The Strolling Astronomer

ASSOCIATION OF LUNAR AND PLANETARY OBSERVERS

VOLUME 7, NUMBER 4 APRIL, 1953

In This Issue

THE STROLLING ASTRONOMER
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THE

STROLLING ASTRONOMER

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NOTICE: In order to facilitate the reproduction of drawings in future issues readers are requested to exaggerate contrasts on drawings submitted. Extremely faint marks cannot be reproduced. Outlines of planetary discs should be made dark and distinct. It is not feasible to reproduce drawings made in colors. Following these precepts will permit better reproductions.

S T A F F

ANNOUNCEMENTS

CORRECTIONS TO MARCH, 1953 ISSUE. On pg. 41, left column, line 13 read "horizontal", not "vertical". Our publishers decided to make the long dimension of Figure 10 on pg. 40 vertical, but this circumstance was not known to the Editor when he wrote the text. On pg. 43, right column, lines 33-34 read "Physics by Hausmann and Slack."

COMING CONVENTIONS. A tasty diet of astronomical fare awaits the amateur able to arrange his vacation to attend one or more of the conventions scheduled for the coming summer and autumn. The Astronomical League will convene at Washington, D.C., over the Labor Day weekend, September 4-7, 1953. The hosts will be the National Capital Astronomers, and the place will be the Carnegie Institution of Washington. The program will include papers on subjects of interest to amateurs, amateur astronomical exhibits, and trips to the Naval Observatory and the Naval Research Laboratory at Anacostia. Contributions of papers and exhibits are requested. Two bulletins have already been released about this Convention. Those desiring further information should write to the Registration Chairman, Mrs. Ione Alston, 20 Plattsburg Court, N.W., Washington 16, D.C., best of all sending in the registration fee of $1.00 before June 1 or $1.50 from then until July 1. We are sure that all who attend will enjoy the League Convention very much.

The various Regions of the Astronomical League will also be holding Conventions during the coming months. Our growing list of subscribers in Texas and neighboring states will be especially interested in the Convention of the Southwest Region at Fort Worth on June 19 and 20. The Convention Manager is Mr. A. W. Mount, 4326 Birchman St., Fort Worth 7, Texas, to whom inquiries should be addressed. The program will include a wide selection of papers, exhibits, a discussion by a panel of experts, and a visit to the Childrens' Museum, whose outstanding display at the League Convention at Dallas in 1952 is remembered by all who were there.

The Convention of Western Amateurs will be at Los Angeles on August 14, 15, and 16 on the beautiful U.C.L.A. campus. The Los Angeles Astronomical Society are Hosts and assure us that this Convention will be the "biggest and best" on the West Coast to date.

SPACE MEDICINE: THE HUMAN FACTOR IN FLIGHTS BEYOND THE EARTH. The amateur interested in space travel - and what amateur doesn't have some ideas on this fascinating subject these days? - will very much want to read the little book of this title. It can be obtained from the University of Illinois Press at Urbana for $2.00. The six chapter titles, each written by an expert in the field it treats, will perhaps sufficiently indicate the contents: Space Medicine in the United States Air Force, Multi-Stage Rockets and Artificial Satellites, Physiological Considerations on the Possibility of Life Under Extraterrestrial Conditions, Astronomy and Space Medicine, Orientation in Space, and Bioclimatology of Manned Rocket Flight. The book is the outgrowth of a symposium held by the University of Illinois in March, 1950. It will supply a very interesting and instructive evening's reading.

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PERSONAL. The Editor is planning to spend a short vacation in England in June, where he hopes to meet at least some of those British colleagues who have contributed so very much to the A.L.P.O. He will spend much of his time near London and will inform Mr. H. Percy Wilkins, 35 Fairlawn Ave., Bexleyheath, Kent, England of details as they are worked out. The Editor will be absent from Las Cruces during much of June, and it will not be practical to forward mail, Therefore, matters requiring urgent action during June should be addressed to David P. Barcroft, Secretary A.L.P.O., 1203 N. Alameda, Las Cruces, New Mexico.

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IN MEMORIAM

We learned with sorrow of the recent death of one of our members, Mr. D. Darrock of Christchurch, New Zealand. We extend our sympathy to his survivors and friends. We regret knowing little of Mr. Darrock; he had belonged to the A. L.P.O. for several years, and we understand that he was a cripple in his last years. It was, of course, gratifying to us to know that THE STROLLING ASTRONOMER was doing something to maintain interest in astronomy in distant New Zealand, where indeed much very praiseworth astronomical work has been done. If any of our readers knew Mr. Darrock, we should be glad to learn more about him.

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FOR THE BEGINNER: THE COMPUTING AND USE OF COLONGITUDE.

(Conscious that a large portion of our members are fairly new to the A.L.P.O. and in part also fairly new to the special problems and vocabulary of the lunar and planetary specialist, we are thinking of running each month a short article on some elementary aspect of our studies. We should be glad to hear from our readers what they think of this proposal; its future will depend upon the interest shown. In this issue we describe the widely used concept of colongitude.)

The greenest tyro learns very quickly that the aspect of a lunar region changes very greatly with the changing solar lighting. It hence becomes important to have some measure of this solar lighting, and in close studies of whether or not certain apparent lunar changes should or should not be ascribed to changing solar lighting a fairly exact measure of the solar lighting is a necessity. One might first try to employ the phase of the moon as given by its age in days. The moon's age has been so used, and is indeed still so used; nevertheless, it is a very rough and inadequate measure because of the moon's libration in longitude (see any text). In an extreme case at the same age of the moon a crater on the lunar equator might be unilluminated at one time and might have the sun 15 degrees above its horizon at another time. Therefore, we must seek a measure of solar lighting independent of the earth's position in space. Such a measure is colongitude. It may be thought of as the lunar eastern longitude of the sunrise terminator, measured at the equator of the moon from the center of the disc at mean libration always toward the lunar east. At mean libration in longitude the colongitude is 0° at first quarter, 90° at full moon, 180° at last quarter, and 270° at new moon. It may be as much as almost 8 degrees on either side of these mean values, however.

The computing of colongitude requires only the most trivial mathematics, but it does require the current annual volume of The American Ephemeris and Nautical Almanac or its equivalent. The Ephemeris is sold by the Superintendent of Documents Washington 25, D.C. for $3.75 (cloth). Colongitude depends, of course, on time; and hence a first step is to convert the recorded time of the observation into the Universal Time used in the Ephemeris. To do so, add 12 hours for P.M. observations; and then also add 5 hours if you use E.S.T., 6 hours if C.S.T., 7 hours if M.S.T., and 8 hours if P.S.T. The U.T. date is thus sometimes one day later than the local date. For example, 8 P.M. by E.S.T. on May 10 is 1^h on May 11 by U.T. Again, 11 P.M. by C.S.T. on May 10 is 5^h on May 11 by U.T. Also, 2 A.M. by P.S.T. on May 11 is 10^h on May 11 by U.T., the date here remaining the same.

