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THE LIMITS OF TELESCOPIC RESOLUTION: A SYMPOSIUM.

(continued from July issue)

[Foreword by Editor. This entire installment of our serial gives the opinions of Mr. Clyde W. Tombaugh, 636 S. Alameda Blvd. Las Cruces, N. Mex. on the fundamentally important subject of instrumental limitations. It is taken almost verbatim from a manuscript submitted by Mr. Tombaugh on January 16, 1953. Mr. Tombaugh's long and skillful studies of lunar and planetary subjects are well known, and we are glad for his contribution to our discussion.]

The experiments on resolution by C. B. Stephenson and L. T. Johnson are of great interest.

The key to the much debated question on resolution below the Dawes Limit is probably in circumstances which lessen irradiation of the spurious disc. From the Third Edition of The Adjustment and Testing of Telescope Objectives by T. Cooke and Sons, Ltd., 1921, pg. 45, I quote: "Since the spurious disc is brightest in the center, and really shades off into the dark ring, it is evident that its apparent linear extension will depend very intimately upon the brightness of the star in question, that the spurious disc formed when a bright star is viewed will appear larger than in the case of a dim one, although the maximum size can never amount to as much as the diameter of the first dark ring. To this must also be added the effect of irradiation in the case of the brighter stars. As a matter of fact, it is notorious how much smaller the star discs appear to be in the case of small stars than in the case of bright ones. On the average perhaps, the diameter of a star disc may be considered as one-half that of the first dark ring."

Now a planet's image is, in essence, a mosaic of spurious discs. A shrinking of these spurious discs may be accomplished by the use of a higher magnifying power, by a dark filter, or by both. I think that this fact explains why astonishingly fine detail has been seen with very modest apertures under very favorable conditions by skilled observers.

Equally astonishing is the lack of detail visible, visually, with large apertures. Observers know well the notoriously large images of Sirius and first magnitude stars when using eyepieces of low power. The visual images of bright stars are many times larger than the angular diameter of the first dark ring. Excessive irradiation is the cause. Consider again the case of a planet's image. It is no wonder that so little planetary detail is visible, visually, on a bright disc like Mars or the moon with a large reflecting telescope, on which low magnifying power per inch of aperture is usually employed.

In April, 1950 I had the opportunity to observe Mars with the 82-inch reflector at the McDonald Observatory. Although the mirror supports at that time caused some disturbances in the mirror's figure, Dr. Kuiper obtained several very fine photographs of Mars which showed more detail than I was able to see visually with the full aperture. For visual observations we used a magnifying power of 660 diameter at all times. On the same night, under the same conditions, we introduced an eyepiece cap between the eye and the eyepiece that was equivalent to a circular diaphragm 30 inches in diameter, eccentrically placed between the edge of the Cassegrain secondary and the edge of the primary and using only one quadrant of the great mirror located between the supporting struts of the Cassegrain secondary. The improvement in definition was phenomenal, as if the seeing (steadiness of the atmosphere) suddenly improved three points on a scale of zero to ten. By quickly moving the disaphragm alternately on and off, we were able to compare carefully the amount of detail visible. With the diaphragm I was able to see considerably more and much finer detail than was recorded on the photographs.

This fact proves that excessive irradiation was the sole factor in rendering the eye inferior to the photograph when using the full aperture because the exposure times were longer than 1/10 of a second so that there could be no atmospheric advantage.

All atmospheric and instrumental factors were the same except the quantity of light energy. On the other hand, the superiority of the eye with a reduced aperture to the photographs was probably due to several factors, namely: (1) Elimination of adverse diffraction effects caused by the secondary mirror and its supporting struts, (2) Use of a relatively more homogeneous portion of both the atmosphere and the mirror (because of reduction of aperture), and (3) Reduction of irradiation (because of less light energy).

On the following day we constructed out of cardboard an eccentric, circular diaphragm, with a 2-inch hole and effectively 30 inches of aperture, and placed it on the Coudé ring in the tube above the primary mirror. Since the angular diameter of Mars is very small, about 14 seconds of arc at that time, there was no appreciable vignetting with such an arrangement. Results with it were very satisfactory.

Let us examine some further consequences of irradiation. Since dark planetary markings represent an absence of luminous energy or a lesser amount than the surrounding background, then constructive and destructive interference is not involved to an appreciable extent. Therefore, there is no undulatory limit to the fineness of a dark marking that can be seen. All dark markings are really larger than they appear to be because irradiation of the boundary row of luminous points of the mosaic of a bright surface enroaches upon the dark markings, thus decreasing their area. The greater the brilliance of the "surround" and the smaller or more narrow the dark marking, the greater is the diminution in size of the dark marking. Very narrow dark markings like divisions in Saturn's rings, filament belts of Jupiter, lava dikes on the lunar mountains, and Martian canals can be greatly diminished or even completely obliterated in very large telescopes, even if the seeing is steady enough for a large aperture. Several canals were recorded on the McDonald photographs with full aperture. The Thoth canal was the only canal which I could see visually with the full aperture. With the 30-inch eccentric diaphragm I saw the following canals: Thoth, Nilosyrtis, Phison, Euphrates, Astaboras, Vexillum, Protonilus, Djihoun, Hiddekel, Sitacus, Gehon, Arnon, Kison, Callirrhoe, one unidentified canal, and a very dark narrow rift in the north polar cap (perhaps a portion of Pierius). The seeing was nine on a scale of zero to ten, with ten perfect; and we used a power of 660. I would have liked to try more power and also a series of neutral density filters, for the disc of Mars was very bright even with the 30-inch diaphragm. Some of the canals were parallel doubles, Arnon was a converging double, and the others were single. During the best glimpses I distinctly got the impression that some of the canals were resolved into myriads of little dark markings along their couses, like mottled narrow bands! [Antoniadi and others have contended that the canals are really imperfect views of much smaller and fully separated dusky markings. - Editor] That night, April 8, 1950, central meridian of longitude 320°-330°, gave about the finest view of Mars that I have ever seen.

Returning to the subject of irradiation, I think that it is possible to see dark lines only 0."1 wide with a 6-inch aperture if circumstances are introduced to reduce the effects of irradiation and if the seeing is very steady.

We can carry the argument of dark marking diminution one step further and explain why two dark markings appear to leap at each other and join when their separation is steadily decreasing in some astronomical event. The observed boundaries of such a dark marking will be inside of the real boundaries. As soon as the real boundaries come in contact with each other, the light-bridge ceases to exist. The irradiation from the light-bridge vanishes, and the dark markings appear to leap at each other and join. There is thus explained the "black drop" at solar transits of Mercury and Venus. The same effect can explain the curious-shaped marking often seen at the junction of the shadow of the ball of Saturn and the different divisions in the rings.

