10, with 10 perfect). Transparency 3 (limiting stellar magnitude). All illustrations in this Venus Report are simply inverted views with south at the top.

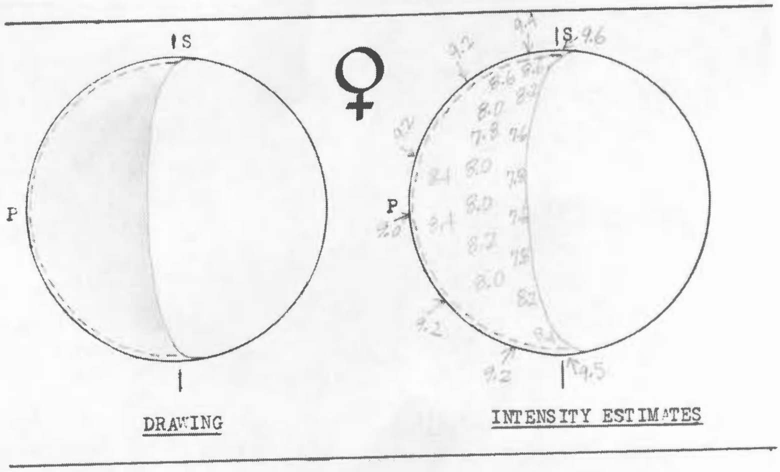

Figure 13. Drawing of Venus by Michael B. Smith on February 8, 1977, $1^h 55^m$ - $2^h 15^m$, U.T. 10.6-cm. refl., 143X and 172X. Seeing 10. Transparency 6. Figures 12-20 were all drawn by Mr. Smith with an apodizing mask and a variety of color filters.

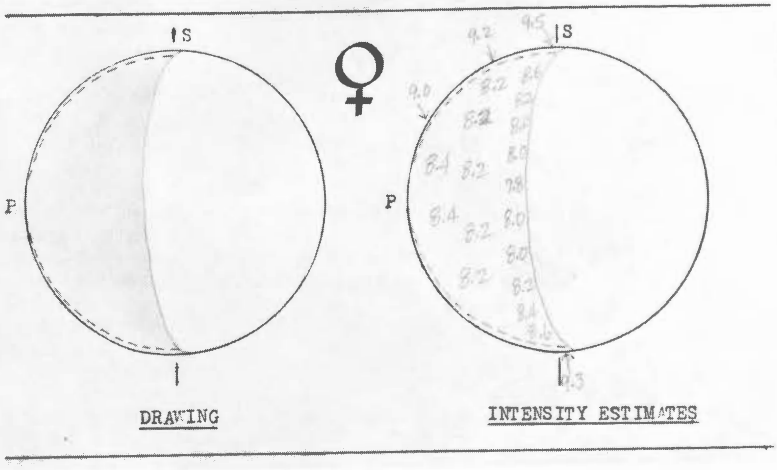

Figure 14. Drawing of Venus by Michael B. Smith on February 9, 1977, $0^h 25^m$ - $0^h 35^m$, U.T. 10.6-cm. refl., 143X and 172X. Seeing 8. Transparency 5. Note terminator shading. Dark side *very* vaguely visible with *very* faint reddish tint in this view.

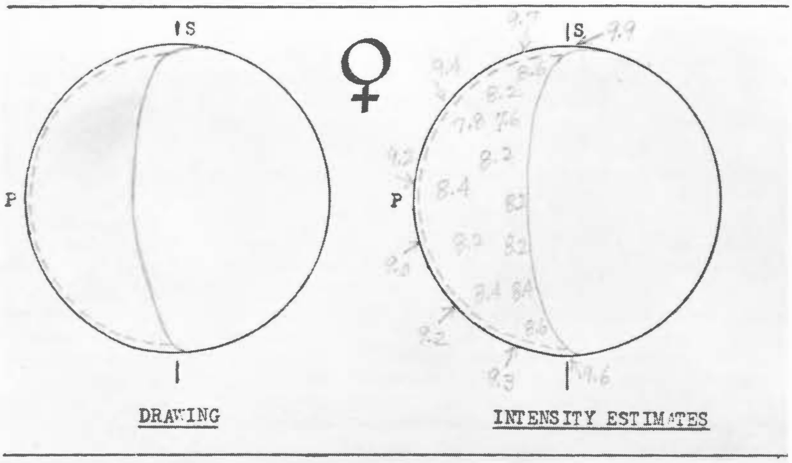

Figure 15. Drawing of Venus by Michael B. Smith on February 16, 1977, 0^h30^m-0^h35^m, U.T. 10.6-cm. refl., 138X. Seeing 10. Transparency 4. Figures 12-20 were all drawn by Mr. Smith on an observing form; the left sketch is an ordinary drawing, and the right sketch carries observed intensities on a scale of 0 (shadows) to 10 (most brilliant features).

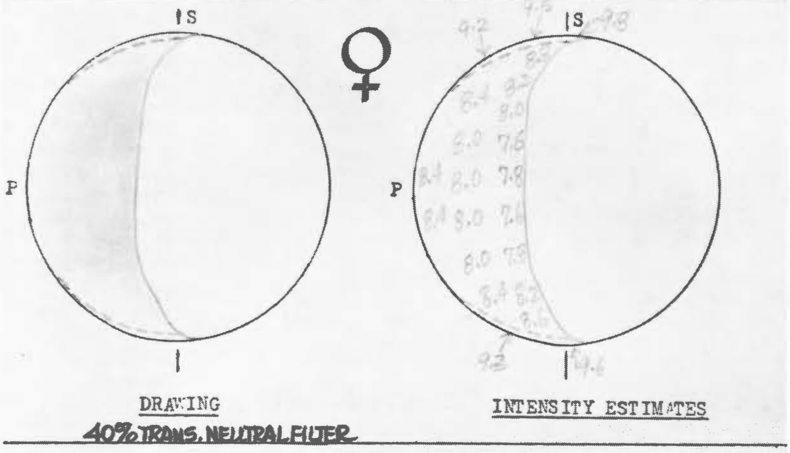

Figure 16. Drawing of Venus by Michael B. Smith on February 17, 1977, 2^h0^m - 2^h15^m, U.T. 10.6-cm. refl., 138X and 173X. Seeing 7. Transparency 5. Note the carefully drawn shape of terminator. Terminator shading more evident than on February 16. Dark sky.

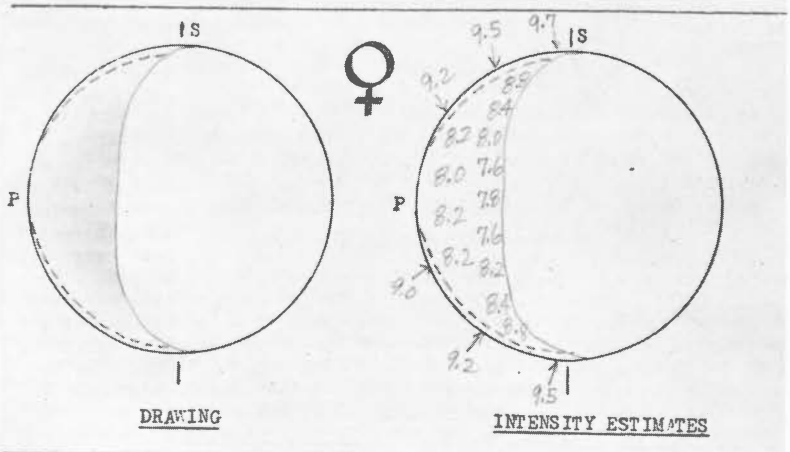

Figure 17. Drawing of Venus by Michael B. Smith on February 27, 1977, 2^h0^m - 2^h20^m, U.T. 10.6-cm. refl., 115X and 138X. Seeing 8. Transparency 5+. Limb band and cusps brightest with orange filter. Terminator shading much more evident with neutral filter and green filter.

