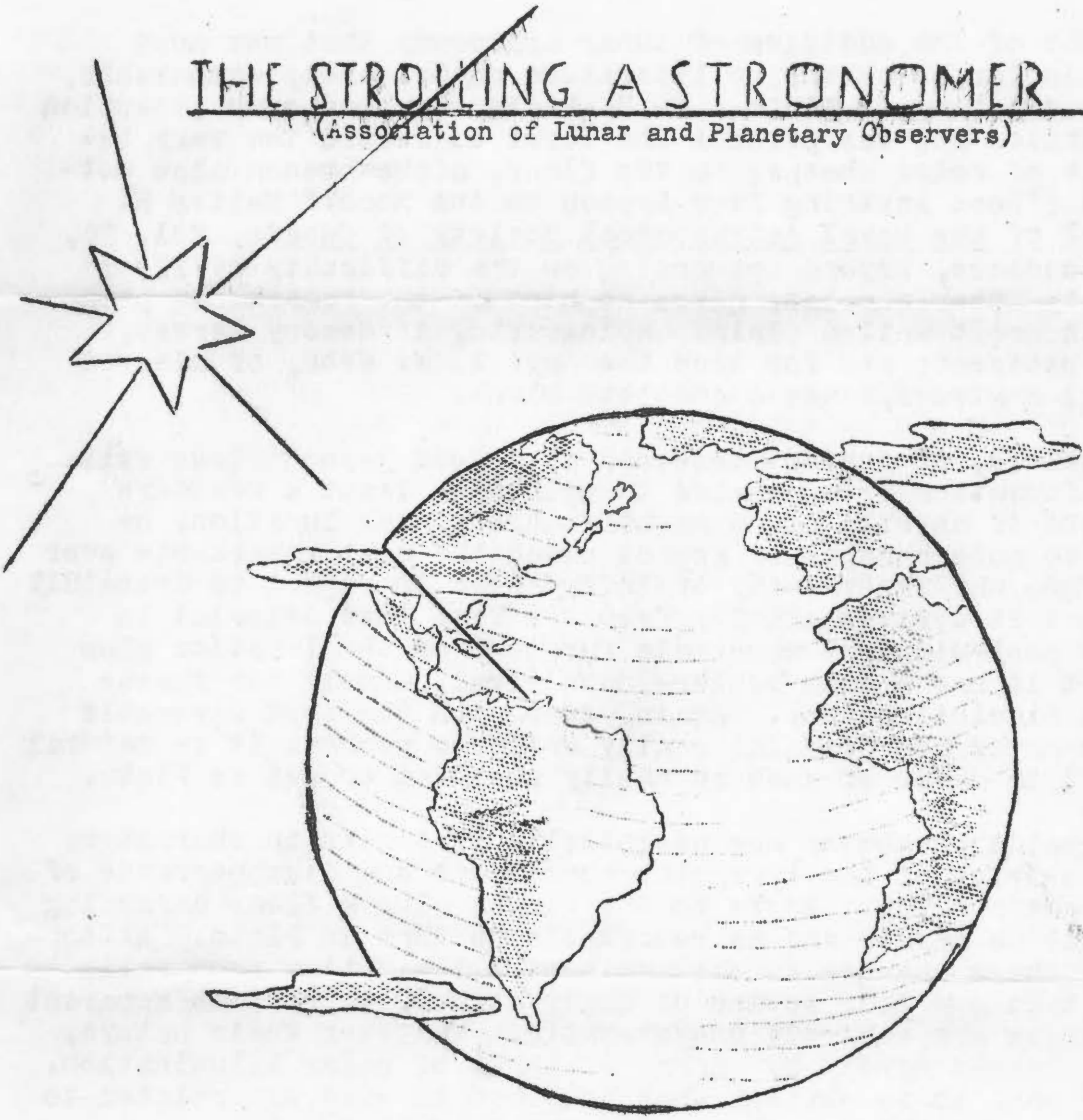
Volume 3, Number 2 February 1, 1949

THE STROLLING ASTRONOMER

(Association of Lunar and Planetary Observers)



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GRIMALDI, A LUNAR ENIGMA

by James C. Bartlett, Jr.

It is one of the oddities of lunar astronomy that one must search in vain for an extensive literature on Grimaldi, comparable, say, to that existing on Plato. W. H. Pickering paid some attention to this formation and was perhaps the first to record the very irregular cycle of color changes on the floor, a phenomenon also noticed by Haas ("Does Anything Ever Happen on the Moon?" Walter H. Haas, Journal of the Royal Astronomical Society of Canada, vol. 36, 1942); but Goodacre, beyond commenting on the difficulty of floor detail shortly after sunrise, gives no hint of the remarkable phenomena of this great walled plain. Molesworth, if memory serves, was equally reticent; and for once the Rev. T. W. Webb, of blessed memory to all amateurs, was a complete blank.