All the round dark dots on Mars, known as oases, look smaller than they really are. Likewise, the canals look more narrow than they really are. If dark markings are really quite dark or black, there will be sufficient contrast to render extremely small dark spots visible as very small dots, like the Fons Juventae. Their diameters are below the angular resolving power of the telescope. If the proper ratio of magnifying power and aperture is used for a given brilliancy, such tiny markings are visible. Let the seeing worsen, and the small black spot becomes larger and gray or vanishes altogether. The conditions for seeing sub-Dawes Limit objects are critical, and a nearly-correct situation can make such small markings look different from an ideal or correct situation. Is it any wonder that there is such a difference in opinion regarding the appearance of fine planetary markings?

I hope that this discussion of irradiation will tempt others to do more experimenting.

It is clear from the above that finer dark lines can be seen than bright lines.

In October, 1951 I performed an experiment that far exceeded my expectations. For several years I have played with eccentric diaphragms on reflectors and have marvelled at the way they clean up stellar and planetary images. My experience with the great 82-inch McDonald Observatory mirror convinced me that reflecting telescopes can, if properly used, surpass refractors for planetary definition. My 12-1/4-inch mirror of 148 1/2 inches focal length is slightly overcorrected. The considerable fall of temperature at night in Las Cruces causes the mirror to be in use even more overcorrected. It occurred to me to push the overcorrected zones farther away from the optical axis, to a new position where greater correction would be needed. I tilted the primary mirror so that a point two inches off the center was perpendicular to the direction of the tube axis and moved my Newtonian diagonal mirror two inches nearer to the eyepiece. I then made an eccentric diaphragm out of cardboard so as to give an unobstructed aperture of 7 1/2 inches. On the second night after the change was made we had some very good seeing. Brother! Talk about superb definition, I had it! (Later I enlarged the aperture to 8 inches so that about 1/3 of the minor axis of the diagonal mirror protrudes into the light-path. This arrangement provides a little more light for color studies and a little more theoretical resolving power). The masked reflector cleaned up the discs of the satellites of Jupiter and Saturn just like a refractor does - only better, completely free of chromatic aberration. I have obtained sharp images with powers as high as 900 diameters, Jupiter filling 1/3 of the diameter of the field of view. I have seen markings on Jupiter's satellites III and IV. I like to use a deep yellow (or light amber) filter to eliminate the blue component of light which is so badly scattered by the atmosphere. It certainly does help to remove the diffraction effects of a central secondary and its radial supports.

While at the Lowell Observatory in past years, I experimented considerably with the adjustable iris diaphragm on the 24-inch refractor, varying it from 6 to 24 inches. I would say that the detail in my special 8-12-inch set-up exceeds that with an 8-inch refractor and is probably equal to that with a 10-inch refractor. Consequently, I cannot agree with Mr. Rosebrugh's contention that a reflector must have double the aperture to compare with a refractor, but I do share his opinion and that of others regarding dark marking detail well below the Dawes Limit. Mr. Reese's observations of Cassini's Division, the Crape Ring, etc. are certainly excellent. His drawings of Mars are tops in regard to accuracy, proportion, and amount of detail.

I am afraid that Mr. Mellish is quite mistaken about resolution of dark markings on planetary discs. The mechanism of dark markings is entirely different from that of bright markings. [E. E. Hare also insisted on this distinction. - Editor] During that superb view I had of Mars at McDonald on April 8, 1950, I estimated that the width of the short dark canal running about 2/3 the length of the north polar cap through the cap was about 1/10 the length of the minor axis of the cap ellipse. The minor axis at that time certainly did not exceed one second of arc and was perhaps only 3/4 of a second of arc. Yet Mr. Reese and a few others, quite independently, made drawings near April 8, 1950 showing that canal or rift correctly as regards the slight bend in the canal, its direction, and its position and width with only about 6 inches of aperture.

I was using a 30-inch aperture, and I can certainly vouch for the correctness of their observations. The detail they saw with so small an aperture is truly astonishing. It proves that the Dawes Limit does not apply to such observations at all.

(to be continued)

BOOK REVIEW

By Guenter D. Roth

Der Schiefspiegler, a telescope of excellent optical definition, by Anton Kutter. Text in German. 88 pages. 31 figures. Copyright by A. Kutter, Biberach/Riss, 1953. For sale: Buchhandlung Fritz Weichhardt, Biberach an der Riss, Germany. Price about D.M. 8.50, exclusive of mailing charges. [This amount is about $2.03 in American currency, but the exchange rate may vary a little.]

In the December, 1952 issue of The Strolling Astronomer, pg. 168 et seq., a paper by Mr. E. L. Pfannenschmidt and the reviewer about the Neo-Brachyt Reflector was published. The type of telescope described by the authors was a first design of A. Kutter, who began in 1936 to solve the problems of an eccentric Cassegrain or Brachyt Off-Axis Reflector. Many dozens of instruments of this first type were built in Germany, especially with apertures of 3 to 6 inches; and many excellent lunar and planetary studies were made with them. The type described is also called the "Schiefspiegler in anastigmatic arrangement" by A.Kutter, for the astigmatism is corrected perfectly. The effects of coma are still appreciable, however, especially with larger apertures. Therefore, A. Kutter in cooperation with Professor Staus of Munich, designed a second type, the "Schiefspiegler in an arrangement free of coma and astigmatism."

To understand the solution of the problem, we discuss an example, the 12-inch Neo-Bracyht or Schiefspiegler at the private observatory of Viktoria Staus von Leuchsenring, Pullach-Munich. As regards the first design, the anastigmatic one, the second mirror would have an inclination of 6°41' to the primary. The astigmatism is thus corrected perfectly, but there is still an uncorrected coma of plus 4."8. This effective coma is enough to injure the image at the focus. To correct the coma perfectly, it is necessary to give the secondary an inclination of 10° 31' to the primary. The coma is thus corrected, but now the astigmatism is corrected too much with the amount of - 31."5. This astigmatism is corrected by A. Kutter with a correcting lens between the secondary mirror and the eyepiece. It should be particularly noted that the achromatism of mirror optics is not endangered by this intermediate lens. A. Kutter epecially computed the refraction and position of such a lens so that the system remains free of chromatic aberration.

All the derivations and computations for the Neo-Brachyt or Schiefspiegler telescope are discussed in detail in the book of A. Kutter. He demonstrates very impressively that it is impossible to have in one telescope both great effective light-power and excellent optical definition. Especially for students of lunar and planetary surfaces and double stars, however, an instrument of excellent definition is very necessary. The book moreover contains a very interesting discussion of the advantages and disadvantages of other reflecting telescopes, the Newtonian, the Herschelian, the Gregorian, the Cassegrain, and others. Compared to these systems, the Schiefspiegler has the advantages of giving better definition, being easier and cheaper to build, and being a much more manageable telescope.