The colongitude is given at 0^h, U.T., for each day in the present year in the sixth column on pp. 446-453 of the 1953 Ephemeris. It increases at an almost uniform rate of 0.°51 per hour. This rate may usually be thought of as half a degree per hour or one-tenth of a degree in 12 minutes. We now give a couple examples of the computation of colongitude.

1. Find the colongitude at 9:12 P.M., E.S.T. on May 16, 1953.

The U.T. is $2^h\ 12^m$ on May 17.

Colongitude at 0^h on May 17 (1953 A.E.)	312.°03
Increase in 2 hrs. (0.°51 x 2)	1.°02
Increase in 12 mins. (0.°51x12 ÷ 60)	. 10
Colongitude at $2^h 12^m$ on May 17	313.°15

This result would almost always be rounded to 313.°1.

2. Find the colongitude at 11:10 P.M., P.S.T. on May 19, 1953.

The U.T. is $7^h\ 10^m$ on May 20.

Colongitude at 0^h on May 20 (Ephemeris)	348.°71
Increase in 7 hrs. (0.°51 x 7)	3.°57
Increase in 10 mins. (0.°51x10 ÷ 60)	0.°08
Colongitude at $7^h\ 10^m$ on May 20.	352.°36

We would round to 352.°4.

We sometimes want to work the problem in reverse and to find the time corresponding to a given colongitude. One example should suffice.

3. An observer using C.S.T. wants to observe Conon at Colongitude 152.°2 in June, 1953. When should he go to his telescope?

We find by inspecting the Ephemeris for 1953 (pg. 449) that at 0^h, U.T., on June 2 the colongitude is 147.°26. Subtracting 147.°26 from 152.°20, we have a needed increase of 4.°94. Dividing 4.°94 by 0.°51, the increase in an hour, we find 9.69 hours or 9 hrs., 41 mins. Hence, the U.T. is $9^h\ 41^m$ on June 2; and the C.S.T. is 3:41 A.M. on June 2.

Colongitude is not a perfect measure of the solar lighting of a lunar crater; for greatest accuracy one should also supply the sun's selenographic latitude, given in the seventh column on pp. 446-453 of the 1953 Ephemeris. However, colongitude alone is usually quite sufficient. Another possibility, longer but giving a very complete picture of the solar lighting is to compute the altitude and azimuth of the sun in the lunar sky from the sun's selenographic colongitude and latitude in the Ephemeris and the lunar latitude and longitude of the position on the moon selected. Spherical trigonometry is used. The resulting formula for the sun's altitude may be found on pg. 633 of the 1953 Ephemeris.

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SOME OBSERVATIONS ON THE MOON'S EAST LIMB TOGETHER WITH A NOTE ON THE FORMATIONS MESSIER AND PICKERING.

by R. M. Baum, F.R.A.S.

The limb-area towards the east of the great formations Grimaldi, Riccioli, and Sven Hedin has, in common with the limb regions in general, been a neglected zone by observers, with the subsequent result that relatively little is known of the topography of this interesting region. This apparent lack of knowledge persuaded the writer in conjunction with that excellent astronomer Mr. P. A. Moore, F.R.A.S., to embark upon a cooperative study of this region, with the intent to produce a first outline chart of a region that had not been mapped before, so far as was known. In consequence of this plan, therefore, throughout the years 1947 and 1948 considerable attention was devoted to the positioning and delineating of the formations of this magnificent lunar region. The aggregate total of drawings executed by Moore and the writer came to 100. Subsequently in 1949 these drawings were combined into a chart, which was eventually published in the B.A.A. Memoirs, Vol. 36, Part 3, pg. 8, together with a short paper written by Mr. Moore.

Since the publication of this, the 1947-1948 series has been reexamined, and closely compared with some more recent observations. There resulted from this restudy several points of great interest relative to the physical aspect of the area, the details of which are now more fully set down for the examination of intending observers. First, however, a brief recapitulation of the earlier work may prove of some small interest to those not fully acquainted with it.

The region studied extends from 70° E. Longitude to the confining limits of the farther eastern boundary of the libratory margin. In latitude the area covered lies between 10° S. and 10° N. Bounding this strip on the west tower the rugged ramparts of Grimaldi and Riccioli, while northward rise the complex, broken walls that encompass the plain of Sven Hedin and the smaller ringwall Olbers. Eastwards from these celebrated formations the only other notable specimens of crateriform character that are marked on the existing mean libration charts are those to which Wilkins has given the names Buss and Lowe, which features can be found on Section XIX of his great map. Goodacre on his map also gives these but does not name them. Certain indefinite indications are also given of these rings on J.F.J. Schmidt's fine chart published in 1878. Apart from these, then, no notable features are shown on the classical maps, which are as mentioned before drawn for mean libration, between Buss and Lowe, and the mean limb. The discoveries that were subsequently made do not imply that, though not charted on the published maps, in view of their extreme position, they have never been seen before. No doubt there may exist in old record books many observations relative to the farther eastern marginal belt, which have never been published. Bearing this matter in mind, therefore, we may proceed to examine the recent studies in some detail.

Perhaps the most important revelation arising out of the study was the detection in September, 1947, of two large ringwalls east of Buss and Lowe of fine appearance. Previous to this, the existence of such objects so far east had not been fully known to either Moore or the writer, and it was only natural that in such circumstances confusion should arise over their similarity to Buss and Lowe. So for some little time considerable doubt existed over whether or not the rings were actually "new", it being suggested that they were in actual fact Wilkins' twin craters. However, these doubts were finally dispelled in 1948, when the elusive ringwalls Buss and Lowe were observed by the writer on March 24 at 21^h, U.T., When the terminator lay immediately east of them. Thus with the new rings truly recognized as such, it became evident that in view of their grandeur, it would be fitting for them to be named. In this naming the final choice was that the southern ring should be called Bolton, after an observer of considerable skill, and the northern after another skillful selenographer, Dr. S.M. Green. These names were suggested with some diffidence; but as the rings belong more to the other side of the moon than to the more familiar face, it was considered imperative to avoid the confusion which other observers might experience when first surveying the area. With this fact in mind, therefore, the names of Scriven Bolton and Dr. S. M. Green, who are no longer among us, seemed appropriate in the extreme.

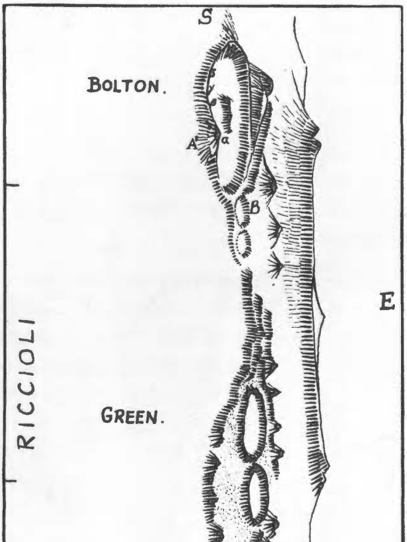

Figure 1. Chart of Craters East of Riccioli on Moon's East Limb by R. M. Baum.