Nevertheless, if anyone possessed of a good 3-inch glass will follow this formation from sunrise to within at least a few days of sunset, and if he will do so nightly during each lunation, he cannot fail to note changes of aspect among the most remarkable ever heard of. Then why the paucity of information in regard to Grimaldi? I suspect that it derives chiefly from the fact that Grimaldi is definitely a post-midnight spectacle for most of the lunation plus the fact that it has a much better-known rival, namely the famous Dark Spot in Riccioli nearby. Again, even with the most favorable libration we never see Grimaldi really well; so perhaps it is natural to neglect it in favor of such an easily observed object as Plato.

The Grimaldi phenomena are essentially Platonian in character; i. e., they consist of the irregular appearance and disappearance of certain streaks and light spots on the floor, plus a floor darkening which is quite as marked and as remarkable as that in Plato. Attempts to relate these changes to the angle of illumination soon fail; and indeed, taking a long series of observations, it becomes apparent that the changes are entirely unsystematic. Whatever their nature, they are not caused merely by change of angle of solar illumination. On the other hand it is obvious that they are in some way related to the movement of the sun in relation to the formation. It seems most probable that they are responses to the heating effect of the sun rather than to its lighting effect. Such is also true of Plato, the maximum darkening of which occurs after noon.

Since the changes in Grimaldi follow no rigid cycle it is impossible to describe them accurately for any given lunation, but in a general way this is what happens:

When the formation is seen just after sunrise, the floor is commonly of a whitish-gray color giving something of a blanched appearance. Usually no detail whatever is seen on the floor, which appears smooth and unmarked, an indication of the very low relief of the various objects actually present and visible when the sunrise terminator bisects the formation. Goodacre remarked that these objects all become invisible a few hours after sunrise. The nature of many of them is unknown, though some at least are craterlets and probably others are crater pits. Of the great streak which runs down the floor from north to south there is not a trace at sunrise and nothing at any time to indicate its nature.

A power of 60x or 100x on a 3-inch telescope will enable one to study the walls easily, especially the east wall at sunrise. It will be noted that the east wall in particular is broken by several deep passes and appears also to be deeply ravined or terraced, one such ravine running from north to south for almost half the length of the wall. The inner slope of this wall is much indented, broken, and roughened and gives the impression of being ruinous. Only the outer glacis of the west wall, of course, can be seen. It is also much broken.

One thing which becomes apparent at once is the dullness of the east wall. It is much whiter than the floor, and indeed may be chalky in appearance - but it has no glitter. In this connection it may be worthy of note that in the writer's experience no lunar formation showing changes of the type described ever has glittering walls. As with Grimaldi, so with Plato and similar spots: the variable features, including the walls, are always chalky white or dull white - but they do not glitter.

The writer is inclined to relate this lack of glitter to the effects of organic erosion, assuming that the observed changes are brought about by the growth, development, and decay of some form of lunar vegetation. Perhaps not - but the identical phenomenon can be observed on earth. A highly feldspathic formation, such as granite, which will glitter brightly if the feldspar crystals are well developed, is soon converted into a dull, whitish, clay-like mass chiefly by the effects of organic acids secreted by minute plants, such as lichens, which cover the formation. Not all granites are so attacked, of course, because not all exposures of the rock are in places favorable to plant life; but wherever they are, they are soon dulled and ultimately reduced to clay over an immensely long period of time. It seems suggestive, therefore, that lunar areas exhibiting changes which are best explained by the vegetative hypothesis are also those which appear dulled and "old".

Continuing with our study of Grimaldi at sunrise, perhaps one will notice a slightly darker border to the gray floor under the east wall. The difference in tone between this narrow area and the rest of the floor is sometimes so slight that only a trained eye will at once perceive it, though at other times it is very marked. This border should be watched carefully, for it is the beginning of a rapid westward creep of darkness across the floor.

Just one day later the floor will be seen to have darkened appreciably; but, what is more remarkable, the inner surface of the east wall has become extremely dark so that it cannot even be recognized as a wall. From then on Grimaldi appears to lie flush with the outer surface, like a great dark stain on the moon. Indeed, its appearance is so radically different from that at sunrise that it is difficult to realize that it is the same formation. The darkness, then, not only creeps westward over the floor but upward and all over the inner east wall. That it also slops over the top, so to speak, and probably continues down the outer glacis is shown by the fact that no bright rim delimits it from the surrounding surface.

At about this time one will also notice a corresponding creep eastward from the west wall. Here is another significant fact. The darkening always begins from east to west across the floor, i.e. it begins at the point first heated by the sun's rays. As the sun is rising in the lunar west it follows that the eastern half of the floor of any crater receives his rays before the western half. Whatever the relation may be, the eastern half of the floor always darkens more rapidly than the western half so that one day after sunrise the eastern darkening has extended farther west than the western darkening has extended east.