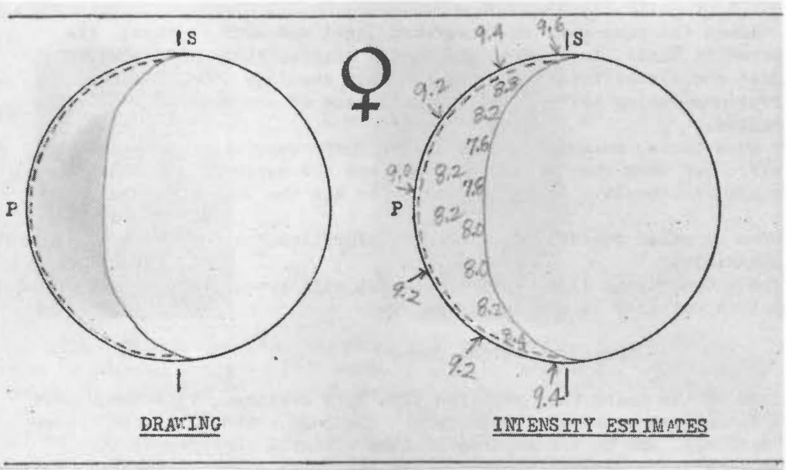

Figure 18. Drawing of Venus by Michael B. Smith on February 28, 1977, 1^h5^m - 1^h30^m, U.T. 10.6-cm. refl., 138X. Seeing 9. Transparency 6. Limb band very thin. Both cusps very sharp with south one slightly the brighter. Terminator shading very slight.

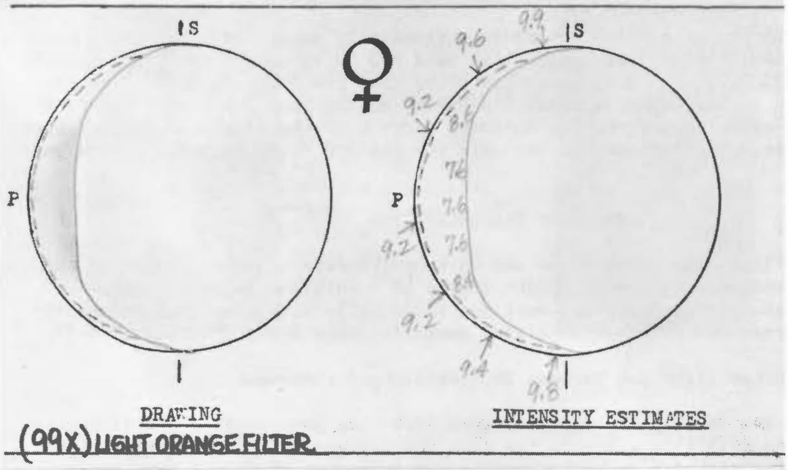

Figure 19. Drawing of Venus by Michael B. Smith on March 13, 1977, 2^h5^m- 2^h25^m, U.T. 6.0-cm. refr., 99X and 128X. Seeing 9. Transparency 6. Limb band visible only with orange filter. Dark side of Venus easily and definitely visible but only in orange light; slightly lighter than sky. Faint north and south "twilight arcs" visible in orange light.

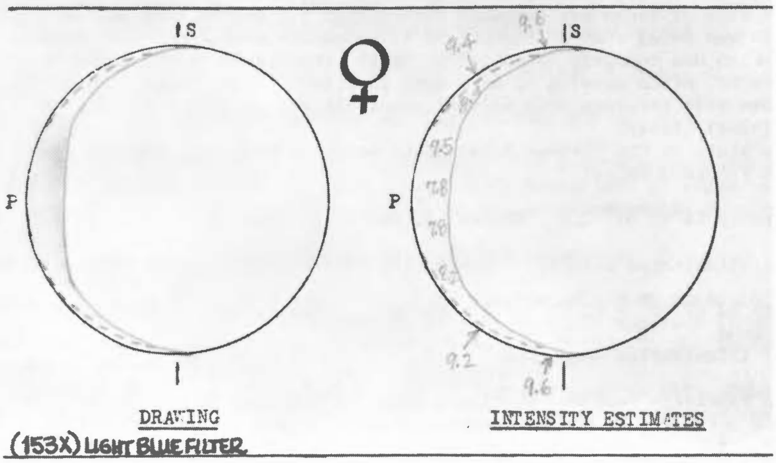

Figure 20. Drawing of Venus by Michael B. Smith on March 13, 1977, 23^h15^m - 23^h35^m, U.T. 10.6-cm. refl., 111X and 153X. Seeing 9. Transparency 6. Cusps strikingly needle sharp. Dark side most evident with blue filter. Crescent seemed thinner in blue light than with other filters.

2. Observers viewed the cusp-caps in integrated light and with filters; the same results as reported in Table II emerged, and it was noticed that a blue (W47) Wratten filter enhanced the visibility of the caps on most evenings. Poor agreement amongst filter observations during 1976-77 was due to a lack of standard usage of filter types and wavelengths.

3. The darker cusp-bands, normally bordering the cusp-caps, were not very common throughout 1976-77; but when they were recorded, both the northern and southern cusp-bands were seen simultaneously. It was not usual to see the cusp-bands individually.

4. No short-term or other variations of a truly significant nature were observed during the 1976-77 apparition.

Reference to the accompanying illustrative examples will reveal to the interested reader some of the points outlined in the foregoing text.

Extension of the Cusps

Slight extensions of the cusps were reported from late December, 1976 throughout the remainder of the apparition by careful observers. The cusp extensions were seldom clearly depicted on drawings, and no indications of them appeared photographically. Near the close of the apparition several observers saw what they reported to be a "twilight arc" encircling all or part of the dark hemisphere of Venus.

Bright Limb Band

The bright limb opposite Venus' terminator frequently exhibited a brilliant banded appearance. On the average, the bright limb band had an intensity (A.L.P.O. scale) somewhere between 9.5 and 9.8. Most observers noted that the feature extended continuously from one cusp to the other, and the visibility of the band appeared to be independent of the cusp-caps. Sometimes the southern portion of the limb band was brighter than the northern arc. Filter observations were too dubious to be included in the analysis.

Terminator Irregularities

The geometric line separating light and dark hemispheres of Venus, commonly referred to as the terminator, showed a slight degree of undulation along its length, sometimes with adjacent irregular dusky markings blending in with the terminator shading. No other deformations or other localized anomalies were noticed during 1976-77.

Ashen Light and Various Dark-Hemisphere Phenomena

Several observers in 1976-77 reported vague dark-side phenomena, and a discussion of these observations will take place in the next few paragraphs. The majority of the contributing observers recorded no variations in the intensity of Venus' dark hemisphere; such impressions were obtained with small instruments right on up to rather large telescopes used by individuals with experience.

Following 1977, January 27, Michael Smith indicated that he had the distinct suspicion that the dark side of Vanus was somewhat darker than the surrounding sky (an impression which also was noted when different sky illumination conditions were encountered). Some coloration was commonly suspected by Smith with regard to the darkened hemisphere of the planet, often showing up as a deep purplish or dark reddish hue. The effects outlined above were recorded with several color filters, namely a Wratten 58 (green) and a W80A (blue) filter.

