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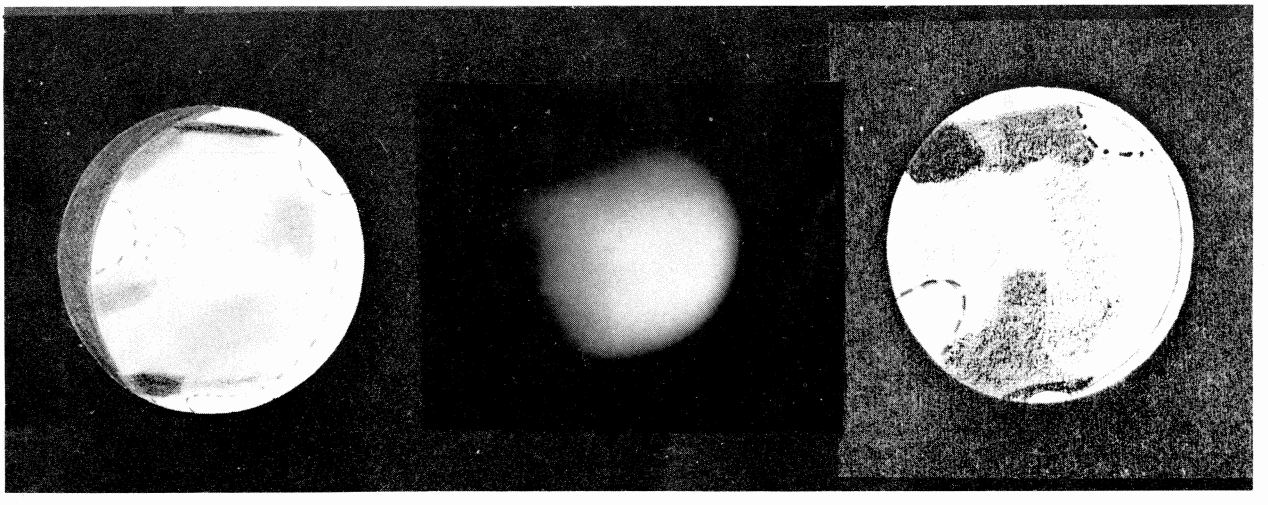
Feb. 11	Mar. 18	Mar. 9
Parker Drawing	Parker Photo	Aerts Drawing



Pre-opposition 1984 views of Mars, where extensive dust storms have been raging during the North Hemisphere late spring and early summer. Simply inverted views with south at top. Left image: Drawing by Donald C. Parker on February 11, CM = 89°. Yellow light. Solis Lacus largely obscured, yellow clouds present as drawn. 32-cm. refl., 590X. Center image: Photograph by Donald C. Parker on March 18, CM = 96°. No filter. Mare Sirenum not visible. 32-cm. refl. at F/198, exposure 2 seconds. Right image: Drawing by Leo Aerts on March 9, CM = 102°. Orange light. Atmosphere clearing of dust. 15-cm. refr., 280X.

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IN THIS ISSUE

THE 1981-82 APPARITION OF SATURN: VISUAL AND PHOTOGRAPHIC OBSERVATIONS

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

Introduction

Visual and photographic observations of the planet Saturn and its satellites for the period of 1981, November 14 through 1982, July 18 form the basis of the present report. Limited regions of the Southern Hemisphere of Saturn remained readily visible to observers in 1981-82, and the Northern Hemisphere of the globe and the north face of the rings were increasingly accessible to our telescopes during the apparition. For the period of 1981, November 14 to 1982, July 18, the numerical value of B, which denotes the Saturnicentric latitude of the Earth referred to the plane of the rings (positive when north) varied within the range of $+12^{\circ}.5$ (1982, January 27) to $+9^{\circ}.7$ (1982, June 12), being maximum opening and closure respectively.

Opposition to the Sun took place on 1982, April 09^{d} 02^{h} U.T.; and Saturn's apparent visual stellar magnitude on that date was +0.5. The major axis of the ring system extended $43''.3$ on April 9th, while the minor axis of the ring system was then $8''.2$ (nearly twice that at opposition in the immediately preceding apparition). Also on the date of opposition, the equatorial diameter of Saturn's globe was $19''.2$, the polar diameter was $17''.2$, and the value of B was $+11^{\circ}.0$ (compared with $+5^{\circ}.6$ for opposition in 1980-81).

Seven observers carried out investigations of Saturn in 1981-82:

Observer	Location	No. of Obs.	Instrument(s)*
Benton, Julius L., Jr.	Warrington, PA	3	8.3cm.(3.3in.)RR 8.9cm.(3.5in.)MAK 10.2cm.(4.0in.)RR
Heath, Alan W.	Nottingham, England	28	30.0cm.(12.0in.)NEW
Leo, Aerts	Heist op den Berg, Belgium	2	6.0cm.(2.4in.)RR 15.0cm.(6.0in.)RR
Robotham, Rob	Springfield, Ontario, Canada	24	8.3cm.(3.3in.)RR 15.0cm.(6.0in.)RR
Troiani, Daniel M.	Chicago, IL	9	25.0cm.(10.0in.)NEW 36.0cm.(14.3in.)NEW 61.0cm.(24.0in.)RR
Wooten, Merry E.	Pensacola, FL	1	15.0cm.(6.0in.)NEW
Wooten, Wayne	Pensacola, FL	2	15.0cm.(6.0in.)NEW 20.0cm.(8.0in.)S-C
Total No. of Observations:		69	
Total No. of Observers:		7	

*(RR=refractor; NEW=Newtonian reflector; S-C=Schmidt-Cassegrain Catadioptric; MAK=Maksutov-Cassegrain Catadioptric)

For the 1981-82 apparition, the tabulation shows that 69 visual and photographic observations were submitted by 7 individuals. By month, the distribution of observations for 1981-82 is presented in the form of a histogram (Figure 1), from which it can be determined that the (rounded) greater percentage of observations was received for the months of 1982, March through May (65%). On either side of this peak period observational activity showed a marked decline. Looking at the dates prior to and following opposition, it can be seen that 43% of the observations were before 1982, April 9, 1% were on the actual date of opposition, and 55% were thereafter. Comparable percentages before and after the date of opposition can be noted with respect to previous apparitions, and it is usually the case that individuals follow Saturn when it is conveniently placed in the evening sky after sunset (near opposition).

The 1981-82 apparition came to an end as Saturn entered the domain of the Sun, conjunction taking place on 1982, October 18^{d} 21^{h} U.T.

The writer extends his warmest thanks to all friends and colleagues mentioned in this report who actively participated in the observational endeavors of the A.L.P.O. Saturn Section. Such consistent, systematic support is most appreciated and is essential to the success of our programs. All individuals, novice or otherwise, who share a keen interest in observing Saturn are cordially invited to contact the author, who will be delighted to discuss potential programs with them in depth.

Section I. The Globe of Saturn

The descriptive report which follows has been based on an analytical reduction of the collective observational data contributed to the A.L.P.O. Saturn Section throughout the apparition of 1981-82. Except where the identity of an individual is pertinent to the discussion, the names of observers have been omitted from the report in the interest of brevity.

Instruments utilized during the 1981-82 apparition ranged in aperture from 6.0 cms. to 61.0 cms (2.4 ins. to 24.0 ins., respectively); and the reader should recognize that inherent large differences exist in terms of optical quality, design, and function among those telescopes cited. A large difference in practical observational experience of those who participated in the program is to be expected as well. The total of 69 observations can be reduced to the following percentages with respect to arbitrary aperture categories:

Apertures of 15.0 cms. (6.0 ins.) or greater 70%
Apertures of 6.0 cms. (2.4 ins.) to 10.2 cms. (4.0 ins.).......... 30%

Compared with the immediately preceding apparition, there was an increase in the percentage of observations made with smaller apertures in 1981-82.

Numerical tables, graphs, and illustrations accompany the current report, and the reader is encouraged to refer to these for a further appreciation of the discussion within these pages.

Northern Portions of the Globe. A somewhat low level of activity characterized Saturn's Northern Hemisphere throughout 1981-82 in much the same manner as in 1980-81. Any reported small details were chiefly described as elusive spots, elongations, and festoons in the environs of the North Equatorial Belt (NEB) as well as in the Equatorial Zone (EZ). Neither the 1981-82 apparition nor the 1980-81 period exhibited activity in the Northern Hemisphere of Saturn which could be stated as being comparable to that of 1979-80. It is important to note, however, that in 1979-80 Saturn was much more intensely observed than in the two subsequent apparitions following the edgewise orientation of the ring system.

To sum up the comparative intensity data, the northern portion of the Equatorial Zone (EZ_n) was only very slight brighter in 1981-82, by a rather insignificant mean factor of 0.1 units, than in 1980-81, while the North Temperate Zone (NTeZ) was darker in 1981-82 than in 1980-81 by the same, almost trivial, amount. The North Polar Region (NPR) showed a mean diminution in brightness since 1980-81 by a mean factor of 0.7 units, while the increase in brightness of the North Tropical Zone (NTrZ) was by a mean factor of 1.2 since 1980-81. This latter mean brightness change with respect to the NTrZ in 1981-82 was the most significant increase in intensity on Saturn's entire globe since the immediately preceding apparition (1980-81).

All of Saturn's belts which were fairly obvious in the 1981-82 period showed a diminution in brightness since 1980-81, chiefly suggesting that they were more prominent during the later apparition. The belt showing the greatest brightness reduction since 1980-81 (and hence a presumed easier visibility) was the North Temperate Belt (NTeB), by a mean factor of 0.9, followed by the North Equatorial Belt (NEB), which was only slightly darker in 1981-82 by a mean factor of 0.2 in intensity. [The changing tilt of the axis of Saturn toward the Earth may play a role in such recorded changes. -Editor]

It is of interest to note that the globe between the North Equatorial Belt (NEB) and the north polar limb was darker by a mean factor of 0.8 units than the region of Saturn's globe between the southern terminus of the outer edge of Ring A in front of the globe and the south polar limb in 1981-82. This was also true in 1980-81, although the difference was more significant during the apparition under consideration here. The impression by comparison is that the Southern Hemisphere had remained fairly stable in overall mean intensity since 1980-81, while the globe north of the rings had undergone an overall mean brightness reduction by 0.5 since 1980-81.

The information which has been the basis for the foregoing summary has been drawn from an intensive comparative investigation of Saturnian belt and zone mean intensity data beginning with the 1979-80 apparition for selected global (Northern Hemisphere) features and has been extended to include data for 1981-82 (see Tables I and II).

A representative sketch of Saturn with its accompanying ring system for a numerical value of B equal to +11° is included with this report. On that sketch is depicted the standard assigned A.L.P.O. nomenclature for belts, zones, and ring components of Saturn (Figure 2).

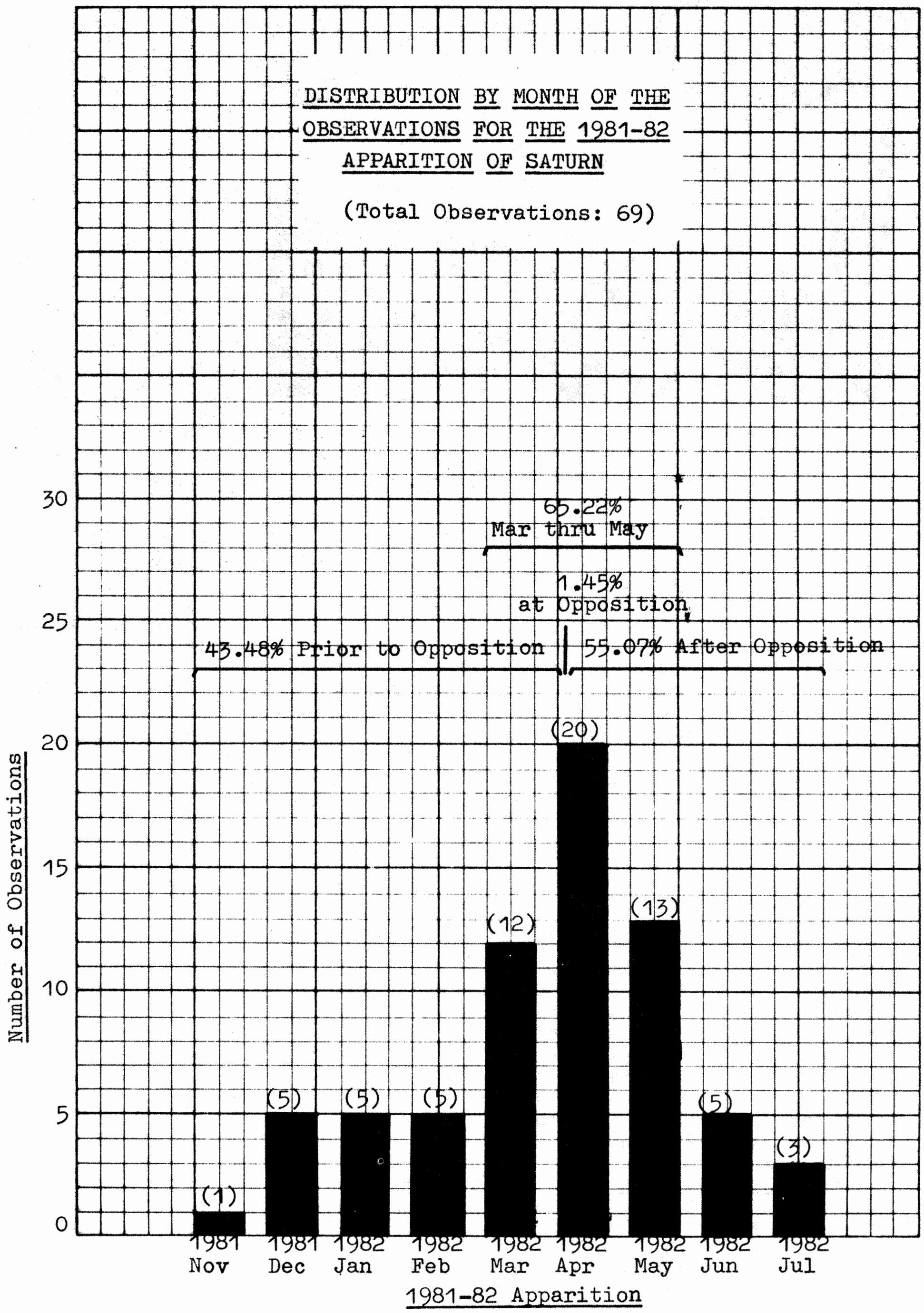

Figure 1. Histogram to show monthly frequency of observations of Saturn by the A.L.P.O. during the 1981-82 apparition. Contributed by Saturn Recorder Julius Benton. See also text of his article on page 133 *et seq*.

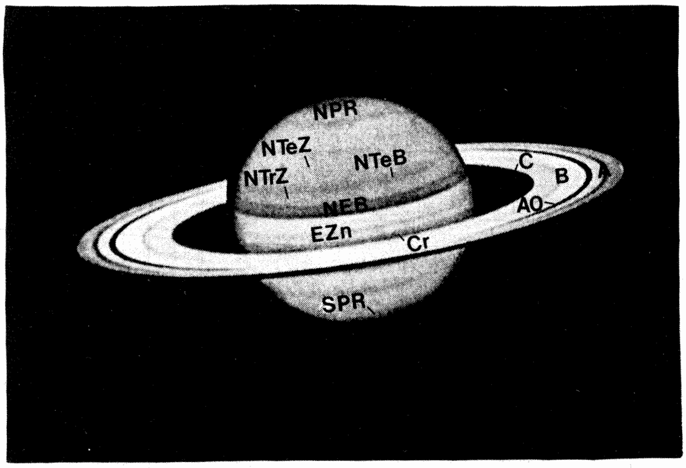

Figure 2. Diagram to show general appearance of Saturn during the 1981-82 apparition and to give the nomenclature of the belts, zones, and ring features. Contributed by Julius Benton. North at top; invert to get the normal astronomical appearance in middle northern latitudes. The features in the order of the descriptive summary in the text are as follows: NPR, North Polar Region; NTeZ, North Termperate Zone; NTeB, North Temperate Belt; NTrZ, North Tropical Zone; NEB, North Equatorial Belt; EZ_n, Equatorial Zone, north component; SPR, South Polar Region; Cr, Crape Band; AO, Cassini's Division; A, Ring A; B, Ring B; C, Ring C.

North Polar Region (NPR). The NPR was somewhat darker throughout 1981-82 than in the immediately preceding apparition (by a mean intensity factor of 0.7), the majority of observers describing it as a region of uniformity in overall intensity, dusky greyish to yellowish-grey in hue, and devoid of any definite North Polar Cap (NPC) or encircling North Polar Band (NPB). The NPR was brighter by a mean intensity of 0.5 than the SPR in 1981-82.

North North Temperate Zone (NNTeZ). No observational evidence of the NNTeZ was received during 1981-82.

North North Temperate Belt (NNTeB). Reports describing the NNTeB were lacking in 1981-82.

North Temperate Zone (NTeZ). In 1981-82 the yellowish-white NTeZ remained essentially the same mean intensity as in 1979-80 and 1980-81. The region was rather uniform in intensity from limb to limb, showing no activity, and a little darker by a mean comparative intensity factor of 0.4 than its southern counterpart, the STeZ. During the two preceding apparitions the NTeZ and STeZ were very similar in mean brightness, the overall difference being no more than a mean factor of 0.1 in 1979-80 and 1980-81.

North Temperate Belt (NTeB). The NTeB was only rarely detected by observers submitting reports in 1981-82; and as was the case in 1980-81, the NTeB was the lightest of the Northern Hemisphere belts in 1981-82. The NTeB was darker in 1981-82 by a mean intensity factor of 0.9 than in the immediately preceding apparition. The belt was described as a diffuse, ill-defined, roughly linear feature having a greyish to yellowish-grey coloration.

North Tropical Zone (NTrZ). The yellowish-white NTrZ was essentially equal in brightness to the STeZ in 1981-82 (the latter was only 0.1 mean intensity points brighter than the NTrZ); and with the possible exception of the STeZ, the NTrZ was second only to the EZ_n in being the brightest zone on the entire globe of Saturn in 1981-82. The NTrZ was diffuse in 1981-82, considerably increased in brightness over its mean intensity in 1980-81, and devoid of any specific activity.

North Equatorial Belt (NEB). For the first time since the edgewise apparition of Saturn in 1979-80, the greyish NEB showed a differentiation into components in 1981-82 (the NEB_n and the NEB_s with an intermediate NEB Z). Taken as a whole, the NEB was only 0.2 mean intensity units darker in 1981-82 than in 1980-81; it was usually wide (as in the two previous apparitions), and aside from faint mottlings and amorphous dark areas, devoid of detail. The NEB as a single feature was the darkest belt on Saturn's globe in 1981-82; and considering the components, the NEB_s was darker than the NEB_n by a mean intensity value of 0.3. No comparison with recent previous apparitions was possible with the components of the NEB nor with the Southern Hemisphere counterpart(s) in 1981-82. The very dark yellowish-grey to yellow-brown NEB Z was very indistinct as a zone between the NEB_n and NEB_s, with each component grading into a lighter intensity where the NEB Z was reported.

Equatorial Zone (chiefly the EZ_n). Showing only a very minor increase in mean brightness since the 1980-81 apparition, the pale yellowish-white EZ_n in 1981-82

Table I. Visual Numerical Relative Intensity Estimates of Major Global and Ring Features for the Planet Saturn During the 1981-82 Apparition with Accompanying Absolute Color Estimates.

Global or Ring Feature	Relative Intensity: No. of Visual Estimates	Mean Intensity and Standard Deviation	Derived Absolute Color
ZONES:			
EZ_n	25	7.34±0.138	Pale yellowish-white
STeZ	22	7.00±1.110	Yellow-white
NTrZ	11	6.85±0.183	Yellow-white
NTeZ	22	6.62±0.176	Yellow-white
Globe S of Rings	3	5.60±0.141	Yellow-grey
NPR	22	4.84±0.282	Dusky yellow-grey
Globe N of Rings	3	4.83±0.236	Dusky yellow-grey
SPR	22	4.32±0.221	Dark yellow-grey
NEB Z	9	3.40±0.156	Very dark yellow-grey to yellow-brown
BELTS:			
NTeB	4	3.83±0.109	Dark yellow-grey
SSTeB	6	3.55±0.126	Very dark yellow-grey
NEB	12	3.30±0.316	Greyish-brown
NEB_n	13	3.08±0.151	Dark greyish-brown
NEB_s	13	2.76±0.194	Very dark greyish-brown
RINGS:			
Ring B (outer 1/3)	STD	8.00	White
Ring B (inner 2/3)	3	6.93±0.094	Yellow-white
Ring A (whole)	25	5.80±0.205	Greyish-yellow
Crape Band	21	1.89±0.532	Dark grey
Ring C (ansae)	3	1.83±0.236	Very dark grey
Shadow Rings on Globe	17	1.64±0.209	Greyish-black
Shadow Globe on Rings	22	1.10±0.400	Dark greyish-black
B10 or A0 (Cassini's)	2	0.65±0.150	Very dark greyish-black

Visual numerical relative intensity estimates (visual surface photometry) are based upon the A.L.P.O. Intensity Scale, where 0.0 denotes complete black (shadow) and 10.0 refers to the greatest brilliant white condition (very brightest Solar System reflectivity). The adopted scale utilized employs for Saturn a reference standard (denoted above as STD) of 8.0 for the outer 1/3 of Ring B, which appears to be usually stable in ov^rall intensity with time at most ring inclinations. All other global or ring features are estimated relative to this reference standard, and details as to the procedures for conducting such visual estimates are to be found in The Saturn Handbook.

* * * * *

was the brightest zone on Saturn's globe. No detail was reported in the EZ_n aside from vaguely suspected whitish areas from time to time. No observers commented on the Equatorial Band (EB), but it was recorded by Aerts Leo in an excellent view (Figure 6).

Table II. Comparative Mean Intensity Data For Saturn's Zones, Belts, and Ring Features.

