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# Strolling Astronomer 

## 

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A. L. P. O. staff members at Tenth A. L. P. O. Convention at Montreal, Quebec, September 1-3, 1962. Photograph by William E. Shawcross. Left to right: Phil Glaser, Jupiter Recorder; Clark Chapman, Lunar Training Program; Joel Goodman, Saturn Recorder; Walter Haas, Director-Editor; Ernst Both, Mars Recorder; Geoffrey Gaherty, Jr., Mercury Recorder; Kenneth Chalk, Lunar Meteor Search Recorder.

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By: Elmer J. Reese

This apparition was remarkable for the unusual aspect of Jupiter's equatorial region. The Equatorial Zone was extremely dusky and orange, while the latitudes normally occupied by the two components of the South Equatorial Belt were relatively clear and bright. A very dark and conspicuous belt was located in the normal latitude of the southern third of the Equatorial Zone. This belt will be referred to as the $E Z_{g} B$ in this report; however, some may prefer to identify the belt as an extremely northerly displaced $\mathrm{SEB}_{\mathrm{n}}$. The Equatorial Zone was a scone of great turmoil, with activity surpassing anything observed there since 1938. In higher latitudes, spot activity was about normal.

A record total of 6,515 central meridian transit observations was submitted by 47 observers. Nearly $66 \%$ of these transits (4,287) form usable drifts for 115 Jovian spots distributed in 10 different currents. The contributing observers are listed below by name and number of transits observed. More detail on telescopes and stations will be found in the list on pp. 89 and 90 of the March-April, 1962, Str. A.

| Anthenien | 8 | Glaser | 28 | Olivarez | 17 |
| :--- | ---: | :--- | ---: | :--- | ---: |
| Bartlett | 2 | Goodman | 17 | Osypowski | 27 |
| Bieda | 10 | Haas | 734 | Pope | 10 |
| Binder | 155 | Hartmann | 74 | Reese | 1731 |
| Brasch | 509 | Henderson | 2 | Ricker | 76 |
| Budine | 29 | Herring | 3 | Rost | 566 |
| Chalk | 2 | Hills | 271 | Sato | 1 |
| Chapman | 395 | Jamieson | 19 | Sitier | 71 |
| Cruikshank | 51 | Joldersma | 7 | Smith, J.R. | 24 |
| Cyrus | 114 | Komoda | 17 | Sneli | 204 |
| Emig | 12 | Low | 3 | Tompkins | 123 |
| Eyer | 32 | Maag | 6 | Wedge | 89 |
| Fallon | 13 | Meisel | 69 | Wend | 51 |
| Foukal | 2 | Melville | 97 | Wililiams | 4 |
| Gaherty | 514 | Milne | 5 | Zurze | 30 |
| Giffen | 17 | Milon | 274 |  |  |

The distribution of transit observations by month is as follows

| 1961 |  |  |  |  |  |
| :--- | ---: | :--- | ---: | :--- | ---: |
| February | 77 | June | 698 | October | 639 |
| March | 107 | July | 1050 | November | 434 |
| April | 90 | August | 1260 | December | 201 |
| May | 317 | September | 1598 | Jan., '62 | 44 |

In the tables which follow, the first column gives an identifying number or letter to each object. The second column indicates whether the object was dark ( $D$ ) or bright ( $W$ ) and whether the preceding end ( $p$ ), center ( $c$ ), or following end ( $f$ ) was being observed. The third column gives the first and last dates of observation; the fourth column, the longitudes on those dates. The fifth column gives the longitude at opposition, July 25, 1961. The seventh column indicates the number of degrees in longitude that the marking drifts in 30 days; the last column, the rotation period.
S. S. Temperate Current (SSTB and SSTeZ), System II

| No. Mark | Limiting Dates |  | Limiting L. | L. | Transits | Drift | Period |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 1 | Wc | Jun. 2-Aug 6 |  | $77^{\circ}-33^{\circ}$ | $41^{\circ}$ |  | 9 | $-20^{\circ} .3$ | $9: 55: 13$ |
| 2 | Dc | Sep. 2-Oct.23 | $80-35$ | $-\infty$ | 10 | -26.5 | $9: 55: 04$ |  |  |



Nos. 1 and 3 were small, intensely bright nodules on the N. edge of the SSTB. No. 3 underwent a slight but abrupt acceleration near October 9 when it was at 1 ongitude (II) $59^{\circ}$. Nos. 2,4 , and 6 were small, very dark condensations on the $N$. edge of the SSTB. No. 5 was the following end of a dark section of the SSTB $_{n}$.
S. Temperate Current (S. edge STB, STeZ), System II

| No. | Mark | Limiting Dates | Limiting L. | L. | Transits | Drift | Period |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| B | Wp | Mar. 25-Dec. 6 | $201^{\circ}-48^{\circ}$ | $132^{\circ}$ | 56 | $-17^{\circ} 9$ | 9:55:16 |
| 2 | Wc | Nar. 25-Dec. 6 | $211-57$ | 142 | 71 | -18.1 | 9:55:16 |
| C | Wf | Mar. 25-Dec. 6 | $221-67$ | 152 | 84 | -18.1 | 9:55:16 |
| 4 | Dc | May 19-Oct. 23 | 199-103 | 158 | 21 | -18.4 | 9:55:15 |
| 5 | Wp | May 3-Ju1. 7 | 228-181 | --- | 7 | -21.7 | 9:55:11 |
| 6 | Wp | Mar. 28-Sep. 12 | 284-148 | 189 | 16 | -24.3 | 9:55:07 |
| D | Wp | Mar. 12-Dec. 14 | 32-195 | 294 | 95 | -21.3 | 9:55:11 |
| 8 | Wc | Mar. 12-Dec. 14 | 41-205 | 304 | 102 | -21.2 | 9:55:12 |
| E | Wr | Mar. 12-Dec. 14 | 50-216 | 314 | 81 | -21.0 | 9:55:12 |
| 10 | Wp. | Ju1. 8-Nov. 30 | 346-249 | 335 | 8 | -20.1 | 9:55:13 |
| 11 | Wc | Jun. 19-Nov. 30 | 9-259 | 345 | 6 | -20.1 | 9:55:13 |
| F | Wp | Apr. 20-Dec. 28 | 62-253 | 354 | 34 | -20.1 | 9:55:13 |
| 13 | Wc | Apr. 20-Dec. 28 | $71-263$ | 3 | 34 | -20.0 | 9:55:13 |
| A | Wf | Apr. 20-Dec. 28 | 80-272 | 12 | 39 | -20.0 | 9:55:13 |

Mean rotation period: $9^{\mathrm{h}} \quad 55^{\mathrm{m}} 13^{\mathrm{s}} .0$
The three long-enduring white ovals on the south edge of the STB were well observed. The length of the ovals remained unchanged at about $18^{\circ}$ to $20^{\circ}$. DE was by far the most conspicuous of the three. FA was very faint and indistinct for several weeks as it passed south of the Red Spot. The center of the Red Spot was in conjunction with the center of DE on May 14, 1961 at longitude (II) $358^{\circ}$ and with the center of FA on July 28, 1961 at $1^{\circ}$. The closest approach of DE and FA probably occurred in early 1961 when Jupiter was too near the sun to be observed. In late Ngvember, 1960 the distance between their centers had decreased to about $50^{\circ}$. During 1961 the distance increased from $53^{\circ}$ to $68^{\circ}$.

No. 4 was a wide dusky column in the STeZ. No. 5 was the $p$. end of a brighter section of the $S_{T e} Z_{n}$. No. 6 was a similar feature in the $S_{T e Z}$. Nos. 10 and 11 pertained to a rather diffuse oval in the STeZ just'p. FA. At times this oval and FA appeared to overlap slightly.

The mean rotation period of the 5 . Temperate Current was lipngef thagn at any time since the apparition of $1939-40$ when 1 ts value was $95^{6} \quad 22^{s}$. Indeed, the oval BC was rotating so slowly that its period would have been a normal one for this current prior to the remarkable acceleration that began in 1940-41 when the long-enduring features made their first appearance. (The mean period of the S. Temperate Current was 9:55:09 in 194041, dropped to a minimum of 9:55:04 in 1944-45, slowly increased to 9:55: 12.5 in 1953-55, decreased again to 9:55:08 in 1957-58, and finally increased to its present value.) The rotation periods of the three longenduring ovals during the apparition of 1961-62 and between the oppositions of 1960 and 1961 are summarized below:

| BC | $9: 55: 16.0$ | $9: 55: 14.6$ |
| :--- | :--- | :--- |
| DE | $9: 55: 11.7$ | $9: 55: 11.7$ |
| FA | $9: 55: 13.2$ | $9: 55: 09.7$ |
|  |  |  |
| Mean | $9: 55: 13.6$ | $9: 55: 12.0$ |

Middle STB, System II

| No. | Mark | Limiting Dates |  | Limiting L. | L. | Transits | Drift | Period |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Dp | May 17-Dec. 6 | $190^{\circ}-63^{\circ}$ | $146^{\circ}$ | 58 | -18.8 | $9: 55: 15$ |  |
| 2 | Df | Apr. 7-Dec.25 | $17-190$ | 299 | 21 | -21.4 | $9: 55: 11$ |  |
| 3 | Df | Jun. 12-Dec.18 | $24-260$ | 357 | 41 | -19.7 | $9: 55: 14$ |  |

No. 1 was the $p$, end of a very much darker section of the STB. The dark section began under the following part of the oval BC. No. 2 was the $f$. end of a slightly darker section of the STB near the $p$. end of the oval DE. No. 3 was the $f$. end of a very much darker section of the STB near the $p$. end of FA. The motion of this striking feature was retarded for a time as it passed south of the Red Spot around July 20.

Red Spot, System II

| Mark | Limiting Dates | Limiting L. | $\underline{L}$ | Transits | Drift | Period |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| RSp | Feb. 11-Jan. 15 | $343^{\circ}-356^{\circ}$ | $349^{\circ}$ | 136 | $+1.15$ | 9:55:42 |
| RSc | Feb. 11-Jan. 15 | $355-9$ | 1 | 222 | +1.24 | 9:55:42 |
| RSf | Feb. 11-Jan. 15 | 7-22 | 1.4 | 156 | +1.33 | 9:55:43 |

Mean rotation period: $9^{\mathrm{h}} \quad 55^{\mathrm{m}} 42^{\mathrm{s}} \cdot 3$
The Red Spot continued to drift in the direction of increasing longitude during the apparition; however, the rate of drift seemed to be almost negligible during the first and last six weeks of the apparition. From Apri1 2, 1961 to December 4 , 1961 the drift was quite uniform at tbe rate of $+1^{\circ} .51$ every 30 days: $9^{h} 55^{\text {mi }} 42^{5} .7$. The period of the Red Spot between the oppositions of 1960 and 1961 was $9^{h} 55^{m} 42 \%$, the same as it was between the oppositions of 1959 and 1960.

The Red Spot was dark and conspicuous throughout the apparition. It appeared as an orange ellipse with a very dark border and a lighter interior. Visual transits gave the Spot a mean length of 25. Measures of five photographs taken by Pope, osypowski, and Glaser indicate a mean length of $25^{\circ} .6$. These figures are in good agreement and correspond to a length of about $18,000 \mathrm{miles}$.

$$
\text { N. edge } \mathrm{SEB}_{\mathbf{s}} \text {, SEB } Z \text {, System II }
$$

| No. Mark Limiting Dates | Limiting L. | L. | Transits | Drift | Period |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Dc | May 23-0ct. 30 | $296^{\circ}-310^{\circ}$ | $299^{\circ}$ | 13 | +2.6 | $9: 55: 44$ |
| 2 | Dc | May 23-Dec. 27 | $341-345$ | 342 | 22 | +0.5 | $9: 55: 41$ |

No. 1 was a very small and difficult object. It consisted of a tiny condensation on the north edge of the very faint SEB from which a delicate festoon extended across the SEB $Z$ to the $E Z_{s} B$. The drift of this interesting little mark was perfectly ligear from Nay 23 to August 8 while its longitude increased from $296^{\circ}$ to $300^{\circ}$. It was not seen again until September 11 at $310^{\circ}$. On September 24 if was at $313^{\circ}$, after which it slowly decreased in longitude and was at 310 when last seen on October 30.

No. 2 was a fairly easy object at times, but at other times it seems to have been quite faint. This mark was a rather complex dusky area located in the middle of the SEB $Z$ on or very near the preceding shoulder of the faintly outlined RSH. A dusky triangle with its base on the EZ $B$ and its apex at the SEB 2 spot was sometimes observed. The SEB $Z$ spot was sometimes seen as a small condensation, at other times as a larger dusky patch. A delicate wisp was occasionally seen connecting the spot to the preceding tip of the Red Spot (Str. A., Vol. 15, Nos. 11-12, Figures 14, 15, and 21).

South Equatorial Current (S. edge EZ $\mathrm{S}_{\mathrm{B}} \mathrm{B}$ ), System I

| No. | Mark | Limiting Dates | Limiting L. | L. | Transits | Drift | Period |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Dc | May 14-Aug. 7 | $5^{\circ}-22^{\circ}$ | $20^{\circ}$ | 30 | $+6.0$ | 9:50:38 |
| 1 a | Dc | Aug. 28-Nov. 26 | 22-26 | -- | 6 | $+1.3$ | 9:50:32 |
| 2 | Dc | May 3-Aug. 8 | 151-140 | 141 | 19 | - 3.4 | 9:50:25 |
| 3 | Dc | Jun. 4-Oct.13 | 175-170 | 171 | 18 | - 1.1 | 9:50:29 |
| 4 | Dc | May 26-Aug. 13 | 200-197 | 198 | 6 | - 1.1 | 9:50:29 |
| 5 | Dc | Aug. 4-0ct. 10 | 230-281 | --- | 24 | +22.8 | 9:51:01 |
| 6 | Dc | Sep, 12-Oct.12 | 232-257 | --- | 9 | +25.0 | 9:51:04 |
| 7 | Dc | Nov. 29-Dec. 22 | 326-341 | --- | 8 | +19.6 | 9:50:56 |
| 8 | Dc | May 22-Oct. 6 | 321-333 | 326 | 26 | $+2.6$ | 9:50:34 |
| 9 | Dc | Ju1. 10-Oct. 11 | 355-363 | 356 | 5 | $+2.6$ | 9:50:34 |
|  | Mean | rotation period | excluding | , | 7): $9^{\text {h }}$ | ${ }^{\text {m }} 31^{\text {s }}$ | EC-A) |

Mean rotation period of Nos. 5, 6, and 7: $9^{\mathrm{h}} 51^{\mathrm{m}} 00^{\mathrm{s}}$ (SEC-B)
These markings on the south edge of the conspicuous EZs Belt were clearly under the influence of the S. Equatorial Current. This fact is a strong point against the idea that the belt was really a northerly displaced SEB $n_{n}$. It was necessary to consider these spots independently of those in the next table in order to determine this very fact. It is evident that the spots in both tables belong to the $S$. Equatorial Current.

During July No. 1 was a remarkable object appearing as a very dark and conspicuous rectangular-shaped hump on the south edge of the EZ $B$. A thin faint belt undulated by a series of small ovals between itself and the $E Z{ }_{s}{ }^{B}$ was repeatedly seen to connect to the two southern corners of the rectangular hump. The dark rectangle occupied the "normal" latitude of the $\mathrm{SEB}_{n}$. No. la may have been a continuation of No. 1 after a slight acceleration in the motion of the latter. Projection No. 5 was very conspicuous from September 5 to 12. This projection was similar in appearance and latitude to some projections such as Nos. 2, 3, and 4; and yet No. 5 had a much slower rate of rotation. No. 7 may have been a continuation of No. 5 .