Postscript by Editor. Mr. Roth's address is Lengmoosstrasse 6, Munich 9, Germany. He is the Foreign Correspondent for the Planetensektion der Sternfreunde for places outside of the continent of Europe. The Planetensektion is an active group of German planetary observers. We hope that those of our readers acquainted with the German language will secure Mr. Kutter's informative book. Even those whose knowledge of the language is somewhat poor will find much of value in the illustrations and the mathematical formulas. An international money order will be a convenient form of payment.

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VISIBILITY OF SMALL DETAILS

by D. W. Rosebrugh

The problem as to how minute detail we can seen on the moon and planets is continually with us as lunarians and planetarians. This question has been under discussion recently in the March and April, 1953 issues of The Strolling Astronomer in the articles entitled "The Limits of Telescopic Resolution: A Symposium."

In the May 1950, April 1951, and December 1951 issues I reported on the results of my naked eye tests on the visibility of thin wires, narrow lines, round spots, and parallel bands and drew certain conclusions from them as to what should be visible on the planets with a 6-inch telescope using 300X. It was admitted in these articles that there was some uncertainty as to whether the results of tests made on wires and drawings could be carried over to objects seen in the sky, but the conclusion was drawn that within reasonable limits they probably could be.

Since then I have had two pieces of confirmatory evidence that such is true. The first piece of evidence was sought for; the second was totally unexpected.

In the late summer of 1951 I was finally able with great difficulty on several occasions on two unusually clear evenings (for New England) to see Epsilon Lyrae double with my naked eye. This was one of the confirmatory tests suggested on pg. 8 of the April 1951 issue of The Strolling Astronomer. The separation of the two components of Epsilon Lyrae is about 200 seconds. This figure agrees closely with the figure of 191 seconds which the writer found was the minimum separation needed between two artificial white stars on a black background for them to be separable. (See April 1951 issue, page 8, last line next to last item). This would appear to confirm the thought that details that one can separate in a drawing one can also separate in the sky.

The second confirmatory piece of evidence was totally unexpected and arose from my solar observations for the Solar Division of the American Association of Variable Star Observers. To make this clear it is necessary to introduce the subject with a description of sunspot observing and some solar data. The sun's diameter is 865,400 miles, its mean apparent diameter is 31' 59."3, and at the distance of the sun 1 second of arc equals 450.89 miles. The photosphere appears truly circular since the sun's oblateness is called 0.0000 as compared for instance to 1/297 or 0.003367 for the earth. The photosphere is the sharp-edged disc of the sun that one sees with a telescope equipped with a dark glass and a Herschel prism. Sunspots have a dark center called the umbra, and in many cases this is surrounded by a paler gray outer border called the penumbra. It is now believed that the umbra is depressed into the photosphere, perhaps to the extent of some 50 or 75 miles; but this opinion is based primarily upon the statistical analysis of sunspots seen near the sun's limb rather than upon direct observation. With the small, low-powered telescopes used for sunspot counting pores are occasionally seen which appear to be little umbrae or spots of small size without penumbrae, about 800 miles in diameter, scattered profusely over the photosphere.

Wolf, in his establishment of the Zurich sunspot number used a Fraunnhofer refractor of 8 cm. (3."15) aperture, 110 cm. (43."1) focal length, and 64X; and this refractor is still used at Zurich for counting sunspots so as to keep constant observing conditions. Accordingly most sunspot counters in the Solar Division of the A.A.V.S.O. use small telescopes; and during the 9 years that I have been observing the sun I have used a 4" Keuffel and Esser refractor with a 40X eyepiece, Willson Goggle Co. welding filter, and Herschel prism.

On May 9, 1951 when engaged in regular sunspot counting, I noticed a very slight distortion of the sun's limb. I also saw distortions on June 24 and July 7, 1951; and Dr. James C. Bartlett, 300 N. Eutaw St., Baltimore (1), Md. and Mr. Ralph N. Buckstaff, 256 Algona Drive, Oshkosh, Wisconsin, both members of the A.L.P.O., also independently saw distortions of the sun's limb on these and other dates. In every case the distortion was associated with a large and very active group of sunspots which was either coming into view over the sun's east limb, as on May 9, or disappearing around the west limb, as on June 24. Distortion was also seen on July 7 when the June 24 group came around again.

These distortions in general consisted of-normal limb-a depression-a hump-a depression-and then return to normal limb-as one allowed one's eye to travel along the sun's limb. Based merely upon an eye estimate, I reported these distortions at first as being 200 miles below the normal limb for the depressions, and 200 miles above the normal limb for the hump, or a total vertical distortion of 400 miles, from the top to bottom. This would be half the diameter of a pore, which I estimate merely from their appearance at 800 miles. These distortions were of course very gradual sinuosities as the whole distorted portion of the sun's limb extended for perhaps 100,000 miles along the circumference of the photosphere.

Mr. Buckstaff thought the distortions were rather greater in heighth than 400 miles. In any case it was apparent that they were bigger both in vertical and in horizontal dimensions than any depression likely to occur over an individual umbra of a spot. To test the amount of the vertical distortion which one could reasonably expect to detect I made a drawing of a portion of the sun's limb with a radius of 10 inches with a hump flanked by two depressions. The depressions I drew were 0.015 inches lower than the normal limb, and the hump was 0.012 inches higher. (The difference was poor draftsmanship.) When viewed by eye at a distance of 54 inches this would correspond to the size of the sun's image when magnified 40X in my telescope. The total vertical displacement of the hump to the depression would correspond to 1161 miles on this scale. However I found the limb distortion on the drawing so easy to see at 54 inches that I moved back to 100 inches, at which distance the distortion was just distinctly visible. This corresponded to a distortion, top to bottom, of 627 miles on the sun; and I so reported it in my letter of Feb. 24, 1952 to the High Altitude Observatory, Boulder, Colorado.

There the matter rested for some time until Mr. Harry L. Bondy, 43-58 Smart St., Flushing 55, N. Y., who has investigated the entire matter carefully, secured from Mr. Richard B. Dunn, Harvard Observatory, some photographs of the sun's limb taken above the very active sunspot group on May 9, 1951, with Mr. Dunn's monochromator, mounted on the 15" refractor at Harvard. These photos were taken in the ruby-red light of the hydrogen-alpha line, but they showed the edge of the photosphere very clearly. They also showed limb distortion very reminiscent of that seen on May 9, 1951 and other dates. Careful measurements of the best of these photographs seemed to the writer to show - normal limb - a depression - a hump - a depression - and then a return to normal limb - with a vertical displacement corresponding to 824 miles on the sun. Measurements by Mr. Bondy seemed to show - normal limb - depression - return to normal limb - depression - return to normal limb - with a total distortion of 550 miles, top to bottom. There was thus a slight difference of opinion in measuring the photograph, but the figures of 550 miles and 824 miles are in striking agreement with the writer's estimate of 627 miles based upon tests upon the drawing referred to above.