Saturnian Feature	Mean Intensity 1980-81	Mean Intensity 1981-82	Mean Intensity Difference
1. The Northern Hemisphere: Zones			
EZ_n	7.2	7.3	0.1 (brighter)
NTeZ	6.7	6.6	0.1 (darker)
NTrZ	5.7	6.9	1.2 (brighter)
NPR	5.5	4.8	0.7 (darker)
NEB Z	---	3.4	No comparison possible
II. The Northern Hemisphere: Belts			
NTeB	4.7	3.8	0.9 (darker)
EB	4.0	---	No comparison possible
NEB	3.5	3.3	0.2 (darker)
NEB_s	---	2.8	No comparison possible
NEB_n	---	3.1	No comparison possible
III. The Southern Hemisphere: Zones			
STeZ	6.6	7.0	0.4 (brighter)
STrZ	6.1	---	No comparison possible
SPR	5.4	4.3	1.1 (darker)
IV. The Southern Hemisphere: Belts			
SEB	5.2(?)	---	No comparison possible
STeB	4.4	---	No comparison possible
SPB	3.8	---	No comparison possible
V. The Ring System (North Face)			
Ring B (outer 1/3) STANDARD	8.0		
Ring B (inner 2/3)	7.4	6.9	0.5 (darker)
Ring A (whole)	6.7	5.8	0.9 (darker)
Ring C (ansae)	2.0	1.8	0.2 (darker)
Ring C (Crape Band)	2.9	1.9	1.0 (darker)
Shadow Rings on Globe	1.7	1.6	0.1 (darker)
Shadow Globe on Rings	0.4	1.1	0.7 (brighter)
B10 or A0 (Cassini's)	0.8	0.7	0.1 (darker)

Shadow of the Rings on the Globe. The projected shadow of the rings on the globe was reported by observers during the 1981-82 apparition as a uniform greyish-black feature, geometrically regular, and most frequently seen in mid-April of 1982.

Shadow of the Globe on the Rings. The shadow of the globe of Saturn on the ring system was reported as a very dark greyish-black feature of regular geometric form during 1981-82. It was apparently not so dark in 1981-82 (brighter by a mean factor of 0.7) as in 1980-81, although it is anticipated that this difference may have been due to seeing, etc.

[Indeed, one may suspect that any deviation from blackness of either shadow was due to poor seeing, small aperture, inadequate telescopic resolution, etc. - Editor]

Southern Portions of the Globe. Increasingly, Saturn's Southern Hemisphere was tilted away from our line of sight during 1981-82; and as a consequence, very few belts and zones were detected. The South Temperate Zone (STeZ) was the only zone sighted by observers in 1981-82, showing an increase in brightness (mean) since 1980-81 by a mean intensity factor of 0.4. Observers noted that the STeZ was second only to the EZ_n in mean intensity during the 1981-82 period (the difference amounting to 0.3 on the mean intensity scale). The color ascribed to the STeZ was yellowish-white. It was devoid of activity and uniform in intensity throughout the 1981-82 apparition.

The South Polar Region (SPR) was dark yellowish-grey in hue, exhibiting a diminution in intensity by a mean factor of 1.1 since 1980-81; and it was darker than the NPR by a mean factor throughout 1981-82 of 0.5. No detail was apparent in the SPR during the apparition, although a few reports of the South South Temperate Belt (SSTeB) were submitted, obervers describing the feature as a very dark yellowish-grey, somewhat discontinuous belt, seldom visible with any certainty

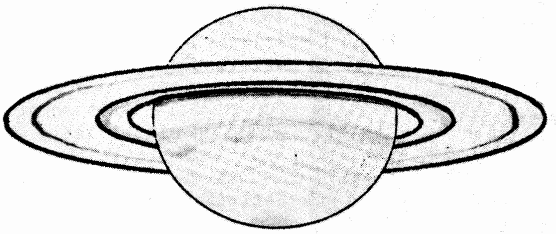

Figure 3. Drawing of Saturn by Daniel M. Troiani on April 7, 1982, 4^h 26^m-4^h 51^m, U.T. 10-inch f/6 Newtonian reflector, 374X. Wratten Filter 11 (yellow). Seeing 5 (scale of 0 to 10 with 10 best). Transparency 6 (limiting stellar magnitude). Simply inverted view with south at top, as in all figures on this page. Some internal detail in NEB. B=+11°0.

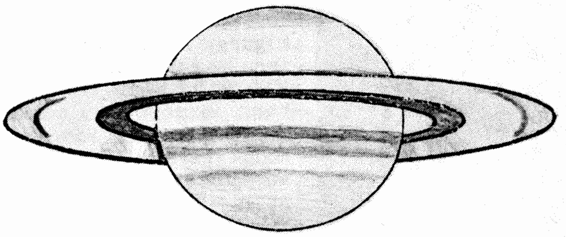

Figure 4. Drawing of Saturn by Rob Robotham on April 9, 1982, 3^h 10^m-3^h 32^m, U.T. 15-cm. (6-inch) Newtonian reflector, 203X. Seeing 4-7. Transparency about 2.B=+11°0.

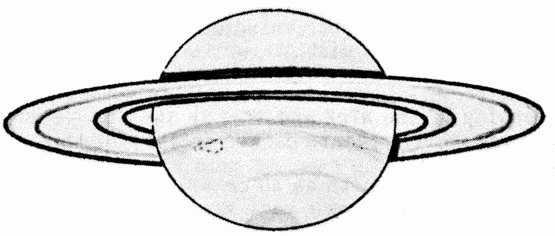

Figure 5. Drawing of Saturn by Daniel M. Troiani on May 3, 1982, 2^h 30^m-2^h 51^m, U.T. 10-inch f/6 Newtonian reflector, 375X and 283X. Seeing 6. Transparency 4. Shadow of ball on rings and shadow of rings on ball both conspicuous. Wratten Filter 11 (yellow). B=+10°2.

* * * * *

except at moments of best seeing. No other belt was reported in Saturn's Southern Hemisphere in 1981-82.

Latitude Data. Visual and other quantitative latitude data were absent during the 1981-82 apparition, and for that apparition and the one of 1980-81 observers have apparently not attempted such work to any degree. In view of the importance of such observations, readers are again encouraged to supplement their observational pursuits with such meaningful estimates or measurements.

Section II. The Ring System

Starting with the 1980-81 apparition, attempts began to amass intensity data for the features and phenomena of Saturn's northern ring face in much the same way as had been done for the southern ring face in earlier apparitions when the numerical values of B were negative (-). Therefore, our discussion here has been based upon, in part, a continuing comparative analysis of mean intensity data since 1980-81. As the ring system continues to open up, the various ring components and associated phenomena should become easier to detect and study. As mentioned earlier in this report, the average numerical value of B in 1981-82 was about +10°5, as opposed to +5°5 (average) in 1980-81.

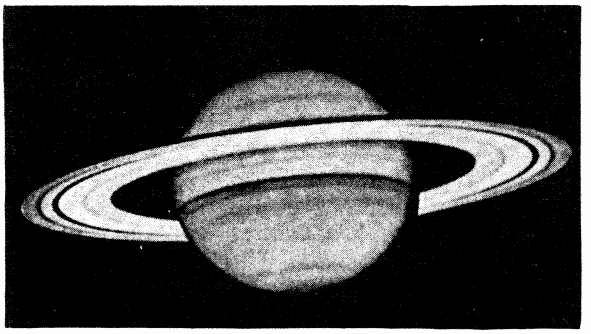

Figure 6. Drawing of Saturn by Aerts Leo on January 20, 1982 at 4^h 30^m U.T. 15-cm. f/15 refractor, 280X. Seeing very good. Sky hazy. South at top, image reversed left-for-right. Note shadow of globe on rings, Terby White Spot beside the shadow, a faint Equatorial Band, Encke's Division in Ring A, and an apparent "division" near the middle of Ring B. B=+12°.5.

Figure 7. Photograph of Saturn by Aerts Leo on January 20, 1982. 6-cm. f/11 refractor. Exposure 5 seconds, ocular projection. Tri-X Kodak film. (The faintest features on the original print may not have been reproduced clearly.)

Ring B. The outer third of Ring B is the adopted reference standard for the A.L.P.O. Visual Numerical Relative Intensity Scale for Saturn, with an assigned value of 8.0.

Throughout the 1981-82 apparition, the outer third of Ring B was stable in intensity, with no suspected variations and a distinct white appearance. It was the brightest Saturnian feature (both globe and rings) in 1981-82. The innermost two-thirds of Ring B was the second brightest ring feature, yellowish-white in hue, and very close to the mean intensity of the NTrZ and STeZ in 1981-82. The inner two-thirds of Ring B was 0.5 mean intensity points darker in 1981-82 than in the immediately preceding apparition.

Cassini's Division, denoted in our pursuits as A0 or B10, could be detected with relative ease at the ansae, exhibiting a very dark greyish-black appearance. Few observers reported that A0 or B10 was easy to see all the way around the ring system; and most impressions were that the feature was similar to what it had been in 1980-81, perhaps a bit wider and marginally darker. No other "intensity minima" could be detected by observers in Ring B during 1981-82 (but see Figure 6).

Ring A. Considered as a whole, Ring A was greyish-yellow in color, showed no differentiation, and exhibited about the same mean intensity in 1981-82 as the globe of Saturn south of the rings (mean difference about 0.2). Comparing it to the immediately preceding apparition, Ring A was darker by a mean factor of 0.9 units in intensity. Ring A was quite uniform throughout, with no indication of Encke's Division (A5) or other "intensity minima" except that the view in Figure 6 is again an exception.

Ring C. Most observers agreed that Ring C was very difficult to see at the ansae in 1981-82; but when it was detected Ring C was very dark grey, uniform in intensity, and slightly darker than in 1980-81 in mean intensity (0.2 points).

Interestingly, the Crape Band (where Ring C crosses in front of Saturn's globe) was much easier to see in 1981-82 than in 1980-81. It was described as a feature nearly equal to the portion of Ring C off the globe during the apparition, having a dark greyish hue, and being more or less linear. The Crape Band was darker in 1981-82 than in 1980-81 by a mean intensity factor of 1.0.

Other Ring Components. Although some observers in the past have suspected Ring D (internal to Ring C) and Ring E (external to Ring A), no indications of these highly elusive features were forthcoming in the 1981-82 apparition.

Terby White Spot. No explicit reports of the Terby White Spot were submitted in 1981-82, but it is present on an excellent drawing by Mr. Leo (Figure 6).

Bicolored Aspect of the Rings. No reported suspected differences in intensity (in integrated light or with color filters) between the east and west ansae of the rings were forthcoming during the 1981-82 apparition.

Section III. The Satellites

Aside from a few observations of Titan (SVI) and Rhea (SV) in March through May of 1982, no reports were submitted on Saturn's satellites throughout 1981-82 which were suitable for analysis.

Section IV. Conclusions

Throughout 1981-82, it became obvious that fewer individuals followed Saturn with their telescopes than in 1980-81. Even so, observational reports were sufficient to give one a reasonable idea of global and ring phenomena during the 1981-82 apparition, although more intense studies of Saturn are certainly sought in coming years.

In summation, activity in the northern and southern hemispheres of Saturn remained fairly low in 1981-82, and ring phenomena were about the same as in 1980-81. Our report, however, suggests some obvious points with regard to the globe and rings which set 1981-82 aside from 1980-81; and continued investigations are important for all Saturnian features and phenomena as the rings open up more and more in subsequent apparitions and as we continue our comparative analyses of intensity data, etc. Observers are urged to pursue, in addition to routine drawings and intensity estimates, some of the badly neglected areas of study pertaining to Saturn.

The writer extends once again his gratitude to all individuals who have participated in our programs, and an open invitation exists for all who share an interest in Saturn to join us in the coming months.

Section V. References

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Postscript by Editor. Students of Saturn may want to compare this report to Mr. G. Adamoli's article, "Visual Observations of Saturn in the 1981-82 Apparition", Journal A.L.P.O., Vol. 30, Nos. 1-2, pp. 11-16. The two groups of reporting observers have only one common member so that their results are largely independent. It should be noted, however, that the groups use different intensity scales for Saturn.

The Editor would join Dr. Benton in urging much more intensive coverage of Saturn by A.L.P.O. members. Surely among our hundreds of members there should be more than seven who submit reports of observations of Saturn! Indeed, we would suspect that many dozens of our members look at that planet in telescopes but report nothing, and probably record nothing. More systematic studies can become more rewarding, and Recorder Benton is eager to help all who are interested. The coming warm summer evenings should encourage observations. Participation in some of the more advanced projects like latitude measures, photometry of the satellites, and central meridian transits of surface features is especially encouraged.

Novice planetary observers are strongly encouraged to enrol in the A.L.P.O. Lunar and Planetary Training Program. Mr. Jose Olivarez, the Recorder for that project, will gladly assist them to learn and to develop good observational techniques. Indeed, many members with some experience in planetary observing might still benefit from the training being offered. We are never too old to learn! Mr. Olivarez's address appears on the back inside cover. New Saturn observers are also reminded of Julius Benton's article in our immediately preceding issue, "A Beginner's Guide to Visual Observations of Saturn," J.A.L.P.O., Vol. 30, Nos. 5-6, pp. 89-96, 1984.

1984 MON.	DAY	EARTH'S SELEN. LONG.	EARTH'S SELEN. LAT.	SUN'S SELEN. COLONG.	SUN'S SELEN. LAT.
JAN	01	+5°.24	−0°.13	239°.03	−0°.69
JAN	02	+4.71	+1.39	251.22	−0.72
JAN	03	+4.01	+2.81	263.41	−0.74
JAN	04	+3.14	+4.08	275.59	−0.76
JAN	05	+2.12	+5.13	287.78	−0.78
JAN	06	+0.99	+5.94	299.96	−0.80
JAN	07	−0.24	+6.48	312.15	−0.82
JAN	08	−1.53	+6.74	324.32	−0.83
JAN	09	−2.82	+6.71	336.50	−0.85
JAN	10	−4.06	+6.39	348.67	−0.86
JAN	11	−5.18	+5.80	000.83	−0.88
JAN	12	−6.11	+4.95	012.98	−0.90
JAN	13	−6.77	+3.85	025.13	−0.91
JAN	14	−7.09	+2.54	037.27	−0.93
JAN	15	−6.99	+1.05	049.41	−0.95
JAN	16	−6.44	−0.55	061.54	−0.98
JAN	17	−5.43	−2.16	073.67	−1.00
JAN	18	−4.01	−3.67	085.80	−1.02
JAN	19	−2.27	−4.96	097.92	−1.05
JAN	20	−0.35	−5.93	110.04	−1.08
JAN	21	+1.58	−6.49	122.17	−1.10
JAN	22	+3.36	−6.60	134.30	−1.13
JAN	23	+4.84	−6.28	146.44	−1.15
JAN	24	+5.95	−5.57	158.59	−1.17
JAN	25	+6.64	−4.54	170.74	−1.20
JAN	26	+6.93	−3.28	182.90	−1.22
JAN	27	+6.85	−1.86	195.07	−1.24
JAN	28	+6.46	−0.38	207.24	−1.26
JAN	29	+5.83	+1.10	219.42	−1.29
JAN	30	+5.01	+2.51	231.60	−1.30
JAN	31	+4.05	+3.78	243.79	−1.32
FEB	01	+2°.98	+4°.86	255°.98	−1°.34
FEB	02	+1.83	+5.72	268.17	−1.35
FEB	03	+0.62	+6.30	280.37	−1.36
FEB	04	−0.65	+6.61	292.56	−1.37
FEB	05	−1.94	+6.63	304.75	−1.38
FEB	06	−3.22	+6.35	316.94	−1.39
FEB	07	−4.47	+5.81	329.12	−1.39
FEB	08	−5.62	+5.01	341.30	−1.40
FEB	09	−6.61	+3.97	353.47	−1.40
FEB	10	−7.37	+2.74	005.64	−1.41
FEB	11	−7.82	+1.35	017.80	−1.41
FEB	12	−7.87	−0.15	029.95	−1.42
FEB	13	−7.45	−1.69	042.10	−1.43
FEB	14	−6.52	−3.18	054.25	−1.43
FEB	15	−5.09	−4.50	066.38	−1.44
FEB	16	−3.24	−5.55	078.52	−1.45
FEB	17	−1.11	−6.23	090.65	−1.46
FEB	18	+1.11	−6.46	102.78	−1.47
FEB	19	+3.21	−6.24	114.92	−1.48
FEB	20	+5.01	−5.60	127.06	−1.49
FEB	21	+6.38	−4.61	139.21	−1.49
FEB	22	+7.25	−3.36	151.36	−1.50
FEB	23	+7.63	−1.95	163.52	−1.51
FEB	24	+7.56	−0.47	175.69	−1.52
FEB	25	+7.11	+0.99	187.86	−1.53
FEB	26	+6.36	+2.38	200.04	−1.54
FEB	27	+5.40	+3.64	212.23	−1.54
FEB	28	+4.29	+4.73	224.42	−1.55
FEB	29	+3.08	+5.59	236.62	−1.56

1984 MON.	DAY	EARTH'S SELEN. LONG.	EARTH'S SELEN. LAT.	SUN'S SELEN. COLONG.	SUN'S SELEN. LAT.
MAR	01	+1°.83	+6°.20	248°.82	−1°.56
MAR	02	+0.55	+6.54	261.02	−1.56
MAR	03	−0.73	+6.59	273.23	−1.56
MAR	04	−2.00	+6.35	285.43	−1.56
MAR	05	−3.23	+5.83	297.64	−1.56
MAR	06	−4.41	+5.04	309.84	−1.55
MAR	07	−5.49	+4.02	322.04	−1.54
MAR	08	−6.45	+2.80	334.24	−1.53
MAR	09	−7.20	+1.44	346.42	−1.53
MAR	10	−7.70	−0.02	358.61	−1.52
MAR	11	−7.85	−1.51	010.79	−1.51
MAR	12	−7.57	−2.95	022.96	−1.50
MAR	13	−6.83	−4.26	035.12	−1.49
MAR	14	−5.59	−5.35	047.28	−1.48
MAR	15	−3.92	−6.10	059.44	−1.47
MAR	16	−1.91	−6.45	071.59	−1.46
MAR	17	+0.26	−6.35	083.74	−1.45
MAR	18	+2.40	−5.80	095.88	−1.44
MAR	19	+4.30	−4.86	108.03	−1.43
MAR	20	+5.83	−3.61	120.19	−1.42
MAR	21	+6.87	−2.17	132.35	−1.41
MAR	22	+7.41	−0.64	144.51	−1.40
MAR	23	+7.46	+0.87	156.68	−1.40
MAR	24	+7.10	+2.30	168.86	−1.39
MAR	25	+6.39	+3.59	181.04	−1.39
MAR	26	+5.43	+4.69	193.24	−1.38
MAR	27	+4.29	+5.57	205.43	−1.38
MAR	28	+3.05	+6.20	217.64	−1.37
MAR	29	+1.75	+6.57	229.85	−1.36
MAR	30	+0.46	+6.66	242.06	−1.36
MAR	31	−0.81	+6.45	254.28	−1.35
APR	01	−2°.02	+5°.96	266°.50	−1°.34
APR	02	−3.15	+5.19	278.72	−1.32
APR	03	−4.18	+4.17	290.94	−1.31
APR	04	−5.10	+2.95	303.16	−1.29
APR	05	−5.88	+1.57	315.38	−1.27
APR	06	−6.48	+0.09	327.59	−1.25
APR	07	−6.84	−1.42	339.80	−1.23
APR	08	−6.92	−2.87	352.00	−1.21
APR	09	−6.67	−4.20	004.20	−1.18
APR	10	−6.04	−5.31	016.39	−1.16
APR	11	−5.01	−6.12	028.57	−1.14
APR	12	−3.63	−6.56	040.75	−1.11
APR	13	−1.95	−6.57	052.92	−1.09
APR	14	−0.11	−6.14	065.09	−1.06
APR	15	+1.74	−5.29	077.25	−1.04
APR	16	+3.46	−4.09	089.42	−1.01
APR	17	+4.88	−2.64	101.58	−0.99
APR	18	+5.92	−1.06	113.75	−0.96
APR	19	+6.51	+0.54	125.92	−0.94
APR	20	+6.67	+2.06	138.10	−0.92
APR	21	+6.41	+3.42	150.28	−0.90
APR	22	+5.81	+4.59	162.47	−0.88
APR	23	+4.92	+5.53	174.67	−0.87
APR	24	+3.83	+6.21	186.87	−0.85
APR	25	+2.61	+6.63	199.08	−0.84
APR	26	+1.33	+6.76	211.29	−0.83
APR	27	+0.05	+6.61	223.52	−0.81
APR	28	−1.17	+6.17	235.75	−0.80
APR	29	−2.30	+5.45	247.98	−0.78
APR	30	−3.30	+4.47	260.21	−0.76

1984 MON.	DAY	EARTH'S SELEN. LONG.	LAT.	SUN'S SELEN. COLONG.	LAT.
MAY	01	-4°.15	+3°.27	272°.45	-0°.74
MAY	02	-4.83	+1.88	284.68	-0.72
MAY	03	-5.33	+0.38	296.92	-0.69
MAY	04	-5.62	-1.17	309.15	-0.67
MAY	05	-5.68	-2.69	321.38	-0.64
MAY	06	-5.51	-4.08	333.60	-0.61
MAY	07	-5.07	-5.25	345.82	-0.58
MAY	08	-4.38	-6.13	358.04	-0.55
MAY	09	-3.43	-6.65	010.24	-0.52
MAY	10	-2.27	-6.77	022.44	-0.48
MAY	11	-0.95	-6.46	034.64	-0.45
MAY	12	+0.46	-5.72	046.82	-0.42
MAY	13	+1.86	-4.62	059.01	-0.38
MAY	14	+3.15	-3.23	071.19	-0.35
MAY	15	+4.23	-1.66	083.36	-0.31
MAY	16	+5.03	-0.01	095.54	-0.28
MAY	17	+5.50	+1.59	107.72	-0.25
MAY	18	+5.61	+3.06	119.91	-0.22
MAY	19	+5.38	+4.34	132.09	-0.19
MAY	20	+4.83	+5.37	144.29	-0.17
MAY	21	+4.01	+6.13	156.48	-0.15
MAY	22	+2.97	+6.61	168.69	-0.13
MAY	23	+1.79	+6.80	180.90	-0.11
MAY	24	+0.54	+6.71	193.12	-0.09
MAY	25	-0.72	+6.34	205.35	-0.08
MAY	26	-1.92	+5.70	217.58	-0.06
MAY	27	-2.99	+4.80	229.81	-0.04
MAY	28	-3.88	+3.66	242.05	-0.02
MAY	29	-4.56	+2.32	254.30	+0.00
MAY	30	-4.98	+0.84	266.55	+0.02
MAY	31	-5.15	-0.72	278.79	+0.05
JUN	01	-5°.05	-2°.28	291°.04	+0°.07
JUN	02	-4.69	-3.74	303.29	+0.10
JUN	03	-4.11	-5.01	315.53	+0.13
JUN	04	-3.32	-5.98	327.77	+0.16
JUN	05	-2.38	-6.60	340.00	+0.19
JUN	06	-1.33	-6.82	352.23	+0.22
JUN	07	-0.24	-6.61	004.45	+0.25
JUN	08	+0.86	-5.99	016.66	+0.29
JUN	09	+1.90	-5.00	028.86	+0.33
JUN	10	+2.85	-3.71	041.06	+0.36
JUN	11	+3.65	-2.20	053.26	+0.40
JUN	12	+4.28	-0.58	065.45	+0.43
JUN	13	+4.69	+1.05	077.63	+0.47
JUN	14	+4.87	+2.58	089.82	+0.50
JUN	15	+4.79	+3.94	102.01	+0.53
JUN	16	+4.44	+5.07	114.20	+0.56
JUN	17	+3.84	+5.92	126.40	+0.59
JUN	18	+3.01	+6.48	138.59	+0.61
JUN	19	+1.98	+6.75	150.80	+0.63
JUN	20	+0.81	+6.72	163.01	+0.64
JUN	21	-0.44	+6.41	175.23	+0.66
JUN	22	-1.71	+5.84	187.45	+0.67
JUN	23	-2.91	+5.01	199.68	+0.69
JUN	24	-3.97	+3.96	211.91	+0.70
JUN	25	-4.81	+2.71	224.15	+0.71
JUN	26	-5.38	+1.30	236.40	+0.73
JUN	27	-5.62	-0.21	248.65	+0.74
JUN	28	-5.51	-1.76	260.90	+0.76
JUN	29	-5.03	-3.25	273.15	+0.78
JUN	30	-4.23	-4.58	285.41	+0.80