Study of the profile drawings of the mighty D'Alembert Mountains revealed very interesting and curious mountain structures, in places rising to some 20,000 feet. From a close examination of a total of 50 profile curves, secured at different libration conditions, it was eminently evident that the highest peaks lie to the east of the ringwalls Bolton and Green, and that in all probability the greater part of the range lies on the averted lunar hemisphere. Such a contention arose from a close scrutiny of the cruves taken at extremely favorable conditions of libration in longitude and latitude.

Finally, some indefinite indications of a lunar mare were registered as lying west of the ring plain Green.

Such were the first results arrived at. The later ones reached from more recent observations and a fresh study of the earlier work are now given as a supplement to the details already published.

BOLTON (new name proposed). A fine mountain ring about 40 miles in diameter, lying east of Lowe and owing to its extreme position, always much fore-shortened. The walls do not rise to any great altitude, though the summit on the west is broken by four peaks α , β , γ , and δ , the foremost being the most noticeable. On the west the exterior glacis is broad and not easily defined - containing a curious formation marked A'. This latter feature is well shown on a drawing taken 1951, January 22, $18^h\ 45^m$, U.T., by the writer; it is also depicted upon a sketch by D.W.G. Arthur, 1947, November 27, at colongitude 88.°0. An aperture of only three inches will show A', but a larger instrument is needed to determine its nature precisely.

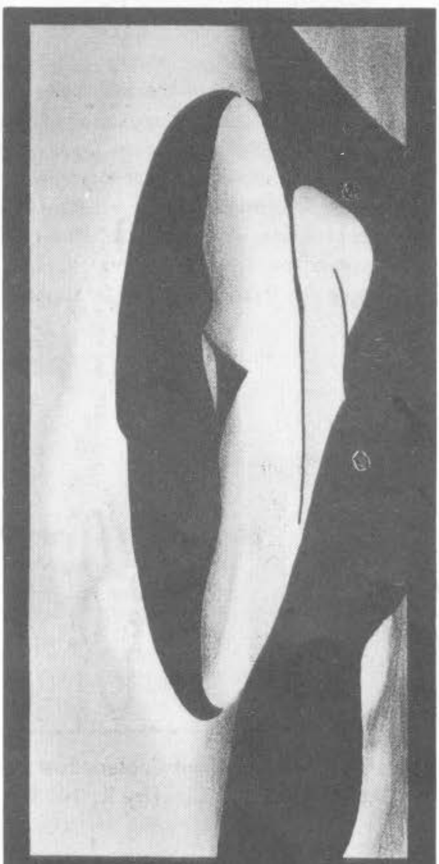

Figure 2. Crater Bolton
R. M. Baum.
January 22, 1951. $18^h 45^m$, UT
3-inch refr. 100X.
Colongitude = 88.°8.

The southern section of the east wall is almost regular, no irregularities having as yet been detected to break its uniformity. Indeed the summit of the wall is very difficult to detect, owing to the great brightness of the interior slopes and the slightness of the shadow cast. Seemingly this east wall would appear to be very little above the terrain to the east. Outside here towers a lofty rounded mountain mass, which appears to consist of a higher southern mass, with precipitous slopes, and on interesting adjoining bank-like mass, northwards - with a much serrated summit. The northern exterior glacis is extended by a gently sloping ridge, running northwards for some distance.

Upon the convex, light-gray floor, which brightens considerably towards high noon on the formation, rises a massive central mountain, with a flattened summit. The base of this mountain appears convex, indicating the possibility that it can possibly be a small crater whose western walls are hard by the western interior slopes of Bolton.

Outside the region to the northeast, at B, contains several meridional ridges suggesting a series of shallow valleys. To the south lies a small pear-shaped crater, Bolton A - the northern exterior glacis of which connects up with the southern outer slopes of the major formation.

GREEN (proposed new name). Slightly larger than Bolton, and north of it. Comparing the two rings, one is left with the impression that Green is by far more irregular, and more open than its southern counterpart. Generally the walls are lower though three lofty peaks rise on the west, while four more rise upon the east wall, three on the southeast, and one on the northeast. The floor is darker [than that of Bolton] , and contains what appear to be two large crateriform objects, which when on the terminator at sunrise give the impression of a longitudinal mountain chain.

Outside, to the east, lies a deep valley, running between two towering masses. On the west, between Buss and Green, a dusky streak-like feature has been noted frequently. Running southwards from the ring and apparently connected to the walls extend two parallel mountain arms of considerable altitude, and of rugged appearance, their summits being broken up by several peaks.

Farthest Peaks of the D'Alembert Mountains. At times of maximum libration in longitude there appears upon the limb what the writer considers to be a mighty ringwall seen in profile - such is the only explanation which can be afforded it. A central peak rises above the depressed curve of the walls, while suggestions of

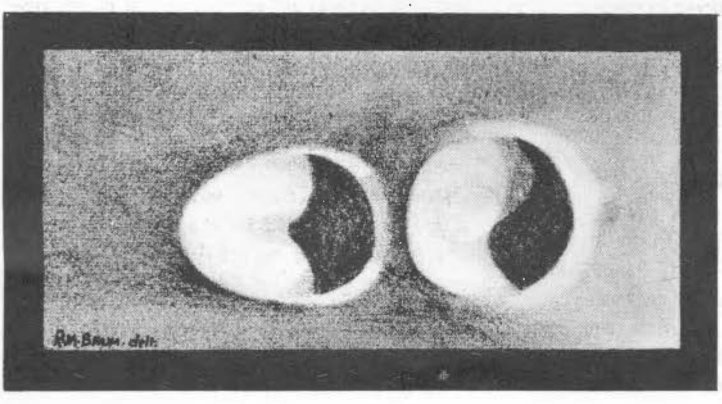

Figure 3. Craters Messier and Pickering. R. M. Baum. November 15, 1951. $20^h\ 45^m$, U.T. 6.5-inch refl. 216X. Colongitude = 112.°5.

outer terraces become evident under good seeing conditions. Upon Figure 1 the position of this formation is given, as is also its appearance. In front of this "ringwall" tower some lofty mountains, whose slopes run into these peaks, lying due east of Green. Seemingly the valley detected by Mr. Moore, mentioned in the description of Green, cuts through these ranges and extends to the outer western slopes of the great ringwall.

Note on Messier and Pickering. While observing these well-known formations on November 15, 1951 at 20^h45^m, U.T., the writer found the shadows in both rings to be not black, but in Pickering grayish black, with a diffuse boundary, and in Messier, grayish brown, but much sharper than in Pickering. (Figure 3). Within Pickering a nebulous white spot, glistening with a bluish white radiance, showed upon the inner western slopes. A similar, though duller, spot existed in Messier.

Could the diffuse character of the shadows have been due to some local atmospheric cause around and within Pickering?

[One of our leading contributors, Mr. Baum is a very active lunar and planetary observer in the British Astronomical Association. His address is 1 Dee Banks, Boughton, Chester, England. He will be glad to correspond with other A.L.P.O. members about our mutual studies. The twilight-like appearances in Messier and Pickering are not the first such to be recorded there. It would be very worthwhile for our observers to examine closely the appearance of the evening shadows in these twin craters. - Editor.]

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PETAVIUS

by H. Percy Wilkins, F.R.A.S.