This apparently means that naked eye tests of solar details made upon a sketch can be carried over to telescopic observations made with a 4" refractor and 40X, but whether it means that tests made upon a drawing of planetary details can be carried over to a 6-inch telescope using 300X I will leave to my readers to conclude for themselves.

One other conclusion can apparently be drawn from the above experience; and that is that Dawes Limit, which applies to the separability of two stars, has little or no bearing upon the minuteness of detail of linear markings that can be seen upon objects in the solar system. Dawes limit for a 4" telescope is 1."14. At the distance of the sun 1 second of arc equals 450.89 miles. Hence 1.14 seconds equals 514.0 miles. Limb distortion of this general order of magnitude was visible when using only 40X. If the distortion had been on, say, one-third the scale, both vertically and horizontally, it would presumably have been visible with 120X, unless of course atmospheric unsteadiness had obscured it; and this diminished distortion would be only about one-third the magnitude of Dawes limit.

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SATURN IN 1953

by Thomas Cragg

During the 1953 apparition of Saturn the following observers sent drawings which contributed to this report:

D. P. Avigliano (8" reflector), 678 Manganite Ave., Sierra Madre, California.

P. W. Budine (3 1/2" reflector), 8 Pine Street, Walton, New York.

T. A. Cragg (12" reflector, 6" refractor), 246 W. Beach Ave., Inglewood 3, Calif.

C. M. Cyrus (10" reflector), 1216 Leeds Terrace, Baltimore 27, Maryland.

O. C. Ranck (4" refractor), Box 161, Milton, Pennsylvania.

The general nomenclature of the disc and ring detail is the same as that of the last report (p. 158, Vol. 6, Nov. 1952, "The Strolling Astronomer") with a few minor exceptions. During this apparition the SEB was no longer visible, being hidden by the ring. Immediately below the ring (north) in the Equatorial Zone (abbr. EZ from here on) was on Equatorial Belt (abbr. EB). The rings were more open (angle "B" has increased positively) than during the last apparition (see both Figs.).

DETAIL ON THE BALL-

EB. This very elusive belt was seen definitely on one occasion by Cragg (see Fig. 1) as a thin broken line in the EZ. In past apparitions this feature has been observed more easily by such observers as Cave, Reese, and Hare. However, it was apparently absent from last apparition's material, possibly due to its proximity to the rings. Several other times in 1953 it was strongly suspected and was mentioned in correspondence with W. H. Haas.

EZ. This zone has continued to be the brightest part of the ball and occasionally presented some very ill-defined oval clouds. O. C. Ranck on numerous drawings has shown streaks similar to the festoons observed in 1952. Certainly these objects are suitable for checking rotation rates, but one is a little dubious of values obtained from such transitory material. It seems reasonable that large numbers of these phenomena keep coming but apparently do not last very long.

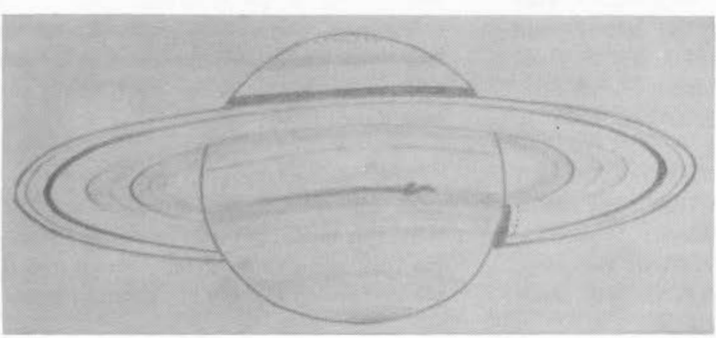

Figure 1. Saturn T.A. Cragg, 6-inch refr. 300X. June 22, 1953, 4^h 50^m, U.T.

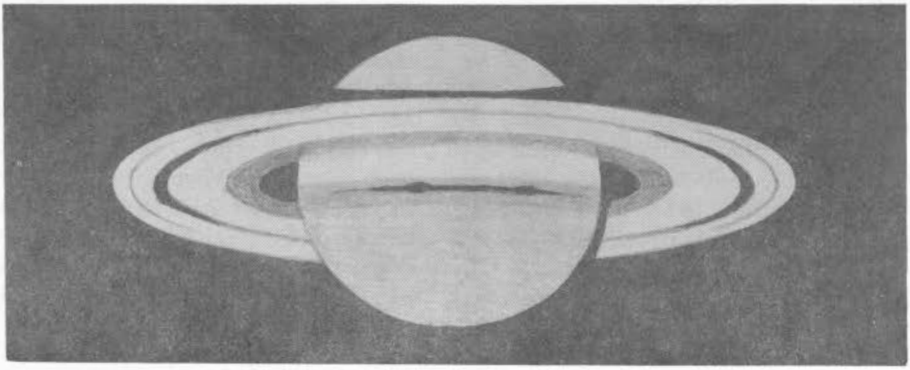

Figure 2. Saturn. C. M. Cyrus. 10-inch refl. 300X. June 23, 1953. 1^h22^m, U.T.

NEB. O. C. Ranck consistently observed this belt as double with the southern component always the stronger of the two. Cragg always saw it double, but on occasion the north component was rather difficult. In a beautiful drawing on June 1 at 06:00 (UT here and later), Avigliano shows the western 2/3 as single and the eastern 1/3 as double. Cyrus and Budine show it single in their observations, but both show fine details characteristic of better seeing. Cragg on one occasion saw it triple (see Fig. 1). A dark central core in the southern component was observed by Cyrus on June 23 (Fig. 2), giving an appearance similar to a spectral line with wide wings. Cragg has observed this phenomenon several times in the past and has mentioned it numerous times in correspondence with W. H. Haas.

Dark spots and streaks were observed by all participants but were much more difficult than "Osawa's Spot" seen in the last apparition (p. 68, May 1952, "The Strolling Astronomer"; "The Most Recent Apparition of Saturn, 1951-1952" in "Proceedings of the Fourth Annual Convention of Western Amateur Astronomers, 1952").

NTB. O. C. Ranck observed this belt a little over 50% of the time, but not at all on two drawings in March. Those being the only two observations covering that period, it is difficult to say with much degree of certainty that the belt was actually gone during the whole month. Avigliano and Budine show this belt fairly well. From all indications this belt was a little easier to observe than last apparition, probably primarily due to the larger positive value of "B" (larger northerly tip of the planet). O. C. Ranck observed several festoons joining the NTB and NEB, but these were undoubtedly rather difficult as no one else recorded any of them. As angle "B" increases positively, this region should become more readily observable.