Smith reported hints of the curious Ashen Light on a few evenings, and the specific observations are recorded below:

1977, February $19^d02^h07^m$ U.T., Michael B. Smith, 11.0-cm. reflector, 115X-173X. Seeing good.
"Dark side illuminated faintly. . .dark side ruby red with orange filter (W21)."

1977, March $13^d02^h05^m$ - 02^h25^m, U.T., Michael B. Smith, 6.0-cm. refractor, 99X - 128X. Seeing good.
"Dark side illumination suspected."

Walter H. Haas regularly recorded instances when the darkened hemisphere of Venus was of the same intensity as the surrounding sky, which was either twilight or dark; but some indications of the Ashen Light were apparent to Haas in early February

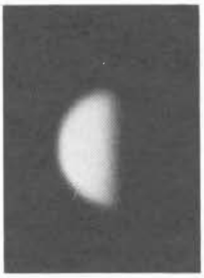

Figure 21. Photograph of Venus by Alan W. Heath on January 21, 1977, $16^{h}30^{m}$, U.T. 12-inch reflector, 318X with eyepiece projection. Exposure 1/25 second. Pan F film. Observed dichotomy in this view?

Figure 22. Photograph of Venus by Alan W. Heath on February 8, 1977, $17^{h}50^{m}$, U.T. Same conditions as Figure 21. Compare to Figures 13 and 14, drawings by Michael Smith 16 hours earlier and 7 hours later respectively.

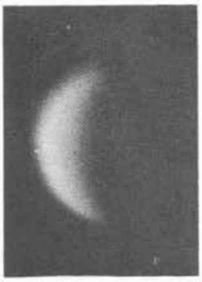

Figure 23. Photograph of Venus by Alan W. Heath on February 16, 1977, $17^{h}30^{m}$, U.T. Same conditions as Figure 21. Compare to Figures 15 and 16, drawings by Michael Smith 17 hours earlier and 9 hours later respectively.

Figure 24. Photograph of Venus by Alan W. Heath on February 26, 1977, $17^{h}45^{m}$, U.T. Same conditions as Figure 21. Michael Smith's drawing in Figure 17 was about 8 hours later. Heath made the drawing in Figure 28 at the same time.

Figure 25. Photograph of Venus by Alan W. Heath on March 12, 1977, $17^{h}50^{m}$, U.T. Same conditions as Figure 21. Michael Smith's drawing in Figure 19 was about 8 hours later.

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and early March, particularly when a blue (W47) filter was employed. Two dates in particular were noted by Haas to be times when the Ashen Light was more certain than at other times; these were as follows:

1977, March $14^{d}02^{h}04^{m}$ - $02^{h}13^{m}$, U.T. Walter H. Haas, 31.0-cm. reflector, 305X. Seeing fair.

"Whole unilluminated hemisphere brighter than the sky by a slight degree."

1977, March $20^{d}01^{h}40^{m}$ - $01^{h}55^{m}$, U.T. Walter H. Haas, 31.0-cm. reflector, 305X. Seeing fair.

"Dark hemisphere visible and lighter than the sky."

Impressions of a lighter dark hemisphere than the background sky were forthcoming from March 22 through March 25 when a blue (W47) filter was utilized by Haas. He also remarked that a mottling of the dark side of Venus was suspected from time to time.

Estimates of Phase and Dichotomy

Over the years, observers of Venus have discovered that there is an apparent and recurrent discrepancy between the dates of predicted and observed dichotomy. The effect noted here is known variously as the Schroeter Effect.[3] The difference usually amounts to somewhere between 4 and 10 days.

During 1976-77, the predicted date of dichotomy was on 1977, January 27, when a phase angle (i) of 90° was to be noted (exact half phase).[2] Observations by Michael B. Smith using an 11.0-cm. reflector at 115-173X and no filter yielded an observed dichotomy on 1977, January $22^{d}22^{h}30^{m}$, U.T. Alan W. Heath in England took a photograph

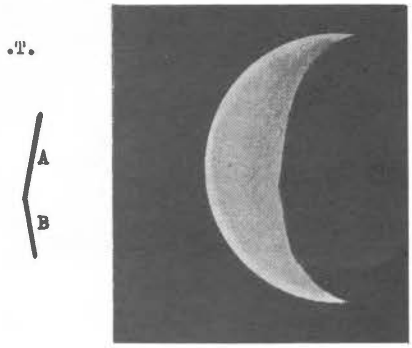

Figure 26. Drawing of Venus by Alan W. Heath on February 27, 1977, 17^h45^m, U.T. 12-inch reflector at 190X. Seeing rather poor. Note the deformed shape of the terminator, shown in an exaggerated manner by the sketch to the left of the drawing. Compare to Figure 24, a photograph by Heath 24 hours earlier, and to Figures 17 and 18, drawings by Michael Smith 16 hours earlier and 8 hours later respectively.

Figure 27. Photograph of Venus by Stephen O'Meara on December 31, 1976 at 21^h0^m, U.T. 9-inch Clark refractor at Harvard College Observatory. Eyepiece projection with 300X. No filter. Daylight view.

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using a Praktica SLR camera and Pan F (50 ASA) film which showed dichotomy on 1977, January $21^d16^h20^m$, U.T. The instrument used was a 30.0-cm. reflector. Dichotomy was noted by Heath to exist visually with all filters used, except perhaps a slight doubt with a Dufay blue filter. The discrepancy noted by Smith and Heath here amounts to about 4 or 5 days, within the expected limits of variation in view of past reports.[3,4]

Conclusions and Remarks

Observations of Venus during 1976-77 revealed the more usual variable phenomena commonly seen in the atmosphere of the planet by visual observers. Photographs taken at the visual wavelengths revealed little more than the drawings, and often not so much. Since there were no ultraviolet photographs of Venus submitted during the 1976-77 apparition, it is impossible to tell what might have emerged from such data. All one can hope for is a moderate wealth of such ultraviolet photographs in coming apparitions, and experienced and equipped observers should consider such a program to be a top-priority endeavor.

Visual observers are encouraged very strongly to use the appropriate observing forms distributed by the Venus Section; and initial sketches of Venus should be made in integrated light, following up with drawings using filters of known transmission (indicating on the form what the transmission characteristics and type are). Use of the standard A.L.P.O. seeing, transparency, intensity, and conspicuousness scales must take place if observations are to be compared effectively in an analysis. In short, careful, organized, and purposeful data acquisition has to be the rule rather than the fortunate exception.

The Venus Recorder again would like to express his gratitude to participating observers during 1976-77, no matter how much or how little work was done by the specific individual. The Recorder stands always ready to assist new, as well as experienced, individuals with interesting visual and photographic programs. Dedicated observers, willing to pursue useful programs faithfully and painstakingly, are always encouraged to write for information.

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2. U.S. Naval Observatory, _American Ephemeris and Nautical Almanac, 1977_. Washington: U.S. Government Printing Office, 1976.
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4. Benton, Julius L., "The 1971-72 Eastern (Evening) Apparition of Venus," _J.A.L.P.O._, _25_ (7-8): 151-160, 1975.

