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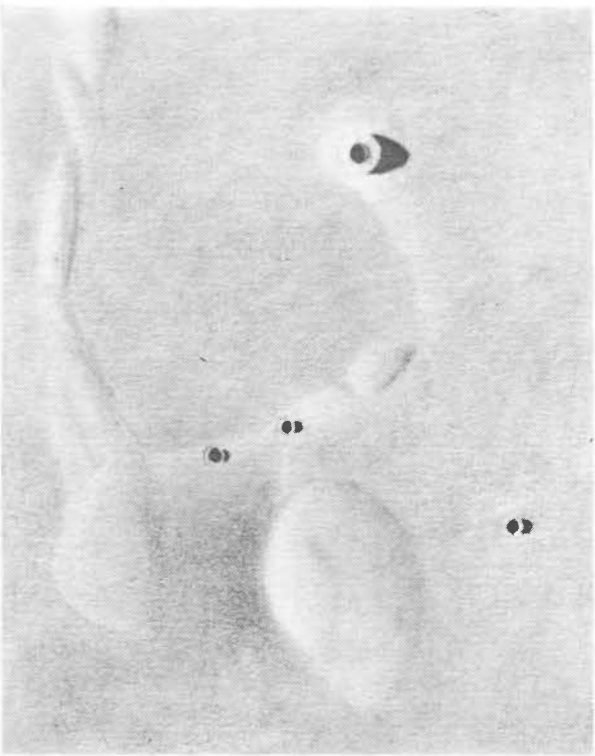

Drawing of Linné and vicinity on the moon by Alika K. Herring with a 12.5-inch reflector at 419X. April 27, 1966, 2 hrs., 40 mins., Universal Time. Seeing 7, transparency 6. Early morning lighting, colongitude 350.9 degrees. Large, low dome in lower part of drawing. There is some discussion of the topographical nature of the Linné region in an article on pages 99 - 101. South at top and west (I. A. U. sense) at right.

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IN THIS ISSUE

RECENT STUDIES OF THE ROTATION OF MERCURY

By: Richard G. Hodgson, A.L.P.O. Mercury Recorder

I. Introduction

In April, 1965, Gordon H. Pettengill and Rolf B. Dyce reported to the American Geophysical Union that radar studies undertaken at Arecibo Observatory in Puerto Rico revealed the rotation of the planet Mercury to be 59±5 days. This was a startling discovery indeed, overturning the widely-accepted view asserted about eighty years ago by G. V. Schiaparelli that Mercury keeps the same face toward the Sun, rotating in 87.969 days, the same period it requires to revolve around the Sun. The Arecibo Observatory discovery thus invalidates Schiaparelli's famous map of the planet,[1] and those subsequent maps which were based upon an assumed 87.969-day rotation. Among these are the maps of Antoniadi (based upon observations with the 83-cm. refractor at Meudon Observatory near Paris in the 1920's),[2] and that of Gary Wegner (founded upon observations by members of the A.L.P.O.).[3]

To many observers the invalidation of these maps and the work that they represent is disheartening. The Arecibo Observatory radar studies, however, should greatly aid interpretation of visual observations of Mercury's surface. One must remember that many of the older drawings were far from consistent. By way of partial explanation the older observers often supposed that clouds of some kind had obscured the surface features when they were not in their anticipated places,[4] an assumption that Mercury's extremely tenuous atmosphere makes very unlikely.[5] These conditions may now perhaps be better explained with reference to the newly discovered rotation period. Without doubt a new day has dawned in Mercury studies which should permit a major advance in visual observations of the planet's surface, and in time lead to the first accurate map of Mercury. In this work members of the A.L.P.O. who have access to telescopes of moderate aperture can play an important part.

II. Recent Discussion of Mercury's Rotation

Since April, 1965, when the Arecibo Observatory discovery was made, there has been considerable discussion of the rotation of Mercury in several learned scientific journals, much of which may not have come to the attention of the members of the A.L.P.O. For this reason it would be well to review these discussions and to consider their implications for the future study of Mercury.

1. G. H. Pettengill and R. B. Dyce

In a letter published in Nature, June 19, 1965, G. H. Pettengill and R. B. Dyce report their discovery of the 59±5-day rotation period, based on radar observations conducted on April 6, 10, 12, and 25, 1965. They also indicate: "The direction of the pole is not well-determined from these limited data, but is approximately normal to the planetary orbit."[6] Thus the polar axis of Mercury is considered approximately perpendicular to the orbital plane with some uncertainty. Perhaps visual observations over a period of time may help to clear up this matter; until Mercury's axial inclination is determined, adequate maps cannot be prepared.

Pettengill and Dyce further comment:

> The finding of a value for the rotational period of Mercury which differs from the orbital period is unexpected and has interesting theoretical implications. It indicates either that the planet has not been in its present orbit for the full period of geological time or that the tidal forces acting to slow the initial rotation have not been correctly treated previously...[7]

While it is possible that Mercury may not have occupied approximately its present orbit for the full period of geological time, a new analysis of solar tidal friction upon Mercury has been recently undertaken by several writers which may provide an adequate explanation.

2. S. J. Peale and T. Gold

In the same issue of Nature[8] S. J. Peale and T. Gold discuss the effect of solar tidal friction upon Mercury. Since the retarding torque exerted by the Sun upon a planet is inversely proportional to the sixth power of its distance from the Sun, the Sun has three hundred times more effect upon Mercury than upon the Earth. Were Mercury's orbit circular or nearly circular, solar tidal friction would have slowed the planet's rotation to equal its revolution period in far less time than the present estimated age of the Solar System. This synchronous or "captured" rotation has been generally noted among the satellites of the Solar System, the Moon and Saturn's satellite Iapetus being the most obvious examples.

The planet Mercury, however, has an orbit of considerable eccentricity (0.205624 at present). Solar tidal friction, being inversely proportional to the sixth power of the planet's distance, is vastly greater at perihelion (28,569,000 miles) than at aphelion (43,347,000 miles). Because of this fact, heretofore generally overlooked with respect to Mercury, a rotation period lying between 56 and 87.969 days should be expected, according to S. J. Peale and T. Gold. They assume that Mercury does not have any permanent deformation from axial symmetry. If Mercury were permanently asymmetrical, they assert that a synchronous or "captured" rotation would result. Since an approximately 59-day rotation has been discovered, this would suggest that Mercury is spherical and without any permanent deformation in their view.

3. G. Colombo

In a letter also published in Nature, November 6, 1965, G. Colombo takes issue with the conclusion of S. J. Peale and T. Gold that permanent deformations on Mercury would necessarily lead to synchronous rotation. Colombo declares: "A very nearly uniform rotational motion of 58.65 sidereal-day period, that is 2/3 of the orbital period, may indeed be a stable periodic solution."[9] He further indicates "...that a 58.65-day rotation period, precisely because it is 2/3 of the orbital period, fits some of the old optical observations as well as the recent radar measurements."[10]

4. W. E. McGovern, S. H. Gross, and S. I. Rasool

While S. J. Peale, T. Gold, and G. Colombo, among others, were investigating the effects of solar tidal friction upon Mercury's rotation, some of the older visual observations of the planet were re-examined by W. E. McGovern, S. H. Gross, and S. I. Rasool.[11] While many of these older visual observations were of doubtful value, six pairs of drawings showing near duplication of markings and phase were found to fit the newly discovered rotation period reasonably well. These included drawings by Antoniadi, Baum, Dollfus, and Lyot. From these they derived a rotation period of 58.4±0.4 days. One must recognize that six pairs of drawings is hardly enough to be conclusive evidence, but it is encouraging to know that some of the older visual observations are still of value. It is to be hoped that in time the older drawings done by leading amateur astronomers will also be re-examined in the light of the newly discovered rotation period.[12]

5. G. Colombo and I. I. Shapiro

The rotation of Mercury was the subject of a lengthy article by Giuseppe Colombo and Irwin I. Shapiro which appeared in The Astrophysical Journal in July, 1966.[13] This article undertakes a careful analysis of both the visual observations and the solar forces working upon Mercury. Because of the psychological influence of Schiaparelli's map, and the supposed **synchronous or a** "captured" rotation, the visual observations were found in most cases to be unreliable, but "...not significantly inconsistent with Mercury's rotation period being 58.65 days."[14]

The major portion of the article of G. Colombo and I. Shapiro is concerned with a mathematical analysis demonstrating the stability of a rotation period of two-thirds of the orbital period. This analysis need not be repeated here; it is very interesting and a plausible case. If such is Mercury's rotation, the comparison of visual observations would be made much easier. The importance of visual observations to resolve this matter should be apparent to all.[15]

References

1. Reproduced in Werner Sandner, The Planet Mercury, plate VII.

2. Reproduced in Ibid., plate III.

3. Cf. The Strolling Astronomer, Vol. 14, Nos. 11-12, (December 1960), pg. 191. Reproduced in Werner Sandner, op. cit., plate IV.

4. Cf. Werner Sandner, op. cit., pp. 40-46.

5. Regarding Mercury's atmosphere, cf. Nikolai A. Kozyrev, "The Atmosphere of Mercury," in Sky and Telescope, XXVII, No. 6 (June, 1964), pp. 339-341. See also Ibid., XXX, No. 6 (December, 1965), p. 360.

6. Nature, Vol. 206, p. 1240.

7. Ibid.

8. Ibid., Vol. 206, pp. 1240f.

9. Ibid., Vol. 208, p. 575. A similar conclusion was reached independently by Han-Shou Liu and John A. O'Keefe of Goddard Space Flight Center and was published in Science, December 24, 1965.

10. Ibid.

11. Reported in Nature, Vol. 208, (October 23, 1965), p. 375.

12. The Mercury Recorder plans to do this with drawings in the A.L.P.O. Mercury files when time permits.

13. The Astrophysical Journal, Vol. 145, pp. 296-307. The serious student of Mercury should give this article careful attention.

14. Ibid., Vol. 145, p. 298.

15. See "Mercury: Research Projects for the Small Observatory" by the writer in The Strolling Astronomer, Vol. 20, Nos. 1-2 (published January, 1967), pp. 7-8. This article outlines the present work of the A.L.P.O. Mercury Section.

A POSTSCRIPT ON SCHIAPARELLI'S INFLUENCE

By: Richard G. Hodgson, A.L.P.O. Mercury Recorder

In a recent letter to the Mercury Recorder, Walter H. Haas has taken issue with the notion that the psychological influence of Schiaparelli's map of Mercury was responsible for the general acceptance of an 88-day rotation period for the planet, a view set forth by G. Colombo and I. Shapiro in The Astrophysical Journal.[1] Haas declares:

> In recent months it has appeared to me that there is entirely too superficial a tendency to account for the long acceptance of the 88-day rotation of Mercury as a simple psychological... influence of Schiaparelli's map. It is true that Schiaparelli was the first to determine such a period. It is also true that Lowell, Antoniadi, W. H. Pickering, and others considered that they had independently determined the rotation period to be synchronous with the period of revolution. Of course they knew of Schiaparelli's work, but... these men...had...ability for original thinking. It is proper to point out that Pickering and Antoniadi, as well as H. McEwen, did not accept Schiaparelli's synchronous period of rotation for Venus, where a similar psychollogical influence might reasonably be supposed to exist.[2]

Haas' point is well taken. The view that Mercury rotated in 88 days was not accepted uncritically by astronomers in the early twentieth century. They were men of independent judgement, whose visual observations supported a very slow rotation period for the planet — a situation which is not radically altered by the newly discovered 59-day rotation period.

Among amateur astronomers, however, this independent and critical cast of mind has not always been present. Among amateurs the maps of Schiaparelli and Antoniadi have had more of a psychological influence, and appear in some cases to have hindered independent judgement. The astronomer should be a faithful witness to what he observes, not a slave to what he may have read.

Haas further comments:

> Perhaps it is also worth remarking in connection with the... [recent discussion] of the poor quality of Mercury drawings long considered to support an 88-day rotation that J. D. Cassini in the late seventeenth century evaluated the period of rotation of Mars to within a few minutes of the correct value. Yet his drawings of Mars are crude in quality, and one can scarcely recognize any of the features...[3]

Here is an argument for an open mind on the question of Mercury's rotation, and the need for visual observations. Many of our drawings of Mercury may seem crude in time to come, as Cassini's drawings of Mars seem to us; but our drawings, like his, may prove useful in deriving accurate information regarding rotation periods. Let us hope this shall indeed be the case!

References

1. Cf. Vol. 145, (July 1966), pp. 296ff.

2. Private letter to Richard G. Hodgson dated March 7, 1967.

3. Ibid.

VISUAL OBSERVATIONS OF AN OCCULTATION OF BD -19°5925 BY SATURN

By: Clark R. Chapman, Dale P. Cruikshank, and William K. Hartmann,
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I. Introduction

An occultation of BD -19°5925, $m_v = 8.0$, G0, occurred on July 23, 1962 (U.T.) and was observed by the authors. Chapman and Hartmann observed the disappearance of the star behind the planet with the 36-inch reflector of the Steward Observatory stopped down to 16 inches of aperture at a magnification of 400X. Cruikshank observed the disappearance behind the planet and part of the star's passage behind the rings with a 12-inch reflector at a magnification of 305X from a location 0.4 miles south of the Steward Observatory. Chapman observed the star's passage through Rings A and B with the 12½-inch reflector of the Steward Observatory (Long. 110°50'W, Lat. 32°15'N), using a magnification of 336X.

II. The Observations

The ingress of the star behind Ring A was predicted to occur at about 05:51, U.T. (B.A.A. Handbook, 1962). Hartmann (36-inch) timed this contact at 05:57.0 ± 0.3 (estimated probable error); Chapman (36-inch) obtained 05:57.8 ± 0.3. Although one telescope was used, these observations were kept independent by means of two recorders and a coded recording system. The ingress occurred very near the apparent junction of Ring A and the ball (Figure 1). Hartmann and Chapman agreed that the star disappeared behind the ring, but Cruikshank felt that the star made contact with the ball. His timing was 05:59 ± 0.5. Later comparisons indicated that the observers, in the same sequence that they timed the disappearance, felt that it occurred progressively closer to the ball, or, in Cruikshank's case, behind the ball. This is consistent with the interpretation that the observers lost the star in the order indicated, and that the resulting positions were simply a function of the path of the star with respect to Saturn. That Cruikshank should have been last to lose the star is supported by the fact that he considered the seeing conditions better at this time than did the observers at Steward Observatory.

Clouds prevented the recovery of Saturn with the 36-inch during the remainder of the occultation. Clouds hid the reappearance of the star from behind the ball to Chapman, then observing with the 12½-inch reflector. Cruikshank, observing during a one-minute break in the clouds, suspected the star on the limb of Saturn at 07:28, U.T.

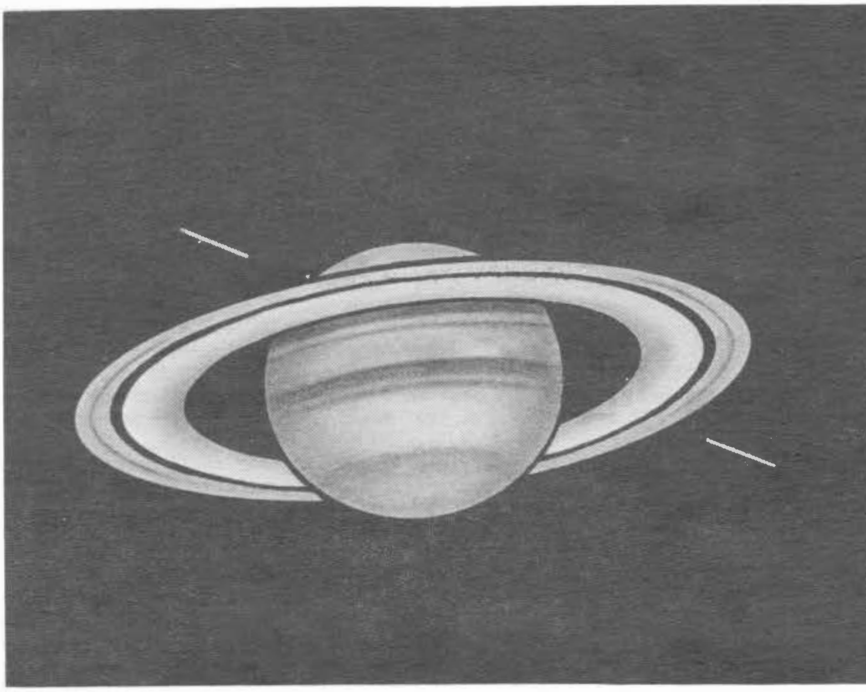

Figure 1. Drawing by Dale P. Cruikshank to show path of BD -19°5925 relative to Saturn when it was occulted on July 23, 1962. 12-inch reflector, 300X, seeing very good. The relative motion of the star was from upper left to lower right. See also text. Note the white cloud in the Equatorial Zone of Saturn.