NPR. Despite the more favorable inclination of the planet, few observations showed much in this area. One drawing each by Budine, Cragg, and Ranck shows a distinct, dark, cap-like region. Three drawings by Avigliano show it as one might expect it this apparition, namely a darkish region covering a sizable portion of the north end of the ball. All the evidence at hand seems to point in the direction that this region was a little more elusive than last time. Observational material is really a little too scanty to say much about general trends in the area.

STB. Budine and Cragg are the only ones observing this feature. Cragg felt that this belt was more prominent than in the last apparition even though the increased positive angle "B" should have decreased the prominence of the feature. Actually, Cragg felt that this belt was stronger than the NTB but has no confirmation of this. The mere fact that few are able to get much detail in the south is indicative of the increasing difficulty of working that part of the ball.

SPR. O. C. Ranck saw a dark cap in the region normally occupied by the SPR at least 50% of the time. Somewhat similarly, Avigliano found the whole southern portion of the planet dusky, while Budine and Cyrus show no noticeable detail in the region. On two occasions Cragg drew a whitish limb in the south, which should have been associated with the SPR. The large number of observations by Ranck which are somewhat confirmed by Avigliano probably indicate that this region was darker than the rest of the planet during most of the apparition.

Of primary interest to all observers of the Ringed Planet are rotation rates at various latitudes. G. D. Roth of Munich has published some rates which are probably quite good enough for recovery of any spots found in the latitudes covered. They were originally published in "Astonomische Nachrichten" but came to the Recorder's knowledge in the "Mitteilunger fur Planetenbeobachter."

which adds additional material to the uselessness of Dawes Limit when applied to planetary detail.

CASINI'S DIVISION. This division was observed on every occasion by all the observers contributing to this report.

ENKE'S DIVISION. This division was seen by Avigliano, Cragg, and Cyrus. In previous years E. J. Reese of Uniontown, Pa. has found that this division is about 0.7 of the way out on Ring A. To quote directly from Avigliano, "I would like to state that Mr. Reese's claim that Enke's Division is about 0.7 the way out on Ring A seems, according to the observations I have made this year, very accurate. I would like to say it might be possibly slightly less than 0.7 if anything."

MINOR DIVISIONS. Cragg and Ranck show the Third Division and Fourth Division rather frequently but the Third much more frequently than the Fourth. Though Avigliano showed the concentric shading on Ring B on the edge of which is normally found the Third Division, he did not show the edge of which is normally found the Third Division, he did not show the division in his drawing. The Fifth and Sixth Divisions were observed by Cave and Cragg. All observers agreed that the outer portion of Ring B was the brightest portion of the rings. Even though the rings were opened up well, the Crape Ring continues to escape detection at the ansae in a number of observations.

TABLE I

Latitude	Belt, Zone	Rotation Period
0°-10°	EZ, EB	$10^h\ 12^m$ - $10^h\ 16^m$
10°-20°	SEB, NEB	$10^h\ 15^m$ - $10^h\ 20^m$
35°-40°	STrZ, NTrZ	$10^h\ 36^m$ - $10^h\ 38^m$
57°	---	$11^h\ 00^m$ - $11^h\ 15^m$

DETAIL OF THE RINGS-

Because of the increase positively of angle "B" over last apparition, it is apparent that ring detail was a little easier. All six divisions recognized by the A.L.P.O. were observed during 1953 at least once by two observers. Several good views were had of Casini's Division showing it clear around the visible portion of the rings,

SATELLITES. Last apparition there was a little work done by two of the contributors on the magnitude of the various satellites.

TABLE II

Satellite	Diameter Miles	Seconds	Magnitude
Mimas	600	0."15	12.5
Enceladus	800	0. 18	12.3
Tethys	1,200	0. 28	11.4
Dione	1,100	0. 27	11.5
Rhea	1,600	0. 35	10.8
Titan	3,000	0. 70	9.4
Hyperion	400	0. 10	13.7
Iapetus (max)	1,200	0. 28	11.4

These estimates were made with the step-scale method assuming Titan (the brightest) to be 8.0 magnitude. None of these estimates have been received to the present time for this apparition, however. One observation by Cragg should be of considerable interest in this project, though. During this year Saturn passed through the field of the variable star S Virginis, thus affording an excellent opportunity to check on the brightness of Titan. This was done with the aid of the A.A.V.S.O. chart of that region, and Titan was found to be 9.4! Since the two objects were not in the same field simultaneously and since Titan was near a bright object, there were chances for error; but the observer felt that these errors did not amount to more than a tenth or two of a magnitude at most. Immediately it was assumed that this was perhaps unique until inquiry found differently. An exceedingly interesting table found in Webb's "Celestial Objects for Common Telescopes" is included in this report. The material is that of W.H. Pickering in 1892 and applies to Saturn at its MEAN distance, and the magnitudes are photometric. Some of the values are not those being published today, but they are certainly close enough to give one an idea of the region of each value.

It is hoped that there will be more vigorous attention given to Saturn by more observers during the next apparition because there really wasn't enough material assembled this time for a realistic analysis of the general intensity variations in the various belts and zones. Since Mars will be available next time with Saturn, the observers will be rewarded by a double treat which may induce more study of our ringed friend.

NOTES BY EDITOR. The satellite magnitudes in Table II are all so much dimmer than more modern values (as given, for example, in the appendix of Volume I of Astronomy by Russell, Dugan, and Stewart) that one must recognize some large systematic error between them. In particular, it is hard to accept 11.4 as the maximum brightness of Iapetus.

Readers should note that Figures 1 and 2 were made 20 hours, 32 minutes apart and thus very close to two rotations of Saturn in low latitudes. They hence show the same part of the planet, and both Cragg and Cyrus drew the thin black streak inside the North Equatorial Belt.

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SOME ASTRONOMICAL HIGHLIGHTS OF A VISIT TO ENGLAND

by Walter H. Haas

The idea of visiting England had been in my mind for a long time; but usually the needed cash was not in my pocket, and it was only from June 1 to June 19, 1953 that the long-intended visit was carried out. Travel should perhaps be especially appealing to the observing astronomer, who is ever failing to observe solar eclipses from the polar regions and occultations of stars by planets from South Pacific islands. There were also reasons to choose England to visit:

the spoken language is closely related to English (apart fromsome mysterious tongue used in telephone conversations), a number of active lunarians and planetarians in England are well known to readers of The Strolling Astronomer, and the Coronation of the Queen on June 2 appeared likely to be the last event of its kind for many years.