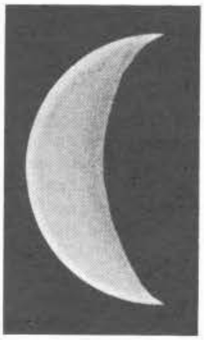

Figure 28. Drawing of Venus by Alan W. Heath on February 26, 1977, 17^h45^m, U.T. 12-inch reflector, 318X. Seeing rather poor. Compare to Figure 24, Heath's photograph in the same view.

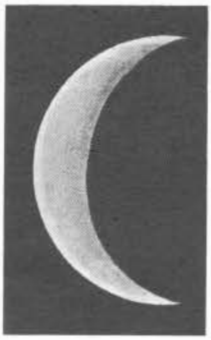

Figure 29. Drawing of Venus by Alan W. Heath on March 12, 1977, $17^h 40^m$, U.T. 12-inch reflector, 318X. Seeing rather poor. Figure 25 is Heath's photograph at the same time, and Figure 19 is Michael Smith's drawing about 9 hours later.

BOOK REVIEWS

Quasars, Pulsars, and Black Holes, by Frederic Golden. Charles Scribner's Sons, 597 Fifth Ave., New York, N.Y. 10017. 1976. 205 pages. Price $7.95.

Reviewed by Terry E. Schmidt, Director, Tiara Observatory

This book can be considered light reading on some current astronomical investigations that have created mysteries of their own both for observationalists and theorists. Although only forty-three pages of the book are devoted solely to the topics presented in its title, they are done well with opposing views being aired without bias.

The first nine chapters lay an historical background for the layman regarding astronomy in general and radio astronomy in particular. Seeing that radio astronomy is the basis for the research in the following chapters, the author's course was a wise one. Discovery techniques are emphasized, and humorous asides are well noted. Omissions of any kind are hard or impossible to note due to the nature of the writing. No book can be all things to all people, even in a tome with a million pages.

The treatment of the three main subjects mentioned in the title of the book is done with a fairly even hand. The answers that fit the observations appear to apply to pulsars only - as rapidly rotating neutron stars with their accompanying phenomena. Quasars and Black Holes still pose problems of interpretation for which man can not fully account. The questions relating to these two research problems appear to have their answers hinged on whether or not one feels that Einstein's laws of relativity can or can not be broken in the known universe. With this thought in mind, it can truly be said that a present day researcher in this field "hangs on the horns of a dilemma"!

The final chapter, entitled "The Fate of the Universe," is a flight into the realm of science fiction. Yet, like the TV show "Star Trek," there is much fact interwoven with the fiction, making the story all the more real to the mind. Here the Big Bang and Steady State universe people clash face to face. The concept of "superspace" is discussed, which enters the area of multiple stages of time and space. Whether our universe as we know it continues to expand into infinity or at some time in the future contracts upon itself to oblivion (or to repeat the cycle over and over again) is a moot question at best. But, like the proverbial mountain, man will continue to ask the questions and to seek the answers.

Errors are hard to find in the book, which is refreshing. On page 64 the author states - "It is the asteroid belt, which is also the presumable source of most meteors." The currently accepted view is that most sporadic meteors and meteor showers have their origins from cometary bodies. On page 21 mention is made of refractors as being restricted in size mainly due to the extreme absorption encountered by the inbound light. The mechanical requirements of the sagging of large lens elements due to gravity and the plastic nature of glass materials should have been included as the primary restrictions in large refractor design.

The reviewer found the book enjoyable. A layman, interested in astronomy or not, will find the book easy to read and enjoyable in content. The expert wishing to know more about the technical side of the research will not find his answers here. For those wishing a general survey on three frontiers of current astronomy, this book will fulfill the need. The questions are asked, but it must be remembered that not all of the answers are in yet.

Russell W. Porter - Arctic Explorer, Artist, Telescope Maker, by Berton C. Willard. The Bond Wheelwright Co., Freeport, Maine, 1976. 274 pages. Price $12.50.

Reviewed by Terry E. Schmidt, Director, Tiara Observatory

Russell Williams Porter has been a legend to the amateur telescope making community for many years and with much justification. He was born on December 13, 1871 and died on February 22, 1949. Numbers of this nature will mark the final resting place for all of us, but they tell nothing of the lives touched by the person behind the numbers. Berton Willard has tried to lend some meaning to the numbers. He starts the tale with the scant knowledge of Porter's childhood and leads the reader quickly to the "Arctic Fever" which consumed Porter until at least 1906. Porter had been a member of a number of expeditions which unsuccessfully had tried to reach the North Pole. The hardships of polar life are well depicted, and you acquire a feeling of kinship for men who try to go where no man has gone before. The remainder of the book deals with Porter's abiding interest in amateur telescope making, sundials, the rites of Stellafane, the detailed drawings made for the 200" telescope project, his war efforts (WWII), and the spirit of a man filled with the joy of living and doing.

Although the author is an ATM, he did not know Porter personally. Therefore, the book is based on the surviving records and personal interviews of those who did know Porter personally. This method of writing a biography inevitably leaves certain gaps in the record and also lacks a personal equation of intimacy which adds color to the life of any man. However, the book had to be written regardless of any lack because Porter was the man that he was. Without shining examples for men of all nations to follow, life would become a rather boring existence. Porter provided this type of example for all to follow.

One aspect of Porter's life which has never before had the shining spotlight of history focussed on it was his paintings and drawings. Almost everyone in the astronomical community knows well of his cutaway drawings for the 200" Palomar telescope and admires the ability responsible for making these drawings from blueprints alone. Yet Porter also did sketches and water colors of great skill and beauty of everything around him, from polar landscapes and Eskimos to ATM projects and cartoons. Fifty-nine sketches and paintings are illustrated in the book, showing what a true artist Porter was. Curators anywhere in the world would be proud to hang Porter originals. Sixty-nine photos are also included, showing much of Porter's activities in many different surroundings.

As "Stellar Fane," contracted to "Stellafane," means "Shrine to the Stars," this book will become the shrine to the genius of Russell W. Porter. If you like a good biography, you will like this book. If you have an interest in astronomy, you will not want to put the book down until all has been read.

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Modern Astronomy, edited by Patrick Moore. W.W. Norton and Company, 500 Fifth Ave., New York, N.Y. 10036. 1977. 184 pages. Illustrated. Price $9.95.

Reviewed by Bruce M. Frank

Modern Astronomy is a compendium of articles which previously appeared in Patrick Moore's Astronomy Yearbook series. As Mr. Moore states in the preface, the selection had to be made from "an embarrassment of riches." However, as the content list shows, there is "something for everybody." The 18 articles contained therein provide the reader with a tantalizing sample from the Yearbooks, ranging from historical observations of Mercurian transits to discussing the composition of Seyfert galaxies. Where appropriate, Mr. Moore has added addenda and footnotes to incorporate the latest findings into several of the older articles.

The first section of the book, History and Instruments, contains information of practical interest to amateur astronomers such as estimating seeing conditions and listing the advantages of a run-off roof observatory. The other sections, in turn, review current research findings pertaining to the Solar System, stellar development, and the composition of our galaxy and other galaxies. All articles are written for the informed layman. Each is liberally illustrated with photos and line drawings, and mathematical terminology is kept to a minimum.

While the caliber of the articles is generally top-notch, there are several features of the book that one should consider in deciding whether to buy it. The major consideration has to be that no new articles are included in the collection. All are reprints, and anyone who purchases the Yearbooks annually would probably not want to purchase Modern Astronomy. In addition, the price is rather high for a collection of reprinted articles. Finally, what one would think would be popular subject areas to review are conspicuously absent. For example, the section on the Solar System contains nothing on the latest discoveries by unmanned spacecraft for Mercury, Venus, and Mars. Considering the scientific importance of these findings, it is reasonable to expect that some coverage would have been provided.