By the kind permission of Prof. Redman and with the assistance of Dr. W.H. Steavenson, I have been able to observe with the 25-inch refractor and the 30-inch reflector at Cambridge University Observatory. Among other lunar formations studied with these fine instruments is Petavius, which was observed on October 3, and again on December 3, 1952, the latter under a slightly higher illumination. The latter drawing is now reproduced as Figure 4.

I do not profess to have inserted all the details seen; the western portion of the interior in particular was literally covered with mounds, ridges, and landswells while on the floor, in general, were various clefts ridges, slight depressions, and mounds. The great cleft from the central mountains gleamed white and is crossed by a distinct ridge. [In a letter dated February 4, 1953, Mr. Wilkins described this "ridge" as "a fault, with a drop on the east, may be a cleft at its foot."] At the point where this ridge joins the cleft a craterlet was discovered on October 5, 1952, using the 30-inch reflector and 300X.

From a crater to the north of the central mountains a cleft runs north and there is another on its west. The great cleft is continued beyond the mountain group as a fine ravine, confirmed by Dr. Steavenson. For the numerous other features reference should be made to Figure 4, which drawing was made on a previously prepared outline. This method greatly conduces to speed of drawing and to the number of sketches that it is possible to complete in a given time.

I wish to acknowledge the invaluable assistance given by Dr. Steavenson in preparing the instruments for observations and placing both giant telescopes at my disposal for lunar and planetary work.

[The preparation of outlines for drawing before going to the telescope is indeed a time-saver and also increased accuracy; for coarse detail certain to be seen can be inserted on the outline, and time at the telescope is thus saved for the finer markings. The outlines may be partly or wholly based upon photographs. - Editor.]

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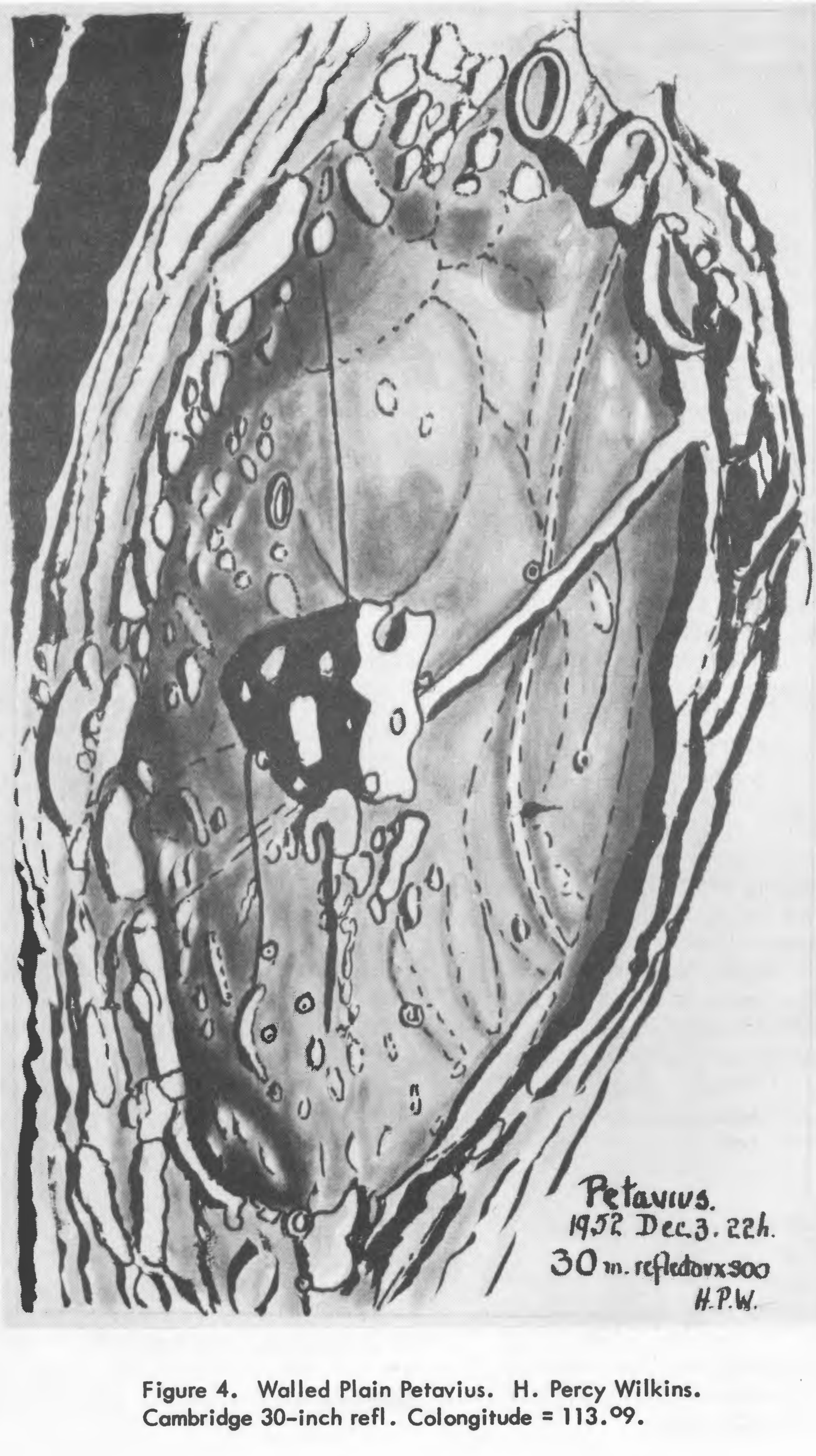

Figure 4. Walled Plain Petavius. H. Percy Wilkins. Cambridge 30-inch refl. Colongitude = 113.°9.

SATURN: A GENERAL DISCUSSION OF WHAT NEEDS TO BE DONE.

by Thomas A. Cragg

It is apparent that numerous people feel that a very large telescope is required to do serious work on the planet Saturn. Obviously, a large aperture is a help, but is not an absolute necessity for quite a few very interesting and worthwhile projects. During the 1951-52 apparition festoons, spots and humps in the N.E.B., and colors were observed consistently with instruments as small as 3.5-inches in aperture.

The standard nomenclature of Saturnian details may be found in The Strolling Astronomer, Vol. 6, No. 11, pg. 158, 1952. The primary difference between the present apparition and the last one is the higher tip of the rings to our line of sight; the rings now completely hide the S.E.B. The following are only a few of the more important items which one can study with a small instrument:

1. Observe and record central meridian transits of spots (light or dark) and the bases of festoons.
2. Study color changes in the belts and zones with filters of known transmissions. (Refer to article The Filter" in this issue.)
3. Record the relative intensities of the various features.
4. Observe closely high latitude spots and festoons to determine the rate of rotation of Saturn in higher latitudes.
5. Observe the relative color of each ring-arm.
6. Determine how close to opposition the shadow of the ball on the rings can be detected.