South Equatorial Current (N. edge EZs $B$ ), System I

| No. | Mark | Limiting Dates | Limiting L. | L. | Transits | Drift | Period |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Dc | Ju1. 22-Oct. 17 | $0^{\circ}-5^{\circ}$ | $0^{\circ}$ | 6 | $+1^{0} .7$ | 9:50:32 |
| 2 | Wc | May 14-Sep. 25 | 25-35 | 30 | 4 | $+2.2$ | 9:50:33 |
| 3 | Dc | Aug. 12-Nov. 25 | $45=45$ | -- | 8 | 0.0 | 9:50:30 |
| 4 | Dc | Sep. 9-Dec. 4 | 85-77 | -- | 14 | - 2.8 | 9:50:26 |
| 5 | Dc | Aug. 8-Sep. 11 | 105-103 | -- | 5 | - 1.8 | 9:50:28 |
| 6 | Dc | Aug. 8-Nov. 12 | 130-115 | -- | 11 | - 4.7 | 9:50:24 |
| 7 | Dc | Sep. 20-Dec. 30 | 148-162 | -- | 12 | $+4.2$ | 9:50:36 |
| 8 | Dc | Aug. 12-0ct. 23 | 175-175 | -- | 7 | 0.0 | 9:50:30 |
| 9 | Wc | Jun. 4-0ct. 23 | 187-187 | 180 | 11 | 0.0 | 9:50:30 |
| 10 | Dc | May 19-Dec. 22 | 198-200 | 192 | 19 | $+0.3$ | 9:50:30 |
| 11 | Dc | Ju1. 19-Sep. 24 | 225-218 | 225 | 8 | - 3.1 | 9:50:26 |
| 12 | Dc | Aug. 1-0ct. 9 | 254-238 |  | 11 | - 7.0 | 9:50:21 |
| 13 | Dc | Aug. 29-Nov. 24 | 273-273 | --- | 11 | 0.0 | 9:50:30 |
| 14 | Dc | Jul. 31-Sep. 29 | 305-305 | - | 9 | 0.0 | 9:50:30 |
| 15 | We | Ju1. 17-Dec. 14 | 338-348 | 338 | 7 | $+2.0$ | 9:50:33 |
| 16 | Dc | Ju1. 22-Sep. 6 | $347-347$ | 347 | 11 | 0.0 | 9:50:30 |

Mean rotation period: $9^{h} \quad 50^{m} 29^{\mathrm{s}}$
These objects were located in the southern part of the Equatorial Zone. The dark spots were condensations or southern bases of equatorial festoons or columns.

No. 16 probably coalesced with No. 1 near September 18.
North Equatorial Current (S. edge NEB, N. part EZ), System I

| No. | Mark | Limiting Dates | Limiting L. | 1. | Transits | Drift | Period |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Wc | Feb. 8-Jan. 14 | $349^{\circ}-356^{\circ}$ | $353^{\circ}$ | 59 | $+0.6$ | 9:50:31 |
| 2 | Dc | Feb. 8-Jan. 14 | $2-10$ | 3 | 87 | +0.7 | 9:50:31 |
| 3 | We | Mar. 17-Dec. 19 | 23-25 | 16 | 62 | +0.2 | 9:50:30 |
| 4 | Dc | Feb. 13-Dec. 19 | $34-41$ | 30 | 98 | +0.7 | 9:50:31 |
| 5 | Wc | Feb. 13-Dec. 7 | 47-60 | 50 | 52 | +1.3 | 9:50:32 |
| 6 | Dc | Feb. 27-Jan. 15 | 65-71 | 65 | 90 | +0.6 | 9:50:31 |
| 7 | Wc | Feb. 27-Jan. 15 | $81-85$ | 81 | 62 | $+0.4$ | 9:50:31 |
| 8 | DC | Feb. 27-Jan. 21 | 94-100 | 100 | 93 | +0.5 | 9:50:31 |
| 8 a | Wc | Feb. 27-Jan. 1 | 108-111 | 111 | 47 | $+0.3$ | 9:50:30 |
| 9 | Dc | Feb. 25-Jan. 17 | 118-122 | 120 | 95 | $+0.4$ | 9:50:31 |
| 11 | Wc | Mar. 25-Jan. 17 | 134-134 | 137 | 55 | 0.0 | 9:50:30 |
| 12 | Dc | Feb. 23-Dec. 30 | 149-156 | 150 | 109 | $+0.7$ | 9:50:31 |
| 13 | Wc | Feb. 23-Dec. 21 | 170-172 | 166 | 52 | $+0.2$ | 9:50:30 |
| 14 | Dc | Feb. 7-Jan. 2 | 184-191 | 181 | 120 | +0.6 | 9:50:31 |
| 15 | Wc | Feb. 7-Dec. 28 | 198-210 | 199 | 54 | +1.1 | 9:50:31 |
| 16 | Dc | Feb. 7-Dec. 28 | 208-232 | 218 | 105 | $+2.2$ | 9:50:33 |
| 17 | We | Feb, 27-Oct. 13 | 222-225 | 231 | 43 | +0.4 | 9:50:31 |
| 18 | Dc | Feb. 27-Dec. 19 | 230-244 | 244 | 102 | $+1.4$ | 9:50:32 |
| 19 | Wc | Mar. 19-Dec. 28 | 249-256 | 259 | 68 | $+0.7$ | 9:50:31 |
| 20 | Dc | Mar. 19-Jan. 27 | 264-273 | 270 | 109 | +0.8 | 9:50:31 |
| 21 | Wc | Mar. 19-Jan. 18 | 277-286 | 284 | 58 | +0.9 | 9:50:31 |
| 22 | Dc | Feb. 3-Jan. 18 | 284-302 | 299 | 104 | +1.5 | 9:50:32 |
| 23 | Wc | Mar. 26-0ct. 17 | 304-306 | 307 | 25 | +0.3 | 9:50:30 |
| 24 | Dc | Mar. 26-Dec. 17 | 315-315 | 314 | 57 | 0.0 | 9:50:30 |
| 25 | Wc | Mar. 22-Dec. 19 | 328-329 | 322 | 67 | +0.1 | 9:50:30 |
| 26 | Dc | Feb. 8-Jan. 14 | 340-345 | 339 | 107 | +0.4 | 9:50:31 |

Mean rotation period: $9^{\mathrm{h}} 50^{\mathrm{m}} 31 \mathrm{~s}$
Very rarely has Jupiter been adequately observed so near conjunction With the sun as it was in late 1960 and early 1961. As a result, it has been possible to identify with certainty many, if not all, of the North Equatorial Current objects observed during the present apparition with those seen during the previous apparition. The identifying numbers used in this report correspond with those used in the report for 1960 (Str. A., Vol. 15, p. 76).

No 2 divided into two parts near the middle of September and was still double when last seen late in the apparition. No 4 was a notably large, dark, and complex object from early July to late September. No. 8 faded considerably after September 7. At about this time the bright oral, 8a, disappeared and the dark projections, 8 and 9 , drew so close together that observers using smaller apertures usually recorded them as one large complex column in the $E Z_{n}$. The bright oval, 8a, reappeared late in November and shortly thereafter the two projections began to diverge. No. 14 was the most outstanding dark object on the south edge of the NEB throughout the apparition. There can be no reasonable doubt that this object was a continuation of No. 14 of 1960 , and it seems very probable that it was identical with No. 9 of 1959. The bright oval, l7, faded away in late September as the dark projections, 16 and 18 , drew closer together and blended into one huge dusky column in the northern part of the EZ. The bright oval, 23, gave way to a large dusky column near the middle of october. The dusky column included the converging projections, 22 and 24. No. 26 was an extremely conspicuous object (rivaling Nos. 4 and 14) from


FIGURE 1. Smoothed drift-lines of the centers of dark features on the south edge of the NEB of Jupiter, 195962. Graph constructed by Blmer J. Reese. Note the evidence for the survival of many of these features through two, and in part three, conjunctions of Jupiter with the sun. It is very probable that late-arriving observations made in early 1962 will shorten the gap caused by the 1962 conjunction with the sun and hence strengthen the evidence for long lives of these features.
early July to mid-October.
As this is being written in September, 1962, it appears certain that many of the long-enduring features in the N. Equatorial Current have persisted well into the apparition of 1962-63 (see Figure 1).

Middle NEB, System II

| 0. | Mark | miting D | Limiting L. | L. | ansits | Drift | Period |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Wc | 14-Sep. 26 | $15^{\circ}-330^{\circ}$ | $358{ }^{\circ}$ | 8 | $-13^{\circ} 0$ | 9:55:23 |
| 2 | fr | Ju1. 30-Sep. 12 | 11-340 |  |  | - 21.1 | 9:55:1 |

These marks may have been somewhat north of the middle of the NEB.

JUPITER, 1961
IHPORTANT FEATURES IN SYSTEM II


FIGURE 2. Drift-1ines for selected features in System II on Jupiter in 1961. Graph constructed by Elmer J. Reese. See also text of his article in this issue.

Sorth Tropical Current (N. edge NEB, NTrZ), System II

| No. | Mark | Limiting Dates | Limiting L. | $\underline{L}$ | Transits | Drift | Period |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Wc | Jun. 14-Sep. 24 | $32^{\circ}-7^{\circ}$ | $22^{\circ}$ | 20 | $-7.4$ | 9:55:31 |
| 2 | Dc | Jun. 29-Nov. 26 | 40-341 | 32 | 48 | -11.8 | 9:55:24 |
| 3 | Wc | Sep. 10-Dec. 1 | 30-359 | -- | 17 | -11.3 | 9:55:25 |
| 4 | Wc | Aug. 30-0ct. 9 | 48-37 | -- | 6 | - 8.3 | 9:55:29 |
| 5 | Wc | Apr. 30-Aug. 2 | 143-62 | 70 | 8 | -25.8 | 9:55:05 |
| 6 | Dc | Jun. 29-0ct. 18 | 127-113 | 124 | 16 | - 3.8 | 9:55:35 |
| 7 | Dp | Jun. 27-Dec. 9 | 194-147 | 187 | 9 | -8.6 | 9:55:29 |
| 8 | Dc | May 27-Aug. 23 | 269-231 | 243 | 5 | -12.9 | 9:55:23 |
| 9 | Wc | May 23-Dec. 25 | 280-187 | 253 | 122 | -12.9 | 9:55:23 |
| 10 | Dc | Feb. 3-Mar. 31 | 324-303 | --- | 5 | -11.3 | 9:55:25 |
| 11 | We | Jun. 21-Aug. 3 | $311-303$ | 305 | 5 | - 5.6 | 9:55:33 |
| 12 | Wc | Oct. 6-Nov. 26 | 338-326 | --- | 10 | - 7.1 | 9:55:31 |

Mean rotation period (vithout No. 5): $9^{h} 55^{m} 28^{s}$
No. 1 was a small bright notch in the N. edge of the NEB which at times was seen to be produced by a bright nodule extending out into the NTrZ. This object seems to have faded suddenly and completely on September 24. It was not seen on September 25 and 26 , or thereafter, although the dark condensation, No. 2, just folloving the notch continued to be clearly visible. No. 2 was sharply accelerated near September 27 when it vas at longitude $17^{\circ}$. Prior to this date its period was 9:55:30; afterwards it was 9:55:16. No. 5 was drifting very rapidly in decreasing longitude compared to other objects in this current. (It is not unusual for one or two spots in this current to possess periods as short as 9:55:05. See The Planet Jupiter, by B. M. Peek, p. 86. Fine examples of such rapidly moving spots were observed during the apparition of 1955-56. See Str. A., Vol. 11, p. 22.) No. 5 usually was recorded as a bright nodule in the NTTZ producing a shallow notch in the N. edge of the NEB. This spot seems to have disappeared before it overtook any of the slowermmoing objects preceding it; however, an extrapolation of its drift places it very near the longitudes where No. 1 faded, No. 2 became accelerated, and Nos. 3 and 4 made their appearance. The suggestion is very strong that No. 5 had a profound influence on the four spots preceding it.

No. 7 was the preceding end of a darker section of the NEB ${ }_{n}$. No. 9 was the most outstanding feature observed in this current during the apparition. It was a very brilliant notch or small bay in the north edge of the NEB. The notch had a longitudinal extent of about $7.3 \pm 2.0$ according to transit observations of its p. and f. ends. The drift of this object was remarkably linear throughout its observed life. (A small bright notch on the N. edfe of the NEB was observed three times from March 28 at $295^{\circ}$ to May 3 at $280^{\circ}$. This drift is parallel to, but displaced by about $8^{\text {b }}$ from, the extrapolated drift of No. 9 )
N. N. Temperate Current (NNTE), System II

| No. | Mark | Limiting Dates | Limiting L. | $\underline{1}$ | Transits | Drift | Period |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Dp | Apr. 20-Dec. 16 | 122 ${ }^{\circ}-114^{\circ}$ | $115^{\circ}$ | 71 | - 1.0 | 9:55:39 |
| 2 | Dc | Apr. 20-Dec. 16 | 130-125 | 127 | 64 | - 0.6 | 9:55:40 |
| 3 | Df | Jun. 29-Dec. 18 | $139-134$ | 139 | 36 | - 0.9 | 9:55:39 |
| 4 | Dp | May 31-Nov. 22 | 147-145 | 150 | 6 | $-0.3$ | 9:55:40 |
| 5 | Dc | Jun. 10-Sep. 13 | 155-163 | 159 | 11 | $+2.5$ | 9:55:44 |
| 6 | Df | Aug. 2-Sep. 25 | 168-171 | --- | 15 | $+1.7$ | 9:55:43 |
| 7 | Dc | May 17-Jul. 24 | 210-183 | -- | 7 | -11.9 | 9:55:24 |
| 8 | Dc | Ju1. 17-0ct. 17 | 205-183 | 204 | 16 | - 7.2 | 9:55:31 |
| 9 | Dp | Ju1. 7-Sep. 13 | 245-244 | 246 | 8 | -0.4 | 9:55:40 |
| 10 | Df | Aug. 8-Oct. 1 | 280-258 | --- | 9 | -12.2 | 9:55:24 |
| 11 | Dc | Apr. 19-Jun. 23 | 307-299 | --- | 9 | - 3.7 | 9:55:36 |
| 12 | Df | *ay 23-Jun. 23 | $311-306$ | --- | 6 | - 4.8 | 9:55:34 |

Mean rotation period (without Nos. 7 and 10): $9^{\text {h }} 55^{\mathrm{m}} 39^{\mathrm{s}}$
The objects listed above were described as lying on the NNTB, the south edge of the NNTB, or on the $\mathrm{NNTB}_{s}$.