In sum, for those who have not read the articles previously, or who have read them before but would like a consolidated set for their personal library, Modern Astronomy should provide enjoyable reading on a cloudy evening.

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Black Holes, Quasars, and the Universe, by Harry L. Shipman. Houghton Mifflin Company, Boston, MA, 1976. 309 pages. Price $12.95 cloth, $5.95 paper.

Reviewed by Dr. Julius L. Benton, Jr.

Upon scanning the first few pages of Shipman's rather lucid text, the reader realizes that he is about to embark upon a journey into the depths of a violent, evolving universe. After examining several basic astronomical terms and concepts and following a few introductory remarks concerning scientific insight into modern astronomical discoveries, the reader becomes gradually acquainted in five chapters (Part One) with various stages of stellar evolution, white dwarfs, novas and supernovas, pulsars, and black holes. Two interesting chapters on the search for black holes and current research are most informative. Part One of the book ends with a short summary in order to emphasize necessary points for continued reading.

The next six chapters deal with galaxies and quasars, in which a discussion proceeds on our Milky Way galaxy, galactic forms and groups, active galaxies, and finally quasars. The reviewer was most impressed with the chapters dealing with energy sources for quasars, and notes on alternative interpretations of the redshift made absorbing reading. Part Two of the book comes to a close with a summary of pertinent information and notes on how to interpret the material in the foregoing chapters; that is, how the topics can be differentiated into observational fact, concrete theory, informed opinion, or pure speculation.

The third portion of Shipman's book is composed of four good chapters on the universe as a whole, its evolution, and the cosmic time scale, followed by a number of considerations dealing with the Big Bang theory and discussion of the presumed relics of the creative event. The future of our universe is discussed intelligently, with a few points on the demise of the Steady State theory clarified for the reader. The critical summary, similar to the previous compilations at the close of foregoing parts of the book, is most useful.

The book comes to a close with an extremely helpful glossary, suggestions for further reading by chapter, references, and a good index.

The black-and-white photographs and illustrative diagrams are quite good and serve their purpose well. The present reviewer would like to have seen more photographs to accompany discussions; but it is likely that they would have increased the cost of the book prohibitively, especially if color was introduced.

The text is relatively free of typing errors and misprints, and practically no factual misrepresentations occurred to this reader. One blunder, however, needs to be mentioned in connection with the wording of the first sentence of the caption for Figure 16-1 on page 268. It is erroneous to assume that a rocket would have to "escape from the earth's gravitational field" to get to the moon!

Shipman's book, while being intended largely for the general non-science student in most undergraduate institutions, does appear to lend itself as a possibly useful parallel reading source for practically any introductory or two-semester astronomy course. All too frequently it is found that most astronomical texts tend to leave out many of the interesting details surrounding black holes, pulsars, and quasars, presumably due to the fact that one is dealing with a field of intense progressive research at the time of writing a given volume. Yet, even though the field is in rapid flux, the need for such an account for the general reader at the college level is not to be disputed. The present reviewer highly recommends the text for the student of astronomy or space science, the non-science major who wants a hint of current research in cosmology and cosmogony, or the more casual reader interested in science and space. Amateur astronomers in particular should find Shipman's book a real asset to their library holdings.

[Note by Editor. Book Review Editor J. Russell Smith and overall Editor Haas hope that the book review feature of this journal is interesting and useful to our readers and welcome constructive criticisms and discussions as to how it can be improved.]

AN UPDATE ON SOUTH EQUATORIAL BELT DISTURBANCE ANALYSIS, PART ONE.

By: Ron Doel, A.L.P.O. Assistant Jupiter Recorder

Abstract. The history, characteristics, and normal development of major South Equatorial Belt Disturbances on Jupiter are summarized. The apparent periodic nature of these events and their relations to activity in other belts and zones of Jupiter are examined. Thus SEB Disturbances may be only part of a planet-wide activity pattern with a cycle of three years. The text and illustrations in Mr. Budine's report on pages 217-231 of this issue will help to exemplify much of the discussion.

If you had the opportunity to observe Jupiter sometime during the 1975-76 apparition, you were probably one of those treated to the fourteenth known eruption of Jupiter's South Equatorial Belt. This event began early in July, when a large white oval--visible in red light though impossible to see in blue--burst through the bright ammonia clouds into the tenacious atmosphere overlying the South Equatorial Belt Zone (SEB Z). Caught there in the prevailing winds, the oval slowly embarked northward across the SEB_n. Few people were aware of it then; the main eruptions had not yet ignited. However, a photograph with the New Mexico State University Observatory 24-inch reflector on July 5, 1975 revealed to Elmer Reese a tightly concentrated knot of reddish material growing behind the bright oval. The Disturbance had officially begun. It soon elongated into a conspicuous crimson festoon, spanning the pale blue SEB_s and its wide, reddish northern component. By July 10, dark spots were retrograding relative to System II in the slower-moving SEB_s current, while similar spots were advancing steadily, in the direction of decreasing longitude, in the far swifter current overlying the SEB_n. As the prevailing winds of the SEB Z carried this festoon away from the seat of the eruption, another blot of red appeared, setting the sequence in motion again. On the far side of the planet, another eruption was beginning to take shape. In early August, observers noticed a second Disturbance forming and then, unprecedentedly, a third. By mid-September the SEB was wreathed in turmoil, impregnated by dusky barges, sections, spots, rods, and myriad white ovals. Then all too soon the activity ebbed, just as was expected. Most SEB Disturbances have rarely lingered on the planet for more than two or three months.

Fortunately, such spectacles are hardly random occurrences. In both 1943 and 1971, twin SEB Disturbances erupted almost simultaneously, each issuing from two "sources" beneath the atmosphere which are now known to be reasonably predictable. Elmer Reese discovered this fact by plotting the longitudes of every observed outbreak on to a graph of System II--and found that every Disturbance but one could be related to two sub-atmospheric "vents," each rotating with a constant period of $9^h\ 55^m\ 41^s\!.6$.[1] His graph also revealed that "major" Disturbances--exceptionally dusky, long-lived events--concentrated along the first of the plots. This source became known as Source Line A. The more minor eruptions, including the secondary outbreaks in '43 and '71, fell along the second plotted line. The rotational plane of these vents, sometimes called System III, lags behind System II by fully two seconds every revolution and corresponds with no known features in the atmosphere. And recently, the one eruption defying Reese's hypothesis lost its uniqueness: the coördinates of Disturbance 1975C matched its position precisely. Thus, we may well suspect that there are three vents active now.

Phillip Budine has further revealed that every recorded SEB Disturbance blossomed near the System II longitude of an adjoining streak or disturbance in the STrZ which had faded or disappeared.[2] His studies indicate that a fresh SEB Disturbance invariably begins within a year of the fade-out of the STrZ feature, a correlation so precise that Budine suspects astronomers probably missed an SEB Disturbance in 1968 because the appearance of the 1967 STrZ Sectional Disturbance seemingly then triggered no response in the SEB!