Observers with larger telescopes may attempt the following:

1. All the items mentioned above.
2. Measure the latitudes of the belts and zones on photographs, on carefully made drawings, or best of all on the planet itself with a filar micrometer.
3. Look for various minor divisions in the rings.
4. Determine how far inwards toward the ball the inner edge of the Crape Ring extends.
5. Watch for a possible dusky ring outside of Ring A.

Let us further stress the tremendous importance of markings in higher latitudes as these rotation rates are not known at present with very much accuracy.

In the form of an announcement it should be added that Mr. A. P. Lenham of England has already observed several humps on the south edge of the south component of the N.E.B., any one of which is very suitable for determining rotation rates.

Saturn is, of course, now well placed in the evening sky.

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THE FILTER

by James C. Bartlett, Jr.

"Things are not always what they seem"
Phaedrus, Book IV

When is a gray planetary marking not gray? Answer: When it is brown. But this is not a compendium of riddles.

Perhaps no science owes more to color than Astronomy. Color has been the magic key which has unlocked many doors to the understanding of stellar physics. When the color of a star is taken, the astrophysicist can at once make more or less valid assumptions about that star's temperature; and when he examines the position and number of lines in its spectrum he can also deduce many facts about its physical constitution. Moreover, by the relation of temperature to apparent magnitude he can determine the intensity of its radiation per square unit of surface and thus obtain the volume. Finally, by measuring the shift of the spectral lines toward the violet or the red end of the spectrum, he can not only tell whether the star is approaching or receding from us but also its velocity.

The planetarian's interest in color is of a different order. Because planetary and lunar colors are secondary colors, i.e. not emission colors, they cannot tell us anything about the temperature or physical constitution of the bodies on which they occur - at least not directly; but they can tell us something about the nature of the planetary surface. A highly colored, bright orange red surface which does not share in obvious seasonal variations going on in adjacent dark areas can hardly be anything but desert; and we might reasonably go a step farther and say that such a desert is composed of materials high in ferric iron. Considerably more stirring possibilities are presented by seasonal changes whereby dark areas, as on Mars, develop green-blue tints in response to the season. Here color becomes an index of living organisms; for it is impossible to contemplate the fresh green of the Martian spring without recalling to mind the vernal flush of Mother earth. Again, the sombre reds, browns, and purples of Jupiter's belts all tell us that here a very different order of things obtains.

For the practical observer, however, it is not enough merely to speculate upon what colors may mean, he is often equally concerned with the problem of how he may see them. This is because planetary colors, with few exceptions, are rather negative and tend to gray off because of the great distances involved. Moreover, the smaller the aperture the less obvious will be the color of faint tones on the one hand or intensely dark ones on the other. To perceive such colors the very largest aperture is required.

The times being what they are, very large apertures are seldom found in individual hands; but let the average observer take heart. For a very moderate outlay he can equip his small telescope with accessories which will show very delicate shadings of color. Such accessories are color filters.

What is a color filter? It is the optical analogue of the semipermeable membrane; and like the latter it passes some things and stops others. Thus a red filter passes red light but stops blue; a blue filter does the reverse. A violet filter passes violet and much of the blue end of the spectrum; but it shuts out the warm colors in the orange and red.

Now this property of filters, i.e. selectivity, enables the owner of a small telescope to "see" colors which otherwise he would not; but it is necessary to understand that he "sees" them in a rather indirect way. For contrary to what is often supposed, such filters do not make an obscure color evident as color; but rather they unmask the nature of the color by the filter's effect upon its intensity.

Let us take a practical example. An observer has equipped himself with three filters; red, green, and blue. He is examining Jupiter and suspects that the NEB may possess a reddish tinge; but the belt chances to be so intensely dark that he cannot be sure of his impression. Switching on the blue filter, he discovers that the belt has now lost all color and appears black. This, however, does not prove that it is reddish; but only that it is of some color which darkens in blue light. However, this does tell him at once that it is one of the warm colors and that the hue will be found somewhere in the red end of the spectrum. Next, he switches to the red filter. The belt now appears somewhat grayish and less intense. He now knows that the true color is one which looks darker to a blue filter and lighter to a red one. Finally he makes an examination in green and notices a faint suggestion of orange-brown. The true color of the belt, therefore, is one which looks black to blue light, grayish to red, and brownish to green; and if the observer is familiar with the relation of his three filters to red, he is able to say that the belt is definitely of some dark reddish hue, probably a reddish-brown. Thus his optical impression is confirmed.

Filters also enable us to "see" colors where none is even suspected; and thus they enable us to make colorimetric observations of such unpromising objects as Venus and the moon. Let us take the case of Venus, the markings of which commonly appear - when they can be seen at all - in tones of gray. If we find such markings equally intense in red, blue, and yellow light, then we may suppose that they are gray in fact; but should they become notably darker in red light, then we would know that the true hue was one of the cool colors and therefore to be found in the blue end of the spectrum. The moon lends itself especially well to filter colorimetry, inasmuch as few eyes can perceive any native color at all. A filter, however, will quickly reveal the presence of color in many surfaces which appeared to the eye in varying tones of gray, ranging from a neutral gray almost to black.

It is not only possible thus to unmask color when actually present; but by comparing results obtained with several filters it is also possible to determine the family to which the unmasked color belongs; and if the observer is thoroughly familiar with the relation of his filters to extensive color charts, then he can make a very reasonable estimate even of the shade.

What is the nature of such color charts? They are simply printed squares or circles of standard colors, and their hues, seen against a white background.

How are they to be used in connection with astronomical filter work? By using them to test the appearance of any given color, and its hues, to the several filters. By practice one very soon learns how given colors appear as seen through a red, blue, or other filter. Finally, by removing the charts some distance from the eye, e.g. by hanging them at the end of a long hall, one gains some notion of the effect of distance. When one has become thoroughly conversant with how a given color, or shade, appears to three or more filters, then it becomes fairly simple to identify that color in a planetary marking which, to the unaided eye, may simply appear grayish or blackish. Naturally the more filters one employs the greater is the accuracy with which one can isolate a given color, and the wider is the range of hues one can detect.

A few general rules of filter behavior may now be briefly considered. A warm color will darken a cool one, and vice versa; e.g. red light will darken blue and greenish tones; blue or green light will darken reddish tones. A very pale color is difficult to determine, since it will more or less perfectly assume the color of the filter. Light yellow is such a color. Through a red filter it looks whitish- red. Through a green filter, whitish-green; through a blue filter a pale whittish-greenish-blue and so on.

The performance of the filter is affected by the aperture of the telescope, the power, and by the apparent magnitude of the object. Aperture should be at least 2 inches, and the larger the better. High power is to be avoided because the intensity of the image is thereby diminished. For the same reason apparant magnitude is a crucial factor. On a very dim planet, such as Uranus, fine determinations of delicate shadings will in general be impossible - unless the aperture of the telescopes is correspondingly large. Filters, like all other optical instruments, have optimum light requirements for given performance.