The visit turned out to be most enjoyable in unexpected and personal ways and included seeing such scenic and/or historical places in or near London as the Tower of London, the Houses of Parliament, Kew Gardens, Windsor Castle, Madame Tussaud's Waxworks Museum, and St. Paul's Cathedral. However, readers are presumably chiefly interested in astronomical aspects of the visit, which included tours of two famous British observatories. These are the ones at Cambridge and at Greenwich.

The Cambridge Observatory is located near the university of the same name in a typically English setting of rare physical beauty. Surely there can be few other places in the world where the gardens are so well kept or so freshly green. Mr. D.W. Dewhirst, the Director of the Solar Section of the British Astronomical Association, kindly gave a detailed tour to a small party including me. Some of the Cambridge instruments have famous histories, such as the refractor used by Huggins in his classic studies of spectra. On the whole the Cambridge equipment is old and partially obsolete; but new instruments are also being obtained, including ones for solar research. Large visual instruments at Cambridge include a 25-inch refractor and a 30-inch reflector, the latter the personal property of Dr. W. H. Steavenson. It is literally a humbling experience to use Dr. Steavenson's telescope since the entrance into the dome housing it is about two feet high. Unfortunately, Dr. Steavenson himself was away from Cambridge on the day of my visit. The 25-inch refractor is not used full time on research programs; and qualified amateurs, like H. P. Wilkins and Patrick Moore, are sometimes invited to observe with it, an opportunity which we must surely envy our British brethren.

The Greenwich Observatory is a government institution and resembles the United States Naval Observatory in having a time-service and in working upon fundamental determinations of the positions of celestial bodies. It was founded by Charles II to promote the science of navigation, then of the very greatest importance to competing European colonial powers. In its very long history of 278 years the Observatory has had only 10 Directors, the present incumbent and Astronomer Royal being H. Spencer Jones. Although Greenwich was originally located in a pleasant royal park well outside of the city of London, observing has now been hampered for many years by the smoke and lights of the great city. The instruments are hence being moved to a more favorable site at Herstmonceux Castle on the southern coast of England. Nevertheless, there will always be much of historical and cultural interest at Greenwich, as became apparent during an enjoyable tour with Mr. E.A. Whitaker of the Greenwich staff. In the Octagon Room one can see the quadrants, zenith telescope, and other instruments used by such famous men as Flamsteed, Bradley, and Halley. Then there is the Airy transit, where east very literally meets west on the prime meridian. The onion-shaped dome of the 28-inch refractor was being dismantled at the time of my visit. The 36-inch Yapp reflector was still in operation, however; and Mr. Whitaker is using it to take lunar photographs in addition to his regular staff duties.

Meeting Mr. H. Percy Wilkins, the Lunar Director of the British Astronomical Association and the author of the very detailed 300-inch map of the moon, was one of the highlights of the visit. Mr. Wilkins is employed as a civil servant by the British government. He and his wife and daughter live in a residential suburb of London, with a 15-inch reflecting telescope as an unusual attraction of their garden. Like the rest of us, Mr. Wilkins finds his telescope definitely too small and is now working upon a 22-inch mirror. When in operation, his new telescope will surely be one of the largest in the world in the hands of an active observing amateur. There are thousands of detailed drawings of different lunar regions in Mr. Wilkins' possession, the fruit of a lifetime of close study of the surface of our satellite.

It is a pleasure to bring a piece of very good news to our readers: Mr. Wilkins and his family are visiting the United States in the spring of 1954. His itinerary will take him from coast to coast. He wishes to lecture to as many amateur astronomical soc-ities and other groups as his schedule permits. Since he will have to adhere to a strict schedule, once it is established, interested persons should write at once to H. P. Wilkins, 35 Fairlawn Ave., Bexleyheath, Kent, England, giving a suggested place and date for his talk to their particular society. I am sure that Mr. Wilkins will be a most entertaining and informative lecturer, even a witty one. His subject will doubtless be the moon, but it will not be over anyone's head on that account. Societies having regular meetings will very probably have to plan to arrange a special meeting for Mr. Wilkins since he would not be likely to be in their city on the date of the regular meeting.

It was also a great pleasure to meet Mr. Patrick Moore, the Secretary of the Lunar Section of the British Astronomical Association. Almost all of us can look up to Mr. Moore, for he is more than six feet tall. He collects pipes and rides a motorcycle with the descriptive name of "Vesuvius". He teaches at a school at East Grinstead, Sussex, about 30 miles south of London. Mr. Moore's excellent book, A Guide to the Moon, was reviewed in our June, 1953 issue. This book is very remarkable in that it was written by an actual observer of the moon, indeed a very keen observer of the moon; most books about the moon in recent years have been written by persons whose knowledge comes from other books or from very superficial personal observational studies. We hesitate to mention that Mr. Moore also writes science-fiction and that at least one other A.L.P.O. member indulges in this vice.

Both Wilkins and Moore have other books either with publishers or in preparation, and we shall look forward to seeing these books in print.

It had been hoped to observe with some of the telescopes with which our English friends see so much lunar and planetary detail, although it was realized that June was perhaps the worst possible month for this purpose. Twilight then lasts all night in the British Isles. It further turned out - and what realist would expect anything else? - that the skies were cloudy most of the time. It was possible to observe with only one telescope, Mr. Wilkins' 15-inch reflector, on only one evening, and then when both the seeing and the transparency were poor. The weather from June 1 to June 19 was cool and damp; with very frequent changes from light drizzle to heavier drizzle to faint sunshine to light drizzle again. It is evident that successful observing in such a climate demands the greatest perseverance; one must ever be alert to take advantage of every favorable break in the clouds. Yet some of the most praiseworthy observational projects ever performed have been carried out in England!

The British Astronomical Association meets each month in the room of the Royal Society, where pictures of past presidents of the Royal Society hang upon the walls. The room is perhaps large enough to seat 200 people, while the B.A.A. membership is now near 2,000. Unfortunately, there was no meeting while I was in London. The B.A.A. Library contains some rare old books, as one might expect. In a museum not far away are some of the plaster of paris casts of lunar scenes constructed by Nasmyth and Carpenter and some old telescopes by famous names of the past. The weary visitor will find that English museums suffer from a fault common in their country - there just aren't many places to sit down.

Other astronomical colleagues met in England were Alan P. Lenham and Keith W. Abineri. Their names have often appeared in The Strolling Astronomer. Mr. Lenham is the young and energetic user of a 3-1/4-inch refractor, with which he sees surprising amounts of lunar and planetary detail. Mr. Abineri observes with an 8-inch reflector and makes very real-looking drawings of considerable artistic merit, perhaps because he is an artist by avocation.