Nos. 1, 2, and 3 pertained to a large dark rod on the NNTB. No. 8 was a small but very dark condensation on the south edge of the NNTB. No. 10 was the following end of a darker section of a belt sometimes recorded as the NNTB, and sometimes as the $\mathrm{NNTB}_{n}$. The drifts of Nos. 7 and 10 suggest that those objects were N.N.N. Temperate Current features.
N. N. N. Temperate Current (NNNTB), System II

| No. | Mark | Limiting Dates | Limiting L. | $\underline{L}$. | Transits | Drift | Period |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Dp | Sep. 24-Nov. 16 | $340^{\circ}-302^{\circ}$ | -- | 5 | -21:5 | 9:55:11 |
| 2 | Dc | Sep. 24-Nov. 16 | 351-311 | -- | 5 | -22.6 | 9:55:10 |
| 3 | Dp | Aug. 4-Sep. 17 | $61-39$ | ${ }^{\circ}$ | 3 | -15.0 | 9:55:20 |
| 4 | Dc | Jun. 29-0ct. 23 | $89-32$ | $76^{\circ}$ | 8 | -14.7 | 9:55:21 |
| 5 | Dp | May 27-Dec. 14 | 255-172 | 223 | 8 | -12.4 | 9:55:24 |
| 6 | Dc | Nay 27-Dec. 14 | 268-181 | 242 | 12 | -13.0 | 9:55:23 |
| 7 | Df | May 27-Dec. 14 | 280-190 | 261 | 9 | -13.4 | 9:55:22 |
| 8 | Dc | Ju1. 27-Sep. 11 | 285-260 | --- | 3 | -16.3 | 9:55:18 |

Mean rotation period (without Nos. 1 and 2): $9^{\mathrm{h}} 55^{\mathrm{m}} 21^{\mathrm{s}}$
The objects above were described as lying etther on the NNTB or the NNNTB. Latitude measures and rotation periods both indicate that the belt was actually the NNNTB.

## C. M. Transits of Satellites and their Shadows

Transits of Jovian satellites and their shadows across the apparent central meridian of the planet have been reported by 15 observers. A total of 52 transits was recorded from April 30, 1961 through October 12, 1961. These transits have confirmed previous indications that the observed time of transit is usually several minutes earlier than the predicted time. The mean longitudinal error corresponding to these differences in time is $-3^{\circ} \cdot 5$ with an average deviation of $\pm 2.0$. of the 52 transits recorded, only five were observed later than the predicted time. (See Str. A., Vol. 15, pp. 142-143 for an explanation of terms.)

The effect which phase exaggeration has on visual transit observations has also been confirmed. The observations are here divided into three groups according to Jupiter's position relative to the sun and earth:

> Mean Long. Error Average Deviation Transits

Nornine quadrature
$-5^{\circ} .7$
Opposition (i less than $3^{\circ}$ ) - 4.1
Evening Quadrature - 2.1
$\pm 2.0$
$\pm 1.6$ 12
$\pm 1.5$
14

This listine indicates mysterious systematic error of - 4.1 near opposition together with a systematic error caused by phase exaggeration amounting to 1.8 , which amount must be subtracted near morning quadrature and added near evening quadrature. The writer feels confident that the large systematic error near opposition does not apply to visual transits of surface features on the planet. On the other hand, the systematic error caused by phase exaggeration does apply to surface features. Visual transit-determined longitudes are systematically low near morning quadrature, and systematically high near evening quadrature. The value of this error given above is an average for a long interval on either side of the date of quadrature. A comparison of longitudes obtained by measuring good quality photographs of Jupiter with visual transit-determined
longitudes indicates that the error caused by phase exaggeration is about $3^{\circ}$ on the date of quadrature.

The only significant difference found when each satellite and its shadow was considered separately was that the longitudinal orror was consistently greater for satellite $I$ than for the other three satellites. Fortunately, the observations of satellite $I$ were well distributed in time; consequentiy the systematic errors of the four satellites combined are typical of those of each satellite considered separately.

Personal Equations in Transit Work
Three different groups of transit observations have been used in an investigation of the personal equations of various observers in transit work:

1. Center of Red Spot, 222 transits, 35 observers: Since the motion of the Red Spot did not seem to be uniform enough to justify the comparison of individual observations to a least squares line, the apparition was divided into intervals of twelve or more days and the mean of all longitudes observed during each interval was adopted as the true longitude during that interval (see Table 1 later in this paper). Next, the observed differences in longitude (observed - adopted mean) were listed for each observer for the entire apparition. The mean of these observed differences (with regard to sign) was taken as the systematic error or personal equation of the observer. Finally, the mean of the differences (without regard to sign) between the systematic error and each observed difference was taken as the mean accidental error. The results foliowa

| Observer | Personal Equation | Accidental Error | Transits |
| :---: | :---: | :---: | :---: |
| Chapman | $-0^{0} 2$ | $\pm 1.2$ | 13 |
| Hi11s | -0.7 | $\pm 1.1$ | 15 |
| Smith, J.R. | -0.7 | $\pm 0.8$ | 18 |
| Gaherty | $+1.5$ | $\pm 1.1$ | 9 |
| Brasch | +1.1 | $\pm 1.9$ | 9 |
| Haps | $+1.0$ | + 2.1 | 15 |
| Binder | - 0.5 | $\pm 1.9$ | 9 |
| Rost | - 0.2 | $\pm 1.5$ | 8 |
| Milon | - 1.1 | +1.7 | 14 |
| Reese | +0.1 | $\pm 0.7$ | 40 |
| Melville | - 0.9 | $\pm 1.1$ | 5 |
| Milne | + 2.1 | $\pm 0.4$ | 5 |
| Zuzze | - 0.4 | $\pm 1.0$ | 13 |
| Glaser | - 0.2 | $\pm 1.5$ | 4 |
| Toupkins | +0.2 | $\pm 1.4$ | 4 |
| Cyrus | - 1.1 | $\pm 0.7$ | 4 |
| Snell | 0.0 | $\pm 0.5$ | 5 |
| Meisel | -0.5 | $\pm 2.2$ | 4 |
| Uedge | - 1.5 | $\pm 1.1$ | 3 |
| Hilliams | +2.6 | $\pm 1.3$ | 3 |
| Komoda | 0.0 | $\pm 1.1$ | 6 |
| A11 others | + 1.2 | $\pm 1.2$ | 16 |

If the personal equation is positive, the observer times transits too late and his longitudes are correspondingly too high; if negative, the observed longitudes are too low. The mean accidental error for all observers vas $\pm 1^{\circ}$.1. The average systematic error, of course, was zero since the mean longitude obtained by all observers was adopted as the true longitude. Systematic errors affecting all observers, such as phase exaggeration, cannot be revealed by the procedure used for the Red spot.

## 2. Center of a White Notch on N. edge NEB, 101 transits, 19 observers.

The procedure here was exactly the same as for the Red Spot except that the rapid motion of the white notch in decreasing longitude made it necessary tó utilize its mean drift line for every date on which a transit was observed (see Table 2 at end of this article). The results follow:

| Observer | Personal Equation | Accidental Error | Trans |
| :---: | :---: | :---: | :---: |
| Chapman | $+0^{\circ} .8$ | $\pm 0.9$ | 8 |
| Hills | - 1.3 | $\pm 1.3$ | 8 |
| Binder | - 2.6 | $\pm 1.1$ | 8 |
| Gaherty | + 2.8 | $\pm 0.7$ | 9 |
| Brasch | + 1.6 | $\pm 2.1$ | 5 |
| Haas | - 0.7 | $\pm 1.3$ | 6 |
| Rost | -0.3 | $\pm 2.3$ | 4 |
| Peese | $+0.5$ | $\pm 1.0$ | 27 |
| Milon | - 1.8 | $\pm 1.2$ | 8 |
| Cyras | - 2.5 | $\pm 0.5$ | 2 |
| Snell | - 3.0 | $\pm 2.0$ | 5 |
| Hartmann | $+3.0$ | +1.0 | 2 |
| A11 others | + 0.9 | $\pm 2.4$ | 9 |

The average accidental error for all observers was $\neq 1.4$.
3. Satellites and Shadows, 52 transits, 15 observers. We might expeot more absolute determinations of systematic errors from an investigation of transit observations of satellites and their shadows, the times of which can be computed from data in the Ephemeris. The value of such an investigation, however, depends upon the accuracy of the predicted times -- and these, we are advised by the Nautical Almanac office, may not be very high since the predictions are meant for guidance and not for comparison of observation to theory. After making allowance for the two systematic errors already found (see previous section), the personal equations of the various observers were found to be comparable to those found in groups 1 and 2 above:

| Observer | Personal Equation | Accidental Error | Transits |
| :---: | :---: | :---: | :---: |
| Chapman | - 0.0 | $\pm 0.8$ | 3 |
| Hills | - 1.4 | $\pm 1.2$ | 7 |
| Gaherty | +1.9 | $\pm 1.0$ | 4 |
| Hass | -0.7 | $\pm 1.2$ | 3 |
| Reese | $+0.7$ | $\pm 0.8$ | 15 |
| Milon | -0.9 | $\pm 1.6$ | 5 |
| Rost | - 1.6 | $\pm 0.9$ | 3 |
| Hartmann | $+3.0$ | $\pm 0.5$ | 2 |
| Meisel | - 3.7 | $\pm 1.2$ | 2 |
| Maag | +1.8 | $\pm 2.8$ | 2 |
| Cruikshank | $+1.4$ | $\pm 2.0$ | 2 |
| All others | -0.5 | $\pm 1.7$ | 4 |

The average accidental error for all observers was $\pm \mathbf{1}^{\circ} .2$.
Fortunately this investigation into personal equations turned out to be much ado about not so much. The personal equations of the various observers are surprisingly small, and they seem to vary a little from one type of object to another. It does not seem necessary to make allowances for these small systematic errors when ploting transit observations on our longitude charts. On the other hand, a correction for phase exaggeration is indicated; however, more data are needed to determine the exact amount.

Mr. S. Cortesi (Locarno-Monti, Switeerland) has sent us reprints of his thorough and up-to-date study of the three long-enduring ovals in the STeZ (Orion, No. 76, p. 106) and his excellent report on Jupiter in 1961 (Orion, No. 75, p. 32).

Mr. Clark Chapman submitted a long mimeographed report entitled "Rotation Rates on Jupiter During the 1961-62 Apparition". The report is based ontirely on Mr. Chapman's own extensive observations. His results are in good general agreement with those presented herein.

Mr. Geoffrey Gaherty, Jr., National Planetary Coordinator of the RASC, has communicated a summary of Jovian rotation periods for 1961 based on observations by members of the RASC. A complete report on the apparition will soon be published in the JRASC.

Table 1. Mean Longitudes of the center of the Red Spot during selected intervals in 1961-62. System II.

| T1me | Interval | Central Date | Mean Long. | Ave. Deviation | Transits |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Feb. | 1-Mar. 13 | Feb. 11, 1961 | $355^{\circ} \mathrm{O}$ | $\pm 1^{\circ} .0$ | 2 |
| Mar. | 14-Apr. 22 | Apr. 2 | 355.0 | $\pm 2.0$ | 5 |
| Apr. | 23-May 12 | May 2 | 357.4 | $\pm 1.2$ | 5 |
| May | 13-Jun. 1 | May 22 | 358.6 | $\pm 0.4$ | 5 |
| Jun. | 2-Jun. 13 | Jun. 7 | 358.0 | $\pm 1.6$ | 8 |
| Jun. | 14-Jun. 25 | Jun. 19 | 0.6 | $\pm 1.6$ | 10 |
| Jun. | 26-Ju1. 7 | Ju1. 1 | 0.3 | $\pm 1.1$ | 7 |
| Ju1. | 8-Ju1. 19 | Ju1. 13 | 0.5 | $\pm 1.9$ | 18 |
| Ju1. | 20-Ju1. 31 | Ju1. 25 | 1.1 | +1.2 | 17 |
| Aug. | 1-Aug. 12 | Aug. 6 | 1.3 | $\pm 1.7$ | 26 |
| Aug. | 13-Aug. 24 | Aug. 18 | 2.4 | $\pm 1.1$ | 9 |
| Aug. | 25-Sep. 5 | Aug. 30 | 4.0 | * 0.9 | 19 |
| Sep. | 6-Sep. 17 | Sep. 11 | 4.3 | $\pm 1.6$ | 26 |
| Sep. | 18-Sep. 29 | Sep. 23 | 4.4 | $\pm 1.4$ | 18 |
| Sep. | 30-Oct. 11 | Oct. 5 | 4.5 | $\pm 0.8$ | 11 |
| Oct. | 12-Oct. 23 | Oct. 17 | 6.2 | +1.2 | 6 |
| Oct. | 24-Mov. 4 | Oct. 29 | 6.0 | $\pm 1.3$ | 7 |
| Nov. | 5-Nov. 16 | Not. 10 | 7.5 | $\pm 1.0$ | 6 |
| Mov. | 17-Mov. 28 | Nov. 22 | 7.3 | $\pm 1.9$ | 9 |
| Hov. | 29-Dec. 10 | Dec. 4 | 9.0 | $\pm 1.3$ | 3 |
| Dec. Jan. | 11-Dec. 31 | Dec. 21 Jan. 15, 1962 | 8.3 9.0 | $\pm 2.4$ 0.0 | 3 2 |

Table 2. Mean Longitudes of the center of a white notch on the 1. edge of the NEB during selected intervals in 1961-62. System II. (XTrC Mark Ho. 9).

| Time | Interval | Central Date | Mean Long. | Ave. Deviation | Transits |
| :---: | :---: | :---: | :---: | :---: | :---: |
| May | 13-Jun. 1 | May 22 | $280^{\circ}$ | $\pm 3.0$ | 2 |
| Jun. | 2-Jun. 13 | Jun. 7 | 272 | $\pm 2.6$ | 5 |
| Jun. | 14-Jun. 25 | Jun. 19 | 268 | $\pm 2.5$ | 6 |
| Jun. | 26-Ju1 . 7 | Ju1. 1 | 261 | $\pm 0.3$ | 3 |
| Ju1. | 8-Ju1. 19 | Ju1. 13 | 258 | $\pm 1.4$ | 5 |
| Ju1. | 20-Ju1. 31 | Ju1. 25 | 252 | $\pm 1.7$ | 10 |
| Aug. | 1-Aug. 12 | Aug. 6 | 247 | +2.5 | 13 |


| Time Interval | Central Date | Mean Long. | Ave. Deviation | Transits |
| :---: | :---: | :---: | :---: | :---: |
| Aug. 13-Aug. 24 | Aug. 18 | $242^{\circ}$ | $\pm 2^{\circ} .0$ | 11 |
| Aug. 25-Sep. 5 | Aug. 30 | 236 | *1.3 | 7 |
| Sep, 6-Sep. 17 | Sep. 11 | 233 | $\pm 2.7$ | 14 |
| Sep. 18-Sep. 29 | Sep. 23 | 229 | $\pm 1.7$ | 7 |
| Sep. 30-Oct. 11 | Oct. 5 | 222 | $\pm 1.3$ | 7 |
| Oct. 12-Oct. 23 | Oct. 17 | 218 | 0.0 | 2 |
| Oct. 24-Nov. 4 | Oct. 29 | --- |  | - |
| Nov. 5-Nov. 16 | Nov. 10 | 206 | $\pm 1.5$ | 2 |
| Nov. 17-Nov. 28 | Nov. 22 | 202 | --- | 1 |
| Nov. 29-Dec. 10 | Dec. 4 | 195 | $\pm 1.0$ | 4 |
| Dec. 11-Dec. 31 | Dec. 21 | 189 | $\pm 0.5$ | 2 |

Note: The observed longitude on any given date during an interval was corrected to the central date of that interval by applying the mean drift of $-0^{\circ} .43$ per day. This was done to eliminate any errors which might have been caused by unequal distribution of observations during an interval.

## IN DEFENSE OF VISUAL OBSERVATIONS OF PLATO

## By: Patrick S. McIntosh, Sacramento Peak Observatory

For the past five years the author has worked intermittently upon compiling a chart of Plato which can represent the maximum accuracy obtainable by visual means. The chart presented here (Figure 3) was essentially in the present form two years ago but has not been published until now because of delays caused by finishing college. While $I$ was preparing an extensive report of these years of observations plus an examination of past observations, Alika K. Herring published his excellent chart based on a Yerkes photograph. 1 This chart substantially reduces the value of the report $I$ had planned; and so $I$ here merely present the chart in Figure 3, which I have compiled for a comparison with the definitive photographic chart.