Finally, one may wish to know where to obtain good color filters, how to apply them to the telescope, and what they cost. Kodak Wratten filters are very good and with proper care will last indefinitely. They may be obtained at any camera shop and come in a fairly wide range of colors including violet. The cost is relatively low, ranging perhaps from two to five dollars per filter depending upon size and color. At the same shop one may also obtain a filter ring, by means of which the filter may be adapted to the telescope. This is an open ring designed to slip over the objective lens of a camera and thus hold the filter in place. These rings may be obtained in several sizes and some, I think, are adjustable. At the telescope the ring would be slipped over the eyepiece and the filter dropped into place. With a little ingenuity such a ring can easily be contrived. If one's choice is limited, filters in the three primary colors should be selected, viz red, blue, and yellow. The best two would be red and blue. The best single choice, either red or blue. If circumstances permit, one should add orange, green, and violet to the three primary colors.

Color charts, showing samples of various colors, may be obtained from any artists' supply house and should be selected with a view to obtaining as many colors as possible. Such charts should be carefully guarded against direct sunlight, as by leaving them in a room near a window, lest the colors fade.

Thus equipped the observer is in position to determine the characteristics of his filters in relation to any given color as shown on the chart; and when he has mastered this technique he is ready to apply them to serious - and very absorbing - work at the telescope.

POSTSCRIPT BY EDITOR. Dr. Bartlett wrote this article in response to an editorial request, one of our leading observers having asked for information on how to use color filters and where to obtain them. We think that others will find the information given helpful, and we hope that the article will encourage A.L.P.O. members to use such filters more. If it does, it will have served its purpose.

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THE LIMITS OF TELESCOPIC RESOLUTION: A SYMPOSIUM.

(continued from March issue)

Foreword. Some published drawings of Jupiter III, or Ganymede, caused Mr. John Mellish, the veteran telescope maker, to offer some comments on optical limitations of our views of planetary detail. These ideas were so basic that they were circulated among a number of A.L.P.O. members known to be interested. This paper is a summary of the comments and contributions made by various persons. It might be profitable to reread pp. 42-44 of the March issue before continuing.

FURTHER REMARKS BY E. E. HARE. Mr. Hare accepts Mellish's explanation of the "black drop" and does not consider that Rosebrugh's failure to see a similar "bright drop" at the tangential occultation of Mars need disprove Mellish's theory; it may instead merely confirm that diffraction effects are different on bright and dark detail. Hare concludes: "From these considerations I believe it can be claimed that as far as the telescope concerns the matter there is no clear-cut limitation on how small a black mark will look to be, and if the contrast is excellent, as with Saturn, it is certain that the eye can perceive and register a black line very fine indeed. However, it seems that we all pretty closely agree with Mr. Mellish when it comes to bright planetary detail that such features look no smaller than a faint star in the same telescope."

C. B. STEPHENSON OFFERS SOME EXPERIMENTAL EVIDENCE. Mr. Stephenson says in part: "With regard to the telescopic appearance of dark markings below the conventional [Dawes] limit of resolution of the telescope, I should say that, in my opinion, Mr. Hare's remark, that in observing dark markings one is dealing with deficiences in a field of light rather than with radiation of black light, is most pertinent. Undoubtedly many observers do yield to the perhaps natural tendency to draw planetary features too sharp and narrow, but O'Toole's comments regarding the appearance of Ganymede with a 6-inch telescope, and Reese's discussion of the appearance of Cassini's division seem to provide rather damaging evidence against the proposal that all dark features below the Dawes limit must be imaged by the telescope as of identical size.

"The present discussion made me decide to test for myself, observationally and under controlled conditions, the idea that Mr. Johnson's computations [to be mentioned later] appear to have sustained, that a difference in size should be detectable for dark features smaller than the traditional Dawes limit, and Airy disk. For this purpose a sheet of white paper was prepared containing a number of pencilled lines and dots of nearly equal intensity, as follows: four parallel lines of varying separation, with widths of about 0.4, 1.6, 2.5, and 4.4 millimeters, arranged in no particular order, a tapered line 3.3 mms. wide at one end and about 0.6 mm. at the other, six dots of approximately 0.4, 0.9, 1.5, 2.3, 3.4, and 3.5 mms. diameter, arranged in a random pattern, two parallel lines in blue-black ink around 1.6 mms. in width with centers 3.2 mms. apart, and two inked dots of about 1.6 mm. diameter on centers 3.2 mms. apart. A 4-inch F:12.5 refractor was used for the tests, diaphragmed to about 0.83 inches in order that manageable distances and available magnifications would be adequate. The Dawes limit for the telescope was then 5."5..... Mr. C. E. Gasteyer also participated in the tests, and paced off the distances; over the distances that could be measured directly we found that his pacing was quite sufficiently accurate for our purposes."

The initial distance used was 400 feet, chosen so that the centers of the inked dots and lines would be separated by the Dawes limit. At this distance some of the features were above the limit of resolution; and others, below. The dots had diameters of 6."1, 5."9, 4."0, 2."6, 1."6, and 0."7. The three smallest were invisible with powers of 50X and 100X; and the other three differed in size in the correct order, though accurate estimates of the ratios of diameters were impossible. The inked dots were 2."7 in diameter and 5."5 apart at their centers. They were easily visible but quite unresolved with 50X and 100X, a slight elongation being seen with the higher power. The two lines 2."7 wide and 5."5 apart at their centers were also unresolved; they would have been depicted as a single line 5 or 6 seconds wide with a slight drop in intensity towards its center. The uniform lines had widths of 7."8, 4."3, 2."8, and 0."7, and the tapering line varied from 5."7 to 1."0. With 50X the broadest line was readily seen to be broadest. The 4."3 and 2."8 lines looked equally wide, but the 4."3 line looked considerably the darker. The 0."7 line appeared very diffuse and would probably have been falsely supposed to be wide and diffuse; it appeared about 3/4 as wide as the 2."8 line. The tapering line seemed to be of sensibly uniform width, though varying greatly in intensity from one end to the other (Gasteyer agreed); it was a trifle broader than the narrow lines. With 100X all lines were seen to differ in width in the correct order, but the narrower ones were disproportionately broadened. The 0."7 line was still almost as wide as the 2."8 one. Though still spuriously broadened, the tapered line was now clearly seen to taper and was about half as broad at the narrow end as at the wide one (Gasteyer agreed). There was less variation in intensity than at 50X.

The distance was now decreased to 330 feet, and 100X only was used. The dots now had diameters of 7."4, 7."1, 4."8, 3."1, 1."9, and 0."8. The two smallest were invisible, an increase in size from 2."6 to 3."1 having made the third smallest visible. The four visible spots all differed in size in the correct order. The two dots were 3."3 in diameter with centers 6."6 apart. They were almost resolved, being best described as a diffuse and elongated feature with two dark nuclei. The two lines were now 3."3 wide with centers 6."6 apart. They were very clearly resolved, the space between them being about as white as the rest of the paper. The widths of the uniform lines were now 9."5, 5."2, 3."4, and 0."8, and the tapering line varied from 6. "9 to 1."3. The lines now differed very clearly in width, but the 0."8 line was estimated to be at least one-third the width of the 3."4 line. The tapered line was seen as more clearly tapered than before but still falsely appeared to be half as wide at its narrow end as at its broad end.