In order to compare our observations of the brightness variations of the star as it passed behind the rings, we selected a numerical ease-of-visibility scale prior to the occultation: 10 (prominence of star away from rings), 7 (noticeably less prominent but easily seen), 3 (difficult but definitely seen), 0 (completely invisible). It should be noted that these are simply subjective estimates of prominence (not brightness) and that changes in the estimates are more meaningful than the assigned values themselves.

Passage behind the entire Crepe Ring could not be observed by Chapman because of clouds. Cruikshank found the star easily discernible (prominence 7) about one-third of the way into the Crepe Ring during a clearing at 07:43. As the star approached Ring B a minor decrease in prominence at 07:47 (6) was followed at 07:47 1/2 by an abrupt brightening (prominence 8), which persisted for about one-half minute. By the time the star was clearly entering Ring B it decreased considerably in prominence, but before it was well into that ring clouds obscured the planet. From this point on the skies remained overcast for Cruikshank.

The clouds cleared for Chapman at about 07:55, U.T.; and he was able to observe continuously with good seeing and transparency until after the star had emerged from the rings. At the beginning of this clearing, the star was strongly suspected behind Ring B as a slightly brighter patch (prominence 1 to 1 1/2), but no evidence for brightness variations was obtained. As the star passed behind Cassini's Division it was definitely seen (3 to 4). It was considered to be at the inner edge of the division at 08:07.7 and was observed on the inner edge of Ring A at 08:10.3.

The passage of the star behind Ring A, as observed by Chapman, was characterized by three phases. While passing behind the inner two-tenths of the ring the star was only strongly suspected (prominence 1). During the next four-tenths of its passage the star was considerably more prominent (3) and could be seen continually. As it passed behind the outer four-tenths of the ring, the star was again very difficult to see (1 to 2). At 08:17.6 it was suspected that the prominence had considerably increased (6), and by

08:18.0 the star was clearly at last contact. The above observations were essentially continuous; the changes themselves were observed. During the passage a number of minor variations were superimposed on the major changes. During this period seeing conditions steadily improved; judging from the appearance of Cassini's Division the major fluctuations could not have been caused by changes in seeing. Furthermore, the transparency of the sky was constant. Chapman made the interesting observation that the star appeared rather blue in hue while passing behind Ring A. Indeed, it was felt that the easy visibility of the star behind the ring was due in large part to the contrast of color. Because of the star's G spectral type, this aspect cannot be attributed to the star's being intrinsically bluer than the sunlight illuminating Saturn. None of the observers observed the star well enough behind any of the other rings to comment on its color. Effects involving color have been reported during previous occultations.

III. Apparent Magnitude Estimates

In order to investigate the existence of a hypothetical dusky ring exterior to Ring A, estimates of the magnitude of the star were made before and after the occultation by Hartmann and Chapman. It was found that the brightness of the star fell within the range of Titan, Rhea, and Dione ($m_v = 8.39, 9.73$, and 10.44 respectively, based on Harris, 1961); therefore, estimates of the apparent brightness of the star could be made consistently to two-tenths of a magnitude. The two sets of independent observations indicated that the star dimmed as it approached the rings. It was found, however, that the observed magnitude of the star was one and a half magnitudes fainter than that given above, which suggested that the star's appearance was affected by the proximity of the bright image of Saturn. Two days later, after the star had moved well away from Saturn, Hartmann again made magnitude estimates of the star by the same technique. The star then appeared somewhat brighter (with Saturn in the field). When Saturn was moved out of the field, leaving only some comparison satellites and the star, the magnitude estimates were compatible with the listed magnitude. These observations show that the apparent brightness of the star was decreased by a contrast effect as it approached Saturn. The uncertainties introduced by this effect make conclusions about an outer ring unreliable; visual magnitude estimates of such phenomena must be viewed with caution.

Acknowledgements — We wish to thank the late Dr. E. F. Carpenter for making available to us the Steward Observatory facilities. We also wish to thank Messrs. Floyd Herbert and Charles Wood, who acted as our recorders during the occultation.

References

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Goodman, Joel W., Robinson, L. J., and Haas, Walter H., "An Occultation of BD -19° 5925 by Saturn and Its Rings on July 23, 1962: Observations Requested", Str. A., Vol. 16, pp. 131-134, 1962.

Goodman, Joel W., "A Preliminary Report on the Occultation of BD -19° 5925 by Saturn on July 23, 1962", Str. A., Vol. 16, pp. 243-245, 1962.

THE OBSERVATION OF LUNAR DOMES

By: Kenneth J. Delano, A.L.P.O. Lunar Recorder

Lunar domes are perhaps the most elusive features on the moon, for two reasons. First, by blending in with their surroundings they become undetectable when the sun is more than three to seven degrees high at their locations. Secondly, when the domes are close enough to the terminator to present their best appearance, even the easiest ones to see can be overlooked since by their very nature lunar domes are not sharply defined. They are low, rounded objects with gradual slopes capable of displaying neither brilliant, eye-catching sunward slopes nor dark, sharply defined shadows. However, there are a few exceptions, such as some of those pictured on page 196 of the Nov.-Dec., 1965 (Vol. 19, #11-12) issue of The Strolling Astronomer. In that photograph the domes north of Hortensius and another dome west (IAU) of Milichius have slopes of above average steepness, and as a result these domes stand out quite prominently.

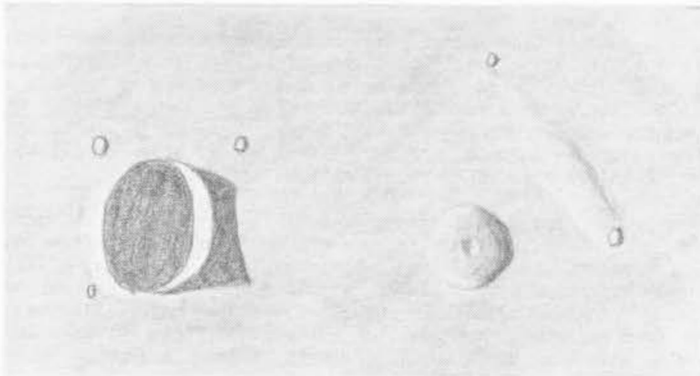

Figure 2. Drawing of Milichius and lunar dome (-510 +175) to its west by Donald Watts. November 23, 1966. 4^h0^m, U.T. 6-inch reflector, 160X. Seeing 5, transparency 5. Colongitude = 34°6. See also text of Mr. Delano's article in this issue.

Figure 3. Drawing of heart-shaped dome northwest of Linné (dome +153 +510) by Charles L. Ricker. July 6, 1965. 2^h30^m, U.T. 10-inch reflector, 194X. Seeing 4, transparency 6. Colongitude = 356°4. In Figures 2-5 lunar south is at the top, and lunar west (I.A.U. sense) is at the right.

Figure 4. Drawing of three lunar domes near Prinz by Donald Watts. September 26, 1966. 5^h45^m, U.T. 6-inch reflector, 170X. Seeing 2-5, transparency 5, Colongitude = 49°0.

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On page 197 of that Nov.-Dec. issue of The Strolling Astronomer, José Olivarez provides a sketch showing the locations of all the lunar domes detectable in the photograph on the facing page. Anyone wishing to begin observing lunar domes would do well to acquaint himself with their visual appearance by taking that photograph and chart to the telescope with him some night when the terminator is near Hortensius and using them as a guide to the locations of the various lunar domes, especially the less apparent ones.

The interested observer might then go on to locating selected domes elsewhere, as listed in "The Lunar, Planetary, and Cometary Prospects" column in each issue of The Strolling Astronomer. Drawings and notes concerning the size and appearance of domes should be sent to the Recorder for the Lunar Dome Survey.

Correspondents will receive a complete listing of known domes and suspected domes and suspected domes for them to try verifying. The listings identify the domes by their lunar rectangular grid co-ordinates. Wilkins' map of the moon makes use of the xi and eta grid, but even better are two University of Arizona publications: The Orthographic Atlas of the Moon, and the very good and inexpensive Lunar Quadrant Charts. Where domes are located very close together or where they are hard to distinguish from nearby hills or rills, a good lunar atlas is essential in order to cite their positions accurately.

The drawings on the **adjacent** pages call attention to a few of the more evident lunar domes, and they also point out how the domes vary in the appearance of surface features upon them. Figure 2 is Donald Watts' drawing of the conspicuous dome west of Milichius (-510 +175). Even a 6" telescope is capable of revealing this dome's central craterlet. There are a number of other domes looking much like the dome near Milichius, such as, for example, some near Hortensius and another just west of Kies; but most lunar domes do not have a craterlet at their summit large enough to be detectable with 6 inches.

There are other types of domes which look quite different from the nicely rounded, central-pitted dome west of Milichius. Figure 3 presents Charles Ricker's drawing of a heart-shaped dome (+153 +510) located NW of Linné. In contrast to the dome west of Milichius, this dome in Mare Serenitatis is quite flat and is considerably larger, measuring 22 kms. in diameter as opposed to 7 kms. for the Milichius dome. In addition, Ricker's drawing shows that this dome has elevations instead of craterlets on its surface.

Most lunar domes, if they have any detectable surface features at all on them, generally have craterlets or a craterlet (not necessarily centrally located). Figure 4 is Donald Watts' drawing of three rather large domes north of Prinz. Dome "A" (-611 +451) is shown with two craterlets on its southern slope and two more at its eastern base. Near its northern base is a small peak. Dome "B" (-620 +452) is depicted with two peaks near its northern base, while Dome "C" (-622 +446) is shown with three craterlets on its NE margin and another craterlet on its southern edge. These three domes north of Prinz are observed to have an unusually dark and rough appearance, which might suggest slopes strewn with immense boulders.

Figure 5 shows three domes in the neighborhood of Gambart B as drawn by Kenneth Delano, none of which has any distinct surface features. However, Alika Herring has reported seeing a bubble-like elevation on the SW slope of the dome nearest Gambart C (-212 +049). The domes -218 +047 and -212 +049 are in the B.A.A. - A.L.P.O. Joint Catalogue. The third dome, -193 +005, lies about two degrees south of Gambart B, has moderate slopes, is somewhat elongated in a north-south direction, and lies at the southern end of a straight mountainous mass which intrudes one-third of the way up the dome's northern slope (Figure 5). The major and minor axes of this elliptical dome are 16 kms. and 12 kms., respectively. No surface detail could be seen on the dome. See caption of Figure 5 for the observing conditions.

Plate LIX of Zdenek Kopal's Photographic Atlas of the Moon, taken at colongitude 17°.7, shows this dome almost exactly as I saw it. The dome also appears on Plate CXXXVI of Kopal's Atlas, where it is pictured under sunset illumination.

A NEW CONTOUR MAP OF THE MOON

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

Introduction

Two recent publications of the Aeronautical Chart and Information Center of the United States Air Force should be of value to mappers of the moon and to persons interested in the moon's figure (i.e., exact shape): Coördinates of Lunar Features. Group I and II Solutions, by Donald L. Meyer and Byron W. Ruffin[8], and Lunar Plate Measurements and Selenodetic Coördinates of Supplementary Control Features.[1] Although these two papers present only the interim results of a project still in progress, the writer feels that their results should be brought to the attention of lunar students. These works are of special value because they catalogue lunar positions in three dimensions--radius vectors as well as latitudes and longitudes. A new lunar contour map, constructed by the writer from the USAF-ACIC measures, accompanies this paper.

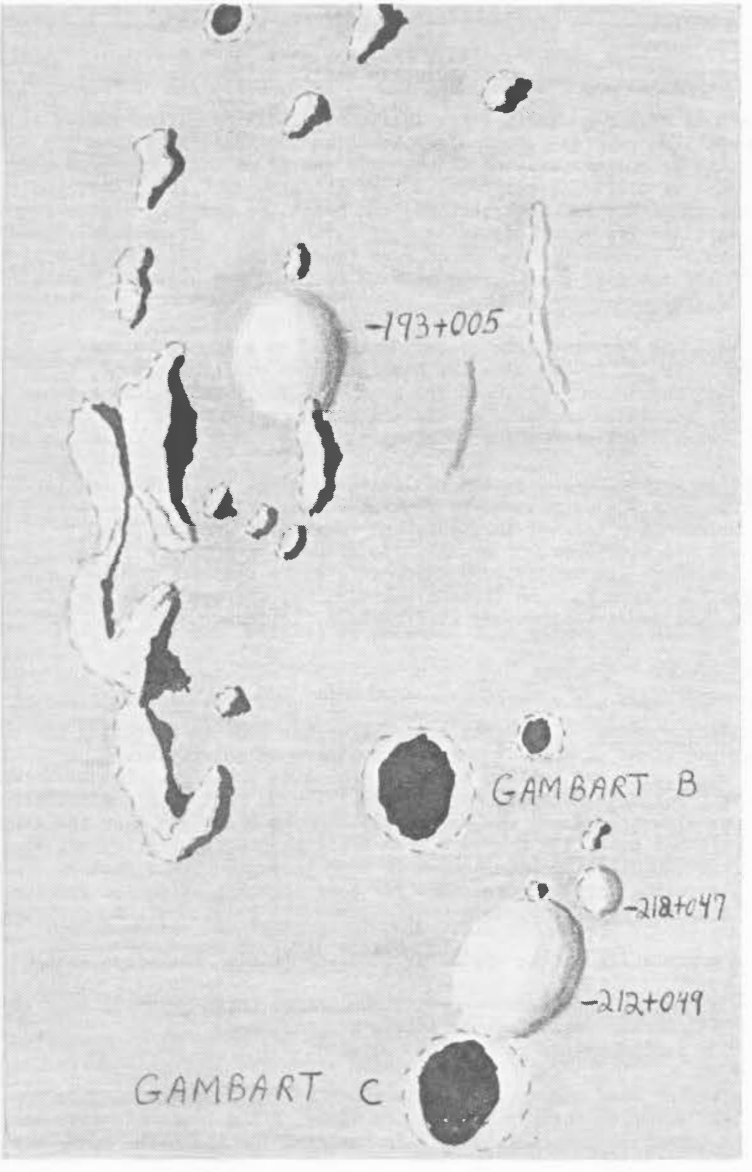

Figure 5. Drawing of lunar domes near Gambart by Kenneth J. Delano. October 23, 1966. 2^{h}0^m, U.T. 12.5-inch reflector, 300X. Seeing fair. Colongitude = 16°3. See also text of Reverend Delano's article.

Coördinates of Lunar Features

Photography.—Measurements on lunar photographs are usually adversely affected by "seeing"; atmospheric turbulence shifts the apparent positions of lunar features. This effect can be minimized by either: (1) long exposures that "average out" the random, transitory shifts, or, (2) averaging measurements from several, short-exposure photographs. The ACIC study employed both methods. One of the photographs used (N-8) was of 36 seconds exposure with the U.S. Navy Astrometric Reflector at Flagstaff, Arizona. The other seven "photographs" are actually arithmetic means of seven sets of five rapid-sequence photographs each, each set taken during a two-minute period, and each individual photograph of 0.1 to 0.2 seconds exposure. These sequential photographs all were taken at the Pic du Midi Observatory in southern France.