1984 MON.	DAY	EARTH'S SELEN. LONG.	LAT.	SUN'S SELEN. COLONG.	LAT.
JUL	01	-3°.17	-5°.65	297°.66	+0°.82
JUL	02	-1.92	-6.37	309.91	+0.85
JUL	03	-0.60	-6.69	322.16	+0.87
JUL	04	+0.70	-6.59	334.40	+0.90
JUL	05	+1.90	-6.06	346.63	+0.92
JUL	06	+2.94	-5.16	358.86	+0.95
JUL	07	+3.77	-3.95	011.07	+0.98
JUL	08	+4.39	-2.52	023.29	+1.02
JUL	09	+4.80	-0.96	035.49	+1.05
JUL	10	+5.01	+0.63	047.69	+1.08
JUL	11	+5.02	+2.17	059.89	+1.11
JUL	12	+4.84	+3.56	072.08	+1.14
JUL	13	+4.47	+4.74	084.27	+1.16
JUL	14	+3.92	+5.66	096.46	+1.19
JUL	15	+3.17	+6.29	108.65	+1.21
JUL	16	+2.25	+6.63	120.85	+1.22
JUL	17	+1.17	+6.66	133.05	+1.24
JUL	18	-0.04	+6.40	145.25	+1.25
JUL	19	-1.33	+5.88	157.46	+1.25
JUL	20	-2.62	+5.11	169.67	+1.26
JUL	21	-3.86	+4.12	181.89	+1.27
JUL	22	-4.96	+2.94	194.12	+1.27
JUL	23	-5.83	+1.61	206.35	+1.27
JUL	24	-6.38	+0.18	218.59	+1.28
JUL	25	-6.55	-1.31	230.83	+1.28
JUL	26	-6.28	-2.77	243.08	+1.29
JUL	27	-5.56	-4.12	255.33	+1.30
JUL	28	-4.42	-5.25	267.58	+1.31
JUL	29	-2.94	-6.07	279.84	+1.32
JUL	30	-1.25	-6.49	292.09	+1.33
JUL	31	+0.49	-6.48	304.34	+1.34
AUG	01	+2°.15	-6°.03	316°.59	+1°.36
AUG	02	+3.58	-5.20	328.82	+1.37
AUG	03	+4.72	-4.04	341.06	+1.39
AUG	04	+5.53	-2.65	353.28	+1.41
AUG	05	+6.00	-1.13	005.50	+1.43
AUG	06	+6.17	+0.42	017.71	+1.45
AUG	07	+6.09	+1.93	029.91	+1.47
AUG	08	+5.79	+3.32	042.11	+1.49
AUG	09	+5.30	+4.51	054.31	+1.51
AUG	10	+4.65	+5.47	066.50	+1.52
AUG	11	+3.86	+6.14	078.69	+1.54
AUG	12	+2.94	+6.53	090.87	+1.55
AUG	13	+1.88	+6.60	103.06	+1.55
AUG	14	+0.71	+6.39	115.25	+1.56
AUG	15	-0.56	+5.89	127.44	+1.56
AUG	16	-1.89	+5.15	139.64	+1.56
AUG	17	-3.22	+4.19	151.84	+1.55
AUG	18	-4.50	+3.04	164.04	+1.55
AUG	19	-5.64	+1.76	176.25	+1.54
AUG	20	-6.56	+0.37	188.47	+1.53
AUG	21	-7.16	-1.06	200.69	+1.52
AUG	22	-7.37	-2.47	212.91	+1.51
AUG	23	-7.10	-3.80	225.15	+1.51
AUG	24	-6.32	-4.95	237.38	+1.50
AUG	25	-5.05	-5.83	249.63	+1.50
AUG	26	-3.36	-6.34	261.87	+1.49
AUG	27	-1.39	-6.44	274.11	+1.49
AUG	28	+0.67	-6.09	286.36	+1.49
AUG	29	+2.65	-5.31	298.60	+1.49
AUG	30	+4.38	-4.18	310.84	+1.49
AUG	31	+5.73	-2.79	323.07	+1.49

1984 MON.	DAY	EARTH'S SELEN. LONG.	LAT.	SUN'S SELEN. COLONG.	LAT.
SEP	01	+6°.67	−1°.25	335°.29	+1°.50
SEP	02	+7.17	+0.32	347.51	+1.50
SEP	03	+7.30	+1.84	359.72	+1.51
SEP	04	+7.09	+3.22	011.92	+1.51
SEP	05	+6.61	+4.42	024.12	+1.52
SEP	06	+5.93	+5.39	036.31	+1.52
SEP	07	+5.08	+6.09	048.50	+1.53
SEP	08	+4.09	+6.51	060.68	+1.53
SEP	09	+3.00	+6.63	072.86	+1.53
SEP	10	+1.81	+6.44	085.04	+1.52
SEP	11	+0.56	+5.98	097.21	+1.52
SEP	12	−0.75	+5.25	109.39	+1.50
SEP	13	−2.09	+4.29	121.56	+1.49
SEP	14	−3.41	+3.14	133.74	+1.47
SEP	15	−4.67	+1.85	145.93	+1.46
SEP	16	−5.81	+0.47	158.11	+1.44
SEP	17	−6.74	−0.94	170.31	+1.42
SEP	18	−7.38	−2.34	182.50	+1.40
SEP	19	−7.65	−3.66	194.71	+1.37
SEP	20	−7.47	−4.82	206.92	+1.35
SEP	21	−6.79	−5.73	219.13	+1.33
SEP	22	−5.60	−6.33	231.35	+1.32
SEP	23	−3.97	−6.53	243.58	+1.30
SEP	24	−2.00	−6.29	255.81	+1.28
SEP	25	+0.14	−5.61	268.04	+1.26
SEP	26	+2.25	−4.54	280.27	+1.25
SEP	27	+4.17	−3.15	292.50	+1.24
SEP	28	+5.73	−1.57	304.72	+1.22
SEP	29	+6.86	+0.07	316.94	+1.21
SEP	30	+7.53	+1.66	329.15	+1.20
OCT	01	+7°.75	+3°.12	341°.35	+1.19
OCT	02	+7.59	+4.37	353.55	+1.19
OCT	03	+7.09	+5.38	005.74	+1.18
OCT	04	+6.33	+6.11	017.92	+1.17
OCT	05	+5.38	+6.56	030.10	+1.16
OCT	06	+4.28	+6.72	042.28	+1.15
OCT	07	+3.07	+6.58	054.44	+1.14
OCT	08	+1.80	+6.15	066.61	+1.12
OCT	09	+0.49	+5.45	078.77	+1.11
OCT	10	−0.82	+4.51	090.93	+1.08
OCT	11	−2.11	+3.36	103.09	+1.06
OCT	12	−3.35	+2.06	115.25	+1.04
OCT	13	−4.50	+0.65	127.41	+1.01
OCT	14	−5.51	−0.80	139.57	+0.98
OCT	15	−6.34	−2.23	151.74	+0.95
OCT	16	−6.91	−3.58	163.91	+0.92
OCT	17	−7.16	−4.77	176.09	+0.89
OCT	18	−7.03	−5.73	188.27	+0.86
OCT	19	−6.49	−6.39	200.46	+0.83
OCT	20	−5.51	−6.69	212.65	+0.80
OCT	21	−4.13	−6.58	224.85	+0.77
OCT	22	−2.42	−6.03	237.06	+0.74
OCT	23	−0.51	−5.06	249.27	+0.71
OCT	24	+1.45	−3.74	261.48	+0.69
OCT	25	+3.31	−2.17	273.69	+0.66
OCT	26	+4.91	−0.47	285.90	+0.64
OCT	27	+6.16	+1.22	298.11	+0.61
OCT	28	+6.98	+2.79	310.32	+0.59
OCT	29	+7.36	+4.16	322.51	+0.57
OCT	30	+7.32	+5.26	334.70	+0.55
OCT	31	+6.92	+6.08	346.89	+0.54

1984 MON.	DAY	EARTH'S SELEN. LONG.	LAT.	SUN'S SELEN. COLONG.	LAT.
NOV	01	+6°.20	+6°.59	359°.07	+0°.52
NOV	02	+5.24	+6.80	011.24	+0.50
NOV	03	+4.10	+6.71	023.40	+0.48
NOV	04	+2.84	+6.34	035.56	+0.46
NOV	05	+1.52	+5.70	047.72	+0.44
NOV	06	+0.20	+4.80	059.86	+0.42
NOV	07	−1.07	+3.69	072.01	+0.39
NOV	08	−2.27	+2.41	084.15	+0.36
NOV	09	−3.35	+1.00	096.29	+0.33
NOV	10	−4.28	−0.48	108.44	+0.30
NOV	11	−5.05	−1.96	120.58	+0.27
NOV	12	−5.61	−3.37	132.72	+0.23
NOV	13	−5.93	−4.62	144.87	+0.20
NOV	14	−6.00	−5.65	157.02	+0.16
NOV	15	−5.77	−6.39	169.18	+0.13
NOV	16	−5.25	−6.78	181.34	+0.10
NOV	17	−4.44	−6.77	193.51	+0.06
NOV	18	−3.34	−6.36	205.69	+0.03
NOV	19	−2.02	−5.53	217.87	+0.00
NOV	20	−0.54	−4.34	230.06	−0.04
NOV	21	+1.02	−2.85	242.25	−0.07
NOV	22	+2.54	−1.18	254.45	−0.10
NOV	23	+3.92	+0.55	266.65	−0.13
NOV	24	+5.05	+2.22	278.84	−0.15
NOV	25	+5.87	+3.70	291.04	−0.18
NOV	26	+6.32	+4.94	303.23	−0.21
NOV	27	+6.39	+5.87	315.42	−0.23
NOV	28	+6.08	+6.48	327.60	−0.25
NOV	29	+5.44	+6.77	339.77	−0.27
NOV	30	+4.53	+6.75	351.94	−0.30
DEC	01	+3°.40	+6°.44	004°.11	−0°.32
DEC	02	+2.13	+5.87	016.26	−0.34
DEC	03	+0.79	+5.05	028.41	−0.36
DEC	04	−0.53	+4.01	040.56	−0.38
DEC	05	−1.77	+2.78	052.70	−0.41
DEC	06	−2.86	+1.42	064.83	−0.44
DEC	07	−3.77	−0.04	076.97	−0.46
DEC	08	−4.45	−1.53	089.10	−0.49
DEC	09	−4.88	−2.97	101.23	−0.52
DEC	10	−5.05	−4.28	113.35	−0.55
DEC	11	−4.96	−5.39	125.49	−0.58
DEC	12	−4.64	−6.21	137.62	−0.61
DEC	13	−4.12	−6.69	149.76	−0.64
DEC	14	−3.42	−6.77	161.90	−0.67
DEC	15	−2.57	−6.46	174.05	−0.70
DEC	16	−1.63	−5.75	186.21	−0.73
DEC	17	−0.61	−4.68	198.37	−0.76
DEC	18	+0.46	−3.31	210.54	−0.78
DEC	19	+1.53	−1.74	222.72	−0.81
DEC	20	+2.57	−0.06	234.91	−0.84
DEC	21	+3.51	+1.61	247.09	−0.87
DEC	22	+4.31	+3.16	259.28	−0.89
DEC	23	+4.89	+4.48	271.47	−0.92
DEC	24	+5.21	+5.52	283.66	−0.94
DEC	25	+5.23	+6.24	295.85	−0.96
DEC	26	+4.93	+6.62	308.03	−0.98
DEC	27	+4.31	+6.68	320.21	−1.00
DEC	28	+3.42	+6.44	332.39	−1.02
DEC	29	+2.30	+5.92	344.56	−1.04
DEC	30	+1.03	+5.15	356.72	−1.05
DEC	31	−0.32	+4.18	008.87	−1.07

1984 LUNAR PHYSICAL EPHEMERIS

By: John E. Westfall, A.L.P.O. Lunar Recorder

Introduction

Observers of the Moon require the values of several variable lunar quantities in order to plan and interpret their observations. Most frequently, they need the Earth's selenographic longitude and latitude, and the Sun's selenographic colongitude and latitude. These values are given for 0 hours, U.T., for each day of the year in The Astronomical Almanac, prepared annually by the U.S. Naval Observatory. Unfortunately, the price of this publication increases each year; and the almanac is difficult to obtain much before the beginning of the year in question. Thus, for use in the Luna Incognita program, the writer has written a BASIC-language Apple-II computer program to generate these data. They are presented here on pages 142-144 for use by A.L.P.O. lunar observers in general who may not have access to The Astronomical Almanac for 1984. This table for 1984 is a continuation of a similar table for 1983 (JALPO, 29, 11-12 (Mar., 1983), 250-254), where additional information on interpolation methods, and on the accuracy of the table, is given.

Quantities

The Earth's selenographic longitude and latitude specify the position on the Moon where the Earth's center is overhead (these are also called "geocentric librations"). Their sign conventions are that positive longitudes are lunar east (i.e., toward Mare Crisium) and negative longitudes are lunar west. With latitude, positive indicates north and negative indicates south. The values of these librations are useful, for example, in determining which limb areas are best presented on a given date. Observers should note, though, that these quantities are strictly accurate only when the Moon is in one's zenith. The apparent (topocentric) librations at a given site may be as much as one degree different from the geocentric ones if the Moon is near the horizon. The procedure for making this correction is given on pages 322, 324, and 325 in The Explanatory Supplement to the Astronomical Ephemeris and the American Ephemeris and Nautical Almanac (London: Her Majesty's Stationery Office, 1961; Rev. 1977).

The selenographic coordinates of the Sun, which describe the Moon's lighting conditions, are independent of the observer's position. Colongitude refers to the lunar longitude of the sunrise terminator (strictly speaking, its longitude on the Moon's equator). It is measured from 0 through 360 degrees westward starting at the mean center of the disk. Colongitude is approximately 0° at First Quarter, 90° at Full Moon, 180° at Last Quarter, and 270° at New Moon. For trigonometric computations, it helps to know that the actual longitude of the Sun (i.e., the lunar noon meridian) is given by subtracting the colongitude from 90°. The latitude of the Sun is measured in the same manner as the latitude of the Earth.

All quantities are given for 0 hours Universal Time (U.T.) of each day, and should be interpolated for the actual time of observation. Final results are usually rounded to 0°.1.

GALILEAN SATELLITE ECLIPSE TIMINGS: 1975-1982 REPORT (concluded)

By: John E. Westfall, A.L.P.O. Assistant Jupiter Recorder, Eclipse Timings

Foreword by Editor. Earlier portions of this article appeared in Journal A.L.P.O., Vol. 30, Nos. 3-4, pp. 45-53 and Vol. 30, Nos. 5-6, pp. 105-115. A re-examination of that material may make the present installment of the article much more meaningful. Observers wishing to participate in this useful program should contact Dr. Westfall for instructions and observing-forms and should use the table of Jovian satellite eclipse predictions in Journal A.L.P.O., Vol. 30, Nos. 3-4, pp. 54-55.

VII. CONCLUSIONS

A. Comparison of Eclipse Timings with Ephemerides

The eclipse timings differ significantly from the predictions published in The Astronomical Almanac for almost every Galilean satellite in almost every apparition. The only cases where significant disagreement was not found were for Ganymede in 1980/81, where its long-term linear trend resulted in a temporary agreement between ephemeris and observation, and for Callisto in 1977/78, where the observational uncertainty was very large. These deviations from theory showed no apparent patterns for Io, Europa, and Callisto. On the other hand, for Ganymede there was a progressive "retardation" of the observed satellite position, relative to the A.A. ephemeris, amounting to about 45 seconds per synodic period, implying an orbital period currently about 0.8 seconds longer than that used for that ephemeris.

In complete contrast, the eclipse-derived Galilean satellite positions never differed significantly from the E-2 ephemeris. The overall mean differences of the eclipse results from the E-2 predictions were $-1^{s}.8 \pm 1^{s}.3$, $+2^{s}.5 \pm 3^{s}.0$, $+3^{s}.4 \pm 2^{s}.8$, and $-8^{s}.4 \pm 4^{s}.8$ for satellites I-IV respectively, corresponding to position deviations of only 31-69 kilometers. This agreement between observation and theory indicates that the E-2 ephemeris is accurate and, in all probability, that the observations and their analysis here are also relatively reliable. Another measure of the accuracy of the eclipse-timing method is the standard error of its residuals form the E-2 ephemeris, which averaged $3^{s}.8$ (65 km.) for Io, $7^{s}.4$ (102 km.) for Europa, $16^{s}.6$ (181 km.) for Ganymede, and $23^{s}.8$ (195 km.) for Callisto.

B. Aperture Effect

This analysis of eclipse timings is based on the assumption that telescope aperture has a consistent effect on observed eclipse times. This effect is measured by the regression coefficient $\underline{B}$ in the model given above (first installment of article). In particular, one would expect that larger instruments would tend to detect eclipse disappearances later, and reappearances earlier, than smaller telescopes. Thus, $\underline{B}$ should be negative for disappearances and positive for reappearances. The actual signs of $\underline{B}$, and their statistical significance, are summarized in Table 36, below.

Table 36. Sign and Statistical Significance of B-Coefficient

Event Type	Number and Percentage of Cases: Astronomical Almanac Ephemeris		E-2 Ephemeris	
Disappearance	Correct Sign:	19 of 21 (90%)	Correct Sign:	17 of 21 (81%)
	Significant:	11 of 21 (52%)	Significant:	12 of 21 (57%)
Reappearance	Correct Sign:	22 of 22 (100%)	Correct Sign:	22 of 22 (100%)
	Significant:	15 of 22 (68%)	Significant:	16 of 22 (73%)
Total:	Correct Sign:	41 of 43 (95%)	Correct Sign:	39 of 43 (91%)
	Significant:	26 of 43 (60%)	Significant:	28 of 43 (65%)

Table 36 shows that the aperture coefficient was usually significant and had the expected sign. Results generally were better for reappearances than for disappearances, probably because more of the former were observed (777 versus 544). Statistical significance was slightly more common with the E-2 ephemeris residuals than with the A.A. residuals, a result of the former's greater precision.

The B-coefficient measures how rapidly a satellite disappears from, or reappears into, visibility as aperture is changed. At first thought, one might expect $\underline{B}$ to be constant for a particular satellite, neither varying between disappearance and reappearance nor between apparitions. However, the value of $\underline{B}$ actually varied considerably for the same satellite. One reason for this is that there are real differences between apparitions because the Jovicentric latitude of the Sun, and thus of Jupiter's shadow cone, changes with the 11.86-year period of Jupiter's orbit. This change will affect the angle at which the satellite enters or leaves the shadow cone. Symbolizing the Jovicentric latitude of a satellite's umbral contact as $\underline{L}$, the duration of eclipse ingress or egress is proportional to 1/cosine $\underline{L}$. Accordingly, the values of $\underline{B}$, as previously determined, have been multiplied by the mean cosine $\underline{L}$-value for each apparition, with the results given in Table 37 below.

Table 37. B-coefficients Adjusted for Jovicentric Latitude (E-2 Ephemeris)

	Satellite and Event Type (D = Disap.; R = Reap.)							
Mean Cos(L) by Apparition	ID	IR	IID	IIR	IIID	IIIR	IVD	IVR
1975/76	-----	.9540	-----	.9163	-----	-----	-----	-----
76/77	.9455	.9513	.8988	.8910	.6311	.6401	-----	-----
77/78	.9699	.9790	.9261	.9339	.8254	.8429	.4264	-----
78/79	.9959	.9992	.9793	.9902	.9814	.9856	.9609	.9719
79/80	.9966	.9953	.9966	.9946	.9836	.9710	.8879	.8892
80/81	.9764	.9674	.9524	.9364	.8175	.8102	-----	-----
81/82	.9521	.9466	.8718	.8532	.6333	.6275	-----	-----
Weighted-mean Adjusted B-coefficient[a]	-157.7 ±41.1*	+263.4 ±19.9**	-173.9 ±100.7	+371.6 ±31.3**	-638.7 ±59.5**	+495.2 ±68.9**	-772.2 ±513.3	+1729.8 ±122.1*
Mean absolute B	207.6±22.8		272.8±52.7		567.0±45.5		1251.0±263.8	
P[b]	$253^{s}.6$		$310^{s}.6$		$655^{s}.6$		$1005^{s}.2$	
$B_R - B_D$	+105.7±45.7*		+197.7±105.5		-143.5±91.0		+957.6±527.6	

[a]Each apparition's B-value has been multiplied by the mean of Cos(L). These adjusted values were then weighted inversely proportional to their standard errors in order to find the overall mean.
[b]Sum of diameter of satellite and width of penumbra, expressed in time.
*Significant difference from 0 at 5-percent confidence level here and in later tables.
**Significant difference from 0 at 1-percent confidence level here and in later tables.

The long-term B-coefficient means in Table 37 all are negative for disappearance and positive for reappearance, as expected. Also as expected, the absolute magnitude of the B-coefficient increases regularly from Io out to Callisto, due both to the increase of the width of the penumbra as one moves away from Jupiter and to the fact that the outer two satellites are noticeably larger than the inner two. As a matter of fact, there is a statistically-significant (5 percent confidence level) correlation of +0.979 between the disappearance/reappearance-mean absolute value of B and the time it takes for the satellite to travel the sum of its diameter and the width of the penumbra at its orbit (designating this last value as P, the linear regression equation relating the two values is: B = (-171±124) + (1.34±0.20)P).

Referring to the bottom row of Table 37, the magnitude of B_R is larger than that of B_D for all satellites except Ganymede. This is interpreted as due to a consistent psychological difference between perceived disappearance and perceived reappearance (see previous discussion in first installment).

C. Satellite Diameters

For each satellite, the diameter was calculated based on the eclipse-timing model and then compared with the Voyager-derived diameter as a check of the accuracy of the model. When the more-precise E-2 ephemeris was used for the long-term mean eclipse-derived diameters, the two diameters invariably differed; this difference was significant for all satellites except Europa. The error of the calculated satellite diameters appears to be related to the width of Jupiter's penumbra, and these two quantities are compared in Table 38, below.