I also present another chart (Figure 4) for comparison which was painstakingly compiled from the several prints of Plato in the Photographic Lunar Atlas. Many of the details on this map are also on the Herring chart. The positions of all specks and craterlets appearing on the prints were carefully measured, and this chart was compiled only from details appearing on more than one print. In this way it was hoped that spurious details would be eliminated. I believe that a few non-existent details remain on the chart, but at the same time many real features are not represented because of being beyond the limit of the photographs or because they appeared on only one print for reasons of suitable angle of illumination. Notice that three small domes, two large hills, and a shallow "saucert were recorded on Figure 4 from the prints. These have never been seen visually, probably because they require a very low angle of illumination to be detected but perhaps because they do not exist. The extreme difficulty of gleaning small detail from the published prints makes these details highly uncertain.

The visual chart (Figure 3) contains all but one of the spots and craterlets on the Yerkes chart; and the positions are in very good agreement, considering the libration differences of the two charts. It is obvious that there are many more details present to the eye than appear on even the excellent Yerkes photograph. Since the positions of the 31 spots confirmed by the Yerkes chart are reasonably accurate and since the positions of all details were obtained in the same careful manner, is it not reasonable to expect the remaining 33 features to be positioned with good accuracy and actually to exist? A few comments on the observing ${ }_{3,4}$ I have described briefly this procedure and will do so again in support of


FIGURE 3. Chart of Plato drawn by Patrick S. McIntosh. Based upon visual observations with an 8-inch reflector, a 7.5-inch Clark refractor, and a 4 -inch Unitron refractor in 1959 - 62. See also text of article by Mr. McIntosh in this issue.
my belief that careful visual positioning of lunar details can reach reasonable accuracy. The rin detail and the five largest craterlets were originally charted rrom an enlargement of a Mt. Wilson photograph which reprea sented approximately mean libration. The detail was not merely sketched. Many positions were carefully measured on the photograph so that a large


FIGURE 4. Composite chart of Plato constructed by Patrick S. McIntosh and based upon photographs in the Kuiper Photographic Lunar Atlas. See also text.
number of primary reference points would be available for use in positioning the visual details. This outline chart was used at the telescopes ( $8^{\prime \prime}$ reflector, $7 \frac{1}{2}{ }^{\prime \prime}$ Clark refractor at Harvard College Observatory, $4^{\prime \prime}$ Unitron refractor at Sacramento Peak Observatory), the delicate and elusive bright spots being positioned by carefully noting the alignment of such features with prominent rim features on opposite rims of plato. The use of two or more sets of reference points insured the accuracy presented here. Each feature was observed and positioned at least three times on each night that it was visible and was further confirmed on several additional nights. Only in the very complex area south of the central craterlet are the positions in doubt. Even here, the Yerkes chart confirms the positions of several spots.

I must agree with Mr. Herring that in the past most of the Plato maps were made with insufficient care, resulting in considerable confusion in the conclusions reached about whether changes actually do occur in Plato. Several careful comparisions have been made of the past maps, and there still exists some evidence for actual changes in the visibilities of features. For example, in A. S. Williams' map of 1883 , spots 1 ardd 13 were charted as crater cones of equal magnitude. Williams comment on 13 is: "Variable; usually fainter thap 1 , yet frequently equal to it, and more than once even surpassing it."6 In recent years it has never been equal to 1 , and $I$ have been tempted to call it variable also. It is quite inconspicuous on both of the photographic charts and visually appears as either a minute crater pit or spot immersed in the complex tip of the bright "sector". There are other reports of variations which are difficult to explain by lack of care in the observations or by differences among the observers. My conclusion is that the question of plato variability is yet to be answered.

Photographs of the quality used by Mr. Herring might be sufficient eventually to establish an answer, when there exist such photographs taken several years apart. The agreement between the photograph and the visual chart indicates, however, that a visual observer may still be the one to produce the next evidence of changes in Plato. Whether his evidence will be accepted as proof will depend on the established reliability of that observer's reports. Repeated confirmation of his observations by photographs or by many other experienced observers should be sufficient to establish his reliability.

Changes can be detected only when there is a reliable chart to use for comparison with future observations. It is hoped that Mr. Herring's chart together with these presented here constitute such reference material.

Patrolling for possible changes in Plato's features is one of the few lunar programs remaining in which amateurs with modest equipment may make a significant coptribution to selenography. A look at the excellent U.S.A.F. Lunar Charts discourages one from attempting to discover much else.

## Footnotes and References

1. A. K. Herring, The Strolling Astronomer, 16, July-August, 1962, page 158.
2. U.S.A.F. Photographic Lunar Atlas, compiled under direction of Gerard P. Kuiper, plates Dla-D1d, D2a-D2e, 1959.
3. P. McIntosh, "Chart of Plato Detail", The Strolling Astronomer, 13, November-December, 1959, page 155.
4. P. McIntosh, "A Precision Map of Plato", paper read at the Sixth Convention of the ALPO, San Jose, California, August 24, 1960 .
5. J. T. Carle, "The Three Riddies of Plato", Sky and Telescope, 14, page 221, Apri1 1955.
6. A. S. Wililams, The Observatory, 6, page 87 and page 112.
7. U.S.A.F. Lunar Charts are available on subscription by writing Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price \$7.50.

Tab1e 1
Plato Detail Confirmed by Two or more Frints

| Ic | 11 c | *23c | * 39 |
| :---: | :---: | :---: | :---: |
| 2 c | 12 c | 24 c | 40 c |
| 3 c | 13 c | $25 d$ | 42 c |
| 4 c | 14 | *26 | 43 c |
| 5 | 15 c | * 27 c | 50 d |
| 6 c | 18 c | 28 c | 51 c |
| 7 c | 19c | 29c | * 57 c |
| 8 c | 20 c | * 30 | 60 c |
| * 9c | 21 c | - 35c |  |
| 10 c | 22 | 38 |  |

Unstarred objects are within $1^{\prime \prime}$ of arc of photographic position. * position within $2^{\prime \prime}$ of arc of photographic position. c shadow-holding pit or cone. d dome.

Number of details on McIntosh map -- 62 Number of McIntosh details confirmed - 38

Table 2
Features on McIntosh Map Confirmed on Yerkes Photograph Noa 822

| 1 | 10 | 21 | 47 |
| :--- | :--- | :--- | :--- |
| 2 | 11 | 23 | 51 |
| 3 | 13 | 26 | 53 |
| 4 | 14 | 27 | 54 |
| 5 | 15 | 30 | 57 |
| 7 | 16 | 46 | 59 |
| 8 | 18 | 41 | 63 |
| 9 | 20 |  |  |



A RBLIEF MAP OF ERATOSTHELES
By: John E. Westfall
I. Introduction

This paper describes an experimental project in selenography, the large-scale, three-dimensional mapping of aingle formation.
II. Area

The formation selected was the crater Eratosthenes, which was chosen for several reasons,
(1) The crater liea near the apparent center of the diso, reducing foreshortening errors.
(i1) Due to the work of D. W. G. Arthur, good horisontal control exists in the area.
(iii) There is considerable local relief, which furnishes a good test for the method of height determination.
(iv) The formation itself is an imposing, interesting feature, much observed and photographed, and is of a size convenient for mapping.
III. The Base Map

After Eratosthenes was decided upon as an object for study, a base map of the crater and the adjoining region was prepared, showing the selenographic grid for every degree of latitude and longitude, along with six control points from the catalogue of Arthur. ${ }^{1}$ The control points (all pits or craterlets) were as follows:

| Catalogue No. |  | $\xi$ | $\underline{n}$ | $\lambda$ (Long.) |  | $\beta$ (Lat.) |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| bC | 6269 | -0.1658 | +0.2291 | $09^{\circ}$ | $48^{4} .3 \mathrm{E}$. | $13^{\circ} 14^{\prime}$ | . 7 N. |
| bc | 8107 | -0.1797 | $+0.2167$ | 10 | 36.5 | 1230 | . 9 |
| bc | 9127 | -0.1917 | +0.2174 | 11 | 19.6 | 1233 | . 4 |
| bc | 9402* | -0.1897 | +0.2417 | 11 | 16.4 | 1359 | . 2 |
| cc | 0360* | -0.2063 | +0.2303 | 12 | 14.4 | 1318 | . 9 |
| c $C$ | 2482 | -0.2276 | +0 2420 | 13 | 34.1 | 1400 | . 3 |

As an aid for later horizontal control, the rim of Eratosthenes was also drawn on the base map.

The projection and scale of the base map were identical with those of the relief model and map, a polyconic projection, with central meridian $11^{\circ} 20^{\prime} \mathrm{E}$., on a scale of $1: 250,000$, based on a reference sphere of radius 1738.0 kms.

## IV. The Model

The next step consisted of constructing a relief model of the crater. This model was constructed of plasticine, upon an aluminum base board to which the base map had been transferred. The determination of relief was based on the following assumptions an accurate relief model of a given area, with equal horizontal and vertical scales, when illuminated and viewed from the same altitudes and azimuths as were true when a given photograph of the region was taken, should duplicate the appearance of the photograph.

In practice, slides were made from selected lunar photographs. These slides were viewed through a magnifier with the lefteye, while the model was viewed directly with the right. Correct orientation was insured by superimposing the images of the photographic control points with the control points as shown on the model. For convenience, the magnifier and slide were mounted on a frame above the model; they could be moved towards, and away from, the model, or tilted to correct for foreshortening.

With the images thus superimposed, the next step was to compute the solar altitude and azimuth at the center of the crater at the time of the photograph. This was done by the expressions:

```
    sin}A=0.2504 sinoD+0.9682 cos D sin (C - 11'20'), an
    sin}0=\operatorname{cos}(C-1\mp@subsup{1}{}{\circ}2\mp@subsup{0}{}{\prime})\operatorname{cos}D\operatorname{sec}A
where: A = Solar Altitude.
    0 = Solar Azimuth.
    D = Solar Selenocentric Declination.
    C = Solar Colongitude.
    14*}3\mp@subsup{0}{}{\prime}=\mathrm{ - North Latitude of Crater Center (sin = 0.2504; cos = 0.9682).
    110}\mathbf{20' = East Longitude of Crater Center.
```

[^0]A floodlight was placed at the corresponding angles in relation to the model. Placing the light at a computed distance from the model closely approximated variations in solar altitude with respect to position on the lunar surface. The distance from center of model to light is found from the formula:

```
                    D = r sin A,
where: A = Solar Altitude, as before.
            D = Distance from light to model center.
            r = Scale Lunar Radius (i.e., 1738.0 kms. X 1:250,000=695.2
                                    cms.).
```

A total of eight photographs of the region were used, all of which, With the exception of SP-15, are available in Kuiper's Photographic Lunar Atlas. ${ }^{2}$ For each photograph, the model-1ight altitude, azimuth, and distance were as follows:

| Plate | A (Alt.) | $\theta$ (Azimuth) | D(Distance) | Light from: |
| :---: | :---: | :---: | :---: | :---: |
| M284 | 08.9 | - 94.1 | 107.5 cms. | West |
| P37b | 10.9 | - 94.1 | 131.5 | West |
| SP-15 | 13.3 | - 94.5 | 160.0 | West |
| Y160 | 22.7 | - 97.4 | 268.2 | West |
| W121 | 18.2 | + 96.4 | 217.2 | East |
| W124 | 18.0 | + 96.4 | 214.9 | East |
| L11 | 15.9 | + 96.7 | 190.5 | East |
| W195 | 05.8 | + 92.7 | 070.3 | East |

After model, photograph, and light were placed in their correct relationship, the model was added to and molded until its shadow pattern duplicated that of the photograph. When this was true, the same was done with a photograph with lighting from the opposite direction. This was continued until all eight photographs had been "worked", at which time the process was repeated as a check. The use of several photographs also served as a check, along with removing ambiguities of slope.

The final result of this step was a $1: 250,000$ scale model of Eratosthenes, which, when illuminated and observed from the same angles as in a given photograph, duplicated the appearance of the photograph. Hence, according to the original assumption, the model was an accurate replica of the crater itself.

## V. The Map

With the model completed, relief could then be transferred from the model to a map compilation. This was done by placing the model in a leveled tray and gradually filling the tray with a solution of water, india ink, and "Photo-F1o" (a Kodak product which reduces surface tension, thus insuring a level surface). The "shoreline" assumed by the solution at a given depth defined the contour line of that level. The contour interval decided upon was 250 meters ( 820 feet) on the moon, or one millimeter on the $1: 250,000$ model. Thus, the model was inundated in one millimeter stages, and photographed at each stage. Then, slides made from the contour level photographs were projected, in sequence, on the map compilation; and the contour lines were traced off directly. The altitude datum was, of course, entirely arbitrary.

Relief shading was added by tracing a photograph of the model, sideilluminated, projected on the compilation sheet. The completed map, as reproduced in this paper in Figure 5, is at approximately one-half the original scale, or 1:500,000 (i.e., $1 \mathrm{~cm} . \mathrm{s} 5 \mathrm{kms.}$, or $1 \mathrm{in} .: 7.89 \mathrm{mis}$. ). The code "IIA-i", at the top of the map, states that the map is "Formation Chart One in Quadrangle A of Quadrant II", per the lunar index system out-


FIGURE 5. Relief map of lunar crater Eratosthenes drawn by John E. Westfall. Lunar north at top, lunar east at left (reinverted from classical lunar orientation). Relief based upon eight photographs at large observatories and detailed study of a plasticine model. Polyconic projection, standard meridian $11^{\circ} 20^{\prime} \mathrm{E}$. and radius of reference sphere 1738.0 kms . Control points by D. W. G. Arthur. Though the linear scales sketched above can be used and remain accurate, on the published reproduction here 1 inch will not precisely equal 7.89 miles, nor $1 \mathrm{~cm} ., 5.0 \mathrm{kms}$. See also text of Mr. Westfall's article in this issue. Contour interval 250 meters, altitude-origin arbitrery.
lined by the author in a previous paper. ${ }^{3}$

## VI. Interpretation

A selenologic study of the crater Eratosthenes was not the object

# ERATOSTHENES•PROFILE DIAGRAMS 



FIGURE 6. Profile diagrams of east-west and north-south diameters of lunar crater Eratosthenes. Contributed by John E. Westfall. See also text of his article in this issue.
of this project, but a few interpretative notes may demonstrate some of the possible uses of a map of this type.

The profile diagrams accompanying this paper as Figure 6 have been prepared from the map. Their horizontal scale is $1: 500,000$, their vertical scale, 1:250,000; vertical exaggeration is 2 X . Some sharp breaks in the slope of the inner wall are evident. The fact that the slopes immediately above the slope breaks are roughly parallel suggests that these slopes are fault scarps. The hypothesized faults causing these scarps are indicated by dashed lines on the profiles. Correlation of the profiles with the plan map shows that the fault blocks between the supposed faults form the terraces of the inner wall of Eratosthenes. Although roughly concentric, these terraces are by no means regular, but start, stop, or branch in their courses. There are many features that a geologist might call splinter faults. In general, the dominant structure of the inner wall seems to be that of step faulting, suggesting large-scale subsidence of the floor. If the floor of the crater did subside, its north portion evidently subsided more than did the south. This is evidenced by three observations: (i) The terraces (fault blocks) tend to slope northwards; (ii) There is a large landslip in the northen.e.portion of the wall, indicated by inwardly-bulging contours, and; (iii) The actual elevation (ca. 200 meters) of the north floor is lower than that of the south (ca. 400 meters).