The Measurements.—A total of 196 reference points were measured on each photograph, using a linear comparator with a readout in microns. In order to avoid apparent changes in position due to shifting shadows, the photographs were taken near full phase; and the features selected were all bright spots--usually small, bright craterlets.

Plate measures were reduced to lunar latitudes, longitudes, and radius vectors by the use of "perspective rays"---- such a ray being an imaginary line from the observer through the feature to a plane passing through the center of the moon. The same features will be intersected by different perspective rays at different librations; and the three-dimensional position of the ray intersection, and hence the feature, can be computed. The published positions are based on two sets of intersecting perspective rays--"Group I and II." Ultimately, another two groups of rays (and, hence, photographs) will be used, allowing average positions of greater accuracy to be found and giving a considerably better idea of the degree of error involved.

Results.--All 196 measured points are identified on a lunar photomap in Coördinates of Lunar Features. The following data are tabulated for each: latitude, longitude, and radius vector. Latitudes and longitudes are given to 0°001, and radius vectors to 0.01 kms. (10 meters). Tentative probable errors are given for each value, and average about ±0°01 (circa 0.3 kms.) in latitude and longitude and about 0.6 kms. in radius vector.

Supplementary Control.--The second publication[1] gives latitudes, longitudes, and radius vectors for some 776 supplementary control points, making a total of 972 measured points. The supplementary points' latitudes and longitudes are tabulated to 0°0001; and the radius vectors, to 0.001 kms. (1 meter). No probable errors are listed for the secondary points, but these are undoubtedly somewhat greater than for the 196 primary points. Supplementary measures were made on fifteen photographs, thirteen from the Pic du Midi, and two from the U.S. Naval Observatory at Flagstaff, Arizona.

The Contour Map

Method of Construction.--The first step the writer took in preparing the contour map was plotting positions of all 972 measured features on an overlay. The tabulated radius vector for each point was written beside the plotted position. The distribution of points was uneven. Points clustered, for example, between Maria Tranquillitatis and Fecunditatis, in the Flamsteed area, the Maurolycus-Janssen area, and near the center of the disc. Coverage was much less complete near the limb and, in particular, West of 40° West Longitude (the IAU direction convention is used throughout this paper). This is partly because the points were selected more for easy identification and mapping control than for determining the lunar figure.

In drawing contour lines, the writer divided the points into three catagories:

1. 31 Schrutka-Rechtenstamm reference points (high weight),
2. 165 primary points (intermediate weight), and,
3. 776 supplementary points (low weight).

In addition, the writer used only those points which he felt represented the undisturbed lunar surface. For example, three points on the floor of the crater Clavius were ignored because they were depressed beneath the outside surface. On the other hand, some rejected points were craterlets on the summits of crater walls, and thus were anomalously high. Points in extensive mountain systems (such as the Apennines) were included since such primary features were taken to represent the true lunar surface.

A one kilometer (1,000 meter) contour interval was used, the contour values being expressed as elevations above a 1730-kilometer radius datum. For example, "8" represents a radius vector of 1738.0 kilometers. Contour lines were drawn upon a USAF-ACIC orthographic photomosaic of the visible hemisphere at an original scale of 1:10,000,000.

Description.--The most striking feature on the contour map is the elevated region running South-Southeast from Sinus Medii, corresponding roughly with the "Central Crater Province" as defined by Mason and Hackman.[7] Assuming an average lunar radius of 1738 kms., most of this area is elevated from two to three kilometers above normal. This large-scale elevated region is the best evidence on this contour map for a fossilized earthward "bulge."

The other relatively elevated areas are lower, much smaller, and are isolated from each other. A small area lies Southwest of Copernicus, and a larger and more elevated one is in the Apennines-Haemus area. A large, U-shaped elevation is found between Maria Crisium and Serenitatis, and a smaller one is South of Mare Tranquillitatis (in the "Pyrenees Province" as delimited by Mason and Hackman[7]). Another elevated area is in the Caucasus Mountains, and several small areas are found South of Maria Nubium and Humorum.

Most Maria tend to lie below the 1738 km. mean radius, and most non-Maria areas lie above it—justifying the term "highlands." However, relatively "deep" Maria basins are fairly rare. Mare Crisium is depressed from three to over four kms. below the mean surface, while portions of Maria Fecunditatis, Nectaris, Frigoris, a small part of northern Mare Imbrium, and Eastern Oceanus Procellarum are all considerably depressed (i.e., under 1736 kms.). Much of Mare Imbrium lies near the mean lunar datum, as does almost all of Mare Nubium. Maria Humorum and Serenitatis are both basins, but only of the order of one km. deep.

Otherwise, most of the Maria areas are neither particularly deep nor true basins. Mare Imbrium appears to slope northwards, and Oceanus Procellarum to the West. Almost the entire area that includes Southeastern and Southwestern Mare Imbrium, eastern Oceanus Procellarum, and the area North of Mare Nubium is actually above the mean lunar radius, reaching its highest point immediately Southwest of Copernicus.

Comparison With Other Contour Maps.—A number of lunar contour maps have been published prior to this study. They may be grouped in three categories. The first are maps based on "geometrical" measures, as is the map in this paper (i.e., radius vectors based on changes in apparent lunar positions caused by libration).[2,3,4,8,10,11] A less popular method involves observing deformations of the terminator.[9,12] Finally, a preliminary map of the selenoid has been compiled from observations of changes in the orbits of the lunar Orbiters—this is the only method, at present, that allows the averted hemisphere to be so mapped.[6]

No two lunar contour maps, even when belonging to the same category, agree well with each other. The writer feels that the following three conclusions are the only ones that can be supported by taking into account all the studies to date:

i. The area of the "Central Crater Province" is the most highly elevated extensive area on the visible disc.
ii. Maria (lunabase) areas tend to lie beneath the mean radius.
iii. Highland (lunarite) areas tend to lie above the mean radius.

Also, it is this writer's opinion that, with present data, the use of an imaginary 1738-km. radius sphere for lunar mapping is still justified, rather than a more sophisticated selenoid (such as a triaxial ellipsoid).

A detailed analysis of the differences between the various lunar contour maps would be too lengthy for a short paper. For a more general comparison, a number of selected areas have been compared on the different maps, and a simplified statistical analysis made to estimate the degree of agreement between any two contour maps. The seventeen areas chosen for comparison were:

> the central crater province, the Apennines, Copernicus, Aristarchus, North Mare Imbrium, Bullialdus, Mare Humorum, Mare Crisium, Central Mare Serenitatis, the Caucasus, Mare Nectaris, Sinus Roris, Fra Mauro, Northern Mare Fecunditatis, South-Central Mare Tranquillitatis, Delisle, and Seleucus.

If a particular area was shown elevated above its immediate surroundings on a particular map, it was rated "+"; if depressed, "-"; if roughly the same level, "0".

Two maps were said to agree if one of the three combinations, "++", "--", or "00", was found. If so, the agreement between the maps was +1.0. On the other hand, an agreement of -1.0 resulted from the combinations, "+-" or "-+". Finally, an agreement of 0.0 was assigned for the combinations "+0", "-0", "0+", or "0-". For every possible pair of maps, values of agreement were found for each of the seventeen selected areas; and an "average agreement" was derived. This method is not precise, of course, involving some subjective judgement; but a rough index of agreement or disagreement can be found. These indices are given in Table 1.

Table 1

"Average Agreement" Between Pairs of Lunar Contour Maps.

Key to Sources: (A - G are based on geometric measures, H and I on terminator observations, and J on Lunar Orbiter observations.)

Letter	Source and Date	Ref. No. (See end of paper)
A.	Westfall (1967)	(present paper)
B.	Goudas-ACIC (1965)	6
C.	ACIC (1965)	4
D.	AMS (1964)	11
E.	Baldwin (1963)	2
F.	Schrutka-Rechtenstamm-Hopmann (1958)	10
G.	Franz (1899)	3
H.	Westfall (1966)	12
I.	Ritter (1934)	9
J.	Lunar Orbiter (1966)	6

	A	B	C	D	E	F	G	H	I	J
A.	+1.0	----	----	----	----	----	----	----	----	----
B.	+0.3	+1.0	----	----	----	----	----	----	----	----
C.	+0.2	+0.9	+1.0	----	----	----	----	----	----	----
D.	+0.8	+0.5	+0.5	+1.0	----	----	----	----	----	----
E.	+0.6	+0.4	+0.3	+0.6	+1.0	----	----	----	----	----
F.	+0.4	+0.6	+0.5	+0.5	+0.5	+1.0	----	----	----	----
G.	+0.3	+0.6	+0.5	+0.5	+0.4	+0.8	+1.0	----	----	----
H.	+0.1	0.0	+0.2	+0.3	+0.3	+0.2	0.0	+1.0	----	----
I.	-0.1	+0.4	+0.5	+0.1	0.0	+0.3	+0.4	-0.1	+1.0	----
J.	+0.2	+0.8	+0.6	+0.2	+0.3	+0.4	+0.4	+0.1	+0.2	+1.0

The only values of complete agreement (i.e., +1.0) result when a map is compared with itself. A value less than +1.0 indicates less than perfect agreement. A value of 0.0 (appearing three times in the table) means no agreement, while a negative value (appearing twice) indicates actual contradiction between two maps. Somewhat more insight will be gained if the results of different categories of maps are compared, as in Table 2.

Table 2

"Average Agreement" Between Different Categories of Maps.

Note: This excludes agreement between a map and itself (e.g., A vs. A, etc.).

	Geometric Method	Terminator Method	Orbiter-Gravity Method
Geometric Method	+0.5	----	----
Terminator Method	+0.2	-0.1	----
Orbiter-Gravity Method	+0.4	+0.15	(only one map)

Table 2 indicates that contour maps derived from geometric measurements are the most self-consistent and also agree fairly well with the one map based on Lunar Orbiter gravity data. On the other hand, contours derived from terminator observations appear to have little worth. This last method has not yet been fully tested (Ritter's method of reduction had serious faults[5], and the writer's observations[12] were qualitative ones); but this writer feels that terminator-deformation observations are best suited to detecting small, local elevations or depressions rather than to determining the general lunar figure.

Another rough indicator of the agreements and disagreements among the various contour maps is the value of the maximum elevation difference of a particular map (i.e., highest elevation minus lowest elevation). Table 3 lists this parameter for the maps

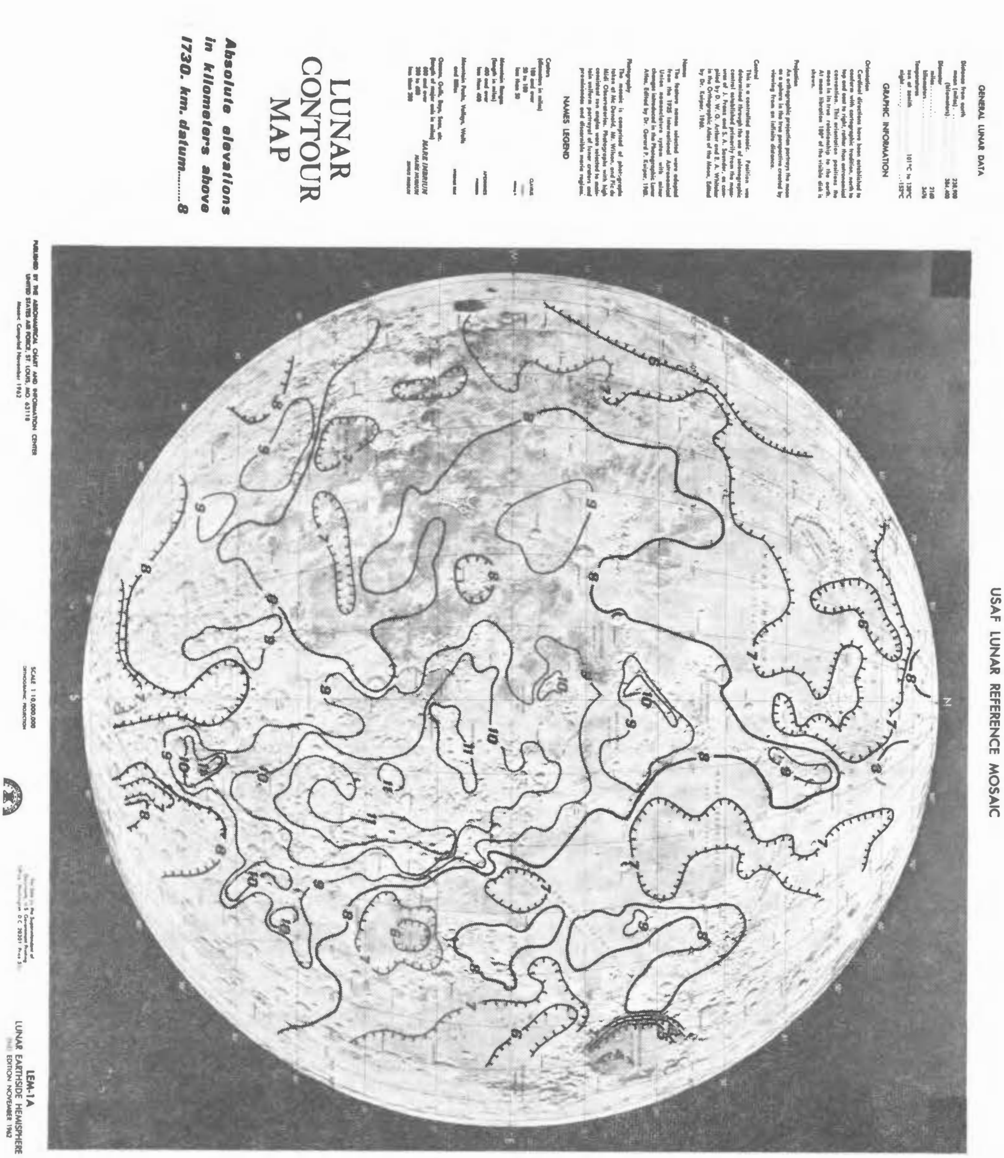

Figure 6. Contour map of the visible hemisphere of the moon, compiled by John E. Westfall on the basis of 972 lunar positions measured by the U. S. Air Force, Aeronautical Chart and Information Center. The contour interval is one kilometer (1,000 meters). Contours are plotted on a USAF-ACIC photomosaic. See also text of article "A New Contour Map of the Moon."

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listed in Table 1 (with the exception of the writer's previous map[12], which was non-quantitative).

Table 3

Maximum Elevation Differences (Approx.)

Source	Max. Elev. Diff. (kms.)
Westfall (1967)	8.
Goudas-ACIC (1965)	circa 6.
ACIC (1965)	3.3
AMS (1964)	10.
Baldwin (1963)	11.
Schrutka-Rechenstamm-Hopmann (1958)	6.
Franz (1899)	6. +
Ritter (1934)	3.0
Lunar Orbiter (1966)	1.9

With the exception of the three low values (3.3, 3.0, and 1.9 kms.), all maximum differences fall in the range 6 - 11 kms., a reasonable degree of uncertainty considering the relative scarcity of observed points for most maps (55 for Franz, 150 for Schrutka-Rechtenstamm-Hopmann, 196 for Goudas-ACIC). With so few points, exceptionally high or low areas easily may be missed. The ACIC (1965) result represents a mathematical model of the selenoid using harmonic analysis—a method that tends to "smooth out" exceptionally high or low points. Likewise, the Orbiter gravity study tends to be sensitive only to large-scale deformations of the selenoid, rather than to small high or low areas. The Ritter study, on the basis of all three tables, stands by itself. Table 3 emphasizes the discordant results obtained when one attempts to make quantitative use of terminator-deformation observations.