Table 38. Error in Eclipse-derived Diameter versus Penumbral Width (km.)

	Io	Europa	Ganymede	Callisto
Mean E-2 Eclipse Diameter	3348 ± 85	2934 ± 143	5890 ± 82	5988 ± 180
Voyager-derived Diameter	3640	3066	5216	4890
Difference	-292*	-132	+674**	+1098*
Penumbral Width	754	1200	1915	3367

There is a correlation coefficient of +0.958 between the error of the eclipse-derived diameter (E) and the width of the penumbra (W), which is significant at the 5-percent confidence level. These two quantities are related by the regression equation $E = (-665 \pm 241) + (0.55 \pm 0.12)\ W$, which "improves" the satellite diameter estimates to a root-mean-square error of ± 164 km.

Both ephemerides define eclipse disappearances and reappearances to occur when the center of the satellite, the center of the Sun, and the limb of Jupiter are in line. This implies that the eclipse-derived diameters would be correct if the observed times of eclipse disappearance and reappearance occurred when the limb of the satellite was internally tangent to the center of the penumbra. Figure 8 graphs the position of each satellite relative to a graph of the penumbral brightness distribution at the observed time of disappearance/reappearance. The brightness graphs are scaled so that 1.0 equals full sunlight. Vertical marks on the brightness curves represent the midpoint of the penumbra, while the shaded portion of each curve shows the portion of the penumbra which actually illuminates the satellite at the observed instant of disappearance or reappearance.

The penumbral brightness curves of Figure 8 are based on a third-order polynomial fit (with a standard error of ±0.014 of central brightness) to the observed pattern of solar limb darkening at a wavelength of 5500 Å (Allen 1976, 169-71). The effects of Jupiter's atmosphere above its cloud tops were not considered, which probably causes small errors in the "tails" of the brightness curves. Using the same data, it was possible to calculate the integrated brightness of the entire satellite at the instant of disappearance/reappearance, the results of which are shown in Table 39 below.

Table 39. Satellite Brightness at Eclipse Disappearance/Reappearance[a]

	Io	Europa	Ganymede	Callisto
Satellite Brightness[b]	0.0223	0.0282	0.0052	0.0149
Magnitudes Dimming	+4.13	+3.87	+5.72	+4.57
Apparent Magnitude[c]	+9.15	+9.16	+10.33	+10.22

[a]As based on "infinite" aperture extrapolation of aperture model.
[b]Brightness of fully-illuminated satellite = 1.00.
[c]Based on fully-illuminated satellite visual magnitudes from The Astronomical Almanac 1983, p. F3.

The result that Ganymede and Callisto are fainter at eclipse disappearance and reappearance than are Io and Europa is probably due to the fact that most eclipses of the former satellites occur farther from Jupiter's disk as seen from Earth. It should be mentioned that the errors indicated by the diameter calculations should be symmetric for disappearance and reappearance and thus should cancel out when the two types of event are combined to find the orbital residual of a satellite. Small errors may be caused by albedo variations on the satellites themselves, which are not considered here.

D. Observations

The quality of the great majority of visual timings was high, and the large total number of timings has permitted a fairly detailed analysis. Nonetheless, the entire period covered is only about one-half Jupiter's orbital period. Even within this period, the number of observations was really sufficient only in 1976-79. It is clear that this program must continue if long-term trends in deviations from the ephemerides are to be detected. Timings should be made with as wide a range of apertures as possible, from 6 cm. up; and timings with large apertures (e.g., 30 cm. or greater) are particularly welcome. In the future, observers should attempt to observe about as many eclipse disappearances as reappearances for each satellite. Europa and Ganymede need to be timed more often. Also, when Callisto begins to undergo eclipses again in 1984, a concerted eclipse timing effort should be made for that satellite in order to detect any possible orbital changes which have occurred since 1978-80.

APPENDIX: OBSERVATIONS LISTINGS

A. Published Observations

The bulk of the eclipse timings analyzed here were published in a series of listings by Dr. Joseph Ashbrook in Sky and Telescope magazine. These are referenced in Table 40.

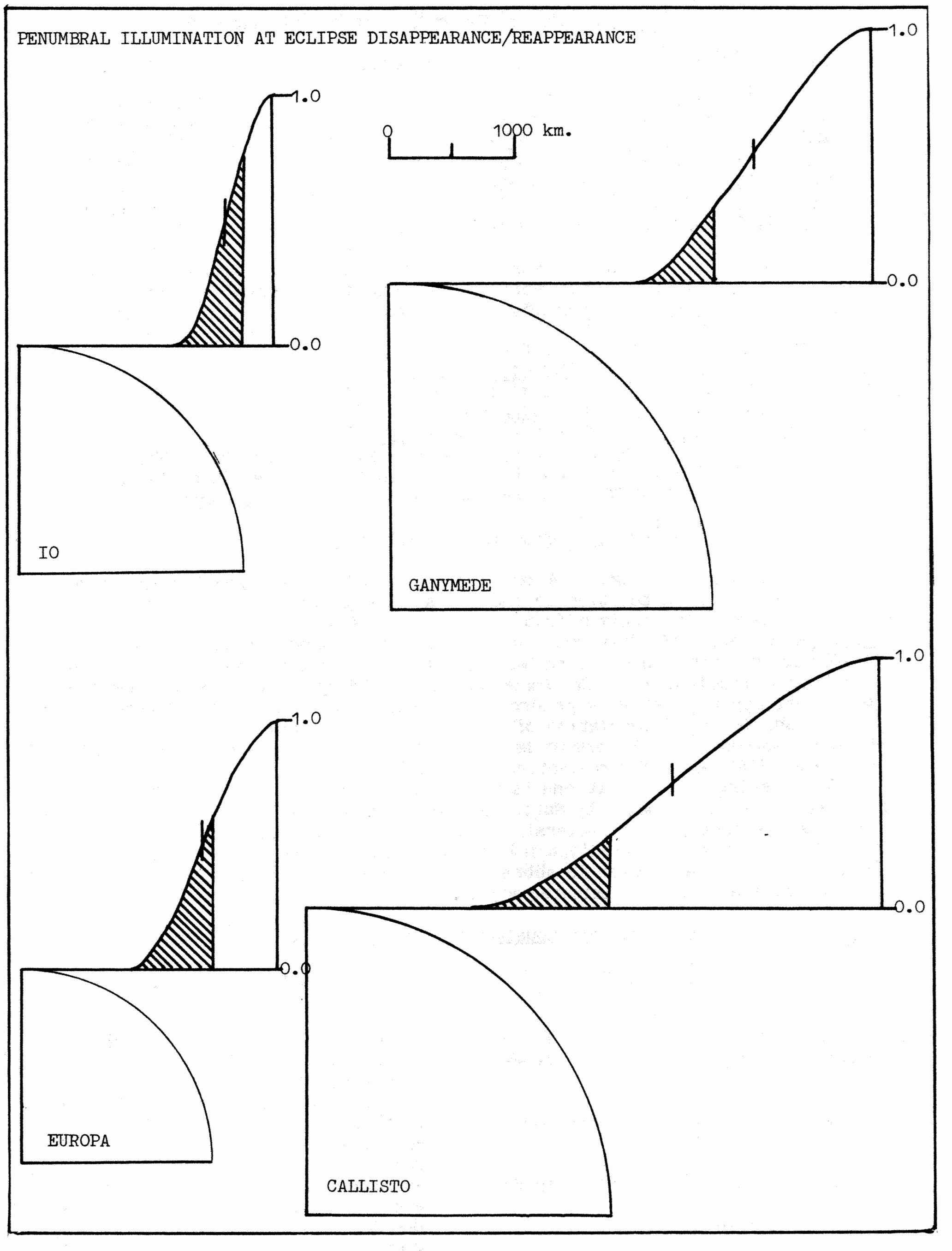

Figure 8. The position of each Galilean satellite relative to the penumbral shadow of Jupiter at the moment of observed eclipse disappearance or reappearance. See text of Dr. John Westfall's article, page 148, second and third paragraphs. The moment of disappearance/reappearance is based on an extrapolation to an infinite aperture of the aperture equation model described in the first installment of this paper. It will also be realized that larger apertures will reveal a satellite deeper into the penumbra than can smaller apertures.

Table 40. Sky and Telescope Eclipse Timing Summaries

Issue and Pages	Apparition(s)	Date Range
Mar. 1977, 230-233	1976/77	7/7/76-1/16/77
Aug. 1977, 153-154	1976/77	10/9/76-3/26/77
Mar. 1978, 265-267	1975/76, 76/77, 77/78	11/9/75-12/20/77
Aug. 1978, 170-172	1976/77, 77/78	12/18/76-5/7/78
Mar. 1979, 309-311	1976/77, 77/78, 78/79	2/1/77-1/15/79
Oct. 1979, 377-381	1978/79	9/14/78-6/28/79
Sept.1980, 258-261	1978/79, 79/80	11/11/78-6/16/80

The present writer has checked these published observations as thoroughly as possible, given the fact that most of the original observations are no longer available. The very few inaccuracies found were:

Mar. 1979,	230	IIID. 10/4/76.	O-C = +5.0 vice - 5.0.
Aug. 1978,	170	IR.	Dec. 27, 1977 vice Dec. 26, 1977.
" "	"	IR. 1/1/78.	UT = 12:16:38 vice 12:56:38.
" "	171	IR.	Apr. 7, 1978 vice Apr. 1, 1978.
Mar. 1979,	310	IIIR. 4/16/78.	UT = 23:46:37 vice 20:46:37.
Sep. 1980,	258	ID. 1/9/79.	Observation previously published (Oct. 1979, 378).
" "	259	IVD. 4/6/79.	Observation previously published (Oct. 1979, 380).
" "	260	IR. 3/15/80.	Two observations repeated on same page.

B. Unpublished Observations

Beginning in 1977, Dr. Ashbrook solicited Galilean eclipse timings from the A.L.P.O. membership in addition to the Sky and Telescope readership. Observations that he subsequently received from A.L.P.O. members were not published in Sky and Telescope and are published here for the first time; these belong to the 1976/77 - 1979/80 apparitions. Also listed here are observations for the 1980/81 and 1981/82 apparitions, received after Dr. Ashbrook's death. Many of the observations for the two latest apparitions were generously forwarded by Mr. Geoff McNamara of the (Australian) National Association of Planetary Observers and by Mr. Brian Loader of the Royal Astronomical Society of New Zealand. These are greatly appreciated, and are marked "(A)" and "(N)" respectively in the listings.

The listing of observations is arranged by apparition and then by satellite and event type, and finally by date. The information given consists of: Observer, telescope aperture (in centimeters), telescope type (C = Cassegrain, N = Newtonian, R = refractor, and X = catadioptric), followed by the observed U.T. date and time. The date and time are given in abbreviated form with two digits for each value: day, month, year and hour, minute, second.

Table 41. Previously-Unpublished Eclipse Timings

1976/77 Apparition

IR		
Westfall, J.(25.4C)	112276	045159
Westfall, J.(25.4C)	040277	042451
IIR		
Westfall, J.(25.4C)	041877	040505
IIIR		
Westfall, J.(25.4C)	040277	030658

1977/78 Apparition

ID		
Haerich, F.(20X)	092477	072434
Westfall, J.(25.4C)	110977	074519
Haerich, F.(20X)	"	074530
Westfall, J.(25.4C)	120277	075641
Haerich, F.(20X)	120477	022534
Verhaegen, W.(15X)	120577	205327
Smith, M.(10.6N)	121177	041934
Moore, G.(7.6R)	"	041951
Haerich, F.(20X)	"	041952

1977/78 Apparition (Contd.)

IR		
Moore, G.(7.6R)	010578	011354
de Bosscher, R.(10R)	011378	213655
Verhaegen, W.(15X)	"	213705
Smith, M.(10.6N)	020478	032223
Westfall, J.(25.4C)	021178	051751
Moore, G.(7.6R)	022078	014254
Haerich, F.(20X)	022778	033723
Verhaegen, W.(15X)	022878	220639
Westfall, J.(25.4C)	030678	053259
Westfall, J.(25.4C)	031378	072832
Verhaegen, W.(15X)	031678	202625
Smith, M.(10.6N)	040778	021150
Smith, M.(10.6N)	041478	040732
de Bosscher, R.(10X)	041578	223630
de Bosscher, R.(10R)	"	223655
Haerich, F.(20X)	043078	022552
Smith, M.(10.6N)	"	022558
Westfall, J.(25.4C)	050778	042057
IID		
Haerich, F.(20X)	091477	081710

Table 41. Previously-Unpublished Eclipse Timings (Contd.)

1977/78 Apparition (Contd.)

IID (Contd.)

Westfall, J.(25.4C)	111777	072033
Haerich, F.(20X)	"	072119
Moore, G.(7.6R)	121277	042000
Smith, M.(10.6N)	"	042007
Westfall, J.(25.4C)	121977	065344

IIR

Moore, G.(7.6R)	123077	012246
Smith, M.(10.6N)	"	012250
Smith, M.(10.6N)	010678	035647
Smith, M.(10.6N)	020778	033806
Haerich, F.(20X)	"	033813
Verhaegen, W.(15X)	021778	193336
Smith, M.(10.6N)	031178	032427
Verhaegen, W.(15X)	032178	192021
de Bosscher, R.(6.1R)	032878	215858
Haerich, F.(20X)	040578	003516
Haerich, F.(20X)	041278	031311
Smith, M.(10.6N)	"	031326

IIID

Haerich, F.(20X)	100577	084758
Verhaegen, W.(15X)	120877	203957
Smith, M.(10.6N)	020478	043951
Haerich, F.(20X)	031278	004207

IIIR

Westfall, J.(25.4C)	111077	072344
Verhaegen, W.(15X)	011378	193034
Westfall, J.(25.4C)	012878	033202
Haerich, F.(20X)	031278	033914
Smith, M.(10.6N)	"	033938
Smith, M.(10.6N)	042478	034618

IVD

Moore, G.(7.6R)	021278	050400
de Bosscher, R.(10R)	022878	225205
Verhaegen, W.(15X)	"	225411

1978/79 Apparition

ID

Westfall, J.(25.4C)	121478	072624
de Bosscher, R.(6.0R)	010179	001116
Westfall, J.(25.4C)	010679	073706
Westfall, J.(25.4C)	012279	055411

IR

Westfall, J.(25.4C)	013179	043323
Westfall, J.(25.4C)	020779	062845
de Bosscher, R.(10R)	022479	231532
Westfall, J.(25.4C)	030279	064154
de Bosscher, R.(10R)	030579	193925
Vingerhoets, P.(20X)	"	193934
Troiani, D.(20N)	031179	030620
Westfall, J.(25.4C)	032579	065625
de Bosscher, R.(10R)	032879	195421
Westfall, J.(25.4C)	040379	032043
de Bosscher, R.(6.0R)	040479	214944
Troiani, D.(25.4N)	041079	051548
Troiani, D.(25.4N)	060479	020808

IIR

Westfall, J.(25.4C)	020179	025930
Troiani, D.(25.4N)	020879	053334
Westfall, J.(25.4C)	021579	080753

1978/79 Apparition (Contd.)

IIR (Contd.)

Westfall, J.(25.4C)	030579	023421
Westfall, J.(25.4C)	031279	050954
Troiani, D.(25.4N)	"	050955
Westfall, J.(25.4C)	041379	045103
Westfall, J.(25.4C)	042079	072543
Troiani, D.(25.4N)	050879	015631
Troiani, D.(15N)	051579	043329
Westfall, J.(25.4C)	061679	041814

IIID

Westfall, J.(25.4C)	120978	080326
de Bosscher, R.(6.0R)	032679	195027
Troiani, D.(25.4N)	041079	035159

IIIR

de Bosscher, R.(10R)	031979	192107
Westfall, J.(25.4C)	040379	032146
Troiani, D.(25.4N)	051679	032038

IVR

Troiani, D.(25.4N)	040779	034244
Westfall, J.(25.4C)	"	034246
Ehrlich, M.(15N)	"	034310

1979/80 Apparition

ID

Westfall, J.(25.4C)	011880	065803
Westfall, J.(25.4C)	012580	085146
Westfall, J.(25.4C)	021080	070805

IID

Westfall, J.(25.4C)	011580	072251

IIIR

Westfall, J.(25.4C)	031980	060453

1980/81 Apparition

ID

(N) Loader, B.(20)	120380	151320
(N) Loader, B.(20)	011881	152711
(N) Loader, B.(20)	012781	114739
Bretones, P.(6.0)	012981	061537
(N) Loader, B.(20)	021081	153433
Bretones, P.(6.0)	021481	043026
(N) Loader, B.(20)	021981	115604
(N) Loader, B.(20)	030581	154310
(N) Loader, B.(20)	031481	120504

IR

(N) Munford, N.(32)	033081	123410
(N) Loader, B.(20)	040181	070125
Bretones, P.(6.0)	040381	013042
Langhans, T.(20)	040881	085524
(N) Loader, B.(20)	"	085535
Bretones, P.(6.0)	041181	215312
(N) Loader, B.(20)	041581	104948
(A) Giller, R.(20)	"	105011
Poitevin, P.(15)	041881	234736
(N) Loader, B.(20)	042481	071315
(N) Loader, B.(20)	050181	090747
Langhans, T.(20)	"	090801
Means, D.(20)	050381	033644
Westfall, J.(25.4)	051081	053130

Table 41. Previously-Unpublished Eclipse Timings (Contd.)

1980/81 Apparition (Contd.)

IR (Contd.)

Martins, C.(6.0)	051281	000052
Langhans, T.(36)	051781	072608
Westfall, J.(25.4)	"	072625
Martins, C.(6.0)	052781	221959
(A) McNamara, G.(20)	060981	074038
Bretones, P.(6.0)	061181	020959
Bulder, H.(15)	061281	203845
(N) Loader, B.(20)	061681	093546
Westfall, J.(25.4)	061881	040442
Bretones, P.(6.0)	062781	002930
Bulder, H.(15)	070581	205309
(A) McNamara, G.(20)	070981	095019
Westfall, J.(25.4)	071181	041914
(A) McNamara, G.(20)	072581	080923
(A) Giller, R.(20)	080181	100445
(N) Loader, B.(20)	081081	062816
(N) Loader, B.(20)	081781	082328

IID

Bretones, P.(6.0)	020281	030421
McDavid, D.(35.6)	022381	104949
(N) Buttner, D.(6.3)	022781	000612
Bulder, H.(15)	"	000625
Bretones, P.(6.0)	030681	024024

IIR

Bretones, P.(6.0)	033181	022250
Means, D.(30)	040781	045738
De Bosscher, R.(10)	041781	204744
(N) Loader, B.(20)	042181	100422
Langhans, T.(20)	"	100448
Westfall, J.(25.4)	050981	043047
Westfall, J.(25.4)	051681	070500
Poitevin, P.(15)	051981	202214
(N) Loader, B.(20)	052381	093900
Bulder, H.(15)	052681	225639
Poitevin, P.(15)	"	225722
Bretones, P.(6.0)	060381	013101
Westfall, J.(25.4)	061781	063941
(N) Loader, B.(20)	062481	091320
(A) McNamara, G.(20)	"	091327
Bretones, P.(6.0)	070581	010623
Langhans, T.(36)	071281	034000
(N) Loader, B.(20)	071981	061323
(A) McNamara, G.(20)	072681	084807
Bretones, P.(6.0)	072981	220717

IIID

Bulder, H.(15)*	060580	223405
(N) Loader, B.(20)	020481	133601
Bretones, P.(6.0)	030581	052656
McDavid, D.(35.6)	"	052832
(N) Loader, B.(20)	031281	092700
(A) Giller, R.(41)	031981	132504
Bulder, H.(15)	051581	211507
(N) Buttner, D.(6.3)	062781	211148
Bretones, P.(6.0)	070581	010931
Langhans, T.(36)	071281	051120
(A) Giller, R.(11)	071981	091105
(A) McNamara, G.(20)	"	091108
(N) Loader, B.(20)	"	091125

1980/81 Apparition (Contd.)

IIIR

(N) Loader, B.(20)	020481	162909
Bretones, P.(6.0)	040381	000914
(N) Loader, B.(20)	042481	120140
Bretones, P.(6.0)	051581	235706
Westfall, J.(25.4)	052381	035536
(N) Loader, B.(20)	053081	075300
(A) McNamara, G.(20)	"	075339

1981/82 Apparition

ID

(N) Loader, B.(20)	010782	143848
Langhans, T.(35.6)	"	143906
(A) McNamara, G.(20)	012182	182433
(A) McNamara, G.(20)	013082	144522
Poitevin, P.(15)	020382	034149
(A) McNamara, G.(20)	020682	163821
(N) Loader, B.(20)	"	163822
(A) Clark, M.(12)	"	163828
Poitevin, P.(15)	021082	053440
(N) Loader, B.(20)	021582	125841
(A) McDougal, D.(20)	022282	145221
(A) Clark, M.(22)	030182	164508
(N) Loader, B.(20)	030382	111320
Westfall, J.(25.4)	031282	073437
(A) Clark, M.(22)	031582	203117
(N) Loader, B.(20)	031782	145934
(N) Loader, B.(20)	032482	165244
Silva, L.(6.0)	033082	001718
(A) McNamara, G.(20)	033182	184556
(A) Herald, D.(32)	040282	131414
(A) McNamara, G.(20)	"	131418
(N) Loader, B.(20)	041682	170114
(N) Loader, B.(20)	041882	112944
Abbott, A.(32)	042082	055733
(A) McNamara, G.(20)	042382	185350
(N) Loader, B.(20)	042582	132310

IR

(A) McNamara, G.(20)	042782	100048
Silva, L.(6.0)	043082	225700
(A) McNamara, G.(20)	050482	115310
(A) McNamara, G.(20)	051182	134705
(N) Loader, B.(20)	051382	081551
(N) Currie, D.(20)	"	081604
(N) Currie, D.(20)	052082	101014
(A) McNamara, G.(41)	"	101100
(A) Cameron, J.(20)	052782	120445
(A) McNamara, G.(41)	"	120457
(N) Loader, B.(20)	052982	063303
Silva, L.(6.0)	053182	010222
(A) Cameron, J.(20)	060382	135931
Langhans, T.(35.6)	060582	082740
(A) Price, R.(15)	"	082832
(A) Cameron, J.(20)	"	083215
(N) Loader, B.(20)	061282	102228
(N) Currie, D.(20)	"	102248
(A) Price, R.(15)	"	102440
(A) McNamara, G.(20)	061982	121737
(A) McNamara, G.(20)	062882	084124
(A) Cameron, J.(20)	"	084128

*This observation is out of place here and should have been listed under the 1979-80 apparition. It was contributed too late to be included in Dr. Westfall's analysis.

Table 41. Previously-Unpublished Eclipse Timings (Contd.)

1981/82 Apparition (Contd.)

IR (Contd.)