Even more interesting, new evidence suggests that the STrZ is merely one among a score of belts thrown into upheaval by SEB Disturbances. Wynn Wacker recently disclosed that the Red Spot has undergone quite abrupt changes in its rotational period several times prior to major Disturbances.[3] He also found that in the year following every eruption of the SEB he's been able to study, the Equatorial Zone (E.Z.) became greatly agitated, filling with amorphous regions of ovals, condensations, and sections, variously described as "orange, brick-red, coppery brown and yellow brown"[4] in color. Within twelve months, he noted, this activity tapers off, its color often tending towards blue. Dark, rapidly-moving spots are likely to be found during this second post-Disturbance year along the NTB_s and the $NNTB_s$--markings which often persist for several years. Wacker coined a term for these events: "Large-Scale Zenological Disturbances."[5]

If such zenological disturbances are indeed systems covering both the equatorial and tropical regions of the Jovian atmosphere, we might be tempted to inquire whether symmetry between the hemispheres exists. Have analogous events occurred in the NEB?

Indeed they have--Wacker has documented three *NEB* eruptions, flaring in 1893, 1906, and 1912.[6] These NEB Disturbances mirrored *their* contemporary southern counterparts in almost every way, first appearing as small and intensely dark concentrations in the latitude of the NEB_n, eventually diffusing across the NEB Z, shading it, and producing spots along the NEB_s. The records of the B.A.A.'s Jupiter Section clearly show that the NEB fluctuated in the beginning of the present century much like the SEB does today. Several observers in 1894 were wondering, in fact, whether periods of activity were reciprocal between the SEB and NEB.[7] Three quarters of a century later, it's their hunch which now appears to be most correct.

South Equatorial Belt Disturbances occurred in 1919, 1928, 1937, 1943 (A and B), 1949, 1952, 1955, 1958, 1962, 1964, 1971 (A and B), and, of course, 1975 A, B, and C. A very minor Disturbance also occurred in 1948. If you look just at the years when full SEB Disturbances took place, you discover what has perplexed many a Jovian astronomer: an uncomfortable lapse of nine years between events until 1943, followed by a wobbly three-year cycle continuing into the present day. But we can now add a few more pieces to the puzzle. Budine noticed that the Red Spot appeared unusually prominent prior to every recorded SEB Disturbance, and decided to check further. He then found that the Spot's intensity was *just as strong* every third year in the cycle, even when SEB eruptions failed to occur--or at least, were not *observed* to be occurring.[8] Coincidentally, or perhaps not, Wacker's zenological pattern also unfolds on a three-year timetable.

My own research suggests that the best *modus operandi* for SEB Disturbances comes from viewing events in both the South and North Equatorial Belts as related over time. Zenological events appear to be interspaced by roughly three years since the beginning of recorded observations--and this relation probably confirms the suspicions of those nineteenth century observers that events in these regions *are* interrelated. In the apparition of 1892, they noted small round reddish spots forming in the SEB Z, but these spots disappeared before the activity developed into a true Disturbance.[9] Unusual features nevertheless began multiplying in the E.Z. the year after, its color warming from a whitish-yellow to deep red. Soon afterward, the first recorded NEB Disturbance rocketed above the clouds, persisting for nearly an entire apparition before finally waning in the year following. Two years of quiescence went by before the SEB reddened again in a partial display of restlessness. This three-year cycle persisted until the 1906 NEB Disturbance--and at no time did the SEB approach invisibility as it often has recently.[10] The STrZ Disturbance, which first made its appearance on the planet in 1901, appeared to temper SEB activity for a while. Although it never lost prominence, the SEB remained brown in most regions, except where it ran adjacent to the preceding edge of the STrZ Disturbance. Here it appeared to be red.[11]

With the STrZ Disturbance dominating Jupiter's southern hemisphere, no further outbreaks occurred until 1912, the year of the third NEB Disturbance. It's a good bet that both the 1906 and 1912 NEB eruptions were zenological by Wacker's definition of sequential activity. Jupiter's E.Z. darkened after the 1906 Disturbance. In 1912, like 1906, the general consensus of the E.Z. was "bright."[12] And similarly, one year later, these observers would agree again: duskiness had invaded the region.

Because of inadequate records, other events on Wacker's timetables could not be positively credited or disputed. Yet when SEB Disturbances in 1919 and again in 1928 broke loose, E.Z. patterns of upheaval once more became evident. Following the 1919 event, large portions of the E.Z. became strongly shaded.[13] Particularly intriguing were the descriptions by Hargreaves and Phillips in 1928, observing from Great Britain, who both noticed a large veil of intense blue invading an already tormented Equatorial Zone. Phillips wrote of a very distinct green tint in the E.Z.--then recorded also a very red SEB.[14] But was it really green? In deference to past observations, it's tempting to consider the SEB "reds" and EZ "blues" as real coloration, and the green tint simply a blend of the former colors--either at the telescope or actually in Jupiter's atmosphere.[15]

Returning to our history: after sequential activity wound down in the NEB, the only outstanding SEB activity remained the reddish material at the base of the STrZ Disturbance. In 1915, when our current timetables would have predicted an eruption, observers merely commented on the redness of the SEB in the vicinity of the Disturbance.

Gradually the post-NEB eruption period of unsettledness showed signs of breaking. The amorphous gray STrZ enigma began diminishing in 1918. That same year saw a red streak developing in the NEB. By 1919 it would be the widest and most distinct feature in the Jovian atmosphere. The E.Z. wore scarlet, and in that same year the first recorded SEB eruption took place.

Though a revival of the STrZ Disturbance appeared ready to ransack the SEB region again, observers were still able to record red protuberances in the SEB in 1925--exactly three years prior to the next "official" SEB Disturbance. The E.Z. in that same year faded from "white," becoming "dull."[17] Pausing to retrace this cycle in the opposite direction, we find that the pattern remains the same: three years after the classic 1919 SEB eruption, observers continued to note the now fading NEB red streak. Reddish coloration and perturbed regions in either the North or South Equatorial Belts have been seen just about every third year since.[18]

Jupiter's Equatorial Zone activity is remarkably similar to the eruptions of Old Faithful Geyser at Yellowstone. When a display there is both high and lengthy, the next event occurs later than when the eruption peaks low or is fairly short-lived. There appears to be an analogy here with Jupiter, the only difference being that the variable is not the length of time between outbursts, for this appears to be fairly constant, but instead the magnitude of the eruptions. Ordinarily (excluding, for example, a concurrent STrZ Disturbance), the SEB remains calm and clear until the three-year cycle calls for a disturbance. If this pattern is disturbed--and in many years such appears to have happened--the "eruption" reveals itself either as restricted activity during the entire cycle, severely curtailed events every three years, or, in rare instances, little or no activity at all--followed afterwards by a phenomenal outpouring. The triple S.E.B. Disturbance of 1975 is a good example of the latter.

The System II longitudes of the intensely dark SEB red spots in 1892 matched rather nicely with Source Line A. Unfortunately, a lack of sufficiently precise records frustrated my efforts to compare the longitudes of the initial condensations of the three NEB Disturbances with the three source lines. It is interesting to note, however, that the "NEB revival" which Paul Mackal wrote about in 1971 surfaced in the neighborhood of Source Line A--and peaked in the same month as Disturbance 1971A![19] In any case, the evidence we now have lends strong support to the idea that SEB Disturbances are but one manifestation of large-scale activity patterns, operating in balance over three-year intervals.