Finally, it should be said that the agreement between certain pairs of charts is not mere chance since they may be derived from the same data. For example, Goudas-ACIC (1965) and ACIC (1965) are based on the same 196 measured points, and their "average agreement" (Table 1) is hence +0.9. Likewise, Westfall (1967) is based in part on the same points (but includes 776 more points). The Schrutka-Rechtenstamm-Hopmann map (1958) is a recomputation based on Franz' studies, thus an agreement of +0.8.

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AN ARTIFICIAL-STAR PHOTOMETER FOR MONITORING BRIGHTNESS VARIATIONS ON THE EARTHLIT MOON

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

(Paper read at the Fourteenth A.L.P.O. Convention at Tucson, Arizona, August 26-28, 1966.)

Although all beginning lunar observers soon become familiar with the "ashen light" appearance of the crescent moon—a pale glow caused by sunlight reflected from the earth—only a few go on to study the lunar surface under earthlight conditions. The first observation we have of an unusual earthlit phenomenon dates from 1587*:

> " a sterre is sene in the bodie of the mone vpon the (blank) of Marche, whereat many men merureiled, & not without cause, for it strode directly between the pointes of her hornes, the mone being chaunged, not passing 5 or 6 daies beford."

During succeeding centuries, reports of such occurrences continued to trickle in, often from famous and presumably reliable observers such as William Herschel, Schröter, Elger, Barcroft, and Wilkins. Approximately 60 per cent of these phenomena were reported to occur near the crater Aristarchus, itself usually the most prominent object on the earthlit moon.

Despite the consistency and increasing frequency of such reports of localized earthlight brightenings, the world of professional astronomy largely ignored them, perhaps because they had not been made by professionals. Since, until recent years, professional astronomers rarely looked at the moon, it was not surprising that they observed nothing unusual. Finally, during a brief and exciting few years' period, the concept of "lunar transient phenomena" became respectable. In 1956, Alter photographed the crater Alphonsus in ultra-violet and infra-red light, which revealed differences he attributed to a local lunar atmosphere. Two years later, Kosyrev obtained a spectrogram of a reddish glow associated with the central peak of the same crater. Lastly, on October 30, 1963, Greenacre and Barr, at Lowell Observatory, made their famous observation of reddish glows in the Aristarchus area.

Thus, the last decade has seen a complete revision of our opinions about lunar surface changes, and more attention is now being given to the moon than ever before. One group that has concentrated on observing the earthlit portion of the moon is the ARGUS

*Miss Barbara M. Middlehurst has discovered a similar observation made as long ago as November, 1540.

Lunar Surveillance Program. This group has pioneered in obtaining reliable, confirmed, observations of the earthlight glows—again, chiefly in the Aristarchus area. Their first positive observation was only a little more than a year ago—on July 2, 1965. In addition, photographs of brightenings associated with the crater Aristarchus were secured by Jack Eastman on October 29, and by Larry Bornhurst on November 26, 1965. In the last year, earthlight phenomena, like other lunar transient phenomena, have become respectable.

It is natural, then, that amateurs have begun to pay more attention to this twilit land "beyond the terminator;" but observing earthlit objects poses special problems. First, earthlight is faint; typically being 1/20,000 or so as bright as sunlight—a difference of 11 magnitudes! This causes a twofold problem—intrinsic faintness as well as contrast glare from the sunlit crescent. Good to excellent atmospheric transparency is required, together with high quality, clean optics. The atmospheric transparency problem is, of course, made even worse by the necessity of sandwiching crescent moon observations between twilight and moonrise or moonset. Second, earthlight is variable from hour to hour and from night to night. Variations in the distance of the moon from the earth can change the apparent earthlit brightness of a particular object by as much as 45 per cent! Even greater relative changes are caused by the less predictable factor of variations in the reflecting power of the earth—for a particular observing site, this will be largely a function of cloud cover on the sunlit hemisphere of the earth. Finally, and largest, there is the effect of the earth's phase. Since the earth's phase (as seen from the moon) is the complement of the moon's phase (as seen from the earth), it is obvious why earthlight fades as the sunlit portion of the disc increases. Useful earthlight observations must be made within a few days of New Moon, and earthlight is hardly visible at all between First and Last Quarters.

Due to the several factors mentioned above, the joint effect of which is not precisely calculable, it is clear that amateur lunar observers have a much better chance of observing short-term brightness fluctuations rather than long-term variations. The problem is to separate variations in incident earthlight from actual lunar surface phenomena. Even short-term observations are made uncertain, however, by psychological and physiological phenomena that vary the sensitivity of the observer's eye. The most dangerous such phenomenon results in illusory flashes that the tyro may report as real.

With the above difficulties in mind, the writer recently has attempted to construct a crude artificial-star photometer intended to be used to monitor the earthlit brightness of Aristarchus. This is done by projecting an artificial stellar image into the field of view (most conveniently, just off the limb adjacent to Aristarchus), and then adjusting its brightness until it appears as bright as the crater. One then observes whether or not Aristarchus changes in brightness relative to the artificial star.

Figure 7 is a diagram of the writer's photometer. The principle is simple—an artificial stellar image is created by a grain of wheat bulb, shining on a diffusing screen and illuminating a pinhole in a sheet of metal foil. The image of this pinhole is directed into the field of view by a collimating lens and a prism beam-splitter. Two flashlight batteries power the bulb, while a rheostat controls the amount of current, and, hence, brightness. (The brightness of the artificial image can be varied also by moving the bulb towards or away from the diffusing screen, or by diaphragming the collimating lens.) Finally, a Wratten 80B filter is used to convert the yellowish artificial light to a color balance approximating that of sunlight.

One "frill" the writer added was a graduated scale on the rheostat knob. This allows him to calibrate the photometer with stars of known magnitude and thus to estimate the stellar magnitude of Aristarchus. Hopefully, the actual amount of brightening can be measured with this scale if an "event" should be observed. One measurement of the normal brightness of the crater Aristarchus gave its stellar magnitude as $+7\frac{1}{4}$ and suggested a typical probable error of $\pm \frac{1}{4}$ magnitude.

It cannot be denied that a photoelectric photometer, or even a professionally-built artificial-star photometer, would be more precise than the writer's. The goal, rather, has been a simple and inexpensive instrument to increase the reliability of the amateur's visual observations. It might be mentioned that all parts for the instrument can be purchased for between ten and fifteen dollars (not including the eyepiece, which can be removable).

Due to haze and clouds, this photometer has so far been tested only on seven evenings following its construction. On all occasions, no variation in the brightness of Aristarchus was noted.

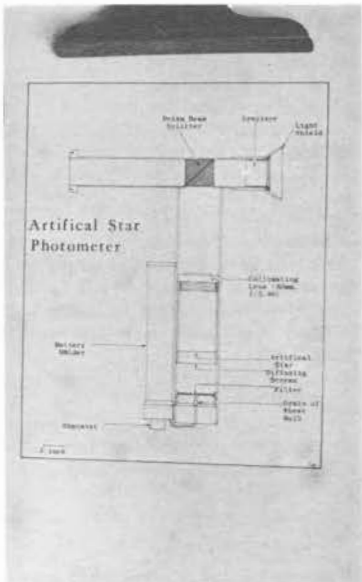

Figure 7. Diagram of John E. Westfall's artificial-star photometer used to monitor brightness of Aristarchus by earthshine. See also text on page 88.

Figure 8. Artificial-star photometer designed by John E. Westfall shown attached to his 4-inch refracting telescope. See also text.

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Figure 8 shows the photometer attached to the writer's 4-inch refractor. A 1-inch eyepiece, giving 60 power, has been the most convenient to use with this arrangement, with a rubber eyeguard to prevent stray light from reaching the observer's eye.

On the basis of this limited trial period, some suggestions can be made:

1. Excellent transparency is almost a necessity. In particular, areas subject to evening haze, or morning mists, are to be avoided.

2. A clock drive is a great convenience, allowing the artificial star easily to be kept beside the observed object.

3. A "richest field" aperture: magnification ratio is the most desirable one. With the most convenient magnification being 60X - 100X, a 12 - 20 inch telescope appears called for. This does not rule out smaller telescopes, although they should be used only under good conditions—excellent transparency and bright earthlight.

4. The sunlit portion of the moon <u>must</u> be kept out of view. The writer does this simply by moving the bright crescent out of the field. This results in some internal reflection, however; and experiments with occulting screens and internal baffles might be rewarding.

In conclusion, the writer feels that this method of detecting local earthlight brightenings on the moon's surface has some promise and is within the reach of most amateurs and their instruments. In particular, this inexpensive artificial-star photometer is recommended to other lunar observers who are interested in detecting earthlit phenomena, but who do not have access to elaborate photographic or photoelectric equipment.

<u>Postscript by Editor</u>. Interested readers are encouraged to build the photometer described by Mr. Westfall. Other simple applications may be found, such as visual measures of the brightnesses of minor planets or of satellites of major planets. And surely, an Aristarchus "event" recorded with Mr. Westfall's photometer would mean more than one which is a completely subjective impression.

OVERLAPPING LUNAR CRATERS

By: M. S. Podanoffsky

Among all the lunar features the most useful are overlapping craters. Relative ages of craters can be determined by the amount of secondary craters per unit area which overlap on a primary crater. Yet, one case of overlapping which has been left out of most, if not all, lunar literature is that where a larger crater overlaps a smaller one.

In an attempt to further our horizons of knowledge of the Moon, I urge A.L.P.O. members to join in a search for overlapping lunar craters. The project consists of assigning areas for study to individual observers. The observations will then be confirmed by other observers, and next a catalog of these objects can be made. Last, but not least, an attempt to find the origin and to learn why the objects are rare will be made. All observations of these objects must include, aside from the usual data (name, date, time, etc...) the following notes for the purpose of classification:

I. Name of larger crater

The name or letter of the larger crater will be given for faster identification of the area. IAU names will be used, of course. In the event the name or letter of the larger crater is not known, leave the space blank.

II. Position

The position of the larger crater in Xi and Eta co-ordinates is to be given. Observers with longitude and latitude maps can convert to Xi and Eta co-ordinates by the use of the formulae:

$$\text{Eta} = \sin(\text{Lat.})$$
$$\text{Xi} = \sin(\text{Long.}) \times \cos(\text{Lat.})$$

III. Percentage of overlapping

1. 0-5%	3. 20-30%	5. 50-70%	7. 80-90%
2. 5-20%	4. 30-50%	6. 70-80%	8. 90-100%

IV. Wall

a. No wall of separation between craters.
b. Wall of larger intrudes on smaller crater.
c. Straight wall separation.

V. Location of smaller crater with respect to the larger one (IAU directions).

9. North (N)	11. E	13. S	15. W
10. NE	12. SE	14. SW	16. NW

To designate ESE use 11-12 (E-SE). For SSW use 13-14, NNW:9-16, ENE:11-10, etc.

There are examples where more than one crater may overlap a smaller one. In that event, write C and a number. The number represents the number of craters which overlap the smaller one. Make one set of classifications for each overlapping case. Example (theoretical):

(xxx-yyy) 2c/16/C3
(xx1-yy3) 3c/9/C3
(xx2-yy5) 2b/12/C3

We also find clusters of overlapping craters. Please write CL and the number of craters in the cluster being overlapped by one major crater. Please make one set of classifications for each member of the overlapping cluster.

The following things must be remembered when studying overlapping. The percentage of overlapping must not be less than 5%. In the event that the overlapping craters are less than 5%, then the overlapping is labeled "doubtful". The observation may be confirmed by other observers, however. One way to confirm overlapping is by the age of the two craters. The smaller one must be older. This, however, is not proof beyond a shadow of a doubt. It only shows an indication of possible overlapping. Observations of the limb features are very difficult, mainly because of the crowding of craters in the area. To

Figure 9. Table Mtn. Observatory photograph, with a 16-inch Cassegrain, of the Phocylides-Wargentin region of the Moon showing the Phocylides cluster of overlapping lunar craters. Photo was taken at 16:58 U.T. on October 1, 1963. Colong. 74°6. Seeing 4-5. Transparency 6. Lunar south at top, lunar west (I.A.U. sense) at right. See also text of Mr. Podanoffsky's article.

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aid observations, many photographs of the limb area will be corrected for foreshortening. In later parts of this project, laboratory exercises will be carried out to simulate observations of overlapping craters.

An interest by A.L.P.O. members is urged since this project can be an enjoyable one as well as a contribution to lunar geology.

Note by author: Special thanks are extended to John E. Westfall for his encouragement and help in starting, and in the preparation of, this paper.

Examples

Neander (+009-643) 4b/15/CL2. Neander (+009-643) 3b/12-11/CL2.	Confused, near Tycho area, with many interesting lunar geological formations. The cluster is two overlapped craters (W & ESE). The region is full of overlapped craters.
Picket (-004-695) 6c/12-11.	Very confused region near Tycho. Good example of an overlapping crater.
Phocylides (-520-793) 4c/9-16/CL2. Phocylides (-520-793) 2b/11/CL2.	See Figure 9.

Postscript by Editor. The article above was forwarded by Lunar Recorder John E. Westfall with a recommendation that it be published. Interested observers can correspond with Mr. Podanoffsky at this address: 29-11 Ditmars Blvd., Long Island City, New York 11105. Overlapping craters can be studied on photographs as well as at the telescope, and certainly Ranger, Orbiter, and Surveyor photographs should be examined carefully in the course of the project here proposed.

BOOK REVIEWS

Intelligent Life in the Universe, by I. S. Shklovskii and Carl Sagan. San Francisco, London, and Amsterdam: Holden-Day, Inc., 1966. 509 pages. $8.95.

Reviewed by Joel W. Goodman, Associate Professor of Microbiology, University of California School of Medicine, San Francisco, Calif.

Intelligent Life in the Universe is a collaboration between I. S. Shklovskii, a Russian, and Carl Sagan, an American, who have never had the pleasure of each other's company. It is actually an expansion of a more abbreviated work by the former author and is concerned with the singularly fascinating and increasingly plausible concept of the ubiquity of life in the universe. While by no means the first treatment of this subject, it is by a wide margin the most comprehensive, eloquent, and entertaining. En route to their conclusion that life is in all likelihood rather commonplace, the authors deal in very knowledgeable terms with the elements of astrophysics, planetology, geochemistry, biochemistry, and communications media. The breadth and depth of their comprehension in these diverse disciplines is indeed impressive; and one is struck by the notion that the authors are, as they refer to J. B. S. Haldane in their dedication, "local examples of what this book is about".

The volume is in three sections: The Universe; Life in the Universe; and Intelligent Life in the Universe. The first considers the nature and size of the universe and the origin and evolution of stars and galaxies. Multiple stars, which are numerous, are special cases of systems in which more than one component is massive enough to support thermonuclear reactions. This is at once an obvious but penetrating point. After all, the Solar System is a multiple in which only the Sun has the requisite mass for stardom. On the basis of contemporary concepts of the formation of stars, it would seem most unlikely to find one unattended by various bits and pieces of cosmic debris.

The biochemical evolution of life is treated in considerable detail, but explained in terms comprehensible to the layman. It is apparent that Shklovskii and Sagan feel that where conditions for macromolecular synthesis are favorable, the appearance of life is inevitable, a tenet which has gained credence steadily since A. I. Oparin's The Origin of Life and the subsequent experiments of Stanley Miller and Harold Urey.

A discussion of the physical conditions on other bodies in the Solar System includes the recent Mariner probes of Venus and Mars. The Jovian planets, laden with the reduced compounds which Miller and Urey showed can serve as progenitors of organic molecules, may have within their atmospheres regions which are rich organic broths.

The parameters leading to the conclusion that the universe has a polydispersity of life are methodically and irresistibly set forth. It is then but a short step from life to technological sophistication. Finally, the rationale and techniques for establishing communication between two such endowed planets are elaborated. It might be recalled that Project Ozma, a recent primitive attempt to scan for structured radio signals at 21 centimeters from two likely neighbors, Tau Cygni and Epsilon Eridani, was unsuccessful. However, it would have been alarming indeed if this first crude probe had borne fruit.