(A) McNamara, G.(20)	070582	103630
(N) Lowe, D.(20)	"	103630
Langhans, T.(35.6)	070782	050504
Silva, L.(6.0)	070882	233400
(N) Loader, B.(20)	071482	070023
(N) Loader, B.(20)	072182	085538
(A) McNamara, G.(20)	"	085545
(A) Giller, R.(20)	072882	105035
(N) Loader, B.(20)	"	105053
(A) Cameron, J.(20)	"	105106
(N) Currie, D.(20)	"	105122
Silva, L.(6.0)	073182	235032
(N) Loader, B.(20)	080682	071452
(A) McNamara, G.(41)	081382	091003
(N) Currie, D.(20)	"	091033
(N) Lowe, D.(20)	"	091040
Langhans, T.(35.6)	081582	033900
(A) Hayward, G.(20)	082082	110525
(N) Currie, D.(20)	"	110554
Silva, L.(6.0)	082482	000544
(N) Loader, B.(20)	090582	092447
(N) Currie, D.(20)	"	092513
Silva, L.(6.0)	090882	222247
(N) Loader, B.(20)	092182	074334

IID

Langhans, T.(35.6)	122281	123319
(N) Loader, B.(20)	122981	150839
(A) McNamara, G.(20)	013082	144902
Duvilliers, E.(12.5)	020382	040610
Poitevin, P.(15)	"	040708
(A) Clark, M.(22)	020682	172459
(A) McNamara, G.(20)	"	172502
(N) Loader, B.(20)	031082	170619
Poitevin, P.(15)	032482	221646
(A) Herald, D.(32)	032882	113456
(A) McNamara, G.(20)	"	113507
Silva, L.(6.0)	040182	005303
(N) Loader, B.(20)	040482	141102
(N) Loader, B.(20)	041182	164612
Langhans, T.(35.6)	072082	050115
(A) Price, R.(15)	072782	073702
(N) Loader, B.(20)	"	073714
(A) McNamara, G.(20)	"	073730
(A) Cameron, J.(20)	080382	101112
(N) Loader, B.(20)	"	101200

IIR

(A) McNamara, G.(20)	013082	171726
(N) Loader, B.(20)	050682	161500
(A) McNamara, G.(20)	"	161535
Westfall, J.(25.4)	051082	053224
(N) Loader, B.(20)	051782	080725
(A) Herald, D.(32)	"	080756
(N) Loader, B.(20)	052482	104216
(A) McNamara, G.(41)	"	104232

1981/82 Apparition (Contd.)

IIR (Contd.)

(A) Giller, R.(20)	052482	104251
Silva, L.(6.0)	052882	000058
(N) Loader, B.(20)	053182	131805
(A) Cameron, J.(20)	062582	102116
Langhans, T.(35.6)	071382	044819
Westfall, J.(25.4)	"	044833
(A) McNamara, G.(20)	072782	095744
(N) Loader, B.(20)	"	095747
(A) Price, R.(15)	"	095800
(A) Cameron, J.(20)	080382	123253
Langhans, T.(35.6)	081482	042404
(A) McNamara, G.(41)	082882	093247
(N) Loader, B.(20)	092282	063348

IIID

Langhans, T.(35.6)	011482	123326
(A) McNamara, G.(20)	012182	162910
(N) Loader, B.(20)	030582	161529
(A) Cameron, J.(20)	041082	120143
(N) Loader, B.(20)	"	120307
(A) McNamara, G.(20)	"	120339
(N) Loader, B.(20)	052382	115139
(A) Giller, R.(11)	"	115140
(A) Price, R.(15)	"	115210
(A) McNamara, G.(20)	"	115216
Silva, L.(6.0)	061382	234800
(A) McNamara, G.(20)	062882	074554
(A) (Anon.)(8)	"	074604
(A) Price, R.(10)	"	074616
(A) Hayward, G.(20)	"	074802
(N) Lowe, D.(20)	070582	114558
(A) Giller, R.(11)	"	114700
(A) McNamara, G.(20)	070582	114805
Silva, L.(15)	072682	234619
(A) McNamara, G.(20)	081082	074418
(A) Cameron, J.(20)	081782	114106
(A) Price, R.(15)	"	114309
Silva, L.(6.0)	090782	233916
(N) Loader, B.(20)	092282	073954

IIIR

Westfall, J.(25.4)	050982	055455
Abbott, A.(32)	"	055559
(A) McNamara, G.(41)	051682	095215
(N) Loader, B.(20)	"	095340
(A) Herald, D.(32)	"	095649
(N) Loader, B.(20)	052382	135150
(A) McNamara, G.(20)	"	135304
Silva, L.(6.0)	060682	215039
(A) McNamara, G.(20)	062882	094438
(A) Cameron, J.(20)	"	094534
(A) Price, R.(15)	"	094655
(N) Lowe, D.(20)	070582	134534
Silva, L.(6.0)	072782	014528
(N) Loader, B.(20)	080382	054200
(A) McNamara, G.(20)	081082	094006

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THE 1976-77 APPARITION OF JUPITER: A SYNOPTIC REPORT

By: Paul K. Mackal, A.L.P.O. Jupiter Recorder

[Note by Editor. We greatly regret the very late appearance of this Jupiter Report. The responsibility for the tardiness is wholly the Editor's. He hopes that the drawings, photographs, and text may still prove of interest to students of Jupiter.]

Introduction and General Remarks

The planet Jupiter was at opposition on November 18, 1976. On that date its declination was +18° so that it was well placed in the sky for Northern Hemisphere observers. The equatorial diameter of the planet on the date of opposition was 48".95, and the tilt of the axis to the Earth was +3°.25(north).

The contributing observers are listed below, where a "disc" is a drawing of the full disc of Jupiter.

Name	Location	Telescope	Contribution
L.M. Carlino	Buffalo, NY	8-inch refl.	3 discs
Don Costanzo	?	6-inch refl.	4 discs
Jean Dragesco	Benin, W. Africa	10-inch refl.	55 discs, 6 black-&-white transparencies
Henry Fergason	?	8-inch refl.(?)	4 black-&-white photos
Alan W. Heath	Nottingham, U.K.	12-inch refl.	5 discs, 1 strip sheet of Red Spot
Richard Hull	Richmond, VA	7-inch refr.	1 photo, black-&-white
S.J. O'Meara	Harvard College Observatory	7.5-inch refr.	1 disc
Toshihiko Osawa	Nara, Japan	12.5-inch refl.	17 discs
T.C. Peterson	Gadsen, AL	14-inch refl.	8 discs
E.J. Reese	New Mexico State University Observatory	24-inch refl.	2 photos, black-&-white
R.R. Richardson	New Hope, PA	12-inch refr.	1 photo, black-&-white
Jim Rouse	Naples, FL	14-inch refl.	1 photo, black-&-white

Name	Location	Telescope	Contribution
Clay Sherrod	N. Little Rock, AR	12.5-inch refl.	5 discs
M.B. Smith	Alamogordo, NM	4.2-inch refr.	6 discs
N. Travnick	Capricorn Observatory, Sao Paulo, Brazil	25-inch refr.	2 discs
S. Zuzze	Skyglow Observatory	8-inch refl.	1 photo, black-&-white

The distribution of observations by months is given below. The decline in the number of observations after December, 1976 may be blamed in part upon a cold winter apparition. As usual, fewer observations were made before opposition, and especially when Jupiter could be observed only in the morning sky. The planet reached conjunction with the Sun on June 4, 1977.

Month	No. of Observations	Month	No. of Observations
1976, August	2	1976, December	34
September	11	1977, January	21
October	13	February	11
November	24	March	6

Total number of observations = 122.

The major events of the apparition included a revival of a minor S.E.B. Disturbance at Source A on Aug. 12, 1976, at 127° (II) and the slow terminal cessation of the previous apparition's N.Tr.Z. activity through Feb. and March of 1977. There remained some residual activity of the N.Tr.Z. at 125° (II) on Feb. 13, 1977, however.

The Recorder now believes that the S.E.B. Disturbance mechanism is a belt in the making. Hence, the S.E.B.$_s$, which was merely a transitory belt in the late 1960's and early 1970's, may become a more permanent feature in a very short order of time! It is also possible that this mechanism may have been responsible for the formation of all of the belts and components of same on Jupiter. If after further historical documentation, this conclusion appears to be true, then the entire planet may someday become a dark brownish ellipsoid!

The observed phenomena in the formation of the S.E.B.$_s$ now, or of the N.T.B. in the 19th century, could be due to vents on the transitional layer of Jupiter, between the gaseous atmosphere and the liquid hydrogen sea. If so, then the previous volcano theory is dubious at best, and the vent events may best be compared to earthquakes.

Description of Surface Features*

North Polar Region: On Aug. 28, 1976, Osawa noted an uneven N.P.R. or white haze at 12°II. A more even N.P.R. was glimpsed by him on Aug. 28 at 59°II. By Sept. 3 Costanzo could not pick up the uneven N.P.R., observing at 337°II. On Sept. 14 Smith noted that the N.P.R. was darker and more extensive than the S.P.R., a relation which was usually true throughout the apparition. Smith's observation was made at 222°II but was not confirmed by Osawa on Sept. 15 at 192°II. Possibly there had been a brownish haze over the N.N.Te.Z. prior to the 15th. A dark uniform N.P.R. was seen on Sept. 18 by Osawa at 270°II and 315°II. The N.P.R. remained uniform about the planet throughout September, according to Dragesco. This polar region remained constant for the rest of the apparition.

North North Temperate Belt: This belt was fairly active over the entire disc of Jupiter, with some festoon activity between it and the N.T.B. From mid-Sept. to mid-Nov. the preceding end of a portion of the belt had a rotation period of $9^h\ 55^m\ 48^s$, while from the end of Oct. to mid-Nov. the following end had a rotation period of $9^h\ 56^m\ 39^s.5$. A gap in the N.N.T.B. was observed by Osawa and Dragesco. The belt appeared to be merged with the N.P.R., though it might have actually been absent.

North Temperate Belt: On Aug. 28, 1976, Osawa recorded the N.T.B. single at 12°II and double at 59°II. By Sept. 15 he saw the N.T.B.$_s$ connected to the N.T.B.$_n$ at 192°II. Spots were seen in the N.T.B. components at various longitudes from mid-Sept. to mid-Feb., according to Osawa and Dragesco. These were dark short

*The adopted nomenclature of the belts and zones is shown by Figure 26 on page 159.

(Text continued on page 159)

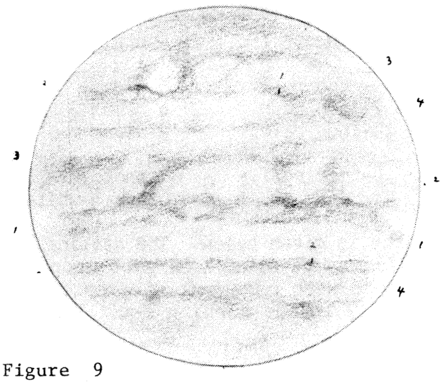


Figure 9

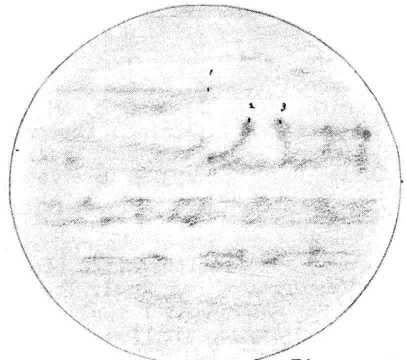


Figure 10

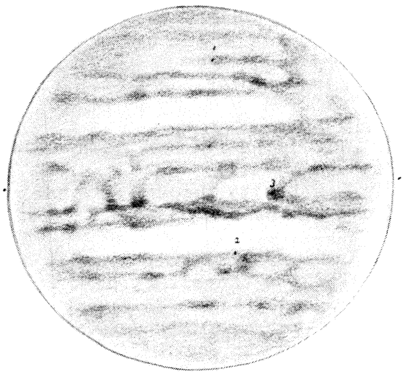


Figure 11

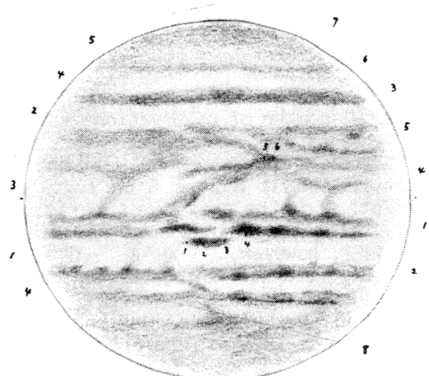


Figure 12

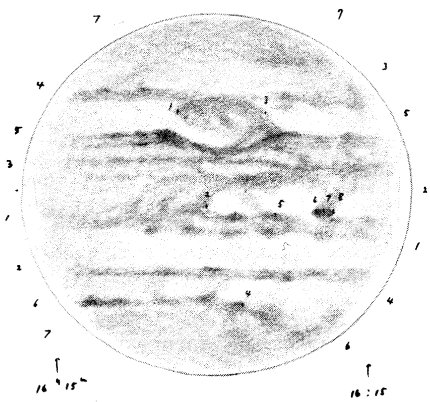


Figure 13

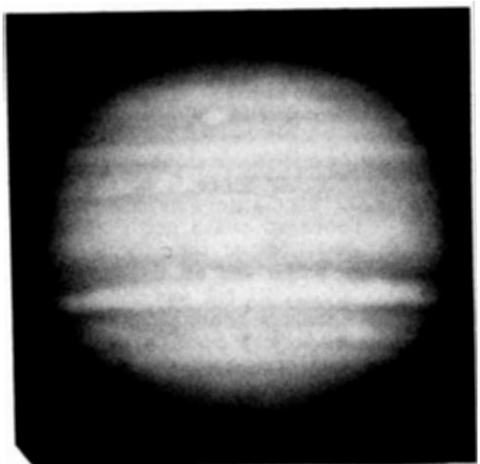


Figure 14

Fig. 9. Drawing by T. Osawa on Aug. 28, 1976, $17^h\ 25^m$, U.T. 32-cm. refl., 335x.CM (I) = 144°.CM (II) = 12°. Seeing S 4 (scale of 0 to 10 with 10 best). Transparency T 4.5 (limiting naked-eye stellar magnitude). Wide EZ and white oval in STeZ. Fig. 10. Drawing by T. Osawa on Aug. 28, 1976, $18^h\ 43^m$, U.T. 32-cm. refl., 335x.CM(I)=192°.CM(II) = 59°. S 4.5. T 4.5. Note preceding end of SEB activity. Fig. 11. Drawing by T. Osawa on Sept. 15, 1976, $17^h\ 17^m$, U.T. 32-cm. refl., 335x.CM(I)=102°. CM(II)=192°. S 4. T 5. First appearance of "triplex system" in SEB. Fig. 12. Drawing by T. Osawa on Sept. 18, 1976, $16^h\ 55^m$, U.T. 32-cm. refl., 335x.CM(I)= 202°. CM(II)=270°. S 5.5. T 4.5. "Barge" in NTrZ. Fig. 13. Drawing by T. Osawa on Oct. 30, 1976, $15^h\ 10^m$, U.T. 32-cm. refl., 375x.CM(I) = 294°. CM(II)=43°. S 5. T 4. Fol. end of Red Spot connected to fol. end of Red Spot Hollow. Triple festoon in EZ. Fig. 14. New Mexico State University Observatory photograph on Nov. 6, 1976, $8^h\ 22^m$, U.T. 24-inch refl. Blue light. CM(I)=72°. CM(II)=129°. Slanted SEB_n.

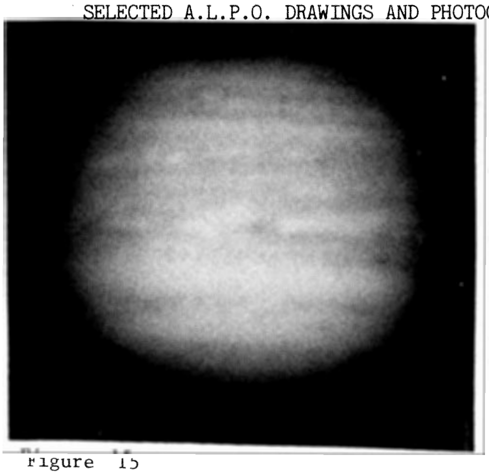


Figure 15

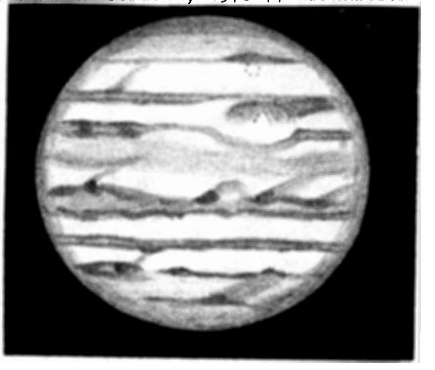


Figure 16

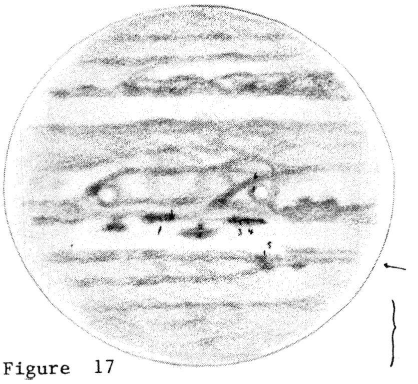


Figure 17

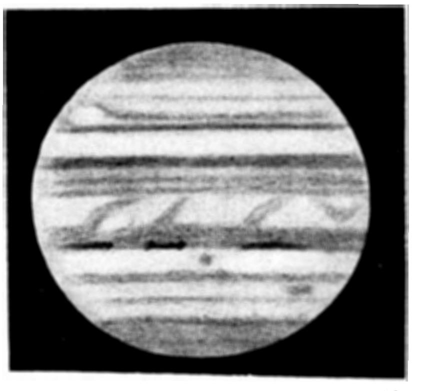


Figure 18

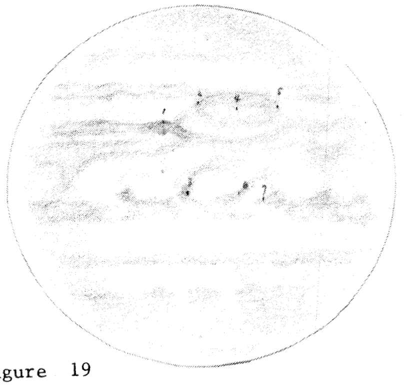


Figure 19

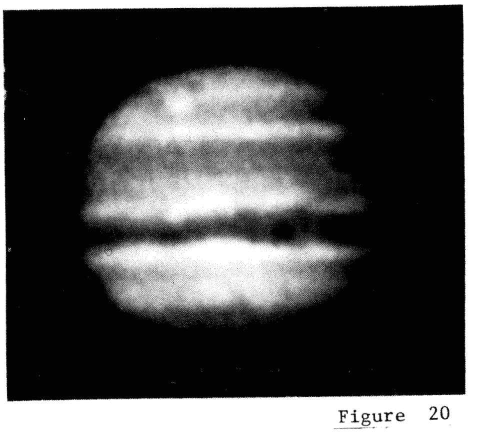


Figure 20

Fig. 15. New Mexico State University Observatory photograph on Nov. 6, 1976, 8^h 28^m, U.T. (6 minutes later than Fig. 14). 24-inch refl. Red light. CM(I) = 76°. CM(II) = 133°. Doubling of EB and merging of SEB_n and SEB_s. Fig. 16. Drawing by L.M. Carlino on Nov. 14, 1976, 2^h 10^m, U.T. 8-inch refl., 135x.CM(I) = 29°. CM(II)=27°. Seeing S 6. Transparency T 5. Red Spot pink. Fig. 17. Drawing by T. Osawa on Nov. 25, 1976, 11^h 32^m, U.T. 32-cm. refl., 335x.CM(I)=311°. CM(II)=221°. S 5. T 3. Detail in NEB. Fig. 18. Drawing by A.W. Heath on Dec. 2, 1976, 22^h, U.T. 12-inch refl., 190x-318x. CM(I)=359°. CM(II)=214°. S good. Another view of the triplex. Fig. 19. Drawing by T. Osawa on Dec. 3, 1976, 13^h 10^m, U.T. 32-cm. refl., 335x.CM(I) = 194°. CM(II)=43°. S 4. T 4. The triplex joined to prec. end of Red Spot Hollow. Fig. 20. Photograph by R.R. Richardson on Dec. 4, 1976. 12-inch refr. Exposure 2 seconds.

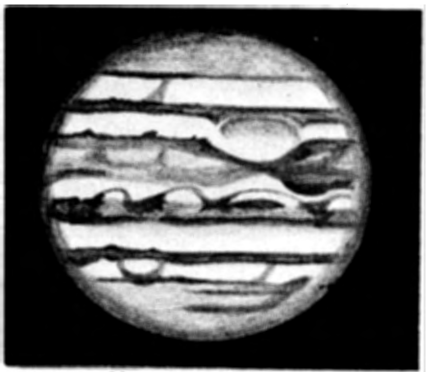


Figure 21

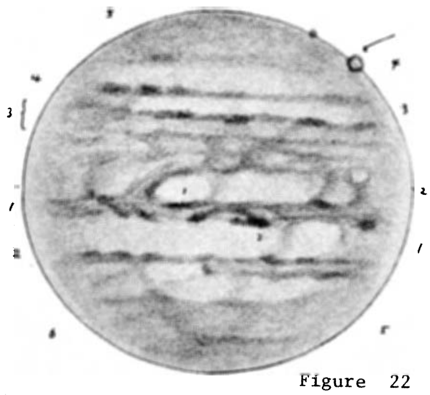


Figure 22

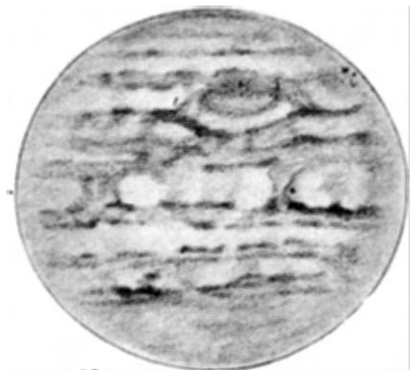


Figure 23

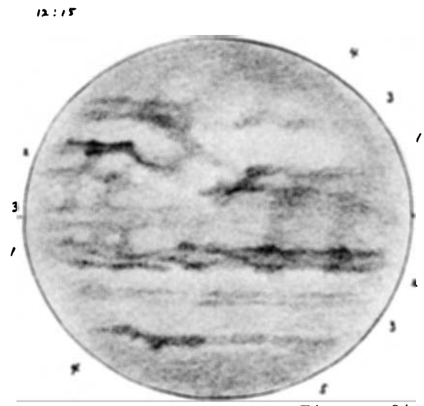


Figure 24

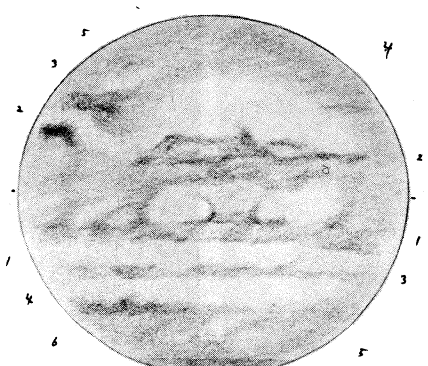


Figure 25

Fig. 21. Drawing by L.M. Carlino on Dec. 6, 1976, 0^h 26^m, U.T. 8-inch refl., 200x.CM (I) = 203°.CM (II) = 33°. Seeing S 4 (on a scale of 0 to 10 with 10 best). Transparency T 4.5 (limiting naked-eye stellar magnitude). Notice Red Spot. Fig. 22. Drawing by T. Osawa on Dec. 17, 1976, 14^h 35^m, U.T. 32-cm. refl., 335x.CM(I)=298°.CM(II) = 40°. S 5.5, T 4.2. First appearance of "quartex". Fig. 23. Drawing by T. Osawa on Jan. 9, 1977, 19^h 5^m, U.T. 32-cm. refl., 335x.CM(I)=134°. CM(II)=59°. S 3.5, T 4. Notice Red Spot and North Temperate Belt. Fig. 24. Drawing by T. Osawa on Feb. 23, 1977, 11^h 50^m, U.T. 32-cm. refl., 335x.CM(I)= 128°. CM(II)=72°. S 4, T 3.5. Red Spot faint and a white cloud over South Tropical Zone and South Equatorial Belt, south. Fig. 25. Drawing by T. Osawa on Feb. 26, 1977, 9^h 50^m, U.T. 32-cm. refl., 335x.CM(I) = 168°. CM(II)=90°. S 5.5, T 3.5. Notice revival of Red Spot and continuing presence of white cloud of Figure 24.