The distance was now decreased to 265 feet, and all tests were with 100X. The dots now had diameters of 9."2, 8."9, 6."1, 3."9, 2."4, and 1."1. The two smallest dots remained invisible; the differences in size among the others were very clear. The dots now 4."1 in diameter on centers 8."2 apart were resolved with great distinctness, the space between them being roughly as white as the rest of the paper.

The two lines now 4."1 in width on centers 8."2 apart were completely resolved. The widths of the uniform lines were now 11."6, 8."6, 6."5, 4."2, and 1."1, and the width of the tapering line varied from 8."6 at one end to 1."6 at the other. It was easy to compare the three widest lines. "The 1."1 line appears to be about 1/2 as wide as the 4."2, but under no circumstances could they be considered to have the same width." Both lines, of course, were well below the Dawes limit of 5."5 The tapered line still appeared almost half as wide at its narrow end as at its broad end.

Mr. Stephenson remarks: "The tests conclusively confirmed Mr. Johnson's result that dark features considerably smaller than the Airy disk can be seen and, if a sufficient difference in size exists, a difference in size in the correct sense will be observed though gross errors may be made in estimating sizes and intensities, absolute as well as ratios - as anticipated. Intensity differences may, of course, be observed in the wrong sense, given sufficient difference in size. The remark may justifiably be made that it would have been better had the markings used been drawn up by someone else, in order that I could observe them in complete ignorance of their nature, but I am of the firm opinion that this omission does not alter the general validity of the results. As far as they go, these results also indicate that, given the required atmospheric conditions, it may be advantageous in making observations of such small detail to use considerably higher magnifications than are customarily employed - at least high enough to bring the conventional limit of resolution of the telescope well above the limit of resolution of the eye." The Editor would heartily agree with this last remark; he has found, for example, that powers near 250X and 325X on a 6-inch telescope will resolve complex patterns of dark detail on Mars when powers below 200X will not. It might be noted that Stephenson made these tests with magnifications of 60 to the inch and 120 to the inch on a 0.83-inch telescope and found that the higher ratio gave the better resolution.

Stephenson does not think that the "black drop" effect frequently seen at transits of Mercury can be wholly attributed to diffraction. If it can be, then it should be inversely proportional to aperture; and in an extensive survey of literature on Mercury Stephenson found such a relation, but less than would be expected. He agrees with D. W. Rosebrugh that if diffraction is the sole cause, then Rosebrugh should have seen (but did not) a "white drop effect" at the tangential occultation of Mars he observed on February 24, 1948. Stephenson offers irradiation as an additional possible partial explanation of the "black drop" and other curious appearances when Mercury is near internal contact at a solar transit. This explanation will be more plausible if the diameter of Mercury on the solar disc is considerably less than the expected diameter for an observer seeing the "black drop". Unfortunately, evidence available on this point is very slight.

ALLYN J. THOMPSON ADDS SOME GENERAL REMARKS. Mr. Thompson is known to all our readers for his writings on optics. He was not among those to whom Mr. Mellish's correspondence and the additions accumulated during its travels were circulated, but he has submitted a short manuscript touching upon the same subject of the limits of telescopic resolution. Mr. Thompson's interest was aroused by Mr. Rosebrugh's experimental work described in our past issues. Because of physiological differences between different observers, Mr. Thompson is very doubtful that such experiments can give us general rules for deciding precisely what planetary markings are within the grasp of a given telescope; each individual would rather have to determine his own limitations. Even so, the amateur may enjoy his own individual exploration and discovery in optical experimentation, although likely to be following well-tradden paths. The limit of resolution of the eye is about one minute of arc, as the amateur experimenter can verify. Below one minute of arc the thicker of two lines or dots will look more intense than the thinner one; but since the images on the retina are now formed by diffraction, the difference in size will not be otherwise apparent. (it will be noted that this statement, reworded to apply to the telescopic image, is exactly what Mr. Mellish originally announced about the size of all planetary markings in his correspondence with Mr. Cave. Several of the participants in the discussion, including Reese and Stephenson, have found evidence of exceptions to such a rule.) Mr. Thompson points out that contrast determines how thin a line can be seen. A black wire can be perceived with the unaided eye against a bright cloud background when its angular width is little more than a second of arc, and the eye can do still better on a spider-thread many yards distant and glinting in the sunlight. Some years ago Thompson conducted experiments in dual pinhole resolution with the eye; results by different persons ranged from one and a half to five minutes of arc. Slightly better results were secured with separating lines, and the dependence of the limit of resolution on contrast with the background was demonstrated. The eye's exact limit of resolution is very important to the practical observer because it determines how much magnification he must use to take advantage of the potential resolving power of his telescope. A limit of two to four minutes and a corresponding magnification of 25 to 50 per inch of aperture are usually assumed, but one must realize that wide variations can occur.

In experiments with the diffraction pattern of a pinhole illuminated by tungsten light, Thompson verified that there are slight differences in color-sensitivity between the eyes of different individuals of apparently perfectly good vision and even between the right and left eyes of one individual tested. Therefore, of two observers looking at Mars in quick succession at the same telescope, one might clearly see a faint colored marking which escaped the other. Mr. Thompson concluded: "In making this color sensitivity test, a brightly illuminated pinhole or slit is placed at the center of curvature of an aluminized mirror (or at a distance greater than f in back of a lens) that is stopped down to a diameter small enough not to resolve the pinhole or slit. A sufficiently strong eyepiece should be used to view the focused image. The filter may be placed in front of either the light source or the eyepiece. The more that participate in the test, the more interesting the results are apt to be.

"I would not venture to say the experiments suggested above constitute 'eye-training', or would lead to anything more than increased knowledge of personal limitations. But there is the chance that such knowledge will lead to more factual reports of what is seen through the telescope."

(to be continued)

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OBSERVATIONS AND COMMENTS

Figure 5 is a reproduction of a chart of Cassini recently submitted by a new French member of the A.L.P.O., Mr. A. C. Larrieu, 52, Rue Breteuil, Marseille, France. Mr. Larrieu says (in translation): "The enclosed drawing results from observations made in 1926 at the Marseille Observatory with the 16- cm. (6.5-inch) 'Comet-Seeker'. The ring Cassini, located in the north part of the Mare Imbrium, is worthy of interest and study. First, its strange and characteristic shape attracts attention. (Does it not resemble one of those old castles with its towers and dungeons?) The region around Cassini is interesting because it is higher than the plain and than Cassini itself. The chief object in the enclosure of Cassini is naturally the larger crater 9 miles in diameter which lies in the west part of the ring, this crater being 700 feet deep, i.e., it reaches the level of the plain. The other and smaller crater is located at the other boundary of the enclosure. Between the two craters three small hills are visible. This ring by its characteristic appearance holds the attention of the least attentive observer. Its easy visibility at first and