If there is one overriding criticism to be levelled at a work of this nature, it is that its conslusions rest so heavily on speculation. While each of the parameters in the equation leading to life appears highly probable, or at least logical on the basis of available information, the product of this pyramid of assumptions is much less likely. Should we be badly astray with respect to even any one of them, then the probability becomes vanishingly small. One substantiated observation of life elsewhere in the universe would be worth an infinity of such discourses. Of course, the authors would be the first to agree with this point of view; and in my opinion the absence of such information does not detract from the value of the book.

This reviewer found himself at variance with the authors on several biochemical points. On page 99, the statement is made: "If the mutation rate is extremely high, any characteristic selected would be mutated away". If the parent type possesses a selective advantage, then all the mutants, regardless of rate, would be selected against. On page 190, the impression is given that DNA can replicate itself and mediate RNA synthesis in the absence of protein. The enzymes DNA and RNA polymerase are required for these events. On page 196, a length of 10 Å is derived for the unit of genetic material, the gene. This would make the gene only three nucleotides long, the length of a single amino acid code word. Since a gene codes for a complete protein molecule, many such triplets are needed. It is probable that the sequence of nucleotides in each gene is arranged transversely across the chromosome rather than longitudinally along it. On page 243, the authors state that the cell walls of some bacteria consist solely of D-amino acids. While some microorganisms do contain D-amino acids in their cell walls, none are composed exclusively of them.

In addition to the above, several inconsistencies and typographical errors have crept into this first edition. On page 48, the statement that the Virgo Cluster contains several thousand galaxies is followed by the statement that some clusters have as many as 1000 galaxies. On page 367, the date of impact of Phobos on Mars is given as 10^8 years hence, while on page 374 it is stated as 10^7 to 2×10^7 years. On page 224, 6×10^8 years ago marked the beginning of the Cambrian, not the Pre-Cambrian, Period. A number of exponents on page 196 have been garbled, and finally the photographs in Figure 7-1 are reversed with respect to their legends.

Shklovskii and Sagan raise a sobering possibility during the course of their commentary: suppose technologically advanced civilizations inevitably turn their technology upon themselves before the bud comes to bloom, a point in evolution at which we find ourselves. What, then, are the chances for intergalactic communication? Despite this discomforting consideration, Intelligent Life in the Universe is a veritable wonderland of contemporary science which should be enjoyed by all.

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Neighbors of the Earth, edited and annotated by Thornton Page and Lou Williams Page. Macmillan, 1965, 336 + xvi pages. Price $7.95.

Reviewed by William O. Roberts

Over the past 25 years or so, the well-known astronomical periodical, Sky and Telescope, has published many excellent popular articles, whose appeal is all the greater for having been written by some of the better known astronomers of the period. The late Otto Struve was one of the more prolific writers, and his monthly contributions set very high standards for the genre. The very existence of so large a collection of first-rate material always presents a temptation to anthologists. The husband and wife team of Thornton and Lou Williams Page has chosen to accept the challenge by creating a series of collections, each one oriented historically, and each covering a different area of astronomy.

The present work follows the pattern established by Wanderers in the Sky, which was reviewed in The Strolling Astronomer for Jan.-Feb., 1965. At that time it was pointed out that the main binding ingredient was celestial mechanics. Now the emphasis is shifted from masses and orbital motions to the appearance of Solar System objects as seen by the eye, by optical instruments, and by other devices. Perhaps we can begin to get a better view of things by mentioning the contents briefly. The opening half of the book deals with the principal planets, followed by sections on asteroids and comets. This goes on to chapters on meteoric and meteoroidal objects, and "Atmospheres, Aurorae, and Exospheres". A final grouping, "Debris of Interplanetary Space", covers such miscellany as the Zodiacal Light, the cloud satellites, and solar particles. The moon is not discussed, but the satellites of other planets are. A great deal of this will appeal to amateurs who are interested in taking up active observing, and some of it is of definite value to those who hope to continue on into systematic observing; but this material should not be considered a substitute for a good observing manual.

I found the section on the warmer planets, Mercury and Venus, interesting because of the scarcity of good semi-popular literature on these bodies. Anyone who has examined Patrick Moore's book on Venus can appreciate the difficulties involved in investigating this planet; and the articles in the present work, being strongly slanted toward radar and space-vehicle findings, do provide a useful supplement to Moore.

A.L.P.O. people should enjoy most of the planetary and cometary material: younger readers will be enabled to read some of the interesting articles from the past, and to note just how spectacular astronomical progress has been during these last three decades. Two articles by Elmer Reese will please the Jupiter Section. The up-to-dateness of this book may be gauged by the fact that it was possible not only to report the success of Mariner IV's mission to Mars, but to make some brief comments on the results, providing an interesting close to the 50-page section on this planet.

The editors have shown skill in selection, cutting, and annotating; and the result is a smoothly running book that promises a great deal of reading pleasure for those who enjoy astronomy on a non-mathematical level. It should be noted in passing that one of the footnotes is marred by the statement, "The brightest stars in the sky are 'first magnitude' or +1". Many articles have undergone drastic abbreviation in order that the collection might not be too long. The discerning reader is going to be aware of unevenness, even without benefit of ellipses; and this is true of the Struve articles, many of which I have enjoyed in their originally published form. This unevenness generally appears to be part of the price we have to pay for enjoying the convenience of anthologized material.

LUNAR TRANSIENT PHENOMENA SELECTED AREAS SURVEY

By: Charles L. Ricker, A.L.P.O. Lunar Recorder

In the Sept.-Oct., 1965 issue of The Strolling Astronomer, a new program was described for the systematic study of the following selected areas: Alphonsus, Aristarchus-Herodotus, Eratosthenes, Kepler, Plato, and Messier-Pickering. The purpose of the program is to study these formations as often as possible, making intensity estimates and color filter intensity estimates in the hope of identifying anomalous changes which cannot be explained by the changing angle of solar illumination alone. Response to the program has been fairly good, with the following observers submitting observations:

Rev. Kenneth Delano	New Bedford, Mass	12½" Refl.
Ronald Domen	Warren, Ohio	4¼" Refl.
Christopher Edsall	Warren, Mich.	4 " Refl.
Rodger Gordon	Ackermanville, Pa.	3½" Questar
Annie Haralambie	Larchmont, N. Y.	4 " Refl.
Leo Hein	Chicago, Ill.	3¼" Refr. *
H. W. Kelsey	Riverside, Calif.	8 " Refl.
Richard Krezovich	Rochester, N. Y.	3 " Refr.
Eugene Lonak	Chicago, Ill.	10 " Refl. *
Paul Pokusa	Hammond, Ind.	4½" Refl.
Charles L. Ricker	Marquette, Mich.	10" & 6" Refls.
Martin Senour	Rochester, N. Y.	6" Refl.
Karl Simmons	Jacksonville, Fla.	6" Refl.
William H. Rickrath	Westchester, Ill.	6" Refl. *
Douglas Smith	Vinton, Va.	6" Refl.

*Members of Chicago Astronomical Society

It is proper to acknowledge here the extraordinary efforts of H. W. Kelsey, who in addition to his numerous regular monthly observations has assisted this Recorder in innumerable ways, such as having the revised forms printed, helping in the analysis of the observations, and carrying out other tasks too numerous to mention.

It should be pointed out that the results contained herein are provisional since only five lunations are covered, and observations over a much longer period will be required to identify correctly the changes taking place.

In view of the large number of observations on file, it is impossible in one article to present a comprehensive report on all of the selected areas. It has hence been decided that this article will be the first in a series of reports. We have decided to report on Messier-Pickering first since we have the best coverage for all colongitudes on this area, thereby allowing more meaningful analysis of the observations.

"Blink Surveys"

Before giving the report on Messier-Pickering, another aspect of the search for "Lunar Transient Phenomena" should be reported here: Since we embarked on the formal program as outlined above, an important development has taken place in this field. Our friends in the BAA Lunar Section have been making extensive observations of various formations, using a visual blink device which has been described by Mr. P. K. Sartory* and which consists simply of red and blue filters mounted adjacent to each other so that a given area may be observed alternately in blue and red without the necessity of changing filters. This alternation tends to cause red-enhanced features to stand out and "blink". Several of our members have been using these devices with some success. There is no question that in the search for red-enhanced features, this method is far superior to ordinary visual surveys; for positive results have been reported using only quite moderate apertures. At present, we feel that more meaningful results will be obtained if our observers confine themselves to employing this method as an extension of the regular systematic study of the selected areas, with one notable exception, namely that Gassendi should also be observed in this manner since the BAA is giving this formation so much attention, and since we are attempting to coöperate with the BAA in this survey. We feel that this method of survey shows much promise, and more information will be sent upon request to interested observers.

Report on Messier-Pickering Observations

This report covers observations from June 24, 1966 to November 30, 1966. There are 56 observations, covering fairly well colongitudes from 315°.4 to 130°.0. Please refer to Figure 10 for the letter designations which are used in this report. The following kinds of analysis have been made:

1. Intensity estimates at comparable colongitudes.
2. Color enhancements dominating at comparable colongitudes.
3. Color enhancements in relation to apogee and perigee of the moon.
4. Relative size and shape of Messier and Pickering in relation to:
   (a) Colongitude.
   (b) Earth's Selenographic Longitude.

After sunrise, the west floors (I.A.U. directions) appear subdued in intensity, at about colongitude 315°. The craters are almost completely immersed in shadow, which sometimes does not appear completely black. (See note 1 below.) The "comet tail" first makes its appearance at about colongitude 315°, and is always visible by 320°. The tail does not seem to display any appreciable changes in intensity throughout the lunation. The usual shapes of Messier and Pickering are oval and slightly triangular, and Pickering usually appears larger than Messier up to 360°. This is not always true, though; for we have observations at 315°.9, 315°.7, and 350°.7 where they appear equal in size and shape. The shape of Messier varies in an unpredictable fashion in relation to Pickering, which is more stable in apparent shape and size. A bright nimbus begins forming around each of the craters at about 320°, and is fully developed by 360°. (See note 2 below.)

The inner walls and floors of the craters are not distinguishable from each other in any of the observations; therefore the inner profiles of the craters are hard to determine. The intensity of the interiors of the craters are usually moderately bright, averaging intensity "7", but upon occasions have appeared as dull as "5" and as bright as "10". There are spots on the walls which are almost always present at intensity "8" to "10", but insufficient intensity estimates have been made to determine if these spots display anomalous variations. These intensities are on an arbitrary scale of "0" (shadows) to "10" (most brilliant features).

At about 340°, dark streaks, or "pseudo shadows" appear in an E-W direction across the floors of Messier-Pickering. (I & J, Figure 10). Messier shows this effect more frequently than Pickering. These markings are not always visible, even under good seeing conditions. Their intensity varies unpredictably between "2" and "5.5". (See note 3 below.)

*Sartory, P. K., "A Method of Rendering Small Differences of Color or Contrast Observations," J.B.A.A., Feb. 1965, Vol. 75, No. 2, pp. 98-100.

Between the craters, there is a dark area which we have interpreted as a rather steep slope (K). This darkness has been observed right up until sunset, which makes its interpretation rather difficult.

Just north of Pickering, there is a small bright spot, which varies in intensity between "4" and "10" (G). The usual intensity is "6" to "8". The intensity at comparable colongitudes shows wide variations, and at this time the intensity for any given colongitude cannot be predicted in advance. West of Pickering, and associated with the comet tail, appears a dark circular marking of moderate size (H). The intensity of this marking varies between "2" and "5", and is usually "3" or "4". This feature has been observed as dark as "2" at 345°2 and "5" at 346°3 so that the intensity does not appear to be dependent upon angle of illumination alone. (See note 4 below.)

Color Filter Observations

Intensity estimates using color filters have been made by several observers (Kelsey and Ricker) throughout the period, and the following effects have been recorded:

1. The bright spot N of Pickering shows a definite trend to redness; i.e., it often appears enhanced in red light, and subdued in blue. This aspect is not invariably observed, though.
2. The dark circular marking W of Pickering always appears enhanced in blue light, but this enhancement never exceeds the intensity of the surrounding Mare. There is usually a corresponding diminution in red. These effects have been recorded by both of us.
3. The "pseudo shadows" on the crater floors were observed on two occasions around colongitude 60° as enhanced in blue.
4. There is a strong tendency for color enhancements to be pronounced at apogee and perigee of the moon.
5. On no occasion was color perceived in integrated light, and it has only been inferred from color filter intensity estimates. More about this matter later.

Note illustrations on pages 97, 98 and 99.

Discussion of Anomalies

1. <u>The Shadows of Messier-Pickering</u>. These sometimes do not appear completely black. This aspect can be explained in several ways: First, observing conditions; poor seeing can make the shadows appear less than black. If this is the case, other shadows should display the effect at the same times. Second, reflections from the walls of the craters. This is the most reasonable explanation, but then we must ask; why isn't the effect visible at every lunation? Possibly a combination of lunar libration and angle of solar illumination plays a part here.

2. <u>Variations in the Apparent Relative Size and Shape of the Craters</u>. Here, of course, is the classic problem in connection with these objects. The anomalies are complicated in that two variables are involved (size and shape). In analyzing the observations, it is found that:

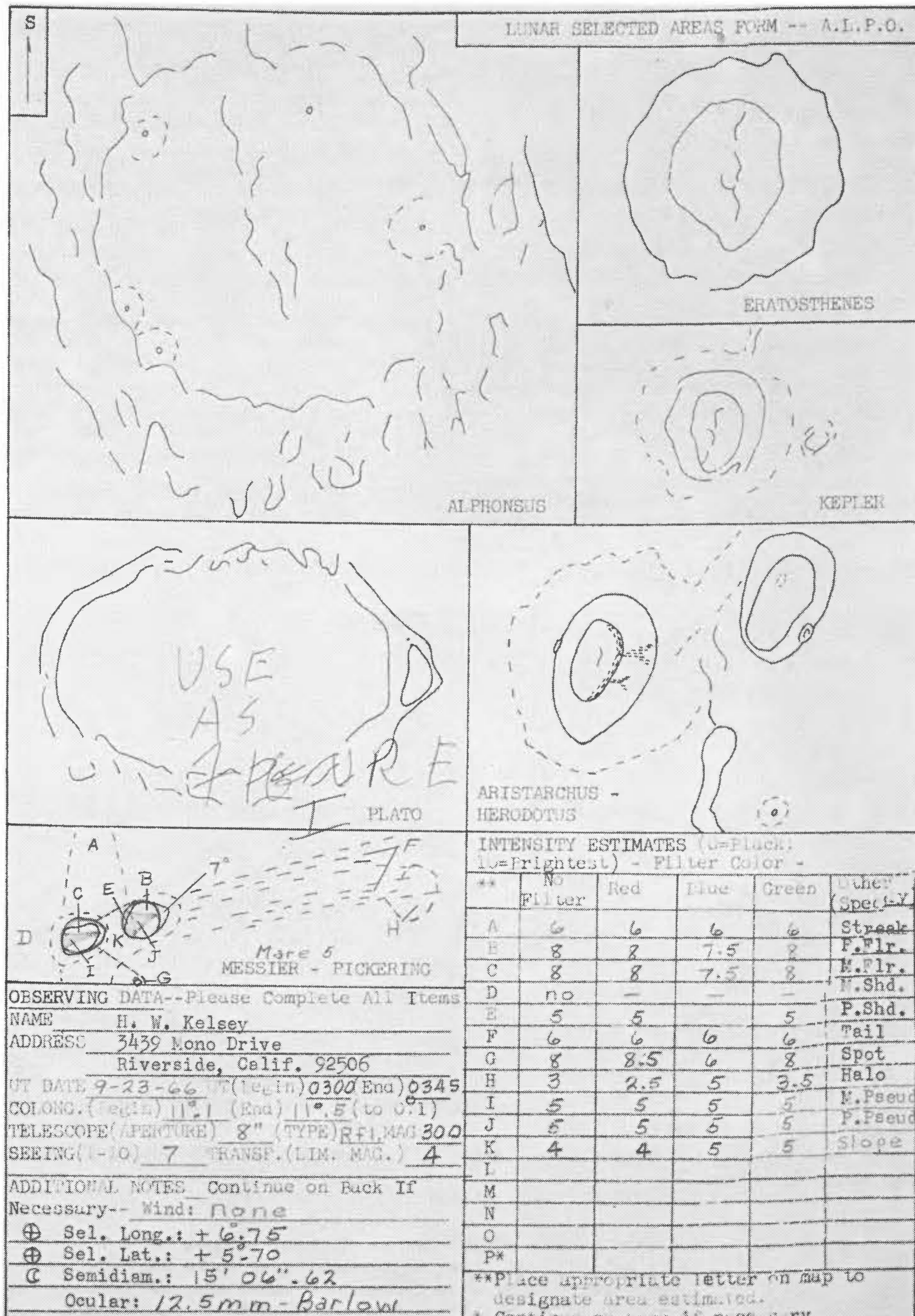
(a) On every occasion, the craters appear equal at negative selenographic longitudes.
(b) Usually, at extreme positive values, Messier appears smaller than Pickering.
(c) Usually, at values less than +4°5 of selenographic longitude, Messier and Pickering appear equal.