The plan map also suggests large scale east-west compression; external ridges tend roughly north-south, the terrace structure of the inner wall is most disturbed in the north and the south, while the central mountain mass runs roughly north-south (this is also indicated by the profile diagrams).

These hasty notes are written solely to suggest the value of large-

## VII. Critique

Due largely to its experimental nature, the map has shortcomings, most of which, I feel, could be corrected in future work. Firstly, a considerably larger number of photographs should be used, and covering a greater range of solar lighting than those used here. Secondly, denser horizontal control should be previously established for the region by photographic measurement. Thirdly, the contours on the map should be systematically corrected for a radial displacement, caused by photographing the model from a finite distance.

In spite of the above shortcomings, I hope that this map will encourage further work in this line. Little equipment is needed, but there is a need for cooperative work - in securing good photographs, making the model, measuring positions, and so on - all in all, furnishing an opportunity for joint work among amateurs.

## References

1) Arthur, D.W.G., Contributions to Selenography, No. 5: The Environs of Copernicus (1956).
2) Kuiper, G.P. et alo, Photographic Lunar Atlas (Chicago, 1960).
3) Westfall, J.E., "A Reconnaissance Chart of the Central Oceanus Procellarum." Strolling Astronomer, 15, 9-10, pp. 159-171.

## FINDING THE HEIGHT OF A LUNAR MOUNTAIN

By: Joseph Ashbrook

1. The observation needed is a visual estimate of the apparent length of the mountain's shadow. We estimate the length as a fraction $f$ of the longest (unforeshortened) diameter of a nearby crater. The time of observation should be known to within a minute or two. Instead of working visually, we could also obtain from measurements of a photograph taken at a known time. Measurements from drawings are not recommended.
2. The crater diameter $D$ can be taken from Arthur's catalogue, when this becomes available. The best current procedure is usually to measure the rim-to-rim longest diameter from Kuiper's Atlas, whose scale can be assumed 100 inches to the lunar diameter. In any case, $D$ must be expressed in units of the lunar radius, dividing it by 1080 miles or $1738 \mathrm{kilo-}$ meters as the case may be.
3. From the American Ephemeris and Nautical Almanac, take out the following numbers, interpolated to the time of observation:

$$
\begin{aligned}
& \frac{L}{B}^{\prime}=\text { Earth's selenographic longitude. } \\
& \bar{B}^{\prime}=E^{\prime}=\text { Earth's selengraphic latitude. }^{\prime} \\
& \text { - Sun's selenographic colongitude. } \\
& \text { - Sun's selenographic latitude. }
\end{aligned}
$$

The interpolation is much easier if the Universal Time is converted to a decimal fraction of a day; e.g., August 31, $3^{h} 00^{m}=$ August 31.125 . There is a handy conversion table on page 456 of the 1962 American Ephemeris.
4. The selenographic coordinates Xi, Eta of the mountain are best taken from Arthur's Orthographic Lunar Atlas, to 0.001 or 0.0005 . The next best general source is the IAU At1as (1935), which is however less reliable positionally in the limb regions. US Air Force Charts are fine for positions, if they cover your region. Do not use Wilkins' or

Firsoff's maps for this purpose. Convert the Xi, Eta coordinates to:
$\frac{L}{B}=$ Mountain's selenographic longitude
by means of the formulae:

$$
\sin \underline{B}=\underline{E t a} \quad, \quad \sin \underline{L}=X_{i} \sec \underline{B} .
$$

5. Calculate the angular altitude $A$ of the sun, as seen from the mountain at the moment of observation:

$$
\sin A=\sin \underline{B} \sin \underline{B}^{\prime \prime}+\cos \underline{B} \cos \underline{B}^{\prime \prime} \sin (\underline{L}+\underline{C}) \text {. }
$$

6. Calculate the auxilifary angle $F$, which is the angle between the earth and sun, as seen from the center of the moon:

$$
\cos \underline{F}-\sin \underline{B}^{\prime} \sin \underline{B}^{\prime \prime}+\cos \underline{B}^{\prime} \cos \underline{B}^{\prime \prime} \sin \left(\underline{\underline{L}}^{\prime}+\underline{C}\right) .
$$

If you have a number of shadow observations during the same night, it is unnecessary to compute for each one. It suffices to make this calculation for the first and last times, and to interpolate for the others.
7. The mountain height $\underline{H}$, expressed in terms of the moon's radius as a unit, is calculated from:

$$
\underline{H}=\underline{f} \underline{D} \sin A \operatorname{cosec} F-\frac{1}{E} \underline{f}^{2} D^{2} \operatorname{cosec}^{2} \underline{E} \cos ^{2} A \text {. }
$$

To convert $H$ to feet, multiply by $5,720,400$; to convert to meters, multiply by $1,738,000$.
8. The value of $H$ obtained in Section 7 is a relative height -the difference in elevation between mountain and summit and shadow tip. orten it is useful to know approximately the horizontal distance $x$
 we already have evaluated in Section 7.)

$$
\underline{x}=1738(\underline{H}) \operatorname{cotang} \underline{A} .
$$

This gives $x$ in kilometers; for miles, replace the numerical factor by 1080 .
9. During these calculations, keep four significant figures throughout, writing the angles to 0.01 . Labor can be saved by using trig tables with decimal division of the degree (e.g., E. V. Huntington's Four Place Tables).

The deduced heights are more accurate when the solar altitude A is small, say $1^{\circ}$ or $2^{\circ}$, making the shadow long. In such cases, the error in height may be only $\pm 20$ meters. For shoft shadows, far from the terminator, the error can be very much greater.

In publishing a list of height measurements by this method, it will be wise to put on record all the data needed for someone to recompute the observation, if needed; date and time, coordinates of the measured point, name of the comparison crater and the estimated fraction, solar altitude, and the height (rounded off to two significant figures, perhaps).
10. Three particularly helpful references are:
T. L. MacDonald, JBAA, $41,367,1931$. By far the best background reference. Covers geometry, gives proofs and detailed explanations for most of the formulae in this abstract.

Gilbert Fielder, JBAA, 72, 216, 1962. Describes a simple visual estimate for gettinf depths of small craters. Author fails to explain that
on p. 218 a more accurate source of east-west diameters (to 0.0001 lunar radius)is needed.
2. Kopal, Physics and Astronomy of the Moon (1962). Has an interesting treatment of height measurements from the viewpoint of the photographic worker.

## 11. Some suggested programs involving visual determinations of heights ares

A. Heights of mare ridges. There is surprisingly little published information, but in most cases mare ridges are under 500 feet high. Hence the shadows must be estimated when the ridge is very close to the terminator. A good deal of care will be needed to getreally accurate coordinates for the observed points.
B. Area studies. Any amateur who makes a detailed study of a specific locality, such as Plato, should make shadow estimates part of his project. Once the height of some prominent feature in the vicinity is known, it is very easy to determine wholesale the heights of hills, craterlet rims, otc., in the neighborhood, with the aid of Mäder's approzimate formula:

$$
\underline{H} / \underline{H}_{0}=\underline{S} \sin \underline{A}\left(\underline{S}_{0} \sin {\underset{O}{0}}^{\prime}\right)
$$

where His the height of the unknown feature, $S$ its shadow length in any convenient unit, and $A$ the solar altitude in its position at the time of observation; $\underline{H}_{0}, \underline{\underline{S}}_{0}$, and ${\underset{A}{0}}$ are the corresponding values for the standard.

## C. Crater profiles. Because the interiors of many craters are

 rounded, the height of the rim above the floor will vary as the shadow edge moves across the crater. Hence, from repeated observations of the same crater on many nights, it is possible to determine the crater profile. Especially desirable are such profiles of the outer slopes of craters.D. Heights of faults. Only in the case of the Straight Wall do we have any detailed information about the heights of lunar faults. A survey of it was published in Publications of the Astronomical Society of the Pacific, $72,55,1960$. Similar surveys of other major faults, like the ones in Burg and in Boscovich and the one near Cauchy, are desirable.
E. Diameter-Depth relation for small craters. This is imperfectly known, and some widely quoted formulae (such as Baldwin's) are badly off. Any amateur who determines a considerable number of depths for craters less than, say, 15 kilometers in diameter will do a valuable service. One often-overlooked fact: Because small craters are fairly steep bowls, the interior depth will be underestimated unless the observation is made with the solar altitude $A$ some $15^{\circ}$ or more. Hence the observations require estimation of quite short shadows, some distance from the terminator, in bright surroundings.

Any amateur who spends some time with height work will certainly think of still other projects, and of new procedures.

Comments by Editor. The two foregoing papers by Dr. Ashbrook and Mr. Westfall were among those read at the A.L.P.O. Convention in Montreal on September 1 - 3, 1962. That meeting is described elsewhere in this issue.

Surely these two papers, and the one in this issue by Mr. Patrick McIntosh also, indicate that there are still lunar problems which the
earnest, capable, persevering, and well-equipped amateur can investigate. Admittedly the requirements for useful lunar work have increased in recent years. The random sketching of scattered individual craters with small apertures and mediocre seeing conditions will ordinarily have little scientific value. It is pointless for amateurs to do poorly what professional astronomers with large government subsidies are doing well. of course, such sketching may still have value as a training program.

There is need now, in the Editor's opinion, for more concentrated work on selected lunar features, for more realistic evaluation on our part of instrumental and atmospheric limitations, and for certain special lunar projects with limited and well-defined objectives. Surely, Messrs. Ashbrook, Westfall, and McIntosh have given us some leads. The Editor realizes that the meaningful implementation of such ideas will demand some well-qualified A.L.P.O. Lunar Recorders. The search for such persons is now going on, and possibly there will be an announcement elsewhere in this issue.

## CONTRIBUTIONS TO SELENOGRAPHY, PART III

By: L. J. Robinson
The two prededing sections of this paper 1,2 have defined and classified the bright-banded lunar craters. It has been shown that they are common objects and that they form a unified morphological group. Having defined our subject, we may now make statements concerning the possible origin of these formations.

Table I ${ }^{3}$ relates certain relevant parameters for twenty-eight randomly selected bright craters. Column one contains the author's general catalogue number for each crater. The second and third columns give these craters' diameters and depths respectively. The smallest of these craters is $2.64 \times 10^{4} \mathrm{ft}$. In diameter while the largest, of which there are two, is $2.955 \times 10^{5} \mathrm{ft}$. - approximately a factor of eleveq. Depth extremes are: minimum depth $1.9 \times 10^{3} \mathrm{ft}$.; maximum depth $1.5 \times 10^{4} \mathrm{ft}$ - a factor of eight. More important, however, than the actual diameters or depths is the ratio of the depth to the diameter, see column four in Table i. The writer has found through a study of these ratios that, given the ratio, the diameter of the crater having that ratio can be calculated from the expression:

$$
\begin{aligned}
& \text { - } 41.4 \mathrm{R} \\
& \text { where } D \text { is the diameter of the crater in feet } \\
& K=\left(2.57 \times 10^{6}\right) \\
& \text { e- base of natural logarithms } \\
& R \text { is the ratio, d/D, depth over diameter. }
\end{aligned}
$$

The exponential curve obtained from the above expression has been plotted in Figure 7. It will be noted that, on the above figure, a dashed 1 ine has been constructed at $0.26 \times 10^{5} \mathrm{ft} .$, this line representing the smallest lunar crater used in the calculation of the elements of the function. To the left of that line a small mark "A" has been plotted; this point represents the position of the Arizona Meteorite Crater and corresponds very well to its position on the extrapolated empirical curve. As the craters become smaller, the ratio $R$ rises rapidiy, providing a sensitive test for the accuracy of the curve. Figure 8 has been included to show some representative terrestrial impact-craters. Those given here are, in order of decreasing diameter:

```
Boxhole crater
Odessa \#1
Estonia
Odessa \#2
Kansas
```

In Figure 8 these small craters have not been plotted as discrete , oints, but rather have been shown as vertical lines. These lines indicate the possible error of measurement of the parameters for each crater. Such errors arise in the many problematic quantities inherent to each object; infilling, weathering, etc. must be estimated before the original depth and diameter may be ascribed. Again, as in the case of the Arizona Crater, one will note the fine correlation between the observed and calculated values. Some scatter exists between the values, but such scatter should be expected. Factors such as impact area density, shock resiliency, compressibility, etc. will all affect the resultant crater. Also, errors in the measurement of the lunar craters initially used in determining the curve influence its placement.

A crude approximation of the volumes of bright craters, see column five of Table I, may be found by assuming them to be prolate hemispheroids represented by the expression:

$$
\text { where } \quad \begin{aligned}
& V=\left(5.93 \times 10^{4}\right) \text { a } b^{2}, \\
& V \text { is the volume in cubic centimeters, } \\
& A=D / 2, \text { in feet, } \\
& b=d, \text { in feet. }
\end{aligned}
$$

Throughout this calculation a and b are related by the function used in Figure 7. To refine this expression for $V$, a more precise determination of the shapes of the bright craters floors is required; this matter is currently under investigation.

The final column of Table I shows the approximate masses of ejectamenta for the listed craters; in this calculation a density of 2.6 gmsfcu. cm. was appended. With this determination of ejected masses, it is possible to arrive at a determination of the energy required to move this mass into the form of a crater. On the assumption that the average particle of mass will be lifted to a height equal to one-fourth the diameter of the crater and that the energy-producing media works at $1 \%$ efficiency in forming the actual crater, it is found that a crater one mile in diameter will require approximately $3 \times 10^{23}$ ergs for its formation. The largest bright craters herewith beipg considered, say like Copernicus, would require approximately $4 \times 10^{28}$ ergs. The energy requirements for intermediate craters is given in Table II and is plotted in Figure 9.

Referring once again to Figures 7 and 8 , there is considerable evidence that bright craters are the result of meteoroid impacts. Is it possible for meteoroids to produce such energies as are required above? Table III shows that meteoroids are indeed a sufficient source of energy. It should be noted that Table III has been compiled only for meteoroids of small size, i.e., less than 0.4 miles in diameter; larger bodies at lower velocities than $60 \mathrm{kms} . / \mathrm{sec}$. would produce sufficient energies also.

A final argument supporting the depth - diameter relationship in particular, and the above theory in general, is found in the laboratory. Researchers have found that circular craters with definite depth - diameter relationships may be produced with very hich velocity projectiles. The angle of incidence at impact or the size of the particle does not appear materially to affect the resulting crater (other than increasing the size of the crater in the case of the latter condition). 5 An effective summarizing statement of this laboratory research was made by C. N. Scully when he said " . . . these photographs [ referring to various photographs showing the results of high velocity impacts of silica particles on differing target materials ]. . . indicate that you can get almost any type feature with selection of target materials and velocity." While such experiments are in no way conclusive, they do lend additional support to the impact theory of bright crater formation.

In conclusion, many efficacious arguments have been presented advocating the impact theory, but one further test remains. If the brifit craters are meteoroidal in nature, then they should show a fundamental


FIGURE 7. Graph contributed by L. J. Robinson to show the curve represented by the indicated function. The dashed line represents the smallest lunar crater used in determining the function. Mark "A" indicates the placement of the Arizona Meteorite Crater on the empirical curve. See also text of Mr. Robinson's article.


FIGURE 8. This graph is merely an extension of Figure 7 for terrestrial craters of small diameter. The range of $R$ is indicated for each crater plotted, due to the difficulty of arriving at a precise determination of this quantity.
Graph made by L.J. Robinson.