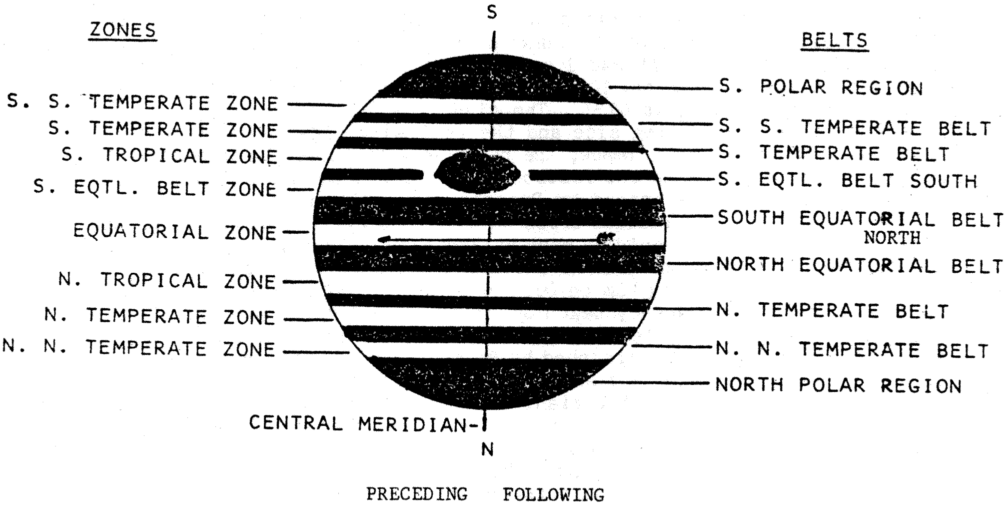


Figure 26. Diagram showing standard nomenclature of the belts and zones of Jupiter. Contributed by Phillip W. Budine but long used by the Jupiter Section of the British Astronomical Association and others. Simply inverted view with south at the top. The arrow shows the direction of the planet's rotation. The Great Red Spot is shown, in the South Tropical Zone, crossing the central meridian.

(Text continued from page 155)

rods. On Sept. 18 Osawa recorded the N.T.B. double at 315°II, while on the same day Dragesco recorded it double at 196°II. The N.T.B. was very dark, intense, and active from mid-Sept. through mid-Feb., 1977. It became very faint thereafter. On Sept. 19 and 20, Dragesco noted twice that the N.T.B.$_s$ was darker than the N.T.B.$_n$ at 346° and 121°II, respectively. On Oct. 10 he recorded the N.T.B. single at 191°II. On Oct. 12 Costanzo noticed a white spot in the N.Tr.Z. near 10°II. On Oct. 18 Rouse observed a single N.T.B. in the Red Spot's longitude. On Oct. 30 Osawa noticed the N.T.B. single at 342°II and 36°II. Osawa on Oct. 31 found the N.T.B. double at 155°II, however. On Nov. 2 the N.T.B. looked single to Osawa at 132°II. On Nov. 6 Reese from photographs recorded it to be single in red light and double in blue light at 131°II. On Nov. 25 Osawa recorded the N.T.B.$_s$ and the N.T.B.$_n$ merged near 241°II. On Dec. 3 Dragesco recorded the N.T.B. single at 327°II. Osawa continued to record it so in the Red Spot's longitude. On Dec. 4 Dragesco recorded it double at 97°II, however. On Dec. 5 he observed the preceding end of the N.T.B.$_n$ near 247°II. The N.T.B. was double on Dec. 6 at 46°II, according to Dragesco. This aspect was confirmed by Osawa on Dec. 17. The belt was seen double at all longitudes throughout December by Dragesco. Another preceding end of the N.T.B.$_n$ was recorded at 92°II by Osawa on Jan. 9, 1977. This was not the same feature seen by Dragesco, however. The belt was mostly double throughout January and the first 20 days of February, according to Dragesco. On Jan. 22 Dragesco observed a white spot at 271°II. On Feb. 23 Osawa continued to record the N.T.B. double at 90°II, though it was very faint. For the most part the belt was single throughout March; e.g., on Mar. 21 Osawa recorded it single at 304°II. However, Dragesco noted that it was double at 18°II only.

North Equatorial Belt, North and South Components: The 1976-77 apparition revealed a dark N.E.B.$_s$ as well as a dark N.E.B.$_n$. There was no demise of equatorial belt activity from Sept. of 1975 through March of 1977! We were once again witnessing an N.E.B. Disturbance of considerable forcefulness, somewhat similar to those of 1972 and 1973, respectively. Once again, in the E.Z. (Equatorial Zone) a giant dark festoon erupted. However, here the comparison ends; for there was a break in activity from 1972 to 1973, whereas there appears to have been no such break between 1976-77 and 1977-78.

According to Osawa, dusky festoons could be seen on Aug. 28 at 144°I, but not at 192°I. A series of white spots separated the two components of the belt in these longitudes. Darker columns could be seen on Sept. 15 at 102°I by Osawa. By

Sept. 18 he and Dragesco noticed dark festoons in the E.Z. at 202°I and 127° I respectively. Also on Sept. 18 Osawa noted a 5°.4-long "barge" off the N.E.B.$_n$ in the N.Tr.Z. at 269°II.* At 248°I on the same day he recorded a dusky E.Z., confirmed by Dragesco on Sept. 19 at 286°I. On Sept. 20 Dragesco observed a giant festoon off the N.E.B.$_s$ at 67°I. The giant festoon appeared to consist of two festoons, on the preceding side and the following side, with very dark filler material in between them. Hence, the relative width steadily decreased, since the rotation periods of these two festoons differed, as a function of time. Another small "barge" could be traced by Dragesco at 58°II on Sept. 29. According to Peterson, the N.E.B. was reddish brown on Oct. 2 at 218°I. Two separate long dusky sections of the N.E.B.$_s$ could be seen at 218°I and at 288°I respectively on Oct. 2 and on Oct. 10. Peterson called the N.E.B. yellow orange on Oct. 13 at 174°I. Weak festoons were seen by him on Oct. 15 at 63°I. Brackish nodules can be seen in the N.E.B.$_n$ on a transparency taken by Dragesco on Oct. 18 at 26°I. A dusky E.Z. and several sets of double festoons were seen by Osawa on Oct. 30 at 234°I. A triple festoon, first photographed by Rouse on Oct. 18, was recorded by Osawa on Oct. 30 with its following end at 288°I. A large festoon was seen at 54°I by Osawa on Oct. 31, but it was not the giant festoon; for by Nov. 2 Osawa's feature had changed its shape to become an inverted triangle. The festoons at 74°I on Nov. 6 were far darker in red light than in blue light according to two black-and-white photographs taken at the New Mexico State University Observatory. A huge white oval in the E.Z. can be seen on a transparency by Dragesco taken on Nov. 11 at 311°I, being flanked by two dark festoons. A long dark slanted festoon seen by O'Meara on Nov. 12 past 49°I was seen again on a transparency by Dragesco on Nov. 14, and also by Carlino on the same day. Another festoon of the same type preceded it at 68°I on Nov. 14, according to Dragesco and Carlino. Two more slanted festoons of a slightly more curvilinear character were observed by Osawa on Nov. 25 at 311°I. Two circular white ovals followed each festoon, and the N.E.B.$_n$ appeared patchy. The color was observed to be grayish-brown by Osawa. On Nov. 29 a transparency by Dragesco recorded white spots separating the N.E.B.$_s$ and the N.E.B.$_n$ at 214°I. Many festoons were seen from 161°I to 194°I on Dec. 3 by Osawa. All of these were slanted, curvilinear, and single in appearance. In early December virtually no part of the E.Z. was not cluttered by festoons of this type in every System I longitude! On Dec. 12 Dragesco noted the giant festoon near the preceding limb at about 24°I, its base being considerably darker than its top or south end. On Dec. 17 Osawa observed a clustering of some of these curious festoons at 298°I. A simultaneous observation by Dragesco and Osawa on Jan. 9, 1977, showed activity in the N.Tr.Z. as well as the E.Z. Festoons continued to be single and activity extensive over every longitude throughout January and February of 1977. The giant festoon was seen somewhat thinner in appearance at 33°I on Feb. 3 by Dragesco. This aspect was confirmed on a photograph by S. Zuzze at about the same time. On Feb. 23 Osawa depicted weak columns at 118°I and a pair of thin backward and forward festoons at 168°I on Feb. 26. A somewhat mottled appearance could be seen at 198°I on Mar. 21, according to Osawa.

<u>The South Equatorial Belt, North and South Components</u>: The roof of an N.E.B.$_s$ festoon fed dark material into the S.E.B.$_n$ at 144°I on Aug. 28, according to Osawa. The preceding end of an S.E.B. section could be located at 192°I (59°II) on Aug. 28, according to the same observer. This result may be somewhat at variance with the preceding end of the S.E.B. Disturbance at 127°II. At 102°I (192°II) an E.B. (Equatorial Band) could be seen, serving as a platform of N.E.B.$_s$ festoons, upon which short gray columns extended southward to the S.E.B.$_n$. This three component system I call "the triplex": E.B., S.E.B.$_n$ and S.E.B.$_s$. It could be seen at various longitudes throughout the 1976-77 apparition. A double S.E.B.$_n$ could be detected past the CM of 202°I on Sept. 18, according to Osawa. At 248°I (315°II) the SEB Z was completely shaded. This aspect was confirmed by Peterson on Oct 15 at 289°II. White ovals were seen in the SEB Z by Dragesco at various longitudes, and not only at the outbreak of the S.E.B. Disturbance, during September of 1976. On Oct. 18, on a transparency by Dragesco, a double S.E.B.$_s$ could be seen at 231°II, a feature not unlike that seen in 1975 following the Red Spot by Mackal. Rouse's photograph of Oct. 18 showed the Red Spot Hollow bordered by the S.E.B.$_s$ plus a large slanted line connecting the S.E.B.$_s$ to the S.E.B.$_n$ in a south-following direction. On Oct. 30 Osawa detected "the triplex" again at 234°I (342°II) and at 278°I (26°II). At 300°I he detected a merging of the E.B. and S.E.B.$_n$ on the same date. These two components were also merged together at 54°I on Oct. 31, according to Osawa. By Nov. 2 he could separate them, however, at 47°I. The S.E.B.$_n$ was slanted southward here and merged with the S.E.B.$_s$ at 65°I.

*A "barge" is a large dark condensation at the edge of a Jovian belt. See Figures 12 and 17.

This aspect was confirmed by Smith on Nov. 5 at 67°I, and by Reese from a photograph on Nov. 6 at 72°I in blue light. An N.E.B.$_s$ festoon produced a false S.E.B.$_n$ in red light on the same day at 76°I. The triplex was seen again by Dragesco at 311°I (325°II). Festoons in the SEB Z could be seen on two transparencies, one on Nov. 14 following the Red Spot and the other on Nov. 29 in the same longitudes. On Dec. 2 Heath recorded the triplex at 298°I (21°II). Osawa observed the components of the triplex merged at the preceding end of the Red Spot Hollow on Dec. 3 at 190°I (39°II). According to Carlino this merger was displaced to the following end of the Red Spot Hollow by Dec. 6, remaining at the same longitude (I) however. By Dec. 17 Osawa showed the triplex normal again near the Hollow at 298°I (40°II). Its color was bluish brown. The color of the SEB Z preceding the Hollow was mustard, according to Carlino. A double E.B. could be seen on Jan. 9, 1977 by Osawa at 165°I, issuing from two sets of staggered N.E.B.$_s$ duplex festoons, thus forming a quartex system. On Feb. 3 Dragesco perceived a strong S.E.B.$_s$ as dark as an intensified S.E.B.$_n$ at 33°I (284°II). The S.E.B.$_s$ remained strong throughout February and March, thereby tentatively confirming the Recorder's hypothesis above. On March 21 Osawa showed the two components merged at 198°I (304°II).

<u>Great Red Spot</u>: The S.Tr.Z. was bright white throughout 1976-77, and the Red spot was visible as a thin red shell, with a south half only and no north half. On Nov. 29 Heath showed the Spot to be intensity 3 in no filter, 0 in a red filter, and 5 in a blue filter.* On Dec. 17 Osawa showed the Red Spot connected to the S.E.B.$_s$ by festoons from the preceding end and the following end respectively. Another festoon could be seen just past the following end festoon connected to the S.T.B. (South Temporate Belt). By Feb. 23 Osawa showed the Red Spot faded to a small spot attached to the S.T.B. The festoon attached to the S.E.B.$_s$ on a previous date was now attached to the S.E.B.$_n$. The Spot had returned by Feb. 26, however, according to Osawa, and was then filled out. The festoons connecting it to the S.E.B. were gone.

<u>South Temperate Belt</u>: On Aug. 28 Osawa recorded it at 12°II to be bluish gray in color. Also on the same date he portrayed it as faint following 59°II. On Sept. 15 he showed it double at 192°II. On Sept. 18 he showed it single and very dark at 270°II. At 315°II it was diffuse. On Sept. 20 Dragesco showed the S.T.B. to be double at 121°II. On Oct. 10 he resolved the following end of this double section at 191°II. A transparency taken by him on Oct. 18 showed this belt to be diffuse at 231°II. On Oct. 30 Osawa observed the S.T.B. connected to the S.S.T.B. (South South Temperate Belt) at 342°II by rods. He also saw the S.T.B. double at 155°II on Oct. 31. New Mexico State University Observatory photos recorded it double on Nov. 6 at 129°II in both red and blue light. On Nov. 7 Heath detected the preceding end of the double section at 108°II. On Nov. 25 Osawa showed it to be most intricate at 221°II. On Dec. 3 he detected it connected by a column to the S.S.T.B. at 358°II. By Jan. 9 he observed it double at 92°II. From this time on, the S.T.B. appeared to be strong in some places and washed out elsewhere. On Feb. 23 Osawa showed it broken up at 72°II. By Feb. 26 the S.T.B. was invisible at 90°II along with the S.E.B.$_s$ just following the Red Spot.

<u>South South Temperate Belt</u>: It was visible at every longitude throughout 1976-77. On Nov. 2 Osawa detected an S.S.S.T.B. connected by a slanted south-preceding line to the S.S.T.B. on the following limb at 132°II.

BOOK REVIEWS

<u>The Fascinating Universe</u>, by Werner Buedeler. Van Nostrand Reinhold Company, 135 West 50th Street, New York, NY 10020, 1983, vi + 252 pages. Price $25.50.

Reviewed by Karl Simmons

This excellent book is divided into five sections: "The Universe in History," "The New Cosmic Home," "Our Sun," "Other Suns," and "The Universe in Space and Time."

The first section is a history of astronomical beliefs and cosmology from prehistoric times to the present. There are special boxes which appear in this section and throughout the book in which terms such as "Retrogressions and Loops," and "Heliacal Rising and Setting of Stars," are clearly defined and are described to assist readers who are unfamiliar with them. Although interesting, this section has explanations three to four pages long on such topics as early calendars and instruments for defining time. These detailed explanations tend to slow the momentum of the reader and should have been shortened or "boxed." <u>The Fascinating Universe</u> was first published in Germany in 1981 so that there are many references

*These intensities are on a scale of 0 (brightest features) to 10 (darkest features).

to German astronomical research and related problems, beginning with the European Southern Observatory in this first section.

"The New Cosmic Home," section two, concentrates primarily on exploration of our Solar System with space probes. It starts with a summary of lunar space exploration and its scientific results. Each of the planets is then discussed, using the results gathered by the various probes which have either landed, sampled the atmosphere, or photographed the planet. A fantastic up-to-date selection of photographs appears in this section, and a color supplement bound into the book is brief but attention-getting and well-selected. An excellent ten-page summary of data about Jupiter's moons contains the latest findings and theories about these objects.

"Our Sun," the book's third section, begins with a discussion of solar physics and our Sun as an energy source. The Sun's interior, surface, and atmosphere are described in interesting terms, and reference is made to recent satellite photography of the Sun.

The fourth section, "Other Suns," although probably needed to balance the book and to preserve its completeness, looks like a repetition of what is found in 100 or so astronomy textbooks. Star types, a star's life history, supernovae, and dwarfs are the major topics. The interesting part of this section is the information on neutron stars, X-ray stars, and black holes, which is complete and up-to-date.

The last section of the book, "The Universe in Space and Time," discusses galactic systems, the expanding Universe, and big-bang and steady-state theories much as most other astronomy books do.

I would recommend The Fascinating Universe to everyone. It's well written and current and keeps the attention of the reader most of the time. At least 50% of the book contains material on the new astronomical discoveries of the last two decades. You could buy this book and have these discoveries and events at your fingertips, or alternatively you could thumb through the last twenty years of Sky and Telescope! The choice is yours!

* * * * *

Taschenbuch fuer Planetenbeobachter, by G.D. Roth - Handbook for Planetary Observers - (in German), 2nd edition, 1983, 206 pp., softbound. Verlag Sterne und Weltenraum, Dr. Vehrenberg, Gmbh., Munich, West Germany. DM30.00 = U.S. $12.00 + import expenses.

Reviewed by Herbert A. Luft

This handbook, written in German, is really a "GEM." It contains almost everything that the beginner or advanced amateur needs to know. The author and his collaborators explain all the necessary conditions and steps for a successful undertaking of planetary observations and photographs.

In the first part of this handbook we find the descriptions of the required optical instruments, refractors, reflectors, long-focus telescopes, photographic attachments, etc. Many special telescopes are in the examples; and they are in use, mostly in Europe. Also a short introduction into the relatively new field of radio-astronomical observations of the planets is remarkable. Following this are the descriptions of the planets (including the asteroids) in great detail as to how and what to observe and the techniques in regard to drawings, collections, reductions of the observations, etc., as well as many formulae and useful tables. Most of the mentioned experiences are those of the author and his collaborators and from publications in Central Europe, but there are also the results obtained by members of the ALPO and the BAA. If the author would have also consulted magazine publications in French, Spanish, Russian, and other languages, the handbook really would have been even much more complete.

The handbook should be translated into the English language, and it would find many enthusiastic friends.

* * * * *

Pictorial Astronomy, by Dinsmore Alter, Clarence H. Cleminshaw, and John G. Phillips. Harper & Row, 10 East 53rd Street, New York, NY 10022. 1983. Fifth Revised Edition. 374 pages. Price $19.95, Hardbound.

Reviewed by Charles S. Morris

Pictorial Astronomy is indeed an appropriate title for this book. Designed for the general reader or amateur astronomer, the authors have produced a well illustrated introduction to astronomy at a reasonable cost. However, inaccuracies in the book limit its usefulness.

The authors had a good idea when they decided to use primarily black and white photographs to illustrate the book. Combined with the many drawings, the photographs convey a true sense of the subject to the reader. This slightly oversized book has hundreds of figures. Indeed, it is difficult to open the book and not see a photograph and drawing some place on the page. There are also eight pages of color photographs.

The 64 chapters in the book cover about every topic in astronomy of which one can think. Besides the photographs, there are tables of statistical information in some of the chapters and a glossary at the end of the book.

When I evaluate a book on general astronomy, I pay special attention to the section on comets for a couple of reasons. It is an area of particular interest to me; and as the subject is not usually in the mainstream of a book like this, it is interesting to see how well the authors handle it. To my delight, I found four chapters on comets. Although these chapters are well illustrated, my delight quickly turned to disappointment. It is clear that these chapters have not been updated since the previous revision (1974), and many of the facts given are simply not correct. For instance, the authors apparently believe that comets consist almost entirely of gas and that dust is only present if the comet comes quite close to the Sun. This is not true. Also, they incorrectly describe the processes which form comet tails. In their section on great comets the authors state that the only "fairly great" comets of this century occurred in 1910 and 1947. What about Comets Arend-Roland, Mrkos, Ikeya-Seki, Bennett, and West?

While the comet chapters represent only a small part of the book, similar problems can also be found in other sections of the book. For instance, the statement that M13 looks like a star in binoculars clearly shows that the authors have never seen the object in binoculars. Another example--the address of the AAVSO is given as Harvard College Observatory. The AAVSO has not had that address for many, many years. There is no excuse for an error of that nature. These and other errors simply suggest that the authors have been careless in the preparation of this revision.

While I like the concept of this book, the text needs substantial improvement. Hopefully, the authors will take the time to do the job right next time. I have reservations about recommending this book. However, the illustrations make up for some of the problems; and at the price, the pictures alone make it worth buying.

NEW BOOKS RECEIVED

Aastronomical Calendar 1984, by Guy Ottewell. Department of Physics, Furman University, Greenville, S.C. 29613. Size 11 x 15 inches. 65 pages. Price $10.00 softbound and postpaid in the U.S. Notes by J. Russell Smith.

The principal part of this handy volume is a sky map for each month in the year. Each map is followed by a page of explanations. The planets are shown at their beginning, middle, and end positions for each month. Following this material one finds sections on the Moon, Mercury, Venus, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto, Meteors, Jupiter's Satellites, Asteroids, Comets, and Space Exploration; and all these are followed by a Glossary.

This is a book suited for the experienced observer as well as the beginner.