But:

(a) At colongitude values of 315° to 340°, Messier always looks smaller than Pickering.
(b) From 340° to 360° Messier and Pickering are equal in size; but Messier is often very elliptical.
(c) At colongitudes 360° to 115°9, the craters almost always appear equal.
(d) At 122°2, Messier appeared smaller and very elliptical.

Some conclusions:

(a) The <u>apparent</u> sizes and shapes may be a function of either libration <u>or</u> colongitude.
(b) Coincidentally, the Earth's selenographic longitude values were near zero when the moon was near zero degrees colongitude through-



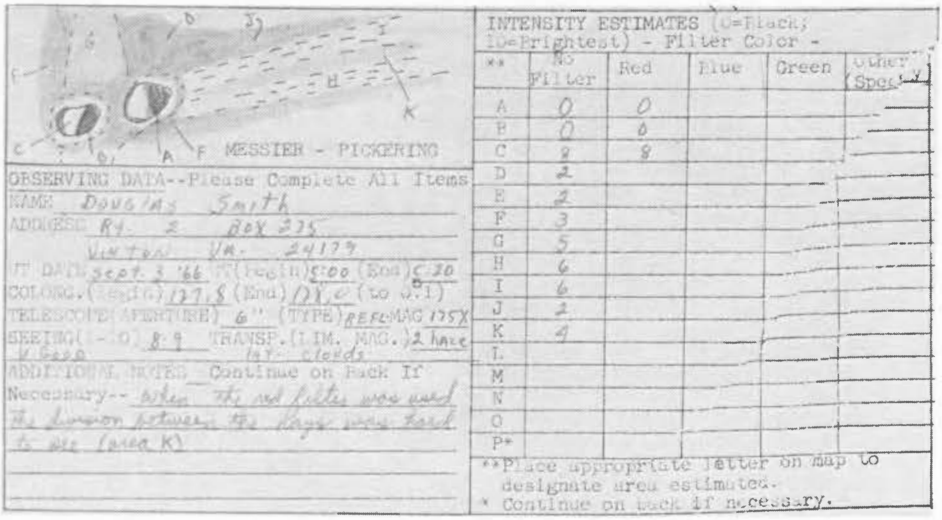
OBSERVING DATA--Please Complete All Items
NAME H. W. Kelsey
ADDRESS 3439 Mono Drive
Riverside, Calif. 92506
UT DATE 9-23-66 UT(Begin) 0300 (End) 0345
COLONG. (Begin) 11°.1 (End) 11°.5 (to 0.°1)
TELESCOPE (APERTURE) 8" (TYPE) Rfl. MAG 300
SEEING (1-10) 7 TRANSP. (LIM. MAG.) 4
ADDITIONAL NOTES Continue on Back If Necessary-- Wind: none
⊕ Sel. Long.: + 6°.75
⊕ Sel. Lat.: + 5°.70
☾ Semidiam.: 15' 06".62
Ocular: 12.5mm - Barlow

INTENSITY ESTIMATES (0=Black; 10=Brightest) - Filter Color -

**	No Filter	Red	Blue	Green	Other (Specify)
A	6	6	6	6	Streak
B	8	8	7.5	8	F.Flr.
C	8	8	7.5	8	M.Flr.
D	no	—	—	—	N.Shd.
E	5	5		5	P.Shd.
F	6	6	6	6	Tail
G	8	8.5	6	8	Spot
H	3	2.5	5	3.5	Halo
I	5	5	5	5	M.Pseudo
J	5	5	5	5	P.Pseudo
K	4	4	5	5	Slope
L					
M					
N					
O					
P*					

**Place appropriate letter on map to designate area estimated.
* Continue on back if necessary.

Figure 10. Observing-form used in Lunar Transient Phenomena Selected Areas Survey. Drawing and intensity-estimates of Messier-Pickering by H. W. Kelsey. The letters on this drawing identify the features discussed by Mr. Charles Ricker in his article in this issue. See also text of Mr. Ricker's article. Note how completely Mr. Kelsey has filled out the form.



MESSIER - PICKERING

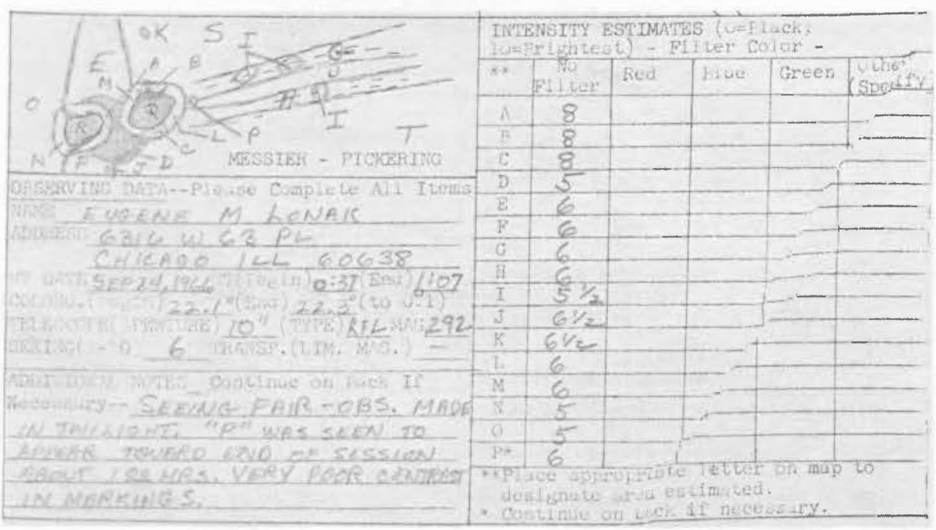
OBSERVING DATA--Please Complete All Items
NAME Douglas Smith
ADDRESS Rt. 2 Box 275
Vinton Va. 24179
UT DATE Sept. 3 '66 UT (Begin) 5:00 (End) 5:30
COLONG. (Begin) 137.8 (End) 138.0 (to 0.1)
TELESCOPE (APERTURE) 6" (TYPE) REFL MAG 175X
SEEING (1-10) 8-9 V Good TRANSP. (LIM. MAG.) 2 haze lgt. clouds
ADDITIONAL NOTES Continue on Back If Necessary-- when the red filter was used the division between the rays was hard to see (area K)

INTENSITY ESTIMATES (0=Black; 10=Brightest) - Filter Color -

**	No Filter	Red	Blue	Green	Other (Specify)
A	0	0			
B	0	0			
C	8	8			
D	2				
E	2				
F	3				
G	5				
H	6				
I	6				
J	2				
K	4				
L					
M					
N					
O					
P*					

**Place appropriate letter on map to designate area estimated.
* Continue on back if necessary.

Figure 11. Drawing and intensity-estimates of Messier-Pickering by D. Smith. Sunset.



MESSIER - PICKERING

OBSERVING DATA--Please Complete All Items
NAME EUGENE M LONAK
ADDRESS 6316 W. 62 PL.
CHICAGO ILL 60638
UT DATE SEP 24, 1966 UT (Begin) 0:37 (End) 1:07
COLONG. (Begin) 22.1° (End) 22.3° (to 0.1)
TELESCOPE (APERTURE) 10" (TYPE) RFL MAG 292
SEEING (1-10) 6 TRANSP. (LIM. MAG.) —
ADDITIONAL NOTES Continue on Back If Necessary-- SEEING FAIR - OBS. MADE IN TWILIGHT. "P" WAS SEEN TO APPEAR TOWARD END OF SESSION ABOUT 1:00 HRS. VERY POOR CONTRAST IN MARKINGS.

INTENSITY ESTIMATES (0=Black; 10=Brightest) - Filter Color -

**	No Filter	Red	Blue	Green	Other (Specify)
A	8				
B	8				
C	8				
D	5				
E	6				
F	6				
G	6				
H	6				
I	5½				
J	6½				
K	6½				
L	6				
M	6				
N	5				
O	5				
P*	6				

**Place appropriate letter on map to designate area estimated.
* Continue on back if necessary.

Figure 12. Drawing and intensity-estimates of Messier-Pickering by Eugene M. Lonak. High solar lighting.

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out this present entire series of observations.

(c) It is evident that observations will have to be continued over a longer period of time to determine whether apparent changes depend primarily on solar illumination or libration. In addition, this writer is convinced that the apparent changes are caused by the bright nimbus which surrounds Messier, and possibly by the fact that Messier is apparently on a higher ground level than is Pickering. What we must find out is what part colongitude and libration individually play in these apparent changes.

3. <u>The Pseudo-Shadows on the Floors</u>. All attempts to correlate the visibility or non-visibility of these features with the angle of lighting or seeing have failed. In this respect, the pseudo-shadows are similar to the bands of Aristarchus, and may in fact be a form of "band". Many more observations will be necessary fully to understand these

features.

4. Bright Spot North of Pickering and Dark Mark West of Pickering. Like many other areas on the moon which display strong colors, the colors and intensity of these objects vary unpredictably. At this time, no explanation can be made to explain this apparently random phenomenon.

It is evident from the above that our conviction that modestly equipped amateurs can make a useful contribution in this field is vindicated. In particular, note that none of the anomalies described above would have been noticed during casual surveys. It has only been by pursuing a systematic program over a number of lunations that any tentative positive results have been attained. It should be stated, though, that none of the results contained herein are conclusive. Observations by more observers and over a longer period of time will be necessary before we can be certain that other anomalies do not occur, and that the ones described are actually occurring. Far too little data exist at this point to attempt to theorize as to the causes of the described phenomena. Although Messier-Pickering has been best observed of all the selected formations from the standpoint of complete colongitude coverage, a larger number of observers are working on the other formations in the program. Such being the case, it will be highly desirable that more observers concentrate on Messier-Pickering so that any possibility of bias from a few observers is removed.

It is possible that the interpretations presented here will provoke some disagreement. If this is the case, then we have accomplished our purpose of stimulating interest in this neglected field.

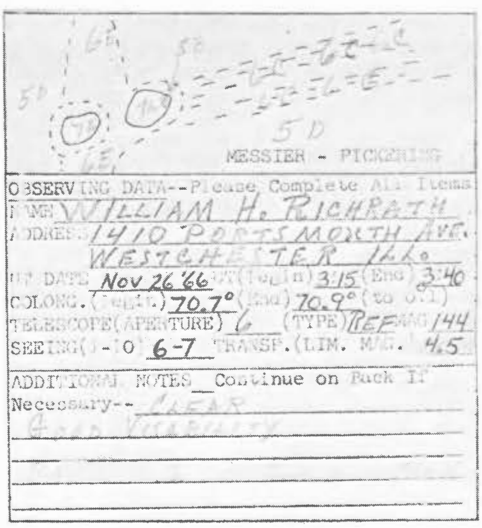

Figure 13. Drawing of Messier-Pickering by William H. Richrath with a 6-inch reflector. Early afternoon solar lighting.

Figure 14. Drawing of Messier-Pickering by Martin Senour with a 6-inch reflector. October 1, 1966. 22^h40^m-22^h57^m, U.T. About a day before sunset.

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LINNÉ AS A LUNAR DOME

By: José Olivarez

Located on the western section (IAU directions) of Mare Serenitatis at rectangular selenographic coördinates Xi: +.181, Eta +.466, the minute craterlet inside Linné which has been computed by Ashbrook[1] as 1.2 kms. in diameter has been the topic of discussions and raging controversies for many years. The problem of whether Linné underwent a physical change in the middle of the last century appears to have been cleared up rather well by the bringing to light of observations by competent observers such as J. F. J. Schmidt.[2] The question of the structure of the Linné craterlet is of more interest today.

The Linné craterlet has been described as a crater-cone, a mound, a hill, and as a dome. Of these descriptions, the most intriguing is the suggestion that the craterlet is the "blowhole" of a dome inside the Linné white spot! This idea was apparently first suggested by the late Dr. H. P. Wilkins in a paper read before the November, 1953 meeting of the British Astronomical Association. Dr. Wilkins intrigued his audience (and later his readers) by reporting that the long famous craterlet was the pit of a lunar dome. His observations with the 33-inch Meudon refractor in France that led to this conclusion were reported as follows:

> "On April of this year (1953), conditions being favorable, Mr. Moore and myself carefully observed Linné with the 33-inch Meudon refractor. On April 20 at 21 hrs., the terminator had advanced beyond Linné. We [could] see the white area, the dome with the shading on its eastern side, and the central pit which was filled with shadow. On April 21st the dome could no longer be seen, but the pit was perfectly visible while the white area was very intense. The dome disappears when the Sun's altitude reaches 10 degrees, but the pit must be very deep as it is still to some extent shadow-filled when the Sun's altitude attains 30 degrees.
>
> "I suggest that these observations indicate a change of some sort in connection with Linné, which is now neither a crater-cone within a shallow crater nor a 'signet ring' but a deep pit on the summit of a dome."[3] Figure 15 shows Wilkins' interpretation of the appearance of the Linné region.

Dr. Wilkins' collegue, Mr. F. H. Thornton, supported his view that Linné indeed contained a lunar dome. Wilkins remarked: "About 18 months ago Mr. Thornton declared that Linné is at present a small but deep pit on the summit of a low, hemispherical dome, which is situated at the center of a perfectly level white spot about five miles in diameter.[4] Mr. Thornton's conclusion was based on observations with an 18-inch reflector, a moderately large aperture."

Reliable observers in the United States observing at the same time period during which Dr. Wilkins recorded the dome in Linné defined the craterlet differently. Of course, they were using modest apertures of from eight to ten inches and indeed a poor match to the resolving power of the 33-inch Meudon refractor or Mr. Thornton's 18-inch reflector.

Mr. D. P. Avigliano's description of Linné in 1953 as "a bright rimmed craterlet roughly 1¼ miles in diameter (and very deep) located on the top of a somewhat irregular mound that is itself located upon the SE edge of an ancient shallow inundated crater ring"[5] is still very true today. Observations by Mr. Elmer J. Reese and myself have verified this appearance with 8-inch apertures. Also, Mr. Frank Vaughn's conclusions as to the true aspect of the Linné craterlet after many years of observation (roughly, 1940-1960) do not include the suggestion that the craterlet is a pit of a lunar dome nor that any type of underlying swelling exists.[6] Mr. Vaughn observed the Linné craterlet mostly with a 10-inch aperture.

It is quite definite that Dr. Wilkins saw something dome-like around the craterlet in 1953 with the 33-inch Meudon refractor. But was it a dome? In spite of the lack of support of Dr. Wilkins' observations by American amateurs (and many BAA members as well) in the last decade, the assertion that the craterlet is the pit on a lunar dome inside Linné as revealed by large apertures cannot be disregarded. It is unfortunate that most amateurs did not have moderately large apertures at hand to verify or repudiate Wilkins' conclusions during the last 13 years!