FIGURE 9. Graph by L. J. Robinson to show: (1) the energy requirements to form a lunar crater, and (2) the energy given meteoroids may produce the four solid curves. The lower abscissa scale should be used with curve (1); the upper, with curve (2). The ordinate applies in both cases. The diameter of the meteoroid for each of the four curves is indicated to the left.
isotropic distribution. A discussion of this distribution and factors which affect it will be considered in Part IV.

Table I
Parameters of craters used in arguments here developed. The final two columns are only approximate but are believed by the author to be sufficient for their purpose in this paper.
Cat. No. Dia. (D) $\times 10^{4} \mathrm{ft}$. Depth (d) $\times 10^{3} \mathrm{ft}$. $\mathrm{D} / \mathrm{d}=\mathrm{R}$ Vol. $\times 10^{17} \mathrm{cc}$. Mass $10^{17}$

| 005 | 18.47 | 11.0 | . 06 | 6.62 | 17.2 |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 019 | 11.09 | 5.0 | . 05 | 0.821 | 2.14 |
| 039 | 8.60 | 7.0 | . 08 | 1.25 | 3.25 |
| 115 | 8.60 | 10.0 | .12 | 2.52 | 6.55 |
| 156 | 4.23 | 8.0 | . 19 | 0.815 | 2.12 |
| 225 | 23:75 | 15.0 | . 06 | 15.9 | 1599 |
| 246 | 10.56 | 8.0 | . 08 | 2.00 | 5.20 |
| 263 | 6.34 | 3.6 | . 06 | 0.244 | 0.634 |
| 323 | 27.42 | 9.9 | . 04 | 7.97 | 20.7 |
| 338 | 11.71 | 7.4 | . 06 | 1.90 | 4.94 |
| 347 | 13.20 | 12.0 | . 09 | 5.63 | 14.6 |
| 414 | 7.92 | 7.0 | . 09 | 1.15 | 2.99 |
| 418 | 26.40 | 11.4 | . 04 | 10.2 | 26.3 |
| 526 | 14.78 | 9.0 | . 06 | 3.54 | 9.20 |
| 702 | 9.50 | 7.7 | . 08 | 1.67 | 4.34 |
| 734 | 11.08 | 8.0 | . 07 | 2.09 | 5.43 |
| 1010 | 3.27 | 3.6 | . 11 | 0.125 | 0.325 |
| 1011 | 5.81 | 5.1 | . 09 | 0.448 | 1.16 |
| 1116 | 4.48 | 6.0 | .13 | 0.478 | 1.24 |
| 1119 | 29.55 | 14.6 | . 05 | 18.7 | 48.6 |
| 1121 | 7.76 | 4.5 | . 06 | 0.465 | 1.21 |
| 1203 | 13.20 | 6.8 | . 06 | 1.81 | 4.60 |
| 1316 | 29.55 | 12.0 | . 04 | 12.6 | 32.8 |
| 1319 | 2.64 | 2.1 | . 08 | 0.0346 | 0.0900 |
| 1428 | 3.96 | 1.9 | . 05 | 0.0403 | 0.105 |
| 1614 | 15.31 | 6.9 | . 05 | 2.16 | 5.62 |
| 1709 | 16.89 | 3.8 | . 02 | 0.722 | 1.88 |
| 1801 | 10.56 | 10.0 | . 10 | 3.31 | 8.60 |

## Table II

This table was prepared for idealized lunar craters in accord with methods described in the text. The formula usedin determining each quantity here and in Table III is given below.

| $\mathrm{R}=\mathrm{d} / \mathrm{D}$ | Dft. | d ft. | $\mathrm{Mc}_{\mathrm{c}} \mathrm{gm}^{2}$ | E ergs ${ }^{3}$ | 99 E |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | $3.20 \times 10 \frac{5}{4}$ | $1.60 \times 10^{4}$ | $1.58 \times 10{ }_{16}^{18}$ | $4.54 \times 10^{26}$ | $4.49 \times 10^{28}$ |
| . 10 | $4.20 \times 104$ | $4.14 \times 10^{3}$ | 1.4.48 $\times 1016$ | $4.54 \times 1024$ $5.43 \times 1021$ | $4.49 \times 1026$ $5.36 \times 1023$ |
| . 15 | $5.14 \times 10^{3}$ | $7.71 \times 10^{2}$ | $4.69 \times 10^{14}$ | $2.78 \times 10^{21}$ | $2.75 \times 10^{23}$ |

$$
\begin{aligned}
& (1) . \mathrm{D}=\left(2.57 \times 10^{6}\right) e^{-41.4 R} \\
& (2) . \mathrm{M}_{\mathrm{c}}=\left(1.54 \times 10^{5}\right)(\mathrm{D} / 2) \mathrm{d}^{2} \\
& (3) . \quad \mathrm{E}=\mathrm{M}_{\mathrm{c}}\left(1.57 \times 10^{2}\right)(\mathrm{D} / 4)\left(3.05 \times 10^{1}\right)
\end{aligned}
$$

Comments by Editor, We congratulate Mr. Hartmann on a long-needed statistical study of the observed dichotomy of Venus in his article in this issue. It is important, as he says, to look for a possible"Schröter effect" on Mercury and even on the moon near First Quarter or Last Quarter, using for the moon only the naked eye or low-power field glasses. Controlled studies of the effect of sky brightness, changing seeing, and variable transparency on the observed phase of Venus are needed.

Table III
Energies obtained from meteoroids under specific conditions are given. Most of these values are also plotted in Figure 9.

| $r \quad \mathrm{~cm}$. |
| :--- |
| 3.75 $\times 103$ <br> 7.50 $\times 104$ <br> 1.50 $\times 104$ <br> $3.00 \times 10^{4}$  |


| $\mathrm{Vc.c}{ }^{4}$ | $M_{m g} . \quad 5$ | 10k./sec. |
| :---: | :---: | :---: |
| $2.21 \times 10^{11}$ | $1.8 \times 10^{12}$ | $9.0 \times 10^{23}$ |
| $1.76 \times 1012$ | $1.4 \times 10_{1}^{13}$ | $7.0 \times 10_{25}^{24}$ |
| $1.42 \times 10_{14}$ | $1.2 \times 10^{14}$ | $6.0 \times 10^{25}$ |
| $1.13 \times 10^{14}$ | $9.3 \times 10^{14}$ | $4.7 \times 10^{26}$ |
|  | (4) $V=14$ <br> (5) $\quad M_{m}=(8$ <br> (6) $\mathrm{E}=\mathrm{M}_{\mathrm{m}}$ | $\begin{aligned} & \left.19 \times 10^{\circ}\right) r^{3} \\ & \left.20 \times 10^{\circ}\right) v^{2} / 2 \end{aligned}$ |

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## VENUS SECTION REPORT: THE SCHROTER DICHOTOMY EFFECT

IN A.L.P.O. OBSERVATIONAL RECORDS, 1951-1961

## By: William K. Hartmann

## 1. Astronomical Background

In Figure 10 we see the orbits of the earth and Venus. When Venus is at either of the two positions shown with respect to the earth, i.f., when the angle between the sun and the earth as seen from Venus is 90 , we should see exactly half of Venus lit by the sun. This half-phase condition is called dichotomy. It occurs near the time of greatest elongation, but not quite at greatest elongation because of the eccentricity of the orbit of Venus. Certainly this orbit is well enough known that we can compute when this situation will occur. In fact, results of such computations are presented in The American Ephemeris and Nautical Almanac, giving the phase angle at five-day intervals. The date of dichotomy may be predicted from these tables.

It turns out, however, that observations give us an unexpected result. From the days of Johann Schroter, observations have indicated that the visually estimated date of half-phase does not occur at the time when it is predicted by the geometrical argument above. Patrick Moore gives a good account of the situation:
"In August 1793 [Schroter] found that theoretical dichotomy differed from the observed date by eight days, and the phenomenon was repeated at subsequent elongations. Forty years later, the German observers, Wilhelm Beer and Dr. Johann Mäder . . . found that the average difference was six days - observed dichotomy being early for eastern elongations and late for western.
"Estimates of the exact moment of half-phase are not easy to make, and different observers produce different timings, but Schroter's effect is so pronounced that its reality cannot be questioned."l

The name "Schröter's effect", which Moore has suggested, has been adopted in this paper. The purpose of the paper is to give a comprehensive summary of A.L.P.O. observations relating to this effect from 1951 to 1961. This paper should be regarded as primarily a description of the observations, but some discussion of the nature of the Schroter effect will be included.

## 2. Method

The problem is to take the observations from each apparition and to find the difference in days between the predicted date and the observed date of dichotomy. Let us call the predicted date the zero day. If dichotomy was observed $\Delta$ days early, we will say it occurred at minus $\Delta$ days; if late, at plus $\boldsymbol{\Delta}$ days.

What constitutes an observation of the date of dichotomy? It is something of a problem to decide on a consistent definition of what we mean by one observation. One possibility would be to consider only separate observers. Thus, we could get a mean date of dichotomy, one "observation" from each observer's report, and combine these "observations" to get a result for each apparition. This method has the serious disadvantage that without a rather drastic weighting system, an inexperienced observer who made only a few observations near dichotomy would get the same weight as an experienced observer who made a careful study. It was decided to let each of the following items constitute an "observation": 1. Drawings or written notes describing the phase near dichotomy, with written descriptions taking precedence over accompanying drawings. 2. Direct estimates or measures of phase, such as by micrometer or straight edge.
3. Summarizing statements combining observations and giving a resulting date for dichotomy.

The condition was imposed that if more than one observation were obtained by a given observer during one-tenth of a day, only the average result of these would count as one observation. This rule had to be Invoked only rarely, and there was therefore little biasing toward one value of $\Delta$ by many close-spaced observations of one observer. The great majority of observers made only one observation per day.

Because observations undoubtedly vary in quality as a result of a number of factors, a weighting system would seem appropriate. Such systems are notoriousiy uncertain in their effect, but in this study, the following set of rules was followed. The weight assigned is the sum of the points given on each of these four criteria:

1. Aperture employed: since large telescopes should provide the best images for study of the phase, we allot points as follows:

$$
\begin{array}{ll}
\text { Aperture range: } & 0<A \leqslant 3 \text { inches gives weight } 0.1 \\
3<A \leqslant 7 & 0.2 \\
7<A & 0.3
\end{array}
$$

2. Seeing: since sharp seeing should allow the best estimates, we have, for the 0 to 10 scale with 10 perfeot:

| Seeing range: | $0<s \leqslant 3$ |  |
| :--- | :--- | :--- |
|  | $3<s \leqslant 7$ | gives weight |
|  | $7<s \leqslant 10.1$ |  |
|  |  | 0.2 |
|  |  | 0.3 |

3. Experience: this criterion is perhaps an intangible, yet most of us would agree that the observations of some of our veteran observers should be weighted more heavily than the first results of newer observers.

Weights of $0.1,0.2$, and 0.3 were used.
4. Directness of measure: here we attempt to weight the observations on how good a measure they give of the date of dichotomy. The following system covers all the types of observations listed above:
$\frac{\text { Drawings or notes }}{\text { on terminator }} \quad$ Phase estimate Summary statement Weight

Looks very nearly straight but not worth 0.2

Looks straight on average
Estimated to a day
but with deformations with $\leq 3$ obs.

Estimated to a day
Looks essentially straight with $>3$ obs. tions, or described as possibly concave or convex

Described as about straight
Estimated to $<1$
day with> 3 obs.
Described as straight or at dichotomy

Measured 50\% Estimated to 0.1 0.6 phase with mi- day with>5 obs. crometer or straight edge

In this system the lowest possible weight is 0.4 , and the highest is 1.5. Very rarely do observations have these extreme weights; $3 / 4$ of them lie between 0.8 and 1.2. It is felt that this system should give better results than if no weights were assigned.

It will be seen that we have counted not only observations where the terminator is thought to be strictiy straight, but also observations where there is some uncertainty. This means that by noting the spread of the observed $\Delta^{\prime} s$ we can get some measure of the duration of this uncertainty. The mean value of the $\Delta^{\prime} s$, however, should not be seriousiy affected by this uncertainty, which occurs both before and after observed dichotomy. Accordingly, the results will be here recorded in the form of a mean $\Delta$ and a standard deviation.

In summary, the analysis consisted of considering all observational reports made near dichotomy, listing weighted values of $\Delta$ from all reports indicating a straght terminator, and computing the mean $\Delta^{\prime} s$ and standard deviations for each apparition and also final results for the 1951-61 period as a whole.

## 3. Initial Results

For the apparitions of Venus from 1951 to 1961, upon applying the above methods we get the results tabulated in Table 1. Standard deviations are given, but it should be remembered that in many of the apparition results the number of "observations" is so small that the standard deviations have little meaning. The predicted date, or eero day, used here is the date when the illuminated portion is $\frac{1}{2}$ (when $k=0.500$, interpolated from The American Ephemeris and Nautical Almanac).

Remark by Editor. What should be determined is not really the interval between observed dichotomy and geometric dichotomy but rather the value of the phase angle $i$ (given in The American Ephemeris and Nautical Almanac) when observed dichotomy occurs. This distinction may be of smail importance, however, since the orbit of Venus is so nearly circular.
Eastern (Evening)
Apparition
a. Individual apparitions

|  | No. | $\frac{\text { Total }}{\text { Weight }}$ | $\frac{\bar{\Delta}=\text { obs'd }^{\prime} \text { d. date }}{- \text { pred}^{\prime} d . \text { date }}$ |
| :---: | :---: | :---: | :---: |
| 1951 | 11 | 9.3 | $-4.3 \pm 3.8$ days |
| 1953 | 8 | 8.3 | $-9.0 \pm 5.5$ |
| 1954 | 5 | 5.0 | $-1.7 \pm 4.0$ |
| 1955 |  |  |  |
| 1956 | 11 | 9.4 | $-6.3 \pm 4.7$ |
| 1957 | 9 | 7.5 | -10.8 $\pm 6.8$ |
| 1958 |  |  |  |
| 1959 | 19 | 18.8 | $-9.0 \pm 6.8$ |
| 1961 | 46 | 44.2 | -8.4土4.2 |

Western (Morning) Apparition

b. Totals and $\bar{\Delta}$ 's for eastern and western apparitions:

| 109 | $102.5-7.8 \pm 5.7$ | 25 |
| :--- | :--- | :--- |$|$| $23.1+7.6$ |
| :--- |

c. General from 134 observations:

$$
\bar{\Delta}=7.8 \quad \pm 5.5 \text { days. }
$$

In table la, we see the $\bar{\Delta}$ 's computed for each apparition. In table 1 b , a ${ }^{\circ}$ has been computed for the eastern apparitions by lumping all those observations together, and similarly for western apparitions. In table 1c, all observations, from both eastern and western apparitions, have been combined (with a change in sign for ${ }^{\prime}$ 's from one of the two groups) to give a general $\boldsymbol{Z}$.

## 4. Statistical Analysis

A survey of the results presented above raises interesting questions. Are the differences recorded in $\overline{\mathbb{Z}}$ from one apparition to another significant? Is there any difference between Schroter's effect as observed in the evening and as observed in the morning apparitions? Could Schroters effect, as recorded here, merely be a sampling error; that is to say, is our $\overline{\widetilde{c}}$ displaced from the "true" value $\mathbb{Z}=0$ merely by the chance effects of observational scatter?