* * * * *

B.A.A. Star Charts, by Wil Tirion. British Astronomical Association. Enslow Publishers, Bloy Street and Ramsey Avenue, Box 777, Hillside, N.J. 07205. 1984. Price $9.95. Notes by J. Russell Smith.

This set of five star charts (epoch 1950) is 18" by 13 1/2" and is printed on suitable paper for lasting use. The charts show stellar magnitudes, double stars, variables, open clusters, globular clusters, planetary nebulae, galaxies, diffuse nebulae, the galactic equator, the ecliptic, and constellation boundaries.

These charts are recommended for plotting meteor trails, cometary paths, and deep-sky objects.

* * * * *

Newton's Apple, by Ira Flatlow with Howard Boyer. General Communications Company of America, 70 West Eighth Street, Los Angeles, CA 90017. 1984. 128 pages, illustrated. Price $9.95, paperbound. Notes by J. Russell Smith.

This book has a number of sections related to astronomy, which you would hence be interested in reading. They are as follows: "Are We Alone in Space?", "Learning to Deliver: The Space Shuttle", "Why is the Sky Blue?", "Black Holes in Space", and "Dressing for Space".

* * * * *

The Crust of Our Earth, by Chet Raymo. Prentice Hall, Inc., Englewood Cliffs, New Jersey 07632. 1983. 135 pages, illustrated. Size 8 1/2" X 11". Price $12.95 paperbound, $22.95 cloth. Notes by J. Russell Smith.

This book is called "An Armchair Traveler's Guide to the New Geology", and it is an appropriate name. After an Introduction, the author covers his subject in sixty short chapters. There is a suitable Glossary from atmosphere to viscosity.

A LUNAR NOMOGRAM

By: Pablo Daumas Ladouce, University of Asunción, Paraguay

Edited by John E. Westfall, A.L.P.O. Lunar Recorder

Using the Nomogram

The lunar nomogram that is reproduced here as Figure 27 on page 167 allows one to estimate the Moon's phase, age, and local meridian crossing time for any date from A.D. 0 (1 B.C.) to A.D. 1999. Its possible uses include "predicting" past values of these quantities in historical studies, and predicting future values in the planning of observations.

Summary instructions, along with two examples, are given at the foot of Figure 27. Users should note that "Phase" is expressed in 24ths (i.e., New Moon = 0 or 24, Full Moon = 12). Also, "Centuries" refers to the first two digits of a year (00-19), and "Year" to the last two digits (00-99). Thus, 1983 is Year "83" of Century "19". One day should be added to any leap year date after February 28th. Unless specifically designated "J" (Julian) or "G" (Gregorian), centuries 00-14 are Julian and 16-19 are Gregorian. Dates and times (except for local meridian crossing) are in Universal Time (U.T.).

The reading of the nomogram requires that diagonal lines be drawn between specific points; to avoid marking the nomogram itself, tracing paper may be used. In order to prevent these diagonals from passing out of the vertical range of the nomogram, several scales are condensed and repeated (Cols. 5-8); in using these columns, select the numerically-correct entry that produces a diagonal which does not intersect the top or the bottom of the nomogram. Such correct locations in Cols. 5-8 are referred to below as belonging to the "appropriate scale." The detailed procedures for reading the nomogram are as follows:

A. For Years 0000-1899.
   1. Find Day (including fraction thereof) in Col. 1.
   2. Find Month in appropriate scale in Col. 6.
   3. Extend Day-Month line to the right to Col. 9, finding RPa (Reference Point a).
   4. Find "19" in appropriate scale in Col. 5.
   5. Extend RPa-"19" line left to Col. 1, finding RPb (Reference Point b).
   6. Find Cent. in appropriate scale in Col. 5.
   7. Extend RPb-Cent. line right to Col. 9, giving RPc (Reference Point c).
   8. Find Year in appropriate scale in Col. 8. (Use its location in Col. 7.)
   9. Extend RPc-Year line left to Cols. 2-3-4. Read lunar age in Col. 2, phase (in 24ths) in Col. 3, and local meridian crossing time (local mean solar time, 00^h-24^h) in Col. 4.

B. For Years 1900-1999.
   (Steps 1-3 as above.)
   4. Find Year in appropriate scale in Col. 8.
   5. Extend RPa-Year line left to Cols. 2-3-4. Read age, phase, and local meridian crossing time as in Step 9 above.

Constructing the Nomogram

The nomogram reproduced here is necessarily much reduced, making it more difficult to read accurately. It is not difficult to construct a larger and thus more accurate version. In making one's own nomogram, the proportions (height:width ratio) are arbitrary, although a square nomogram (height = width) will give more accurate results than an elongated or flattened outline. Once a width and height have been selected, however, the horizontal positions of columns and the vertical positions of reference marks ("ticks") must be placed precisely in terms of the width and the height. In the instructions and tables which follow, the height is designated h and the width w. Thus, the nomogram's top is at 0.0000h, the bottom at 1.0000h, the left margin at 0.0000w, and the right margin at 1.0000w.

The vertical columns are drawn from 0.0000h to 1.0000h, except for columns 1 and 6, which extend to 1.0159h and 1.0305h respectively. Their horizontal positions are:

Col. 1	at 0.0000w	Col. 6	at 0.5000w
2-3-4	at 0.1667w*	7-8	at 0.5833w
5	at 0.3333w	9	at 1.0000w

The vertical locations of values and their reference marks in the columns, expressed as y, where y is given in h-units, are:

Col. 1. y = (day - 1)/29.53059;
Col. 2. y = Age/29.53059;
Col. 3. y = Phase/24;
Col. 4. Use same ticks as for Col. 3, where Time = Phase + 12 (for Phases 00-11) or Time = Phase - 12 (Phases 12-23).
Col. 5. y = (29.53 - Age_0)/88.59, where Age_0 is the age at 00 U.T. on Jan. 1 of the beginning year (00) of each century. These y-values are given in Appendix Table A. This scale is condensed and repeated three times, so also plot y' = y + 0.3333h and y" = y + 0.6667h.
Col. 6. Plot months at the following y-values:

Jan.;	0.5295h, 1.0295h	Jul.;	0.4649h, 0.9649h
Feb.;	0.5045h, 1.0045h	Aug.;	0.4399h, 0.9399h
Mar.;	0.5305h, 1.0305h	Sep.;	0.4151h, 0.9151h
Apr.;	0.5058h, 1.0058h	Oct.;	0.4072h, 0.9072h
May ;	0.4976h, 0.9976h	Nov.;	0.3822h, 0.8822h
Jun.;	0.4728h, 1.9728h	Dec.;	0.3743h, 0.8743h

Col. 7. y = ("Code"/480) + 0.0295; also plot ticks at y' = y + 0.5000h.
Col. 8. y = Age_1/59.06, where Age_1 = Age at 00^h U.T. on Jan. 1 of each year from 19<u>00</u> to 19<u>99</u>. These y-values are given in Appendix Table B. This scale is repeated twice, so also plot y' = y + 0.5000h.
Col. 9. y = (RPa - 100)/295.3.

The tick marks whose locations are so calculated should then be plotted and labeled as on the nomogram version given here.

Accuracy and Corrections

This nomogram has been designed for ease of use, necessitating two compromises in its accuracy:

1. It refers to the position of the "Mean Moon", ignoring variations in the Moon's motion caused by its orbital eccentricity. The resulting error can reach 3°.14 (i.e., $0^d.26$ in age, 0.21/24 in phase, and 13 mins. in meridian crossing time).

2. The time of local meridian crossing (upper transit) is based on the Moon's position at the time originally selected, rather than on its position when it actually transits. Spot checks for 10 dates in 1983 gave the following errors in this quantity:

0^h U.T. 8 to 61 minutes early (mean = -33, standard deviation = ± 22);
12^h U.T. 37 min. early to 36 min. late (mean = -9);
24^h U.T. 13 min. early to 60 min. late (mean = +15).

For the same 10 dates, the root-mean-square errors for the other two desired quantities were ± $0^d.46$ for age and ± 0.37/24 (0.016) for phase. These provide for all sources of error, including plotting and reading of values.

Another source of error which is serious only for dates far in the past is caused by the difference between Ephemeris Time (E.T.) and Universal Time (U.T.). The Moon's actual motion is described in terms of E.T., while U.T. is defined by

*This value is somewhat arbitrary but provides an equal spacing among Cols. 1-6; it influences the placement of Cols. 7 and 8.

the Earth's rotation period, which varies over time. For greater accuracy, one should add the following values to U.T. when one locates "Date" in Col. 1. (For specific years, interpolate values from this table.)

Year	T	Year	T	Year	T
0000	2^h38^m	0700	58^m	1400	7^m
0100	2 20	0800	48	1500	4
0200	2 04	0900	38	1600	1
0300	1 49	1000	30	1700	0
0400	1 35	1100	23	1800	0
0500	1 21	1200	16	1900	0
0600	1 09	1300	11	2000	1

Because U.T. is used as a standard, the time of local meridian crossing (which is based on the Earth's rotation) should not be corrected for the E.T. - U.T. difference. Local meridian crossing times are affected by the observer's longitude, however. The small correction scale in the lower-right portion of the nomogram gives this correction, but it is difficult to read accurately. The table below gives appropriate corrections to apply for the observer's longitude. This correction should be added for west longitudes and subtracted for east longitudes.

Long.	Corr.	Long.	Corr.	Long.	Corr.
$0-3^o$	0^m	$56-62^o$	8^m	$115-121^o$	16^m
4-11	1	63-70	9	122-129	17
12-18	2	71-77	10	130-136	18
19-25	3	78-84	11	137-143	19
26-33	4	85-92	12	144-151	20
34-40	5	93-99	13	152-158	21
41-48	6	100-107	14	159-166	22
49-55	7	108-114	15	167-173	23
				174-180	24

Thus, to obtain as accurate a local meridian crossing time as possible, one should apply the longitude correction given above as well as the lunar position correction given earlier.

Finally, phase is expressed in units of 24ths in order to conform with the ticks for local meridian crossing time. Observers may be more familiar with phase expressed in terms of percent of the disk which is illuminated, or in terms of solar colongitude. The table below converts the nomogram's phases into these units.

Phase	Approx.* Colong.	Percent Illum.	Description	Phase	Approx.* Colong.	Percent Illum.	Description
0/24	270°	0%	New Moon	12/24	090°	100%	Full Moon
1	285	2	Waxing Cres.	13	105	98	Waning Gibb.
2	300	7	" "	14	120	93	" "
3	315	15	" "	15	135	85	" "
4	330	25	" "	16	150	75	" "
5	345	37	" "	17	165	63	" "
6	000	50	First Quarter	18	180	50	Last Quarter
7	015	63	Waxing Gibb.	19	195	37	Waning Cres.
8	030	75	" "	20	210	25	" "
9	045	85	" "	21	225	15	" "
10	060	93	" "	22	240	7	" "
11	075	98	" "	23	255	2	" "

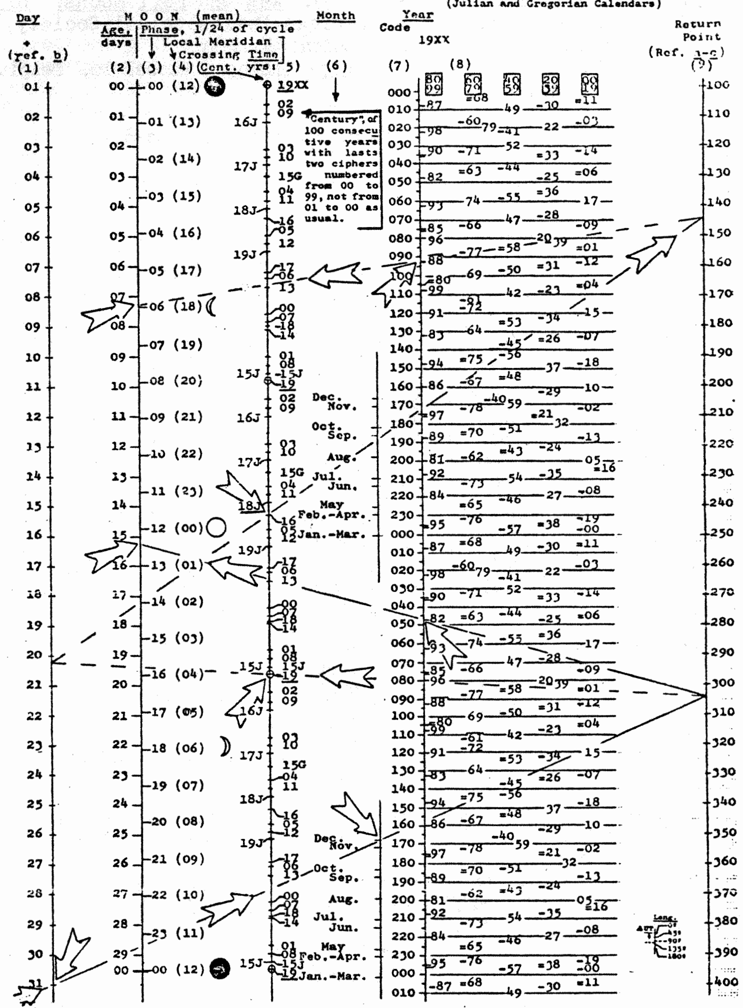
*Subject to a maximum error of $\pm 7°$.

Appendix. Tables for Nomogram Columns 5 and 8.

Table A. y-Coordinates of Centuries for Column 5.

Notes: Repeat ticks, using $y' = y + 0.3333h$ and $y'' = y + 0.6667h$. J = Julian Calendar; G = Gregorian Calendar. Century 20 has been added to extend the nomogram's usefulness through the year 2099.

NOMOGRAM giving the PHASE, AGE and LOCAL MERIDIAN CROSSING TIME
of the MEAN MOON for every day of the Christian Era.
(Julian and Gregorian Calendars)



-Julian Calendar Centuries (from 15th): read at left of Column 5.-
-Gregorian Cal. (from Oct. 15th 1582), Col. 5 right; take "15G" for Century 15th.

- For Centuries preceding 1900: Day-Month-RPa-"19"-RPb-Cent-RPc-Year- M O O N,
  follow columns: 1 6 9 5 1 5 9 7-8 2-3-4
  Example I.- For December 30th 1688 (leap year, add 1 day: Dec. 31) we find MOON Phase 06, Age 7,3days, Meridian Crossing Time (local) 18 hours.-
- For Century 1900: Day-Month-RPa-Year- M O O N,
  follow columns: 1 6 9 7-8 2-3-4
  Example II.- For December 31th 1982 at 00hs. GT: Phase 12,5/24th of cycle, Age 15,2 days, Meridian Crossing Time (local) 00hs. 30m.-
- -All hundreth years (except 1700, 1800 and 1900 Gregorian Calendar): proceed with the day before from January 1st to February 29th.-
  -All other leap years: proceed with the following day after February 29th. Remember: in Gregorian Calendar 1700, 1800 and 1900 are not leap years.-
- Code (col. 7) = Lunar phase (1/24th x 10) at 00hs (GT) of Jan. 1st; read as follows, see Col. 7-8: for 1924(¯) 19,25; 1943(=) 19,5; 1962(_) 19,75; 1905/81(——) 20,0.-

Figure 27. Lunar nomogram contributed by Pablo Daumas Ladouce. See text on pg. 164 *et seq.* for its construction and use.

Century	y	Century	y	Century	y
00J	.2755h	09J	.0475h	18J	.1483h
01J	.3170	10J	.0974	19J	.2056
02J	.0352	11J	.1392	20J	.2628
03J	.0893	12J	.1916	15G	.1163
04J	.1317	13J	.2460	16G	.1717
05J	.1795	14J	.2890	17G	.2165
06J	.2355	15J	.0034	18G	.2725
07J	.2829	16J	.0588	19G	.0077
08J	.3257	17J	.1036	20G	.0649

Sources for table at bottom of pg. 167:

00-16--Herman H. Goldstine (1973). New and Full Moons. 1001 B.C. to A.D. 1651. Memoirs of the American Philosophical Society, Vol. 94. Philadelphia: American Philosophical Society.
17-20--Jean Meeus (1963). Syzygies Tables. Kessel-lo, Belgium: Kesselberg Sterrenwacht.

Table B. y-Coordinates of Years for Column 8.

Note: Repeat ticks using y' = y + 0.5000h

Year	y	Year	y	Year	y	Year	y	Year	y
00	.0000h	20	.1575h	40	.3547h	60	.0384h	80	.2140h
01	.1680	21	.3607	41	.0520	61	.2308	81	.4101
02	.3496	22	.0430	42	.2392	62	.4065	82	.0901
03	.0312	23	.2272	43	.4064	63	.0840	83	.2763
04	.2179	24	.4064	44	.0828	64	.2653	84	.4653
05	.4194h	25	.1001h	45	.2763h	65	.4929h	85	.1595h
06	.0985	26	.2753	46	.4573	66	.1502	86	.3390
07	.2757	27	.4517	47	.1383	67	.3349	87	.0161
08	.4509	28	.1300	48	.3253	68	.0144	88	.1913
09	.1443	29	.3303	49	.0240	69	.2086	89	.3849
10	.3224h	30	.0124h	50	.2066h	70	.3838h	90	.0632h
11	.0020	31	.1990	51	.3842	71	.0604	91	.2460
12	.1873	32	.3818	52	.0608	72	.2384	92	.4328
13	.3910	33	.0772	53	.2530	73	.4382	93	.1314
14	.0721	34	.2533	54	.4306	74	.1197	94	.3143
15	.2526h	35	.4285h	55	.1097h	75	.3065h	95	.4924h
16	.4289	36	.1055	56	.2946	76	.4897	96	.1692
17	.1221	37	.3019	57	.4985	77	.1852	97	.3615
18	.2978	38	.4866	58	.1796	78	.3617	98	.0384
19	.4771	39	.1688	59	.3607	79	.0384	99	.2179

Sources: 00-59--Berenice L. Morrison (1966). Phases of the Moon 1800-1959. United States Naval Observatory Circular No. 112. Washington, DC: U.S. Naval Observatory.
60-84--Individual annual issues of The American Ephemeris and Nautical Almanac (1960-80) and The Astronomical Almanac (1981-84).
85-99--Meeus op. cit.

METEOR TRAILS

By: David H. Levy, A.L.P.O. Meteors Recorder

The Meteor Section continues to grow; and the time has come to announce the birth of its first offspring, a new A.L.P.O. newsletter that will be dedicated in considerable part to meteors. If you are interested in joining the Meteor Section, participating in its programs, and in receiving this newsletter, simply send some 20-cent stamps (not SASE's, just stamps); and I'll be happy to add you to the mailing list. To join the Section, of course, you must be a member of the A.L.P.O.

We have had some reports on this year's Quadrantid shower, and those who watched it agree that it was the most successful one in recent years. There was some uncertainty in the literature as to when the hour of maximum would occur this year, with different sources predicting different hours all through the night of maximum. Our group, consisting of Rolf Meier, Linda McRae, Gerald Schieven, and me, observed for 2 hours on a (relatively) balmy January morning from Jarnac Observatory, and saw 180 meteors. I'd be happy to hear from anyone else who observed the Quadrantids and who has not yet reported.

The two main Spring showers are the Lyrids, which peak at one day before a Last Quarter Moon on April 22. Two weeks later come the Eta Aquarids, which will be competing with a bright First Quarter Moon but which of, course, would be out of the way before the best, post-midnight observing occurs.

If you would like to observe these showers and send your results to the Meteor Section, please use the following format. For a single observer: Please record for each meteor the brightness, to half a magnitude, and whether it belongs to the main shower or not. Record time to the nearest five minutes, which should be fine for our statistical purposes. Do not try to cover the entire sky, just one selected area and preferably the darkest quadrant visible from your location. If you are observing in a group of four or eight persons, divide the sky appropriately into sections so that each observer concentrates again on a small area.

Meteor observing is going to gain some respectability in the next few years as Halley's Comet approaches. The Eta Aquarid shower is suspected of coming from this comet; thus it is important to observe the shower as accurately and as thoroughly as possible. Whenever there is a chance for amateurs to contribute to the advance of astronomy in a special way, it is a good idea to take advantage of it.

Later on in the year, we will be observing two more exciting showers, the Delta Aquarids and the Perseids. This is a very complicated situation because these two showers peak only two weeks apart and within 60 degrees of each other. Between July 20 and August 15 there is an almost constant display of meteors; and with the added attraction of warm summer nights, these two showers have become by far the most popular ones. Recently, Hal Povenmire has postulated the existence of a small shower with a radiant near Upsilon Pegasi, as well as a midsummer peak. Although the existence and strength of this shower has yet to be proven, amateurs are participating in a network to observe and to record any meteors which may belong to it. Until next time, happy observing!

AN A.L.P.O. TRAINING PROGRAM LUNAR AND PLANETARY DRAWING KIT

By: Jose Olivarez, A.L.P.O. Training Program Director

An A.L.P.O. Training Program Lunar and Planetary Drawing Kit consisting of high quality drawing supplies, instructions, and drawing forms is now available from Mr. Jose Olivarez, the Lunar and Planetary Training Program Director. The basic drawing kit consists of two special drawing pencils (grades B and 6B), a kneaded rubber eraser, and a quality artist's stump. In addition, six printed drawing and recording forms for Jupiter, Saturn, and Mars are also included, as well as instructions on how to draw the Moon and Jupiter.

A.L.P.O. observers wishing to acquire this Training Program Kit should send $4.00 (to cover cost of supplies, printing, and postage) to Mr. Jose Olivarez, 220 South Main, Wichita, Kansas 67202.

Successful students of this Training Program will have their drawings published in future issues of this Journal.

ANNOUNCEMENTS

<u>New Lunar Magazine</u>. A new journal called <u>Selenology</u> is of interest to amateur astronomers and is exclusively about the Moon. Three issues have already appeared and deal with such subjects as: eclipses to come of the Sun and Moon, articles showing that there are no "alien bases" on the Moon, ideas for future manned exploration and use of the Moon, and Lunar Transient Phenomena.

<u>Selenology</u> averages 30 pages and is published semi-annually. Subscription rates are $4.00 per year. To order this journal, send a check or money order made out to the Pennsylvania Selenological Society, c/o Francis G. Graham, 417 Franklin St., East Pittsburgh, PA 15112.