It would have been pleasant, of course, to meet many other astronomical friends and colleagues in different parts of Great Britian and even those on the continent of Europe. The days, alas, were each one too full and sped by all too rapidly. Perhaps, however, one should always save something for the next time.

The trip left me with an increased respect for the astronomical achievements of our friends in England and with a feeling that A.L.P.O. members who have the opportunity to travel will find personal contacts with colleagues in foreign countries stimulating and profitable. Let us hope that a better day will come when international cooperation will not be the lost cause which it has too often appeared to be in recent years.

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FOR THE BEGINNER: SOME NOTES ON THE AMATEUR'S TELESCOPE.

There are few more lively subjects for discussion among amateur astronomers than the one in the title. As is fitting for members of the A.L.P.O., we shall here suppose that our amateur is chiefly interested in lunar and planetary studies. Thus we shall not consider such special forms as Richest Field Telescopes and Schmidts; rather we are concerned with the best possible visual definition. The Editor should perhaps next admit that lively arguments rage about telescopes and that what he says in the sequel will be challenged in one part or another by qualified judges. The Editor has never made a telescope, but he has used in regular lunar and planetary studies more than a dozen different telescopes ranging in aperture from 4 to 18 inches during the last 18 years. These include both refractors and reflectors, both amateur and professional instruments.

The first question for the amateur considering obtaining a telescope to decide is that of whether it should be a refractor or a reflector. The Editor will risk the wrath of champions of both types and dozens of cancelled subscriptions by saying that it doesn't matter. There is little to choose between the performance of good refractors and reflectors of the same aperture. If the reflector suffers from diffraction around the secondary mirror and its supports, the refractor suffers from chromatic aberration. It is perhaps more difficult to make an optically excellent reflector than an equally excellent refractor of the same aperture. There is no doubt, however, that a given sum of money will buy much more optical performance in a reflector than in a refractor because of the much higher price of the latter for a given aperture. In other words, the amateur of limited means who wants to see as much as possible on the moon and the planets for his money should choose a reflector.

Perhaps the next question will be that of how large the telescope should be. If the goal is lunar and planetary views as good as possible, then the instrument should be as large as possible. Much nonsense has been written by people who should know better that in certain unfavorable regions 6-inch or 8-inch telescopes will show as much or more than larger ones. It is sufficient answer to say that the Editor saw much more detail with an 18-inch refractor in Pennsylvania, even with mediocre or poor atmospheric conditions, than he ever did with small telescopes in that same general geographical region. Also, in 1952 and 1953 P. A. Moore and H. P. Wilkins enjoyed lunar views in the Meudon 33-inch refractor far superior to what their own 12- and 15-inch reflectors had ever revealed, even though the seeing at Meudon was mediocre. It is very true, of course, that a good small telescope can outperform a poor larger one. It is also true that we must greatly admire what some very worthy observers, including several members of the A.L.P.O., have done with very modest instrumental means. Nevertheless, we repeat; the serious planetary student should equip himself with as large a telescope as his purse and other conditions permit.

Few amateurs attempt to make the optics for refractors, but many have made very creditable reflectors. The amateur making his own mirror will be greatly helped if he has an expert neighbor to take his problems to. There are several optics specialists in the A.L.P.O., and we shall be glad to refer to them letters of inquiry which we feel unable to answer ourselves. A Newtonian reflecting telescope is usually the best design for the beginner. Long focal lengths are preferable for planetary work with focal ratios of 9 to 11 being perhaps best. (Thus a 6-inch reflector would have a focal length of 54 to 66 inches.)

In recent years Mr. Clyde W. Tombaugh has carried out some extremely interesting experiments with off-axis masks on reflectors, mentioned elsewhere in this issue. At the price of reducing the aperture to about 40% of its original value one can have an unobstructed reflecting system which should surpass the ordinary reflector, because there is no secondary mirror or its supporting arms in the light-path, and should surpass the refractor, because it is free of color. Mr. Tombaugh is of the opinion that reflectors may show more detail when used in such a way than with the full aperture, and certainly we have here a fruitful field for amateur experimentation - and why not by A.L.P.O. members?

The amateur who wants to observe frequently should plan with some care for his comfort and convenience at the eyepiece. The telescope which needs 45 minutes to be put into operation will not be used so much as the one which is ready in 5 minutes. If trees and other obstructions are not too numerous, it may be an advantage to sacrifice portability of the instrument to having a permanently located mounting, from which the barrel is detached. It is also important to make observing as comfortable and convenient as possible. The observer ought to be seated when at the eyepiece; and eyepieces, notebook, charts, etc. should be within easy reach.

Poor seeing, or atmospheric unsteadiness is a constant sore trial for the planetary observer; and there is no real cure for those of us who find it impractical to move to Flagstaff, Arizona or to Manderville, Jamaica. However, some of the trouble does originate in the tube of the telescope in addition to those difficulties high in the atmosphere; and the alert amateur can actually do a little about reflector tube currents. It will be best to make the diameter of the tube at least a couple inches more than the diameter of the mirror. It may also help to line the inside of the tube with cork or some other insulating material. A wooden tube or a latticework tube will be preferable to a solid metal one from this point of view.

These remarks hardly scratch the surface of our subject; but we shall be glad if some of our readers find them helpful.

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THE MERCURY TRANSIT OF NOV. 14, 1953

by Jackson T. Carle

Observers in Western Europe, Africa and most of the western hemisphere will have an infrequent opportunity on November 14, 1953 to view a transit of the planet Mercury across the Sun's disc. Both ingress and egress of the transit will be generally observable in North and South America except in the northwestern part, which includes Alaska. Part of Alaska and the central and eastern Pacific Ocean areas will see the egress. The transit will take about 2 hrs., 34 mins. between first and last contacts. In most of the United States the entire transit will take place during the morning hours, but in the Atlantic Coast area egress will occur shortly after 1 P.M.

Amateurs with instruments not equipped for solar observation should plan in advance for adequate reduction of the intensity of the Sun's light to avoid possible serious injury to the eyes. Under no circumstances should the Sun be observed without proper protection. Probably the best and safest equipment is the substitution of a Herschel wedge for the regular diagonal or prism of a Newtonian reflector or the star diagonal of a refractor, together with use of a filter of high heat absorption value, such as that used in welders' goggles. Other methods include reduction of aperture to 1 inch or less, use of an unaluminized mirror, and projection of the Sun's image on a white card. Detailed instructions on equipment for solar observation may be found in most books on amateur telescope making.

Accurate timing of one or all of the four contacts of the transit can be of great value particularly in view of the often-noted irregularities of Mercury's motion. This timing probably can best be accomplished by a team of two observers, one at the eyepiece and the other keeping track of the time. It is well to use, if possible, a timepiece of known rate of variation and to check and correct the observed time with time signals by radio before and after the observation.