During the initial preparation of this paper, a number of statistical tests were applied to the data from 1951 through 1959. Based on such statistical concepts as the $t$ distribution and Fistribution, these tests permit some investigation of the questions above. The tests are somewhat artificial in that they require the observations to be thought of in terms of populations (produced by errors) and samples (produced by observations), and require the assumption that the populations are normal. Nonetheless, the following results for 1951-1959 may be of interest.
a. There is no evidence that time of dichotomy is much more sharply defined at one apparition than at another (in statistical terms, that the standard deviations of the populations differ from one apparition to another).
b. There is little evidence that the "true" $\bar{\Delta}$ 's differ from apparition to apparition (that the population means differ from one apparition to another). The strongest evidence that they might is that, assuming the same populations for 1951 and 1959, we would expect onlyabout 1 time in 10 to haveas large a difference in the $\bar{\Delta}^{\prime} s$ as was observed in those two years).

If the Schroter effect is essentially the same from year to year, a may combine the observations into two groups, those for eastern appariions and those for western. We find:
c. There is no evidence that the time of dichotomy is any more sharply defined for eastern than for western apparitions, and vice versa (that the standard deviations of the populations are different).
d. There is no evidence that the "true" $\bar{\Delta}$ 's differ between eastern and western apparitions (that the population means differ between these two groups). Table lb shows the good agreement. We assume that, on the average, the eastern and western apparitions are simply mirror images of each other. McEwen referred to "... the observed fact that the difference between the visible and the theoretical terminators is greater at the west than at the east elongation." This is not confirmed here.

If the eastern and western apparitions are mirror images, we may combine them into one large sample of observations (changing the sign of the $\Delta$ 's for one group). We find:
e. There is evidence that Schröter's effect is not simply a sampling error whereby our $\bar{\Delta}$ is displaced from $\bar{\Delta}=0$ because of chance scatter. (If we assume that the 1951-1959 observations were taken from the same population, which had a mean of 0 and a standard deviation found from that observed, we would expect a $\bar{Z}$ as large as that observed much less than 1 time in 200.)

By virtue of points $a$ and $b$, we may draw up histogram showing weighted frequency of observation versus number of days from predicted dichotomy for both eastern and western apparitions. This is done in rigures 11 and 12. Similarly, by points $c$ and $d$, we may draw up a histogram presenting the same information for all observations combined. This is done in Pigure 13.

## 5. Purther Analysis

In Figure 13, we see the A.L.P.O. records presented in their broadest sense. We may say that due to the observations' intrinsic scatter, we cannot identify any real differences between what happens near the time of one predicted dichotomy and another. This fact is the basis for the assumption made in Pigure : 3 that all observations may be lumped together. The peaking of this histogram some seven days from the predicted zero day clearly confirms Scnróter's effect and demonstrates the statements made in point e above.


FIGURE 10. Geometric meaning of a dichotomy of Venus. As seen from Venus, the sun and the earth are 90 degrees apart.


FIGURE 11. Weighted observations (average weight about unity) of straight terminator of Venus versus number of days from predicted dichotomy, eastern or evening apparitions. Contributed by William K. Hartmann. See also text.


FIGURE 12. Weighted observations (average weight about unity) of straight terminator of Venus versus number of days from predicted dichotomy, western or morning apparitions. Drawn by William K. Hartmann. Figures 11 - 13 are based upon A.L.P.O. observations in 1951-61.

A closer inspection of Figure 13 is of interest. Two facts may be noted: the distribution cuts off more sharply on the zero day side, and a small subsidiary peak occurs near the zero date. These facts can be explained as follows. Most observers must have been aware of the predicted zero date. A few had never heard of Schröter's effect. They expected to see dichotomy on the zero day, and therefore did record it on that day. This explains the peak near zero. The rest of the observers had heard of Schröter's effect, and expected to see dichotomy before ( or, for morning work, after) the predicted day. Therefore, they did record it at this time, rarely on the other side of the zero day. This explains the longer tail on the side away from the zero day. This paragraph constitutes just another chapter in the recent and continuing discussion in the pages of The Strolling Astronomer of observational error. The observer who goes to the telescope expecting to see such-and-such a thing is in


FIGURE 13. Weighted observations (average weight about unity) of straight terminator of Venus versus number of days from predicted dichotomy, all observations. See also discussion in text.
serious trouble. It cannot be denied that the 6-to-8. dary peak in Figure 13 is in part due to observers who expected to see dichotomy 6 to 8 days from the predicted date, although it is not felt that this effect completely destroys the value of Figure 13. The only solutions to the problem are to avoid knowing just what to expect (in this case don't look up the predicted date) or else to go to the telescope with the attitude that perhaps you can prove the rest of the world wrong. Schröter, in discovering the effect, did just that. Perhaps he was the only one to approach the problem with an open mind.

The considerable spread of the observations in Figure 13 remains to be discussed. In part 2, it was pointed out that this spread is expected to relate to the period of uncertainty, during which the observer is uncertain whether the terminator is slightly concave, straight, or slightly convex. According to the experience of the writer and others, this period may last about four days. Thus, if all observers centered on the same $\boldsymbol{\Delta}$, we would expect a standard deviation of perhaps two days. That our standard deviation is some five days means that while some observers are calling the terminator concave, others are calling it convex. This fact in turn proves a certain lack of objectivity in the observations, in that they are not entirely reproducible.

The basic question associated with Schröter's effect is: Is Schröter's effect caused by some phenomenon arising on the planet Venus? McEwen? in 1937, gave an affirmatiwe answer and discussed a theory invoiving a slope of the Venus cloud layer near the terminator downward toward the dark side. It is true that this nicely explains the observations. However, it is a rather far-reaching assumption to make about Venus; we must be convinced that its observational support is valid.

No one who has estimated the date of dichotomy at the telescope and found that the corresponding phase was supposed to be gibbous would agree to passing off Schröter's effect as imaginary. However, the following points argue against a too ready assumption that Schroter's effect is the result of a peculiar physical phenomenon on Venus:
a. We have seen above that there exists a bias on the part of observers who know what to expect to see.
b. That observers may feel uncertain about the phase for only four days, yet place dichotomy perhaps as much as ten days apart, shows the uncertainty of all such observations.
c. The effect of variables such as aperture, sky brightness, and transpareqcy is uncertain. Aperture did not seem to affect the results in 1961? Heath ${ }^{4}$ pointed out that the apparent phase of Venus may be observed to change from gibbous to crescentric when a light cloud passes across the disk, and this statement has been strikingly confirmed by the writer. This makes it virtually certain that small departures from perfect transparency help to produce Schröter's effect.
d. The known rapid decrease of brightness toward the Venus terminator, which explains the observation noted in part $c$, may contribute to the effect. Perhaps the last few degrees of the illuminated side are lost near the center of the terminator. However, in moderate-sized telescopes, one has the impression that the terminator is well-defined.
e. Observations of Mercury in January, 1962, by the writer and two other experienced observers, using a 4 -3-inch refractor, confirmed a similar effect whereby the planet looked less full than was predicted near the time of dichotomy. This result may indicate that a dense planetary atmosphere is not required, and that the fall-off of light toward the terninator or instrumental effects are influential. [ This "Schröter effece on Mercury has been well known for many years and has been recorded by various experienced observers. - Editor .]

> 6. Summary

A total of 134 A.L.P.O. observations are used to derive the dates of dichotomy for apparitions from 1951 through 1961. These are 1isted in table 1. It is felt that one cannot distinguish between one appardtion and another, nor between eastern and western apparitions on the basis of these observations. Combined results are given for eastern and western apparitions, and for all observations together. The mean discrepancy between observed and predicted dichotomy is 7.8 days, with the predicted phase being gibbous when dichotomy is observed. The Schröter effect is thereby confirmed qualitatively and quantitatively. The standard error of a single observer might be expected to be about $\pm 2$ days, although the standard deviation of all the observations is $\pm 5.5$ days.

No single theory of the origin of Schröter's effect is advanced here. However, several reasons are listed for viewing with reserve any hypothesis of a peculiar phenomenon on Venus. Schroter's effect is all the more remarkable when it is remembered that both irradiation effects and the known scattering of light beyond the terminator of Venus (witness the illuminated atmosphere) might lead one to predict that Venus should appear more nearly full than predicted. It is hoped that this paper will provide new data for those with an interest in the effect, and that the discussion of sky brightness, transparency, and similar parameters may encourage further observational experiments (on both Mercury and Venus, perbaps with filters) to isolate their influences.

The writer is indebted to all the observers who subaitted reports to the Venus Section in the past decade. Only through their work was this paper possible.

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## BOOK REVIEWS

ASTRONOMY FOR AMATEUR OBSERVERS, by James S. Pickering, Fawcett Books, Greenwich, Conn., 1961. Abridged Version of The Stars Are Yours, by the same author - Macmillan Co., 1948, 1953. Price Fawcettedition 754.

## Reviewed by Rodger $W$. Gordon

Essentially the book is primarily for the "intermediate amateur", that is, the amateur who has acquired his first telescope and has begun his first survey of the sky in a detailed fashion. The book is also a very suitable reference for the more advanced amateur. Almost every branch of astronomy is covered, but some subjects such as Solar System objects are dealt with briefly. Less than 40 pages are used to cover the chapters on the Sun, Moon, Planets, Comets and Meteors. The author makes up for this deficit, however, by including some very interesting photographs of each object and by his inclusion of a moon map and a planet calendar. Each, however, could be mure detailed; and they are only suited to amateurs who are beginners or intermediates.

There is a chapter on how to build a $4 \frac{1}{\prime \prime}$ reflector for a modest sum; and there are also many pages listing telescopes, accessories, astronomy books, and binoculars. Quite a few advertisements are run by several well-known telescope manufacturers, and many beginners and intermediate amateurs will certainly be awed by the amazing variety of instruments and accessories available. (The prices of these instruments will certainly awe them also.) However, by far the major portion of the book is devoted to the constellations and the interesting objects located in each constellation. There are 24 star charts and a description by the author of many of the interesting features such as doubles, nebulae, galailes, planetaries, etc. to be found in each constellation. The author uses very vivid language to convey glowing descriptions to the amateur of these objects, most of which are within the grasp of $2^{\prime \prime}$ - $8^{\prime \prime}$ telescopes. There are over 100 photographs in the book, including a beautiful color photograph of the Ring Nebula in Lyra (M 57) on the frontispiece.

Minor errors have crept into the book. In his description of the brightness of the planet Jupiter the author states - "only the sun, the moon, and at times, Venus, are brighter." To my knowledge, Venus is always brighter than Jupiter; and Mars at a perihelic opposition is certainly brighter than Jupiter. These errors, for the most part, are rather insignificant.

To sum up, I would say that here is a very useful book for a beginner or an intermediate amateur who is looking for "show objects" in the sky. Advanced amateurs will find it primarily a reference book for telescopes and telescopic supplies, books, and other equipment, although they (advanced amateurs) will certainly onjoy reading its contents for sheer enjoyment. The vivid phrases the author uses to describe some of the objects certainly add to the onjoyment of the book.

THE TECHNIQUE OF OPTICAL INSTRUMENT DESIGN, by R. J. Bracey. The English Üniversities Press, Ltd. U.S.A.i The Macmillan Company. XIII +316 pp. Price $\$ 9.00$

Revieved by Stephen P. Maran

We have here a straightforward treatment of the geometrical optics pertinent to lenses and lens systems. Anyone who plans to design and build an optical instrument in which not everything is done with mirrors, prisms, and gratings will profit by reading Bracey's text, especially the clearly-written and practical chapter on ray tracing. Considerable attention is devoted to aberrations, and hou to minimize them. Perhaps the best feature of this book is the extensive use of numerical examples which shows how the characteristics of a given lens system may be calculated.

There are also short chapters on "The Design of Eyepieces", "Teles-" copes, Periscopes amd the Microscope" and "Illumination and Lens Systems." To the observer, the trelve pages on "Image Assessment" will be among the most interesting in the book, but one wishes that this section had been expanded considerably.

THE ASTRONOMICAL UNIVERSE, by Yasley S. Krogdahl. Second edition. The Macmillan Company, New York, 1962. 585 pages. Price $\$ 7.95$.

Reviewed by John Cline
The Astronomical Universe has been designed with the purpose of making both the beginning student of astronomy and the general reader avare of the universe around us. Using a relatively non-mathematical approach, the book presents a comprehensive, accurate, up-to-date account of what is presently known about the Solar System, the stellar population, and the universe of galaxies. This edition incorporates the results of the past decade's vork on solar and planetary physics, stellar evolution, galactic structure, and cosmology and cosmogony. Data from nev telescopes and radio telescopes are considered. The book is divided into two parts, "The Solar System" and " "The Stellar Population". Each chapter has a set of questions at the end; there are also some very good star charts plus a glossary.

THE PICTURE HISTORY OF ASTRONOMY, by Patrick Moore. Grosset \& Dunlap, Yev York, 1961. Price $\$ 5.95$.

Revieved by Paul M. Kubinsky

During the last fev years, the direct exploration of space by the United States and Russia has resulted in an increasing interest in astronomy on the part of the layman. More and more people are nov looking up i It is the author's intention in this book to acquaint these newcomers with the fascinating reala of the heavens and space travel. He does this by means of very vivid explanations, drawings, and 425 illustrations, of which 161 are in color.

This book is the result of a gigantic effort on the part of Mr. Moore to set doun the history of astronomy from its earliest beginnings in about 2,000 B.C. continuing to the recent flight of Commander Alan Shepard in the Mercury capsule. As the reader explores almost 4,000 years of astronomical history, the author will introduce him to such famous astronomers as Tycho Brahe, Kepler, Ptolemy, and Copernicus; be will visit many observatories throughout the world and viev the planets and stars as only the largest telescopes can reveal them. All in all, the reader is in store for a very fascinating and rewarding journey into space.

ChALLENGE OF THE UNIVERSE, by J. Allen Hynek and Norman D. Anderson, Scholastic Book Services, 904 Sylvan Avenue, Englewood Cliffs, New Jersey, 1962, paper, 143 pages. Price $50 \%$.

## Reviewed by J. Russell Smith

This is another paperback of the Vistas of Science series which presents facts and concepts as well as methods in modern astronomy. The topics discussed are as follows: A Look into Space, Units of the Universe, Earth - Mankind's Space Station, Earth and Its Shadow, The Moon: Satellite and Space Station, Gravity and Orbits, Yardstick for the Solar System, Other Worlds, Yardstick for Star Space, Light - More Light, Exploring Outer Space from Inner Space, Sun-Close-Up Star, Stars and Starlight, Stars of the Milky Way, Galaxies Galore, Relativity-1y Speaking, and The Challenge of the Universe. A number of excellent experiments and projects are suggested for those interested in learning by doing. There is also a list of selected readings as well as a glossary and index.

While this book has been written as source material for the junior and senior high school student, it is recommended as interesting reading material for teachers, laymen, and amateurs.

THE 1962 MONTREAL CONVENTION OF THE A.L.P.O.
By: Francis J. Manasek
This past Labor Day, the ALPO, now 15 years old, met in Montreal, Canada as a guest of the Montreal Centre of the RASC for its 10 th convention. The convention was unique in several ways. Besides having a splendid series of papers, it was the first time that the Alpo has convened as a separate group. It was also the first convention held outside of the United States. This circumstance, along with the fact that papers were received from England, Hungary, and Japan, gave the convention a truly international scope.