<u>Note to Users of Personal Computers</u>. Mr. Don Spain sends us this announcement:

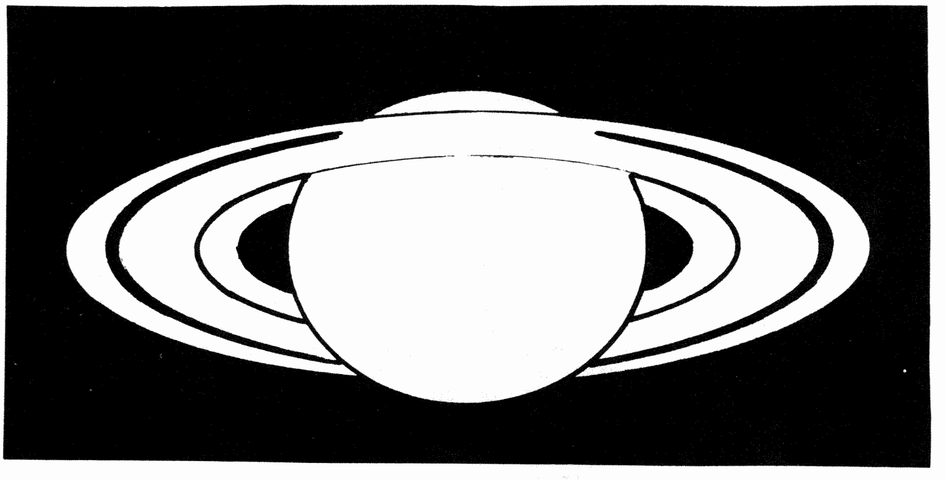
"The National Deep Sky Observer's Society has formed a computer sub-group. The purpose of this group is to promote the use of the personal computer in theoretical and observational astronomy. Members of the A.L.P.O. with any interest in astronomy and computers are invited to join with us. You do not have to belong to the N.D.S.O.S. to join the sub-group. For more information contact Mr. Don Spain, 216 Inglewood Drive, Fairdale, KY 40118."

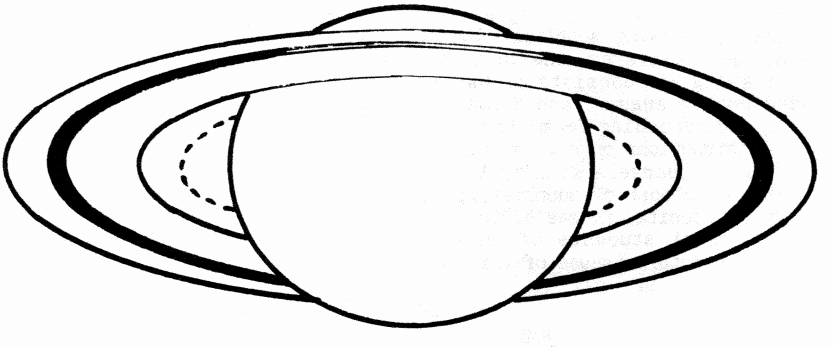
<u>Change in Comets Section</u>. Mr. Dennis Milon is giving up the Comets Recordership, where he has served for approximately 20 years. We thank him very much for his assistance and support over the years in corresponding with amateur observers of comets, in drawing their attention to new comets, and in studying their contributed data. The demands of doing a good job on our volunteer staff will be best appreciated by those who have been, or who are, Recorders. We are grateful to all those who have thus made the A.L.P.O. and its services possible, and we miss them when for various reasons they cannot continue.

The new Comets Recorder will already be known to many of our readers: he is Mr. David H. Levy, Route 7, Box 414, Tucson, AZ 85747. Mr. Levy writes:

"The A.L.P.O. Comets Section has lasted for many years under the leadership of Dennis Milon, who has retired from this time-consuming and increasingly demanding post. At the request of Walter Haas, I have agreed to take on the position of

SATURN





INTENSITY ESTIMATES

Figure 28. These finished Saturn outlines, along with finished discs of Mars and Jupiter, are included in the A.L.P.O. Training Program's new Lunar and Planetary Drawing Kit. See text on page 169.

Comets Recorder. I know that Dennis' shoes will be hard to fill, and I understand that the Section he so ably headed is an important one. I shall try my best to preside over continued growth and development of this Section.

"The Comets Section faces a special time, especially with the upcoming appearance of Comet Halley. While amateur observations for the International Halley Watch will be expertly handled by Steve Edberg, I see no reason why our A.L.P.O. Section should not assist I.H.W. in an active way. There are groups that study comets, particularly the International Comet Quarterly. The A.L.P.O. Comets Section does not wish to duplicate these important efforts, but instead should supplement and cooperate with them, as well as going off in different directions of its own.

"During the next few months the Comets Section will be evaluating its role and purpose, and I would be grateful for any help and suggestions from Journal ALPO readers. Also, while the Comets and Meteor Sections will remain separate, one newsletter will be published to serve the scientific and social needs of both. Please let me know if you wish to receive it."

Riverside Telescope Makers Conference. This extremely popular annual meeting will be held on May 25-28, 1984 at Camp Oakes, about 5 miles east of Big Bear City, Calif. on Highway 38 at Lake Williams Road. This location is 50 miles northeast of Riverside, high in the San Bernardino Mountains. The elevation of Camp Oakes is

7300 feet. It is a clean mountain camp, which is ideally suited for deep-sky celestial observing and photography. There is a choice of several different meal plans and camping arrangements; there are also motel accommodations in Big Bear City. The Conference will include a guest speaker, amateur papers, workshops, Merit Awards, a Panel of Experts on telescopes and related equipment, commercial exhibits, a Swap Meet, a Proceedings of the meeting which will cost $10, and recreational facilities.

Those wanting more information should write to: Riverside Telescope Makers Conference, 1000 Central Ave. #1, Riverside, CA 92507.

Error in Vol. 30, Nos. 5-6 of This Journal. Mr. Randy Tatum calls attention to an error in his article. On page 97 the first sentence after the abstract should start "Prior to the year 1860. . .", not 1868.

Union List of Astronomy Serials Now Available. The Physics-Astronomy-Mathematics Division of the Special Libraries Association is offering a 170-page, loose-leaf compilation of the astronomy holdings in 14 astronomy collections, including the U.S. Naval Observatory, the Kitt Peak National Observatory, and the Yerkes Observatory. There are over 1800 titles. Orders should be directed to Judith A. Lola, Yerkes Observatory Library, P.O. Box 258, Williams Bay, WI 53191. The price is $20.00 prepaid, $25.00 for billing. Checks should be made payable to PAM Division, Special Libraries Association.

Computer Program for Comets and Minor Planets. A.A.P.O. Assistant Comets Recorder Derek Wallentinsen wrote as follows on January 2, 1984: "To those who wish to compute the positions of comets and Minor Planets and who have access to an HP-41 pocket computer system, I have available a fully documented program for astrometric ephemerides from osculating elements. The program outputs the date, right ascension and declination, Earth and solar distances, phase angle, elongation, and stellar magnitude.

"The documentation is $3, to cover postage and duplication costs. Those who also wish to have the program on magnetic cards can send me five blank cards. I'll write the program on them and return them with the documentation."

Sustaining Members and Sponsors. The persons and groups listed below support the work of the A.L.P.O. by voluntarily paying higher dues, $40 per volume for Sponsors and $20 per volume for Sustaining Members. Their generous assistance and meaningful support are here gratefully acknowledged. This financial aid is particularly valuable in the present period of inflation and rising costs. It is certainly much needed. If there are errors in the list below, the Editor would appreciate being told about them.

Sponsors - Philip and Virginia Glaser, Dr. John E. Westfall, Dr. James Q. Grant, Jr., Ken Thomson, Darryl J. Davis, Dr. A.K. Parizek, James H. Fox, Dr. Howard W. Williams, Sky Publishing Corporation, and Michael McCants.

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"Worlds in Comparison". The Astronomical Society of the Pacific is offering a slide set with this title, giving dramatic visual answers to such questions as how many Earths would fit into the Great Red Spot of Jupiter and how much room would the largest volcano on Mars occupy if it were placed on the Atlantic Seaboard of the United States. The 15 slides were designed by former NASA Visual Information Specialist Stephen Meszaros, using the best spacecraft and radar images of various planets and satellites. The set includes a detailed caption booklet. The price is $14.95, including postage and handling. Order from A.S.P., Worlds Slide Set Dept., 1290 24th Ave., San Francisco, CA 94122.

Annular Solar Eclipse on May 30, 1984. An invitation to witness this event has come from the City of Petersburg, Dept. of Tourism, 15 West Bank St., Petersburg, VA 23803. The eclipse will be 99.8% total at Petersburg. Moonshadow Expeditions are offering an excursion to Manzanillo, Mexico, where the annularity will last more than 30 seconds. Their address is Unitrex, 1403 E. Green St., Pasadena, CA 91106. One package for their trip costs only $389.

A GUIDE TO OBSERVING MARS - I

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

Introduction

This observing guide is intended to introduce the fascinating world of Mars to the novice and to acquaint the beginning observer with the basic Martian problems and with observing techniques for the telescope. The text has been presented in summary form in order to simplify the essential knowledge necessary for full or partial participation in systematic observing programs of the A.L.P.O. Mars Section, according to the level at which the planetary observer wishes to become involved. There are few limitations to contributing useful data to the scientific community. The primary ones are: the amount of time the observer can spend at the telescope, local weather conditions, and the quality and size of telescope used. A modest size telescope of 4 to 8 inches in aperture can produce useful information about Mars if used in an aggressive and systematic manner with the aid of color filters.

The Mariner and Viking space missions to Mars have given us much close-up information and have identified or confirmed most of the telescopic observed features and meteorological phenomena. More importantly, these space missions have defined and outlined areas for continued future telescopic observing programs and research upon past observational data which has been meticulously acquired over decades by planetary astronomers. Because all spacecraft have run out of gas or cash, the only future knowledge of Martian changing phenomena for mankind, until the Mars Geoscience/Climatology Orbiter (MGCO) arrives in the 1990's, will come from Earth-bound telescopes--from you the Planetary Astronomer!

Part I. Mars - the God

The fiery-red planet has been associated with bloodshed, disaster, and war ever since the Babylonians called it the Star of Death. Ancient Syrian priests made human sacrifices to Mars from their temples which were painted and draped in red. The Chaldeans named it Nergal, the master of battles and their great hero. The Greeks called it Ares after their God of War, also Hercules, champion of the gods. It was the Romans who named it Mars for their bloody God of War.

From the Greek Ares (Mars) and grapho (I design) the words Areography, or geography of Mars, and Areology, the study of the geology of Mars, came into the vernacular in the last century. When Asaph Hall discovered the two moons of Mars in August, 1877 with the U.S. Naval Observatory 26-inch refractor telescope, he named them Phobos, Greek for "fear", and Deimos, Greek for "terror", after the mythological horses that pulled the war chariot for the god Mars. Without doubt, there is no planet which has been the object of so much research, study, and controversy as Mars. Astronomers have devised a most intriguing scheme for naming Martian surface features which has created a world more fantastic than Edgar Rice Burroughs could ever have dreamed up for Barsoom. More has been written about Mars in fact and fiction than about all other planets in our Solar System. Some astronomers have devoted their lives to him!

Part II. Mars - the Planet

A. The Martian World. Even after the successful space missions of the Mariners and the Vikings, Mars has remained an object of scientific interest to planetary observers for several reasons: It is our nearest neighbor beyond the Earth in relation to the Sun, still a planet of mystery, and a possible harbor for life. Due to a thin atmosphere, Mars is the only planet whose surface can be plainly seen and charted from Earth. With only a modest size telescope, the planetary observer sees the small globe of Mars as an intriguing, challenging, and dynamic world with the most Earthlike features of any other planet in the Solar System: four seasons, global climates, changeable weather, storm clouds of water vapor, howling dusty winds, annual thawing of polar ice caps, and a variety of alien, grotesque surface features which predictably change with the seasons, while other features mysteriously move during decades. The diameter of Mars is only 4,2000 miles, or about 53% that of Earth, and its mass is about a tenth of the Earth's; but surprisingly, its charted land area available for exploration is about equal to that of our own planet because Mars has no oceans. Recent investigations have suggested that some Martian volcanos may still be active; and if so, perhaps their grayish ash clouds may be visible from Earth.

B. The Martian Day. The rotation period of Mars, or solar day, also called a "sol" by space scientists, is about 40 minutes longer than a day on Earth, which allows Mars to rotate through only 350° of longitude in 24 hours. Consequently, the planet appears to back up about 10° from night to night, causing an illusory retrograde rotation in about 36 days. Thus, any given Martian region can be observed for about 10 days at intervals of about 36 terrestrial days.

C. The Martian Seasons. The one attribute which makes Mars unique among all the planets and the most Earthlike is that it displays white polar caps. The polar caps are affected by the seasonal position of the 25° axial inclination to the orbital plane of Mars, which cases the caps to thaw and fluctuate in size in an annual seasonal cycle. Indeed, many of the observed surface changes and atmospheric phenomena appear to be directly coupled to the seasonal climate which causes the spring thawing phase of one polar cap and the fall formation phase of the opposite cap.

Mars and Earth have four comparable seasons because their axes of rotation are each tilted at about the same angle to their respective orbital planes. Mars' axial tilt is 25°.2 as compared to 23°.5 for Earth. The Martian year lasts 687 Earth days, nearly twice as long as ours, so that the Martian seasons are similarly longer. While Earth's are nearly equal in duration, the length of a Martian season can vary as much as 51 days because of the greater eccentricity of the orbit of Mars. See Table 1 and Figure 29.

The axis of Mars does not aim at our North Star, but is displaced about 40° towards Alpha Cygni. Because of this celestial displacement the Martian seasons are 85° out of phase with the terrestrial seasons, or about one season in advance of ours. Consequently, when you make telescopic observations of Mars this spring and summer, you will be seeing summer and fall, respectively, in the Martian Northern Hemisphere. Refer to Table II and Figure 29.

* * * * *

Note by Editor. We regret that it has not been possible to include all of Mars Recorder Capen's article in this issue. We regret it the more because the planet wil be approaching its May 11, 1984 opposition when this issue reaches our readers. There is a good discussion of the current apparition by Mr. Capen in Journal A.L.P.O., Vol. 30, Nos. 5-6, pp. 125-130, 1984.

Table I. Earth-Mars Seasonal Durations

Areocentric longitude of the Sun L_S	Season: Northern Hemisphere	Season: Southern Hemisphere	Duration of the seasons on Mars: Martian days	Duration of the seasons on Mars: Terrestrial days	Duration of the seasons on Earth: Terrestrial days
0° - 90°	Spring	Autumn	194	199	92.9
90° - 180°	Summer	Winter	178	183	93.6
180° - 270°	Autumn	Spring	143	147	89.7
270° - 360° or 0°	Winter	Summer	154	158	89.1
			669	687	365.3

Table II. Related Mars Season when opposition occurs during a given Earth Season.

Mars Season: North Hemisphere	Mars Season: South Hemisphere	Earth Season: North Hemisphere
Summer	Winter	Spring
Autumn	Spring	Summer
Winter	Summer	Autumn
Spring	Autumn	Winter

Part III - Planetary Telescopes and Accessories

A. The Telescope. The planetary astronomer usually has to use a telescope that he/she can afford to construct or to purchase commercially, or else may borrow observing time on an instrument at an established observatory. The most common telescopes in use today are: the refractor (Rfr) achromatic lens system, the Newtonian reflector (Newt) all mirror optical system, the Cassegrain reflector (Cass) folded mirror optical system, and the Schmidt/Cassegrain (Sch/Cass), which combines elements of both the refractor and the reflector. This last lens-mirror instrument is also called a Catadioptric telescope. Telescopes are also classified for different uses according to the focal length (fl) of their optical systems. The most important consideration for an astronomical telescope is to have quality optics throughout, including eyepieces, and a sturdy equatorial mount. All three types of telescopes have certain strengths and certain weaknesses.

Several decades ago, when the author was a young amateur and student of astronomy studying under the renowned optician, Carl Nickelson, and the astronomer who discovered the planet Pluto, Dr. Clyde Tombaugh, he learned from these mentors that a long focal length telescope was a necessity for planetary and lunar studies; and surprisingly, it is also excellent for deep-sky work, because the optical design gives high powers, high contrast images, and a very dark background field of view in city skies. These qualities are ideal for faint celestial objects with small angular diameters, e.g., planetary nebulae, double stars, small star clusters, and distant galaxies. Planetary telescopes have long focal ratios which range from f/15 to f/60, giving good contrast images at high magnifications.

1. Refractor Telescopes usually have f/15 or f/16 focal ratios, are the most light efficient optical design, give maximum image contrast at high powers, are simple to use, and require little cleaning and maintenance. However, moderate size refractors are expensive per inch of aperture, difficult to house, not portable, and not completely achromatic, thus requiring a new focus each time a different color filter is used for visual observation or photography.

2. Planetary Newtonian Telescopes have focal ratios from f/8 to f/12 with small diameter secondary mirrors. Image contrast is a function of the area of the central obstruction caused by the secondary mirror, its mirror holder, and the spider support system. The simple rule is: the smaller the ratio between the diameter of the primary mirror and the size of the minor axis of the secondary mirror, the better the apparent contrast. For example, a 1-inch minor axis of the secondary mirror divided by an 8-inch diameter primary mirror gives a 12.5% ratio. Values between 10% and 15% make excellent planetary telescopes. Color image contrast is also affected by the physical condition of the observer's eyes, his experience, image brightness, and color filter used, which will be discussed later. The Newtonian reflector is completely achromatic, which gives sharp images through all color filters. However, large long-focus scopes require heavy duty equatorial mounts and an observing ladder or platform in order to reach the eyepiece. The open tube exposes optical elements to air and dirt, resulting in needed regular cleaning and alignment.

If you have an f/5 or f/6 Newtonian reflector, it can be improved by replacing the secondary mirror with a smaller one. The use of an off-axis optical stop mounted across the open end of the tube will also improve contrast, with the loss of some image brightness.

3. Planetary Cassegrain Telescopes have focal ratios from f/20 to f/60 with small secondary mirrors. They are comfortable to use, have folded compact optical systems, require medium size mounts, and in modest size instruments are portable. Normal maintenance and cleaning of optics are required. The optical design is completely achromatic for all color filter work, gives excellent color image contrasts, and is a stable scope for photographic patrol programs.

4. Schmidt/Cassegrain Telescopes are usually a compromise between a planetary type and a deep-sky system, having f/10 or f/11 focal ratios. This type of telescope is extremely compact, easy to use, light in weight, and portable. Little maintenance is required because of a closed tube. Image quality may vary from fair to excellent in commercially produced models. It is advised thoroughly to test the quality of the optical system before the warranty expires. With the use of a Barlow Lens, this type of instrument can become a fair planetary telescope by increasing the focal ratio two- or three-fold, to f/20 or f/30. A systematic photographic patrol of the planets is also possible by the use of eyepiece projection.

5. Richest Field Telescopes (RFT) have short focal ratios of f/3 to f/5 and are used for wide-field observation, deep-sky objects, and comet studies and are excellent fast photographic systems. This type of instrument is not suited for planetary studies because of inherent low contrast images and low magnification, which gives small image scale.

The following is a list of possible Martian studies for various telescope sizes:

a - Telescopes of less than 150 mm (6") aperture. Observations are limited by resolution to only the study of large surface features, bright clouds, limb brightenings, extensive yellow dust clouds as indicated by low contrasts of gross features, polar region conditions, and violet-clearings within 2 or 3 months of opposition. A routine use of light color filters, which allow high transmission of light, can collect a useful set of observations showing seasonal changes.

b - Telescopes of 150 mm to 250 mm (6" to 10") aperture. Observational studies of conspicuous surface detail are possible within 3 or 4 months on either side of opposition. Variations of surface features, seasonal cloud activity, and violet-clearings can be successfully studied in a routine manner with the aid of a full set of color filters. Positional micrometric work on the retreat of polar cap boundaries and on dark feature boundaries showing change can be done. Much needed planetary photography with medium to fine grain films (Tech. Pan 2415, Kodachrome 64, Ektachrome 200) and using large f-ratios of f/150 to f/200 is possible.

c - Telescope of 300 mm and larger (12" +) aperture. All of the observations mentioned above can be done with a higher standard of accuracy and ease. Critical visual and quality photography at f/60 to f/200 of surface variations and atmospheric meteorology is possible on a professional level. Color intensities and color changes are possible to detect with these larger apertures. Quality color slides and multi-color black and white photography in red, yellow, green, blue, and violet light is practical. A professional-type synoptic color filter observational program is most useful for Martian research.

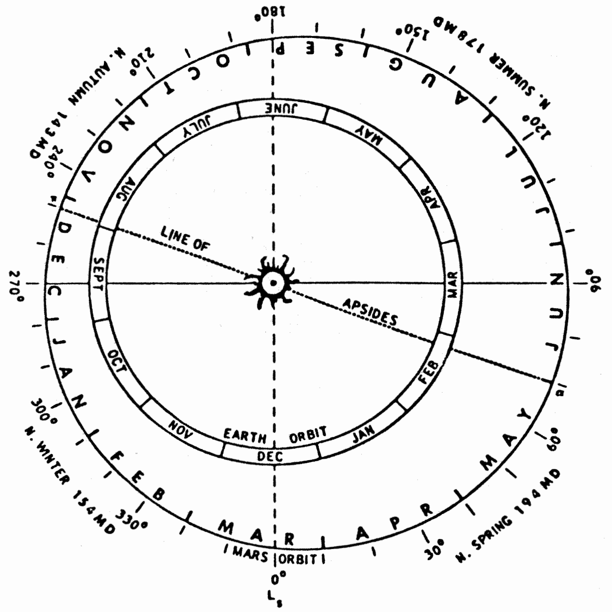

Figure 29. A heliocentric chart of the orbits of Mars and the Earth showing the relative seasons of both planets in the planetocentric longitude system L_S.

B. <u>The Eyepiece</u>. The quality of an ocular, or eyepiece, is just as important to the telescope optical system as the primary mirror or objective lens. Good color contrast images can only be obtained with high quality multi-coated oculars. There are many types and brands on the market today with focal lengths from 4 mm to 75 mm. A basic set of 3 to 6 oculars is a good investment that will last a lifetime. The new American made plossl and orthoscopic type eyepieces with standard 1 1/4" diameter barrels and multi-coatings will give excellent planetary images. They should be threaded on the field lens end to accept standard color filters and polarizers. Short (4 mm or 5 mm) to medium (7 mm to 18 mm) focal length oculars are best for the high-power work required for planetary observation.

C. <u>The Barlow Lens</u>. A quality Barlow Lens, or telenegative amplifier lens, is a most useful optical device for the planetary astronomer and astrophotographer. It can double or triple the effective focal length (Efl) of your telescope. Its effect is to double or triple the power of each ocular used, which expands the choice of focal lengths of your set of eyepieces. Also, importantly, the Barlow Lens allows greater eye-relief at the viewing end of the ocular because a longer focal length ocular can be used to obtain an equivalent power, which allows the use of a color filter between the eyepiece and your eye. A quality Barlow Lens is achromatic and multi-coated, and has all optical elements centered on, and perpendicular to, the optical axis. The lens must be mechanically well constructed. Most Barlows have a set amplification factor of -2X or -3X. There is available a research grade Barlow that is multi-coated and achromatic and offers a continuously variable amplification between -2X and -3X, with a calibrated scale. This one important optical tool can expand your effective set of oculars many times.

(to be continued)

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