A number of phenomena not fully understood and explained have been irregularly observed during past transits of Mercury. These include the "black drop" which has at times been seen at internal contact of ingress, the varying bright spots, areas and streaks sometimes observed on the black disc of the planet as it travels across the Sun, and a halo rimming the planet. The "black drop" effect has been variously reported as a dark filament apparently attaching the planet disc to the Sun's limb as the two separate, as a pear-shaped elongation of the Mercury disc, and as a drop-shaped contour. Other observers have reported a clean and sharp separation inside the limb without evidence of the phenomenon. The bright spots or streaks, sometimes stationary and at other times apparently moving, have at some past transits been reported as equal in intensity to the Sun's photosphere surrounding the planet, while at others they have been dimmer or entirely absent. These bright areas have not been conclusively explained. It has been thought that they may be evidence of the Arago white spot resulting, through the wave nature of light, from a dark sphere seen against an illuminated background.

V. Axel Firsoff, Carstran House, Lochearnhead, Pertshire, Scotland, who has given considerable study to such phenomena, is inclined to the view that the bright spot results from refraction of the Sun's light by a tenuous Mercurian atmosphere, amounting to an annular magnifying lens. This action would, he points out, form a real image of the Sun at a point between Mercury and the Earth. He sets forth the possibility that Mercury has picked up a considerable envelope or ring of meteoritic matter, which acts as a reflecting medium and makes this image visible. As an alternative theory, Mr. Firsoff thinks that the bright spot may be an auroral phenomenon caused by a gaseous envelope in an intense and varying electro-magnetic field.

Mr. Firsoff points out that some observations of the bright spot have been ascribed to purely instrumental optical defects. He suggests that this source of the apparent phenomena might be checked by moving the image in the telescope field. If the spot is instrumental he believes that this procedure would cause the bright area to shift on the Mercury disc as the disc is shifted in the field of view. On the other hand, he thinks that if the bright spot is due to a projection of a beam of light refracted in the atmosphere of the planet onto a meteoritic halo, it should show a small but appreciable movement on the disc of the planet in the course of the transit, this movement being in the opposite direction to that of the planet itself.

Another phenomenon reported from past transits, but apparently varying greatly, is a wide, bright halo rimming the planet. At times this halo has been reported to be more brilliant than the photosphere, while other observers have described it as darker than the background. This halo has been ascribed both to irradiation and to Mercurian atmosphere, the latter hypothesis being somewhat negatived by A. Dolfuss' finding of a Mercurian atmosphere only about 0.003 as dense as the terrestrial.

It is apparent there is much unknown and much still to be learned about Mercury from widespread and careful observation of its transits. Members of the A.L.P.O. and others are urged to arrange for timing and observation of the event and to communicate notes and drawings to the writer. Owen C. Ranck, Box 161, Milton, Pa., arranged for cooperative observation of the transit by a considerable group of observers. Their results will be made available to interested professionals and to the A.L.P.O.

Data on the transit in the American Ephemeris and Nautical Almanac, 1953 reveals that it will be considerably off-center on the Sun's disc. It is predicted that Mercury will touch the Sun's limb at position-angle 51°, measured from the north point of the limb toward the east. Egress will be at 356°. At their least distance between centers, Mercury's center will be 14' 21".5 from the Sun's center. As the Sun's true semidiameter is 16' 10."21, it follows that Mercury at this point of greatest encroachment on the Sun's disk will be approximately 1.'8 from the limb. Mercury's diameter will be 9".86.

The ephemeris predicts the Universal Time of the geocentric phases of the transit as follows:

Ingress, exterior contact $15^h\ 37^m\ 04.^s4$ U.T., Nov. 14, 1953.
Ingress, interior contact $15^h\ 40^m\ 41.^s1$
Least distance of centers $16^h\ 53^m\ 55.^s6$
Egress, interior contact $18^h\ 07^m\ 11.^s3$
Egress, exterior contact $18^h\ 10^m\ 48.^s0$

Predictions for various points in the United States and the Pacific Ocean area, depending upon latitude and longitude, indicate that times may be up to a minute earlier for ingress and a little over a minute later for egress than those given. Within the United States variations up to 0.9 minutes are predicted. As Mercury will be extremely difficult to detect prior to first contact, it is suggested that orientation of the Sun's limb be accomplished well in advance of the expected time of contact and that the general area of expected ingress be closely observed, with concurrent timing, for several minutes before the predicted moment of contact. On this basis of the predictions, ingress will occur in the Eastern Standard Time Zone of the United States at about 10.37 A.M., in the Central Zone at 9.37 A.M., in the Mountain Zone at 8.37 A.M. and in the Pacific Zone at 7.37 A.M.

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OBSERVATIONS AND COMMENTS

Mr. Toby Owens, 5238 N. Shoreland Ave. Milwaukee 11, Wisconsin planned simultaneous lunar meteor searches during the 1953 Perseid epoch with Mr. Clayton Smith of Chicago. Their thought was, of course, that members of the Perseid swarm might strike the moon as well as the earth; and the period of several weeks needed by the earth to pass through the swarm does indeed strongly suggest that its cross-section may reach to the moon. Conditions were unusually favorable in 1953 in that the moon was new on August 9 at 16^h, U.T. and hence near the Perseid maximum. As any sensible amateur would expect, Smith and Owen did not have simultaneous clear nights. Mr. Smith was able to observe only on August 14 and suspected two streaks, one at $1^h\ 31.^m5$, U.T. and the other at $1^h\ 39^m$, using a 6-inch refractor at 90X. Mr. Owen observed on August 15 from $1^h\ 40^m$ to $2^h\ 5^m$, U.T., without seeing anything and on August 16 suspected a "short trail" at $2^h\ 0^m$ and a "flash" at $2^h\ 1^m$, both being first. Owen employed a 3-inch reflector at 60X. Mr. Owen hopes that searches for lunar Perseids may be organized in the future, preferably on a nation-wide and even international basis to reduce the risk of failure from poor skies. Of course, it is necessary that the moon be new near the Perseid maximum. It will also be an advantage to compute in advance by means of trigonometry at what point on the surface of the moon the Perseid radiant is in the zenith, for lunar Perseids can occur only in the lunar hemisphere having that point at its center. Finally, it will be best to use as large a telescope as possible; for we must remember that a meteor is 17 stellar magnitudes dimmer at the average distance of the moon than at a distance of 100 miles. Thus a fireball of stellar magnitude -6 would be reduced to a faint object of stellar magnitude 11, which must be viewed against a background of earthshine not far from the brilliant sunlit crescent. Naturally, other terrestrial showers besides the Perseids may provide lunar meteors; but it is vain to consider ones which do not furnish some terrestrial fireballs.