Although the convention officially began on Saturday, September 1, many members arrived the day before. The Observatory of the Nontreal Centre was open for the early arrivals, and some excellent views of Jupiter were obtained with the $6^{\prime \prime}$ refractor. Convention registration took place on Saturday morning in Sir George Williams University, where a large lecture room was made available for the presentation of the papers. An adjacent room held an extensive display of work done by Alpo members. The exhibit, prepared largely by Clark Chapman, included a great deal of material on the moon, reflecting the current trend in professional circles. Some of Alika Herring's rectified lunar charts were on display, as were many of his well-known lunar drawings. Among the other displays were reports on the lunar meteor program and an exhibit concerning the application of an IBM 650 computer to the reduction of data on the 1960 transit of Mercury. The first paper session began that afternoon with a welcome address by the president of the Montreal Centre, E. E. Bridgen, who was followed by Walter $H$. Hass with some introductory remarks. Phil Glaser, Jupiter Recorder, presented the first paper, a discussion of recent unusual activity on Jupiter. Both this paper and the one following, by Joel Goodman, pointed out many exciting developments recently made in the photography of Jupiter and Saturn. Some very surprising color photographs of Jupiter taken with amateur instruments were displayed, and an example of professional planetary photography with the Lick 120" reflector was shown. Joel Goodman's paper discussed the ring system of Saturn, giving an historical background to recent developments in the determination of the true nature of the ring "divisions". The remainder of the afternoon was taken up with papers of equally high quality. Dr. Joseph Ashbrooke spoke on measuring heights of lunar objects, giving a method which is well suited for amateur use. George Wedge presented an interesting account of the morphology of the lunar feature Heraclitus, and Clark Chapman discussed the Simultaneous Observation Program.


FIGURE 14. The Tenth A.L.P.O. Convention at Sir George Williams University, Montreal, Quebec, Canada, September 1 - 3, 1962. Photograph by William $\mathbb{E}$. Shawcross. See also text of article by Francis J. Manasek in this issue.

Saturday evening was spent at the Observatory of the Montreal Centre, where excellent refreshments were very kindly provided by the ladies of


FIGURE 15. The 1962 A.L.P.O. Convention Exhibit, collected and arranged by Clark Chapman. See also text. Figures 15 18 are photographs taken by William E. Shaweross.


FIGURE 16. Joel iv. Goodman presenting paper at Montreal Convention.


FIGURE 18. Informal discussion between Clark Chapman (center) and Keith Peterson during the Convention.
the Centre. Besides the six-inch refractor already mentioned, the Observatory, which is located on the campus of McGill University, has an amateur radio station, a work shop, and an extensive library. There is also a large meeting room and an observing platform. The Observatory is open to the public on specified nights.

The Sunday afternoon paper session included a report by Dr. Albéric Boivin of Laval University at Quebec about increased resolution obtained from an optical system in which the diffraction characteristics had been modified. Also heard were papers on the 1960 transit of Mercury by David Zackon and a report of an interesting study of Icelandic yolcanic structures and their possible similarity to lunar objects by Patrick Moore. George Rippen presented a talk on a subject which has frequently caused ALPO members anguish - the weather. This exposure to the weather, however, was both enjoyable and instruative.

The convention dinner was held on Sunday evening. The ALPO was presented with a cake to honor its 15 th year. The ALPO Award was given to Phil Glaser; and the evening was terminated with a talk by Joel Goodman, who spoke about amateur astronomy in England.

The last paper session was held on Monday forenoon and included papers on the construction of a relief model of Eratosthenes by John Westfall, use of glare reduction screens by Rodger Gordon, and a mathematical treatment of the problem of proper telescope powers for optimal resolution and visibility of weakly contrasting areas by Charles Giffen.

A complete list of the papers presented follows. As space allows, it is intended to publish abstracts of many of these in The Stroliline Astror nomer during the coming months and the full texts of which appear to be unusually significant. Joel Goodman, Geoffrey Gaherty, and Walter Haas acted as chairmen of the three paper sessions.

1. "Some Recent Changes in Jupiter's Aspect", by Philip R. Glaser.
2. "The Rings of Saturn", by Joel W. Goodman.
3. "Some Observations of the Lunar Features Heraclitus and Licetus", by George E . Wedge.
4. "Some Aspects of the 1961 A.L.P.O. Simultaneous Observation Program", by Clark R. Chapman.
5. "Astronomy and the General Public", by Carlos E. Rost. Read by Louis Duchow in absence of author.
6. "Measuring Heights on the Moon", by Dr. Joseph Ashbrook.
7. "Dynamics of Planetary Atmospheres", by James Sitler.
8. "The Nature of Jupiter's Atmosphere", by Walter Murawski.
9. "The Red Spot Project Program", by José Olivarez. Read by W. J. Cullinan.
10. "The Distribution of Bright Lunar Craters", by Leif J. Robinson. Read by William B. Shaweross.
11. "New Vistas in Astronomical Optics", by Dr. Albéric Boivin.
12. "Theoretical Aspects of the Lunar Meteor", by Kenneth Chalk.
13. "Lunar Meteor Search", by Madame Jean-Pierre Jean.
14. "Calculations of Mercury Transit 1960", by David Zackon.
15. "Lunar-Type Terrestrial Vulcanoids", by Patrick Moore. Read by Frank de Kinder.
16. "The Scientific Conscience", by Robert M. Adams. Read by Bryan Rawlings.
17. "Current Research in Atmospheric Science", by George W. Rippen.
18. "A Relief Model of Eratosthenes", by John E. Westfall.
19. "Resolution, Contrast, and Seeing in Planetary Astronomy", by Charles E. Giffen.
20. "The Reduction and Elimination of Instrumental and Atmospheric Effects Using Glare Screens and Filters", by Rodger W. Gordon.
21. "Klein's "New' Crater - Another Lunar Puzzle", by Francis J. Manasek.
22. "Studies of the Maria in the Libratory Regions of the Moon", by Dr. S. Miyamoto. Read by E.E. Bridgen.
23. "A Semi-Empirical Brightness Law for Cometary Objects", by David D. Meisel. Read by Geoffrey Gaherty, Jr.
24. "Cloud Satellites", by Richard Hodgson.
25. "The Instability of Small-Size Planetary Cores and the Development of the Moon", by Péter Hédervári. Read by Klaus Brasch.
26. "Plato and Its Mysteries", by Keith Peterson.

The official registration was 29 persons from the United States, 48 from the Montreal Centre, 7 from Le Centre Francais in Montreal, and 3 from elsowhere in Canada - a total of 87. Miss Ruth J. Northcott, the President of the R.A.S.C., was among the registrants.

We are greatly indebted to the Montreal Centre of the RASC for their very generous hospitality and for making the convention such a resounding success. Special thanks must go to Mr. W. A. Warren, the Convention Committee Chairman; to his committeemen, Messrs. Wedge, Gaherty, and Cullinan; and to Sir George Williams University for providing facilities for the meeting over a holiday week-end.

Postscript by Editor. A splendid article about the Tenth A.L.P.O. Convention appeared on pp. 194-196 of the October, 1962 Sky and Telescope. Accounts have also appeared in Skyward, the monthly bulletin of the Montreal Centre, and in The Eyepiece, the periodical of the Observing Group of the A.A.A. in New York. We express our thanks to all these magazines for their coverage of our metting.

## A RED SPOT PROJECT PROGRAM

## By: José Olivarez

Much has been said and conjectured about the Red Spot, but very little has been definitely established. Perhaps the main reason that there has been no satisfactory explanation for the Red Spot's behavior is that very little is actually known about the RS in spite of more than 60 years of systematic observation and study. The nature of the RS can be grasped, one hopes, from the realms of mere conjecture by simply studying the RS in every possible detail; carefully, no matter how insignificant it may seem. This is the purpose of the Red Spot Project Program.

The Red Spot Project Program was started in early 1962 for the purpose


FIGURE 19. Red Spot and Vicinity. Clark Chapman. 10 -inch refi. June $8,1962$. 9 hrs., 15 mins., U.T. $S=4 . T$ variable. C.M.I $=73^{\circ} \mathrm{C} . \mathrm{M}$. II $=342^{\circ}$.


FIGURE 21. Jupiter. Red Spot at upper right. Paul Doherty. 8.5-inch ref1. August 30,1962. 22 hrs., 45 mins., U.T. $S$ very good. $T$ not recorded. C.M. $I=0^{\circ}$ C.M.II $=351$.


FIGURE 20. Red Spot and Vicinity. Clark Chapman. 11-cm. Zeiss refr. July 7, 1962. 8 hrs., 35 mins., U.T. $S=5 . \quad T=4$. C.M. I $=309^{\circ}$ C.M.II $=356^{\circ}$.


FIGURE 22. Jupiter. Red Spot at upper left. Paul Doherty. 8.5-inch refl. August 31,1962 . 0 hrs., 30 mins., U.T.
$S$ very good. T not recorded. C.M. $I=64^{\circ}$ C.M. $I I=55^{\circ}$.


FIGURE 23. Two 1961 drawings of Red Spot region by Elmer J. Reese.
of more penetrating RS studies.
The author was fortunate enough to secure the names and addresses of some of the ALPO's outstanding observers and asked them to participate in such a program. Many of the solected observers have submitted numerous notes and drawings on the Red Spot both in color and in pencil. Some of the drawings accompany this short article.

The goals of this program follow:

1. To stimulate more interest in the Red Spot area.
2. To collect all available Red Spot data for close study.
3. To examine in detail the vortex theory by means of observed results and to decide on the possible nature of the Red Spot. Floating island or vortex? or neither?
4. To decide on the authenticity of the more delicate Red Spot detail. Other goals will be added as the program advances.

The program has special RS recording sheets that will be supplied to all participating observers. A special "required information sheet" has been drawn up and will also be supplied to participating observers. In closing this short paper I would like to thank Prof. Haas for his advice in drawing up a suitable RS recording form and for his muoh needed oncouragement. I would also like to thank all the ALPO observers who have contributed to the program thus far.

All interested AlPO observers should send their RS data to the following address:

José Oliverez
804 St. Marie
Mission, Texas
Postscript by Editor. This article largely follows a paper contributed by Mr. Oilitarez to the Montreal A.L.P.O. Convention program.

We shall certainly be very glad to have interested Jupiter observers participate in this special program. It is regarded as a supplement to the regular Jupiter work handled by Section Recorders Glaser and Reese. The Red Spot Project in part calls for work in the library as well as at the telescope. The published Red Spot reports of such groups as the A.L. P.O. and the B.A.A. can of necessity describe only a very small portion of the observational records contributed. The successful student of the Red Spot will also want a detailed knowledge of the considerable literature upon the Giant Planet.

## AHMOUNCEMENTS

Now Address of the A.L.P.O. Since August 25, 1962 the address of the Association of Lunar and Planetary Observers and The Strolling Astronomer has been:

> Box 26
> University Park
> New Mexico, U.S.A.

Members will greatly assist us and the post office by using this new address in all correspondence. Your cooperation is very much appreciated. The Editor is now employed as a mathematician by the Physical Science Laboratory of New Mexico State University, just outside of Las Cruces, New Mexico.

The Editor realizes that out-of-town visitors cannot find someone at a post office box. His present residence address, which should not be used for correspondence, is 1120 Skyway Drive, Las Cruces. His residence telephone is 524-2786 (area code 505).

Future A.L.P.O. Conventions. The A.L.P.O. has been invited to meet With the Western Amateur Astronomers in San Diego, Calif. near August 25, 1963. Their Chairman is now Mr. Martin Sloan of Escondido, Calif. We have accepted this invitation with thanks. Details will be given in future

We have also agreed to participate in a second nationwide Amateur Astronomers' Convention at Denver, probably in late August, 1964. The Chairman-to-be is Mr. Ken Steinmetz, who graciously invited the A.L.P.O. to take part. Many American amateurs will remember with pleasure the first national meeting of this kind, at Denver in 1959. The 1964 meeting will be similar in concept and scope, with some enlargement and some modifications based on experience.

Personal Thanks by Editor. "It is a singular pleasure to express my thanks to all those who contributed to the success of the recent A.L.P.O. Convention at Montreal - by means of papers, display materials, help with physical arrangements, personal attendance, or what have you. Certainly I would consider this meeting, our first solo Convention, also our most successful Convention to date. I find the new and renewed personal contacts at such annual meetings most enjoyable; they truly highlight each summer. I could only wish that more of our members would make the necessary effort to attend - they would not regret doing so. We gain from our interest in astronomy in proportion to what we invest in time, effort, and devotion. I do appreciate all that so many of you have so selflessly done and look forward, with your help, to making the A.L.P.O. a more effective organ for astronomical work in future years." - Walter H. Has.

Jupiter Photographs Requested. We are planning to publish several pages of current (1962) Jupiter photographs in our next issue, the November - December, 1962 issue. Members having photographs of good quality are accordingly invited quickly to submit these to the Jupiter Recorder, Mr. Philip Glaser, 200 Albert St., Waukesha, Wisconsin. Glossy prints should be supplied, with an enlargement that will make the planet's equatorial diameter between $3 / 4$ and 2 inches. The greatly improved quality of recent Jupiter photographs by a fair number of A.L.P.O. members is one of the most gratifying aspects of our current observational studies.

Total Solar Eclipse Expedition Planned. We have received two bulletins from Mr. Harry C. Stubbs, Milton Academy, Milton 86, Mass. describing early planning for an expedition to observe the total solar eclipse of July 20, 1963 from Copeland Hill, Holden, Maine. Persons interested in helping as workers or observers and certain of going on the expedition (barring unforeseen emergencies) should contact Mr. Stubbs at once. The general concept is that of amateur studies (not basic research) and ofexperiments pertinent to teaching science in secondary schools. Equipment is being designed and built. Projects include color photography with a 4.5-inch refractor of the complete sun and corona, large scale color photographs with an 8 -inch reflector of individual prominences, photographs of the Zodiacal Light near the eclipsed sun with a wide angle camera, sky brightness measurements with light meters, slitless spectrograms of the eclipsed sun, and possibly flash spectra.

New Address for A.L.P.O. Library. Our A.L.P.O. Librarian writes that he wil $\overline{\mathrm{l}} \mathrm{be}$ able to give better and faster service if correspondents will use this address:
E. Downey Funck

Box 156
Boca Raton, Florida.
However, continuing use of the old address ( 7698 Country Club Blvd., Delray Beach, Florida) is also permissible.

New Lunar Recorder. We are very glad to be able to announce the appointment of another A.L.P.O. Lunar Recorder. He is:

John E. Westrall
3104 Varnum St.
Mount Rainier, Maryland.

Mr. Westfall has been an active contributor to this periodical for many years, and one of his lunar articles appears in this issue. He has in mind some definite lunar projects for A.L.P.O. members. These will involve the study of selected lunar regions by both photographic and visual methods, with appropriate horizontal and vertical controls. Mr. Westfall will partially describe his program soon in a later issue.

Congratulations, Elmer Reesel It is typical of his modesty that Assistant Jupiter Recorder Reese should have listed without comment his 1,731 Jovian contral meridian transits during the 1961-2 apparition. We congratulate Mr. Reese very heartily on this outstanding observational achievement Very few American observers of Jupiter have ever surpassed 1,000 transits in a single apparition.

Errors in Recent Issues. The data on Mr. Fennelly's drawing of Jupiter on pg. $1 \overline{05}$ of our May-June, 1962 issue were wrongly given. 0 The true galues ares July 9, 1961; 8 hrs., 15 mins., U.T.; C.M.I $=258^{\circ}$; C.M.II - 196. Mr. George Wedge points out some misstatements about time signals on Pg. 132 of the same issue. Station WWV is in reality operated by the U.S. Naval Observatory and transmits time signals every five minutes. The station which transmits every minute is CHU, operated by the Dominion Observatory in ottawa.

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