It appears surprising that we've yet to witness an "NTrZ Disturbance." But if we remember that our observations of Jupiter on the cosmological clock have lasted for mere seconds of time, we realize the necessity of considering this mystery in the widest possible perspective. Such activity may indeed occur on a timetable extending over many hundreds or thousands of years--patterns which our tightly lumped mass of observations can give only vague hints of, like the three blind men examining the elephant.*

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*Happily, we were not obliged to wait quite that long. A.L.P.O.'s Richard Hull observed the first recorded NTrZ Disturbance on October 4, 1975, a discovery confirmed by Jupiter Recorder Phillip Budine.[20] Its coördinates placed it within a degree of Source Line A. See J.A.L.P.O., Vol. 25, Nos. 11-12, pg. 258 and Mr. Budine's report in the present issue, pages 230 and 231.

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Postscript by Editor. Mr. Doel has promised us a sequel to this paper; in Part Two he will consider the formation and physical development of S.E.B. Disturbances.

ANNOUNCEMENTS

Future Meeting of International Union of Amateur Astronomers. This body will hold its 4th General Assembly in Dublin, Ireland during August, 1978. Both professionals and amateurs are invited to attend and to participate. It is hoped that delegates from national and regional societies will represent their groups. The five-day gathering will include commission meetings, paper sessions, tours, and a closing banquet. Further information, including program timetable, accommodation arrangements, and admission forms, is available on request from the Assembly Secretary, 26 Cedarwood Park, Ballymun, Dublin 11, Ireland. For general information and for business correspondence, please write to the Secretary for the Americas, 135 West 18th St., Hamilton, Ontario L9C 4G3, Canada.

The material above was communicated by Dr. Kennedy J. O'Brien of St. John's, Newfoundland, Canada.

New Address for Ron Doel. This Assistant Jupiter Recorder now receives his mail at 9 Delwood Road, Cherry Hill, New Jersey 08002.

Change in Comets Section Staff. We have just appointed as a new Assistant Comets Recorder Mr. Derek Wallentine, 3131 Quincy N.E., Albuquerque, NM 87110. Mr. Milon and Mr. Wallentine will divide the work of the Section. It is intended that the new Assistant Recorder will work up reports on recently observed comets in our files. Mr. Wallentine has already been very active in the Minor Planets Section, particularly in the accurate visual photometry of these bodies.

Directory of Western Astronomy Clubs. Miss June LoGuirato, 12200 Chapel Road, Clifton, Virginia 22024 has prepared a "Directory of Amateur Astronomy Clubs in the Dakotas, the Rocky Mountains and the Far West." She made this survey as a project of the Astronomical League. An address is given for each society listed. While the directory is known to be incomplete, many of the persons and groups contacted having failed to return the survey circular, the directory will certainly be useful to anyone concerned with amateur astronomy clubs in the region surveyed (enhanced, we note, by Guam and the Philippines).

A wire should be soldered between the lower ends of R_1 and C_2 and top ends of C_1 and L_1 .

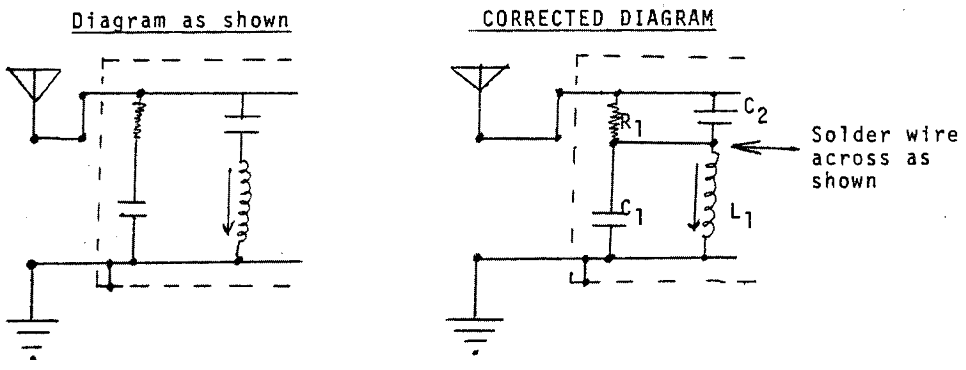

Figure 30. Correction to diagram on page 46 of book *Observe and Understand the Sun*. Contributed by Mr. Russell C. Maag.

Correction to Erroneous Diagram in a Book Previously Reviewed. Russell C. Maag expresses his appreciation for the review of the Astronomical League book, Observe and Understand the Sun, which appeared in this journal, Vol. 26, Nos. 9-10, pg. 204. He requested that we carry a correction to a faulty diagram in this book; the original diagram and the needed correction are reproduced in Figure 30. Mr. Maag is the Planetarium Coördinator of Misouri Western College at St. Joseph, Missouri.

AANC-NASA Joint Conference on Astronomy. The Astronomical Association of Northern California and NASA are sponsoring a joint conference on astronomy. The dates are Saturday, September 17, and Sunday, September 18, 1977. The place is the Ames Research Laboratories at Mountain View, CA. NASA speakers will present up to the minute reports on such subjects as the recent discovery of the rings of Uranus and the upcoming probe to Venus. An unusual door prize will be a free passage on an 11-day total solar eclipse cruise, which will view the eclipse of October 12, 1977, off the west coast of Mexico. Those interested in attending should pre-register at once with Denni Frerichs, 6154 Overdale, Oakland, CA 94605. Those wishing to present papers should send a short abstract only to Jerry Rattly, 185 Homestead Road, #2, Sunnyvale, CA 94087. The conference will include the usual exhibits, star parties, telescope displays, and banquet, and also awards to two outstanding amateur astronomers.

New Address for Comets Recorder. As of now, all correspondence to Mr. Dennis Milon, the Comets Recorder, should be addressed to 10 Colbert, Maynard, MA 01754.

Welcome Addition to Jupiter Section Staff. We are especially glad to announce the appointment of another Assistant Jupiter Recorder, namely, Dr. Joseph Ashbrook, 16 Summer St., Weston, Massachusetts 02193. Dr. Ashbrook has helped the A.L.P.O. frequently over the years, and our longtime readers will remember papers he has authored. He will be in charge of the program of accurate timings of eclipse disappearances and reappearances of the four large satellites of Jupiter. This project is described by Dr. Ashbrook in this issue on pages 233-235, and A.L.P.O. members are most cordially invited to participate and to follow the guidelines given in that article.

The duties and responsibilities of the other Jupiter Recorders and Assistant Recorders remain unchanged.

Addition to Minor Planets Section Staff. Our hard-working Minor Planets Recorder, Reverend Richard Hodgson, now has an Assistant Recorder, namely, Dr. Frederick Pilcher, Illinois College, Jacksonville, IL 62650. Our thanks go to Dr. Pilcher for his helpfulness in accepting this A.L.P.O. staff appointment.

Sustaining Members and Sponsors. The persons listed below support the work of the A.L.P.O. by paying higher dues, $30 per volume for Sponsors and $15 per volume for Sustaining Members. The generous assistance of these colleagues has been, and is, most valuable.

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New Associate Director. At the annual A.L.P.O. Business Meeting at Boulder, Colorado on August 12, 1977, Dr. John E. Westfall was elected to the new post of Associate Director.