Verification of the existence of the Wilkins feature has come recently from Mr. Alika Herring of the Lunar and Planetary Laboratory. Mr. Herring has kindly communicated the following to me:

> "The Linné craterlet does indeed rest upon a slight uplift — I would hesitate to call it a dome — which except for size, is apparently quite similar in appearance, and probably origin as well, to the swellings that underlie Aristillus, Copernicus, Kepler, and many other lunar craters. The Linné uplift is about twice the size (diameter) of the crater-cone itself and, as I recall, is best observed under low evening illumination."

Mr. Herring also points out that true domes and the swellings underlying most craters are of distinctly differing origin. The domes are the result of natural selenological actions while the underlying crater swellings are the result of the meteoritic impact that produced the crater. Mr. Herring defines the mechanisms as follows:

> "A lunar dome is essentially the same as on Earth. It is the result of the uplift of the upper layers due to the intrusion of magmas from below. The mechanism producing the swelling underlying most craters results from pushing outward and upward of the underlying surface from the force of impact, as well as the deposition of the expelled material in the vicinity of the impact point. These swellings, then, are NOT true domes."

Mr. Herring's solution as to the probable nature of the swelling that underlies the Linné craterlet is much more plausible than Dr. Wilkins' definition, which now appears to have been a wrong conclusion based on the misinterpretation of the observed phenomena by himself and Mr. Thornton. Another point that works against Wilkins' interpretation is the "rule" that summit craters on domes are rimless. No single exception to this rule has been observed.

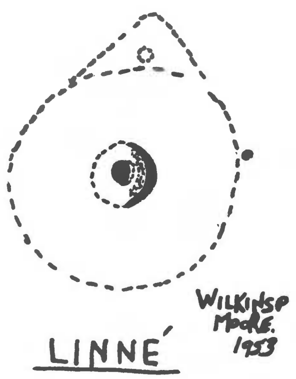

Figure 15. Linné in 1953, according to Wilkins and Moore. This sketch is a copy by José Olivarez of the original on page 87 of The Journal of the British Astronomical Association, Vol. 64, No. 2. See also text of Mr. Olivarez' article about Linné in this issue.

*****

By adopting Mr. Herring's solution for the Linné dome problem, we may offer a more complete description of the structure of the Linné craterlet. Thus, the Linné craterlet whose walls are 94 meters higher than the surrounding plain has a diameter of about 1.2 kms. and is situated on top of a slight uplift which is about 2.4 kms. in diameter and is a normal feature of the craterlet's structure. We may conclude that the Linné craterlet is not a secondary feature of a swelling as defined by Dr. Wilkins in 1953, but instead the swelling is a secondary feature of the craterlet!

The front cover photograph of this issue is an excellent drawing of Linné and vicinity by Mr. Herring.

Acknowledgment

I would like to thank Mr. Walter Haas and Mr. Alika Herring for their interest and comments during the preparation of this paper.

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PLANETOLOGICAL FRAGMENTS - 6

Surface Structures of the Terrestrial Planets

Lunar observers are familiar with the extensive systems of linear structures on the moon, called the "grid system". Straight portions of the walls of craters, elongated mountain ranges, crater chains, wrinkle ridges, and a variety of other structure elements in the size range of a few hundred feet (Ranger and Orbiter photographs show these) up to a few hundred miles comprise this category of lunar structural features. The lineaments, as they are called, occur in great quantities and thereby lend themselves to analysis by statistical techniques. Robert Strom of the University of Arizona has studied the dimensions and orientations of over 10,000 lunar lineaments (avoiding the limb regions where foreshortening causes problems) and has plotted the results in "rose diagrams" showing the azimuth-frequency occurrence of the orientations. An example is shown in Figure 16. Strom found that many lineaments are associated with major structures such as Mare Imbrium because they lie in directions radial to the near-geometric center of the Imbrium basin. These have been eliminated from the lineaments shown in the figure. The most striking feature of the rose diagram is the appearance of the very pronounced azimuth-frequency maxima in the NE-SW and NW-SE directions. There is another maximum oriented NNE-SSW and a smaller maximum with a N-S direction. The absence of a substantial E-W component may be partly related to the difficulty in seeing low-relief features in this direction because of the angle of solar illumination.

Orthogonal diagonal fractures are well known to geologists both from field and laboratory observations. Compressional forces on rigid bodies commonly cause the diagonal shear directions, but the exact angle that they make with the direction of stress depends on the properties of the materials. Large-scale geologic studies of the earth's continents and ocean floors have shown that structural lineaments on this planet show a pronounced orientation in the NE-SW and NW-SE directions. They are most nearly orthogonal at the equator, and the angle between the principal lineaments increases as one approaches the poles. Among some of the major lineaments on the earth are the shorelines of the continents, volcanic belts, earthquake belts, major mountain chains (Urals, Rockies, etc.), and faults. The earth also has pronounced N-S and E-W components. In 1947, F. A. Vening-Meinesz related the lineaments on earth to the dynamic history of the earth as the crust underwent stresses caused by the slowing rotation, thermal contraction, and tidal interaction with the moon. He was able satisfactorily to account for the change in angle of the two diagonal components with increased latitude.

The television photographs of Mars obtained with Mariner IV afforded the opportunity to make detailed studies of structures on that planet. Alan Binder, also of the University of Arizona, measured and plotted lineaments on the best of the Mariner frames and found the same NE-SW and NW-SE trending lineaments. The scan lines on the photographs made it impossible to determine if there were N-S or E-W components. Binder found an increase in angle with latitude, as in the case of the earth.

So, then, we have at least three terrestrial planets whose upper crusts have been altered to give lineament patterns related to the direction of imposed stresses and to the mechanical properties of the materials. While a quantitative determination of the amount of stress in a planetary crust that is required to yield a given lineament configuration can not be accurately determined, it is of considerable interest that three bodies of rather different histories have undergone similar large-scale tectonic evolution. Mars, for example, has developed without the benefit of a massive body close by, in contrast with the earth and moon. Tidal forces may not be the dominant effect for Mars, therefore. The thermal histories of these three bodies are certainly different; the earth is highly differentiated with a dense core comprising 55% of the total radius of the planet, Mars is apparently differentiated to a lesser extent with a small core, and the moon is probably differentiated very little if at all. All three planets have one common historical and modern process, however, the slowing down of the rotation and the consequent transfer of angular momentum. We know that for the earth, great energy is represented in earthquake events; and these represent adjustments of stresses on fault planes in the crust. There remains indecision about the source of the energy; most earthquake zones are related to volcanic regions.

It will be of considerable interest to look for structural features on the surfaces of Mercury, the Galilean satellites of Jupiter, and Titan. In general, we must await spacecraft views of these objects; but with Mercury some insight may be gained when new high-quality maps become available. Old maps based on the incorrect 88-day rotation period are naturally quite useless.

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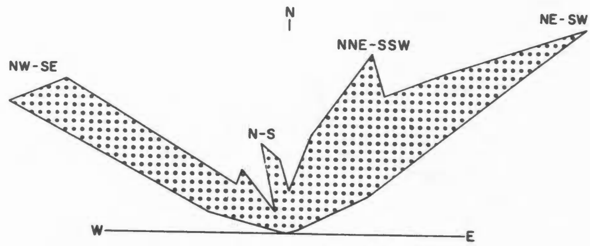

Figure 16. Azimuth-frequency diagram of "lineaments" on surface of moon. See text of "Planetological Fragments - 6".

Vening-Meinesz, F. A., "Shear Patterns of the Earth's Crust", Transactions of the American Geophysical Union, 28, 1, 1947.

DPC

SOME RECENT OBSERVATIONS OF JUPITER

The Jupiter drawings on this page and the next one represent recent contributions from Recorders Wend and Mackal. It is hoped that they will prove interesting and instructive for the Jupiter observers among our members. Mr. Phillip Budine and several co-workers in Binghamton, New York have been most active observers of the Giant Planet and have recorded thousands of C.M. transits of Jovian surface features during the 1966-7 apparition. The general style of drawing in Figures 19 and 20 may be praised as artistic and natural-looking. Those who have tried will appreciate the difficulty of committing to paper a satisfactory representation of the appearance of Jupiter. We would also encourage those with different, and even cruder, drawing styles by saying that a factually accurate observation may be worth more than a great many pretty pictures.

Mr. Mackal and Mr. Budine have expressed the idea in correspondence that the STrZ feature shown and noted in Figure 20 is a new STrZ Disturbance, an analogue to the famous and long-lasting Disturbance of 1901-40 and to shorter-lived features in the same zone in 1941-2 and 1946-7. Mr. Mackal observed the preceding end of the new Disturbance, if such it should be called, at 220° (II) on April 8, 1967. Mr. Elmer J. Reese has expressed oral doubts that this feature should be regarded as an STrZ Disturbance; he points out that diagonal columns across the STrZ have been numerous in 1966-7 and that the new feature fails to resemble recognized STrZ Disturbances of the past in such matters as great conspicuousness, rotation-period, and deflection of the South Equatorial Belt South from its normal latitude in the longitude of the Disturbance.

Object	Long. (II) on May 20, 1967	Drift/30 days (II)
center Red Spot	28°	0°0
c. STeZ oval FA	80	-19.0
c. STeZ oval BC	188	-18.5
c. STeZ oval DE	330	-22.0

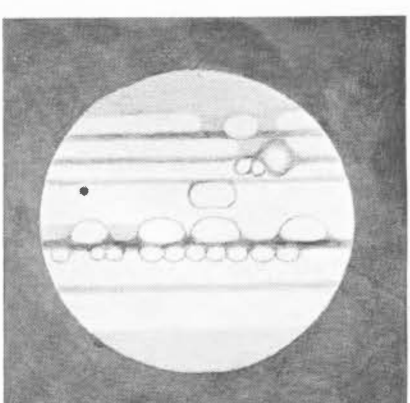

Figure 17. Drawing of Jupiter by Carlos E. Rost on February 23, 1967 at 1^h15^m, U.T. 6-inch catadioptric refl., 270X. Seeing about 6-8. Transparency about 3-5. South at top but Jovian longitude increases to the left. Red Spot past (right of) C.M. Shadow of J. I near left edge of disc; it began to transit at 1^h5^m, U.T. C.M.$_1$= 314°. C.M.$_2$= 54°.

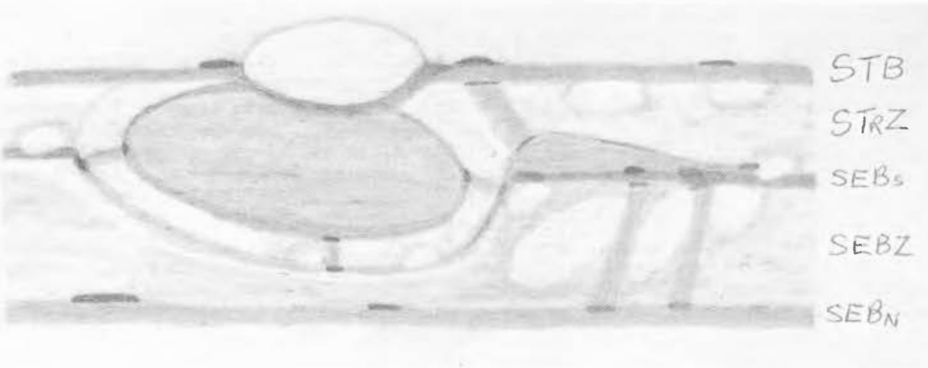

Figure 18. Drawing of Red Spot on Jupiter and vicinity by Phillip W. Budine on February 27, 1967, 4^h5^m - 4^h30^m, U.T. 10-inch Cave refl., 250X and 300X. Seeing 7-8. Transparency 5. South at top, Jovian longitude increases to right. Same orientation in Figures 19 and 20. Note whitish Red Spot Hollow around the dusky Spot and STeZ oval DE. The South Equatorial Belt South was deflected northward around the Hollow in the usual way. There was considerable structural detail in the South Equatorial Belt Zone.

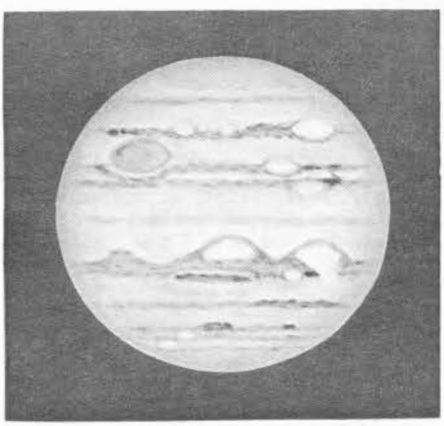

Figure 19. Drawing of Jupiter by Charles Pollak on October 8, 1966 at 8^h5^m, U.T. 8-inch refl., 200X. Seeing 9, transparency 5. Red Spot near left edge of disc. C.M.$_1$= 3°. C.M.$_2$= 74°

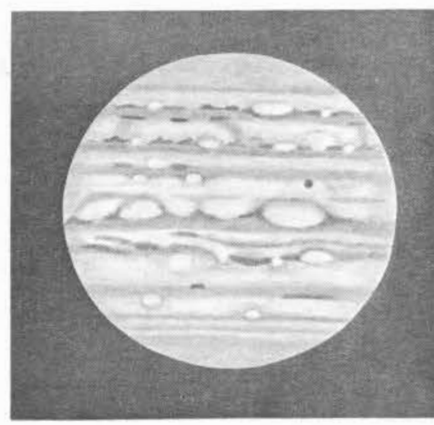

Figure 20. Drawing of Jupiter by Phillip W. Budine on February 7, 1967 at 3^h10^m, U.T. 10-inch refl., 250X and 300X. Seeing 8. Transparency 3. This drawing is the "discovery observation" of a dark streak in the South Tropical Zone. It is shown here crossing the zone diagonally and near the C.M. Note also STeZ oval BC and the shadow of J. I.C.-M.$_1$= 17°. C.M.$_2$= 238°.

******

The data on the preceding page were supplied by one of our members on the basis of a visual inspection of photographs and rough measures. They thus claim no high order of accuracy, and the table is really intended only to enable observers to find these four long-lasting features and in particular to recover them after Jupiter's imminent conjunction with the sun. The use of the table should be obvious enough. Oval FA, for example, would lie near 61° on June 19, near 42° on July 19, and near 23° on August 18.

ANNOUNCEMENTS

Sustaining Members and Sponsors. As of May 26, 1967, we have in these groups:

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Sustaining Members of the A.L.P.O. pay $10 per year; Sponsors, $25 per year. The surplus above the regular rate is used to support the work and activities of the Association.

In Memoriam. We announce with regret the death of Mr. S. Walsom of Port Credit, Ontario, Canada on January 17, 1967. He had been a member of the A.L.P.O. since 1957.

Concerning the A.L.P.O. Library. Mrs. Walter H. Haas, the A.L.P.O. Librarian, has contributed the following note: "The Librarian wishes to thank the National Investigations Committee of Aerial Phenomena, Washington, D.C. 20036 for sending us a copy of their documentary report, The UFO Evidence. We quote from the Assistant Director's letter: "'We hope this information will be helpful to ALPO members and we would welcome queries from any who might like to participate in a scientific investigation of UFO's.'

"We also wish to acknowledge the following publications which we have received from Mr. Douglas Smith of Vinton, Virginia: The Virginia Junior Academy of Science Proceedings; May, 1964; May, 1965; and May, 1966.

"Mr. Smith also contributed a book entitled 'Splendor in the Sky' by Gerald S. Hawkins. These books are all very welcome additions to our library, which now has a total of some 140 volumes.

"If you wish to borrow a book or two, please write to Mrs. Walter Haas, 2225 Thomas Drive, Las Cruces, New Mexico 88001. Books are loaned for one month at a time; the borrower pays the cost of the postage both ways plus 10 cents for handling. A list of available Library books can be obtained by sending a postcard request to the Librarian."