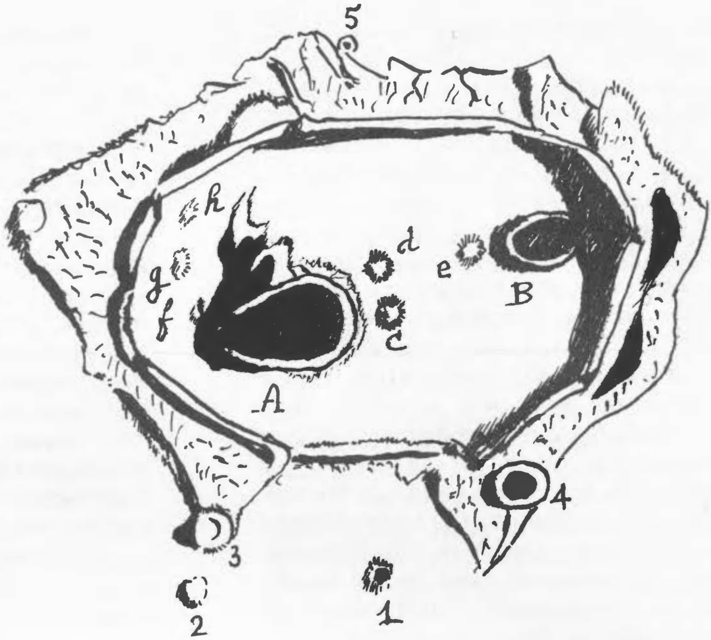

Figure 5.
Chart of Cassini by
A. C. Larrieu.

last quarter of the moon should encourage amateurs to study it more."

On November 26, 1952 J. T. Carle drew the lunar object Linné with his excellent 8-inch reflector at 400X, helped by excellent seeing. The Colongitude, a term discussed elsewhere in this issue was 20.°8. Within the familiar white area, which is visible in any telescope, he saw a small craterlet only a few miles across and holding a crescent-shaped shadow. The rim of the crater looked complete, although previous observations had indicated breaks in the rim to Mr. Carle. In previous views under very low lighting, lower than on Nov. 26, he had seen the craterlet to be in the top of a steep elevation so that there was a good resemblance to a terrestrial volcanic cone. Linné has been of the greatest interest to lunarians since Schmidt of Athens announced in 1866 that the craterlet drawn and described by Maedler and others during the first half of the nineteenth century had vanished. Although it has been seen by perhaps a dozen A.L.P.O. members in all, the craterlet recently observed by Carle is not an easy object by any means and is quite beyond the capabilities of many present-day 6- to 12-inch telescopes of only fair optical quality. That Maedler and his contemporaries can have seen "our" crater with the imperfect telescopes of more than a century ago appears quite impossible. Conversely, their crater, if it still exists, should certainly be easy for modern telescopes.

At colongitude 21.°1 on November 26, 1952 Carle also drew the walled plain Archimedes. Several craterlets were visible on the floor, and one of them still held a detectable crescentic shadow. Carle was much interested by the pattern of light and dark streaks crossing the floor of Archimedes in an east-and-west direction, and R. M. Adams has also called attention to them. The floor of Archimedes has always impressed the Editor as similar in its general appearance to the floor of Plato, which has supplied numerous riddles and mysteries for close students of the moon during the last 85 years. Yet our textbooks assure us in sonorous tones that "nothing ever happens on the moon." Perhaps a close study of the floor of Archimedes would be instructive and rewarding.

Keith W. Abineri, 102, Chalk Hill Rd., Wembley Park, Middlesex, England, writes to praise the great amount of detail on E. E. Hare's chart of the giant walled plain

Bailly, pp. 8 and 9 of the January, 1953 STROLLING ASTRONOMER. Mr. Abineri points out that there are indications of Valley V on the east inner wall of Bailly on a photograph taken by E. A. Whitaker with the Greenwich 36-inch reflector on December 11, 1951. Valley V is shown and labelled on a drawing by Abineri published as Figure 4 on pg. 137 of THE STROLLING ASTRONOMER for October, 1952; its absence from Hare's chart is presumably due to the fact that the east inner wall was shadowed in his late afternoon observations.

The famous walled plain Plato has been observed recently by Jackson T. Carle (8-inch refl.), Eugene Epstein, 1914 N. Curson Ave., Hollywood, Calif. (10-inch refl. and 20-inch refl.), and Henry P. Squyres, 3608 N. Durfee, El Monte, Calif. (6-inch refl.). Mr. Epstein suggests that the 20-inch Cassegrain reflector at the California Institute of Technology is the largest telescope now being used regularly by an A.L.P.O. member. As many of our readers will know, this telescope was made to test structural features for the Palomar 200-inch. It has a spherical primary and a very aspherical secondary. Mr. Epstein writes that he is able to observe with this large telescope frequently.

In October, 1952 Mr. Carle observed Plato when the lighting was so low that the shadow of a west wall peak reached to the east end of the floor. He looked in vain for the hook near the south end of the west wall shadow drawn by Wilkins at Meudon (Figure 1 on pg. 96 of our July, 1952 issue), for evidence of a rolling or uneven nature of the Plato floor, as he had suspected in former views, and for the very dark marking a little southeast of the center of the floor he had observed on February 5, 1952. If this spot was shadow, it is most curious that Carle could not find it under lower lighting in the October view. On November 26, 1952 Carle had an excellent view of Plato in splendid seeing, and his drawing is here published as Figure 6. Using E. J. Reese's terminology, Carle saw as shadow-holding craterlets the near-central craterlet A, the south-eastern craterlet C, the north central twins D, and a craterlet near the northeast rim. The twins were cleanly and continuously resolved from each other. Reese's B, to the east of A, was visible only as a whitish patch. The two tiny craterlets between A and C on Figure 6 were seen with difficulty. A round black spot, perhaps a craterlet full of shadow, was remarked just inside the south rim. Mr. Carle writes: "The peculiar part of the whole thing is that though I spent an hour on Plato, using every combination of powers available, this was all I could see. There was not even a vestige of the numerous spots and craterlets I have heretofore observed with far less favorable seeing. I have counted as many as 19 at a single session with approximately the same colongitude."

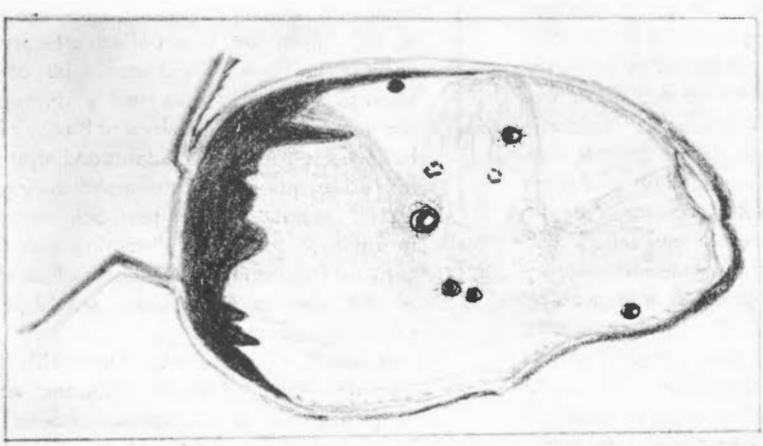

Figure 6. Walled Plain Plato. Jackson T. Carle. Nov. 26, 1952 $4^h 45^m$, UT 8-inch refl. 135X - 700X Colong. =20.°2