OBSERVATIONS AND COMMENTS

More on the Curious Lunar Valley. Mr. Rodger W. Gordon of Nazareth, PA communicated on June 15, 1977 an interesting sequel to Mr. Alika Herring's "curious lunar valley" article (Journal A.L.P.O., Vol. 26, Nos. 9-10, pp. 209-211). The article reminded him forcibly that he had seen this very same feature on either May 25 or 26, 1977 (U.T. date) without realizing its unusual nature. He was using a 3.5-inch Questar at 80X, showing the whole Moon with a 50° apparent field. The feature was obvious, perhaps in large part because the eyepiece used did show the entire Moon. The observer recorded nothing at the time--he was just enjoying some lunar gazing. Perhaps the low power is a clue to why the

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As will be realized, the content coverage of the journal is far too large and beyond the scope of this sheet to cover adequately. However with what has already been described together with the subjects listed below, an insight into the journals subject coverage can be gained. Usually, every issue contains some items on the above and below mentioned subjects.

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feature is not better known --active lunar observers would usually employ higher powers.

Mr. Gordon points out that there is a fair view of this feature, much less striking than in his visual observation, in Kopal's Photographic Atlas of the Moon, Plate VI, taken on August 18, 1961 at 20^h13^m, U.T., colongitude $0^{\circ}.14$.

Opportunities for Magnitude Estimates of Periodic Comet Arend - Rigaux. Using the elements on IAUC 3034, Assistant Comets Recorder Derek Wallentine has computed three marginal passes of this comet through AAVSO fields, as follows:

Variable R FOR, 0224-26.b and d charts. October 30, 1977. Position R.A. = $2^h27^m.7$, DEC. = -26°19'. Separation 41', position angle 314°.

Variable W TAU, 0422 + 15. d chart. February 28, 1978. Position R.A. = $4^h25^m.1$, DEC. = +15°56'. Separation 37', position angle 315°.

Variable CQ TAU, 0529 + 24. d chart. March 23, 1978. Position R.A. = $5^h32^m.9$, DEC. = +24°43'. Separation 32', position angle 176°.

The comet will be at opposition on November 1, 1977 and will then be as bright as 12-13 total magnitude, according to Dr. Marsden. The closest approach to the Earth will occur in early December at about 0.831 Astronomical Units. Perihelion on February 2, 1978 will find the comet 1.442 AU's from the Sun and about 0.961 AU's from the Earth.

Periodic Comet Grigg-Skjellerup 1977 b. Mr. Charles S. Morris of metropolitan Boston reports three observations, given below. The degree of condensation is on a scale of 0 = diffuse to 9 = stellar.

Date (U.T.)	Stellar Magnitude	Coma Diameter	Degree of Condensation	Instrument
1977, April 18.36	10.2*	3'	2	15-cm. f/4 refl., 48X
April 19.36	about 10.0	?	?	"
April 30.34	9.8*	3-4'	1	"
April 30.34	9.3*	6'	1	20X80 binoculars

*Used AAVSO charts to make estimate.

Some Statistics for Features on Venus. Dr. James C. Bartlett of Baltimore, Maryland is a very longtime member of the A.L.P.O. and a former Venus Recorder. In a letter dated January 23, 1977 he included some interesting statistical data on his extensive personal observations of Venus. He has found the most readily visible features to be the two cusp-caps. Moreover, the two caps are more apt to be seen together than separately. In 303 observations over the interval 1944-1976 Dr. Bartlett found the following:

Cusp-caps invisible for 38.6% of the observations.
Both caps visible for 38.9% of the observations.
South cap alone visible for 17.2% of the observations.
North cap alone visible for 5.3% of the observations.

Stressing the vagueness and difficulty of Venusian surface features other than the cusp-caps, Dr. Bartlett still considers that genuine (non-illusory) detail exists. An analysis of 307 observations from 1944 to 1976 yielded these results:

Markings absent for 58% of the observations.
Markings present for 42% of the observations.
When markings were present, the types could be analyzed as follows:
Streak-like decail for 45% of the observations.
Mare-like detail for 35% of the observations.
Both kinds of detail for 20% of the observations.

Dr. Bartlett further found that the "Ashen Light," the luminescence of the unilluminated hemisphere of Venus, was recorded in 12% of 322 observations over the period 1944-1977. Since this phenomenon is chiefly detected when Venus is a narrow crescent, the Editor would opine that this figure tells us little without more knowledge of the 322 observations by phase.

Dr. Bartlett further wrote: "An even more convincing indication of objective reality in the Venusian markings, whatever their true nature, is the undoubted return of the same marking at irregular intervals. Thus of 200 observations of markings, 50, or 25%, were of apparent returns of the same marking or group of markings. This would strongly indicate the permanent character of some of the markings, though not necessarily that they are surface features; atmospheric patterns which were determined by underlying surface features would show periodic returns."

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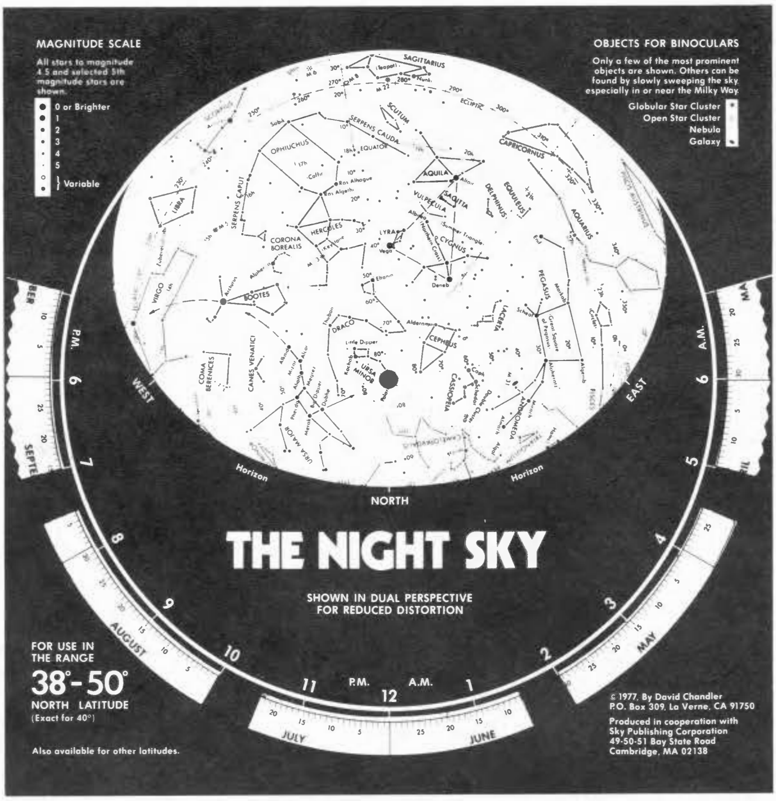

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HINTS ON LEARNING THE NIGHT SKY

□ To help preserve your eyes' adaption to the dark, avoid white light. Star charts should be read with a small flashlight covered with red cellophane. □ Learn each constellation in relation to its neighbors. Each can serve as a stepping stone to the next. □ Very few constellations look like their namesakes. Don't worry about seeing Canis Minor as a dog or Andromeda as a beautiful girl. The ancients had vivid imaginations! The primary purpose of constellation figures is to help you recognize and remember permanent star patterns. Once you have identified the proper stars, use your own imagination. (What does Andromeda look like to you?) □ A number of other prominent star patterns, or "asterisms," are labeled in parentheses. These are not official constellations, but they are just as useful. □ Learn the brightest stars by name. These are "landmarks" in the sky that enable experienced observers to recognize groups of constellations at a glance. □ If you find a bright star out of place somewhere along the "ecliptic," you have probably found a planet. Mercury, Venus, Mars, Jupiter, and Saturn are usually as bright as first magnitude stars.