New Address for Mars Recorder. The mailing address of this staff member is now: Klaus R. Brasch - Department of Biology - Carleton University - Ottawa 1, Ontario, Canada. A.L.P.O. members are requested to send all 1966-7 observations of Mars to Mr. Brasch at the address given above as soon as they can.

A.L.P.O. Observing Manual. We receive inquiries about this prospective book, which was edited by Dale P. Cruikshank and Clark R. Chapman. The completed manuscripts were submitted to a well-known publisher of scientific books some months ago, and at this date (May 27) we are still awaiting his reply. It is our hope that the book may be published and made available to A.L.P.O. members and others interested in amateur observational lunar and planetary astronomy this year. The project represents a very considerable amount of work on the part of Messrs. Chapman and Cruikshank and a number of others. The overall plan was to have different chapters on different subjects authored by various specialists within our Association. It can be said without qualification that the book, if and when published, will be an indispensable guide for all serious amateur observers in its selected field and an extremely valuable source of reference material for others.

National Convention of Astronomical League. This meeting will be held at Washington, D.C., on June 30-July 4, 1967. All sessions will be in the new Science Building at Georgetown University, 35th and O Streets, N.W. The program will begin on Friday evening, June 30, with an informal gathering at Copley Lounge, an open house at Georgetown Observatory, registration, and setting up exhibits. The morning of Saturday, July 1 will be given to the opening session, a business meeting, and an address by Father F. J. Heyden, with the title "Atmospheres of the Planets." In the afternoon there will be a general session for papers and a Junior Session. In the evening there will be a session about telescope-making. On Sunday, July 2, the forenoon will be kept open for church attendance and sightseeing. The rest of the day will be occupied with the Middle East Regional Convention and a visit by busses to the Goddard Space Flight Center. At 7:00 P.M. there will be the Convention Banquet in the New South Cafeteria Building. An Astronomical League Award will be presented. The banquet speaker will be Dr. C. L. Cowan, Professor of Physics at Catholic University, Washington, D.C.; and his subject will be "Far Out from Down Under", a discussion of neutrino astronomy. A special feature of the evening will be introductions of past presidents of the League and past recipients of the League Award. On July 3 there will be an A.A.V.S.O. paper session in the morning and an A.L.P.O. paper session in the afternoon. We have ten papers on a variety of lunar and planetary subjects for the latter session. In the evening of July 3 the delegates will visit by bus the U.S. Naval Observatory. On July 4 there will be the final paper session and business meeting in the morning, a visit to the Smithsonian Institution in the afternoon, and fireworks at the Washington Monument Grounds in the evening.

Mr. John E. Westfall, 1530 Kanawha St., Apt. 110, Adelphi, Maryland 20783 is in charge of the A.L.P.O. Exhibit at this meeting. He will welcome photographs, drawings, charts, and similar display material; these naturally must reach him before the Convention begins.

The General Chairman is Mr. G. R. Wright, 202 Piping Rock Drive, Silver Spring, Maryland 20904. Registration fees of $2.00 per person or $3.00 per family should be sent to Mr. Fred Cornelius, 3101 Chichester Lane, Fairfax, Virginia 22030. The pre-Convention registration stood at 205 on April 25, 1967.

LUNAR AND PLANETARY PROSPECTS, JUNE-AUGUST, 1967

Mercury. This planet is at greatest elongation east (24° from the sun) on June 12, at inferior conjunction on July 9, at greatest elongation west (20° from the sun) on July 30, and at superior conjunction on August 24. The June evening apparition and the subsequent July-August morning apparition are both only moderately favorable as regards the position of the planet above the horizon in the dawn or twilight for observers in middle northern latitudes. The first two articles in this issue of The Strolling Astronomer relate to the new 59-day period of rotation for Mercury, and we would again invite interested A.L.P.O. members to make a serious attempt at an optical re-determination of the rotation. Good drawings obtained for this purpose will assist in the needed re-mapping of the planet. It may also prove of interest to compare the observed phase with the geometric one near dichotomy.

Venus. The dazzling Evening Star is at greatest elongation east (45° from the sun) on June 21, at greatest brilliancy (stellar magnitude -4.2) on July 24, and at inferior conjunction at 22^h, U.T. on August 29, when it will pass 8 degrees to the south of the sun. The Venus Section Observing-Forms may be obtained by writing to the Recorder, Mr. Cruikshank. Their use makes the Recorder's work easier and often improves the quality of the observations. Equipped observers are again invited to photograph Venus in ultra-violet light. Visual observers may look for such aspects as the relative conspicuousness of the north and south cusp-caps, the relative conspicuousness of the bordering dusky cusp-bands, the "twilight arc" which extends the cusps around the dark limb when the planet is a narrow crescent, and the visibility or otherwise of the unilluminated hemisphere. Mr. Joel S. Levine will welcome A.L.P.O. data about the unilluminated hemisphere for his studies of possible auroral activity on Venus; see his article in Str. A., Vol. 19, Nos. 9-10, pp. 149-154.

Those who observe Venus within a few days of inferior conjunction should be very careful that they do not accidentally look at the sun through an unshielded eyepiece. Permanent damage to the eye could easily result.

Mars. The Red Planet is receding from the earth, and fairly large telescopes will be needed for good results.

Date	Diameter	Tilt	Heliocentric Longitude
1967, June 15	11"5	+24°	234°
July 1	10.2	+23	243
July 15	9.3	+22	250
Aug. 1	8.4	+20	259
Aug. 15	7.8	+18	267

The vernal equinox of the southern hemisphere of Mars falls at heliocentric longitude 268°, or on August 16, 1967. The usual phenomena of the spring "melting" of the south polar cap may be expected to follow. It will be noted that the north end of the axis of Mars is tipped toward the earth by a large angle during June, July, and August.

Jupiter. This planet will be in conjunction with the sun on August 8. Increasingly poor telescopic views in the evening sky may be expected in June and early July. Some current notes and drawings relating to the Giant Planet may be found on pages 103 and 104.

Saturn. Our ringed neighbor will have recovered his customary appearance since the edgewise phenomena of the 1966-67 apparition. Opposition will occur on October 2, 1967. Thus Saturn will be favorably placed in the morning sky during June, July, and August. The earth will be about 8 degrees south of the plane of the rings during these three months, and the sun will be about 6 degrees south of the same plane. Previous Saturn Reports in this journal can serve to guide the efforts of new observers. The Saturn Recorders would very much like to see more numerical intensity estimates with color filters of different parts of the ball and rings. A good set of filters to use would be Eastman Kodak Wratten Filters 25 (red), 58 (green), and 47 (blue).

Uranus and Neptune. Uranus was at opposition on March 13 and will reach conjunction on September 18. Readers are reminded of Mr. Abbey's program on the satellites of Uranus outlined in Str. A., Vol. 20, Nos. 3-4, pp. 44-45. Neptune was at opposition on May 14 and is thus well placed in the summer evening sky. The following table may help in finding these remote planets:

Object	Right Ascension	Declination
Uranus, June 15	$11^h\ 25^m\ 57^s$	+4° 30'
Uranus, July 15	11 28 58	+4 09
Uranus, Aug. 15	11 34 27	+3 33
Denebola (Beta Leonis)	11 47 23	+14 45
Neptune, June 15	15 21 00	-16 36
Neptune, July 15	15 18 57	-16 29
Neptune, Aug. 15	15 18 39	-16 30
Antares (Alpha Scorpii)	16 27 23	-26 22

Moon. Lunar Recorder Kenneth J. Delano has again furnished a list of favorably placed lunar domes during the coming months. The "Night" column is a double date by local standard times; thus June 15/16 is that night which begins on the evening of June 15 and ends on the morning of June 16. (It would be almost wholly June 16 by Universal Time for lunar observers in the United States.) Mr. Delano uses lunar east and west in the I.A.U. sense, where east is the hemisphere of the Mare Crisium.

Night	Dome	Long.	Lat.	Remarks
June 15/16	-138+447	-08°53'	+26°37'	SE of Beer. Small.
17/18	-566-131	-34 49	-07 32	W. of Euclides.
18/19	-620+452	-44 03	+26 54	1 of 3 N. of Prinz.
19/20	-884-326	-67 33	-19 02	Within Darwin. Large.
27/28	+255+304	+15 32	+17 44	1 of 2 N. of Menelaus.
29/30	-138+447	-08 53	+26 37	SE of Beer.
July 1/2	-510-220	-31 31	-12 43	1 of many near T. Mayer.
2/3	-622+446	-44 03	+26 30	1 of 3 N. of Prinz.
3/4	-643+651	-57 55	+40 38	Rümker.
12/13	+363-130	+21 20	-07 30	N. of Arago.
14/15	-104+316	-06 32	+18 35	N. of Apennines. Large.
15/16	-301-233	-18 02	-13 32	As large as nearby Guericke.
16/17	-458+137	-27 32	+07 53	1 of 7 N. of Hortensius.
16/17	-510+175	-31 00	+10 05	1 of 2 W. of Milichius.
17/18	-630-155	-39 31	-08 55	NW of Kepler. Has a central pit.
19/20	-895+059	-63 37	+03 23	1 of 3 NE of Hevelius.
25/26	+593+131	+36 44	+07 32	S. of Cauchy.
27/28	+160+510	+10 30	+30 42	NW of Linné. Large & flat.
29/30	-218+047	-12 34	+02 43	Between Gambart B & C.
30/31	-458-130	-27 30	-07 29	1 of 7 N. of Hortensius.

Various lunar projects for A.L.P.O. members are described elsewhere in this issue. In addition, Lunar Recorder Charles Ricker invites all interested observers to join an incipient "steep places" program. "A Working List of Steep Places on the Moon" by Joseph Ashbrook, Str. A., Vol. 20, Nos. 3-4, pp. 37-42, will provide the most ambitious lunar observer with plenty of material for several lunations to come.

Mr. H. W. Kelsey calls attention to the curious appearance of Plato shown in Figure 21. He found the sunlit streak on the floor to show a slight enhancement in red light (Wratten Filter 25) as compared to blue light (Wratten Filter 47). By 4^h30^m, U.T. another and parallel streak on the floor had formed farther south; the sunlight was striking the floor through gaps between the peaks on the east rim of Plato. While these appearances are presumably quite normal, they are present for only a short time each lunation and are seldom reported.

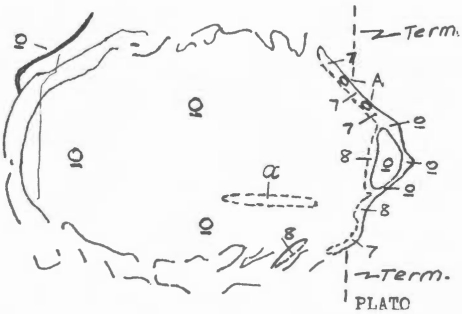

Figure 21. Drawing of Plato by H. W. Kelsey with an 8-inch reflector at 300X on April 18, 1967, 3^h10^m -4^h0^m, U.T. Seeing 8, transparency 4.5. Colongitude = 11°.0 -11°.4. Altitude of sun above center of floor of Plato 1°.3-1°.5. One bright streak on floor within shadow.

*****

Mr. Kelsey wonders whether "lunar transient phenomena" may follow the outbreaks of major flares on the sun. With solar activity rapidly rising, lunar observers should watch regions suspected of such activity a little more closely after a large flare is witnessed. The telephone and amateur radio may prove useful in alerting lunar observers.

With the extremely widespread use of Daylight Saving Time this summer, observers need to be doubly careful in reporting the time system which they use. A suspected error of an hour in the time may make an observation utterly useless or, even worse, ambiguous and confusing. If reporting in U.T., also record in civil system used (e.g., East.Daylight Saving Time).

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Whether your interest in astronomy is amateur or professional, there is something for you in our varied list of Sky Publications, in addition to the monthly magazine *Sky and Telescope* itself. General readers and students will find wide topical variety in our books and booklets; observers from beginner to observatory research worker will have use for one or more of our atlases and catalogues; telescope makers will find valuable instructions for specific instruments from a 6-inch Newtonian reflector to 11-inch Maksutovs; teachers and astronomy club study groups will want ESSCO charts and laboratory experiments (sold in multiple quantities for classroom use); and those who like to adorn observatory, den, or classroom walls will find pictures on every astronomical subject in our six sets of photographs (in total area the 110 halftones cover nearly 90 square feet).

To facilitate the selection of useful items, they are roughly coded into three grades of difficulty, but not necessarily of difficulty. *Elementary* indicates material good for beginners and casual observers, also for naked-eye and binocular observing; *Intermediate* items are especially suited to experienced amateurs and telescope makers; *Advanced* indicates material mainly for advanced amateurs and observatories. This coding is not applied to ESSCO Publications.

Section A — Star Atlases

Elem.	1.	Popular Star Atlas	*Book with text*
Elem.	2.	Constellations from Southern Hemisphere	*Book with text*
Inter.	3.	Norton's Star Atlas and Reference Handbook	*Book with text*
Inter.	4.	Skalnate Pleso Atlas of the Heavens	*Clothbound*
Inter.	5.	Field Edition Atlas of the Heavens	*Unbound*
Advan.	6.	Atlas Borealis (Northern Sky)	*Clothbound*
Advan.	7.	Atlas Eclipticalis (Equatorial Zone)	*Clothbound*
Advan.	8.	Atlas Australis (Southern Sky)	*Clothbound*
Advan.	9.	Vehrenberg Photographic Atlas (Northern)	*Boxed*
Advan.	10.	Vehrenberg Photographic Atlas (Southern)	*Boxed*
Advan.	11.	Atlas of the Selected Areas — I (Northern)	*Boxed*
Advan.	12.	Atlas of the Selected Areas — II (Southern)	*(Boxed)*

Section B — Books

Elem.	1-8.	Macmillan Sky and Telescope Library (three titles published)
Elem.	9-16.	Harvard Books on Astronomy (seven titles)
Elem.	17.	Larousse Encyclopedia of Astronomy
Inter.	18-19.	Lowell Observatory Books on the Planets (two titles)
Inter.	20.	History of the Telescope

Section M — Maps of the Moon and Sky

Elem.	1.	Lunar Map of 326 features (available in quantity)
Elem.	2.	Elger's Map of the Moon (on flexible canvas, and keyed)
Elem.	3.	Color Charts of the Moon (wall display pair)
Elem.	4.	Color Map of the Northern Sky (wall display size)
Elem.	5.	Color Map of the Southern Sky (wall display size)

Section O — Observing Aids and Catalogues

Elem.	1.	Selected List of Star Names (booklet)
Elem.	2.	Philips' 42° North Planisphere (transparent dial)
Elem.	3.	Naked-Eye Stars (booklet listing stars by constellations)
Inter.	4.	Arizona-Tonantzintla Catalogue of 1,325 Bright Stars
Inter.	5.	Visual Observing of Double Stars (booklet)
Inter.	6.	Atlas Catalogue (book of data)

Section S — Sets of Astronomical Photographs

Elem.	1-3.	Sky Sets I, II, and III (24, 24, and 18 pictures)
Elem.	4.	Jumbo Sets (16 double-size pictures)
Elem.	5.	Moon Sets (18 pictures of first and last quarters)
Elem.	6.	Lunar Crescent Sets (waxing and waning crescents)

Section T — Telescopes and Cameras

Elem.	1.	Telescopes for Skygazers (book)
Elem.	2.	Outer Space Photography for the Amateur (book)
Elem.	3.	Making Your Own Telescope (6-inch reflector)
Advan.	4.	Construction of a Maksutov Telescope (booklet)
Advan.	5.	Gleanings Bulletin C (Maksutov reprints)

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Elem.	1.	Dictionary of Astronomical Terms (book)
Inter.	3.	Relativity and Its Astronomical Implications
Elem.	4.	Astronomy on Stamps (reprint)

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SC1	Equatorial constellation chart — with star designations
SC1T	**Test** equatorial chart — **without** star or constellation names
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SC2T	**Test** circumpolar chart — **without** star or constellation names
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S508B	Ecliptic star map list — positions and magnitudes of 224 stars
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