Eventually the two areas meet, and here follows another singular phenomenon. They meet - but on either side of a long, yellowish-white streak, which appears coincidentally with the approach of the two dark areas and which serves as an effective barrier between them. This great streak runs down the floor from north to south for almost its entire length. It is not a "ray", similar to the "rays" from Tycho, Copernicus, etc. Under a low sun there is nothing to show its nature, and indeed it appears merely to be a contrast effect, a narrow strip of surface which in some unexplained manner completely inhibits the development of the darkness along its entire length.

There appears, however, to be one small segment of this streak in the south where the two dark areas occasionally do cross it and merge, indicated by the fact that it sometimes appears to be shorter than at other times; but this appears to be the only point where the apparent inhibiting influence is not manifested. Yet this streak, though one of the steadiest features of Grimaldi, occasionally appears rather as a chain of small, dull, whitish spots.

As the darkening of the floor progresses it will be observed that the darkness creeps from south to north along the line of the north-south streak and on both sides of it, yet at a peculiar angle. On the east side of the streak, the darkness will creep northeast away from the streak towards the east wall. On the west side it creeps northwest away from the streak towards the west wall. The result is a very distinctive pattern which resembles a chevron, and which I have ventured to call the Chevron Pattern of Grimaldi. The apex of the Chevron is always pointed south, and when it first becomes manifest, about a day after sunrise, this apex is situated much farther south than later in the lunation. In other words, the apex appears to move north, as if the Chevron were being constantly narrowed. As a rule it appears to halt at the center of the floor of Grimaldi, the two sides of the Chevron touching the central streak. At this particular point there is sometimes seen a large, dull white spot through which the central streak appears to run.

Like everything else about Grimaldi, this very distinctive Chevron Pattern sometimes completely fails. Then the northward advance of the darkness simply parallels the white central streak which acts as a separation between eastern and western floor areas; but it is much more often visible than invisible. Occasionally the apex appears to move much farther north than usual; at other times it keeps much farther south. Its exact appearance - or even its appearance - can never be accurately predicted for any lunation.

(to be continued)

COMING PHENOMENA OF SATURN'S SATELLITES

The phenomena of the four large satellites of Jupiter are well known to all amateur observers. We refer, of course, to occultations of these bodies behind the disc of Jupiter, to their eclipses in his shadow, and to transits of the satellites and their shadows across the face of their primary. These easily observed events are an endless source of interest for the student of Jupiter. The corresponding phenomena of the Saturnian satellites are almost unknown to most observers both because the tilt of the axis of Saturn precludes their occurrence for years at a time and because they are much harder to observe with small telescopes. Those relating to the largest satellite, Titan, are naturally the easiest to see; such Titan-phenomena will be observable in December this year. Between February 4, 1949, and March 4, 1949, the period to which we shall now limit attention, we shall have eclipses, occultations, satellite-transits, and shadow-transits involving the three innermost satellites, Mimas, Enceladus, and Tethys. It is thought that only those phenomena relating to Tethys can be observed without large telescopes.

On pg. 36 et seq. of the Handbook of the British Astronomical Association for 1949 one finds information about these Saturnian satellite phenomena. We copy below their predictions (egress-times we have computed from their data) for the period from February 4 to March 4. All relate to Tethys. Before opposition on February 21 one has an eclipse immersion and an occultation reappearance; after opposition, an occultation disappearance and an eclipse emersion. The eclipses will take place close to the limbs of Saturn during the period in question. The occultations will be seen at high southern Saturnian latitudes in February-March, perhaps a little north of the South Polar Band; and the transits of Tethys and its shadow will be seen about midway between the north edge of the projected rings and the north limb. In a simply inverted view with south at the top occultation disappearances are at the left limb; transit ingresses, at the right limb.

Since most of our readers live in the United States and Canada we include no phenomena occurring before 6 P. M., E. S. T., or after 6 A. M., P. S. T.

It appears difficult to say how large a telescope will be needed to watch these events. On pg. 32 of the B. A. A. Handbook for 1948 one finds the statement that Tethys is visible in a 4-inch. It will presumably demand somewhat more aperture when it is near the limb of Saturn, where the events here considered occur; and the satellite and its shadow projected against Saturn in transit will almost certainly be much more difficult still. We are, therefore, anxious to hear from our readers how successful they are in observing these phenomena. If interest is great enough and if the events do not prove too hard to see, we plan to publish further lists of predictions.

Do not fail to note that the predictions below are given by Eastern Standard Time. Subtract one hour for C. S. T., two hours for M. S. T., and three hours for P. S. T.

Pheonomena of Tethys

Date, 1949	Time (E.S.T.)	Phenomenon	Remarks
Feb. 5	8:40 a.m.	Eclipse immersion	
Feb. 6	7:19 a.m.	Shadow transit ingress	
Feb. 6	7:25 a.m.	Satellite transit ingress	
Feb. 7	5:58 a.m.	Eclipse immersion	
Feb. 7	8:08 a.m.	Occultation reappearance	
Feb. 8	4:37 a.m.	Shadow transit ingress	Egress near 6:30 a.m.
Feb. 8	4:43 a.m.	Satellite transit ingress	Egress near 6:46 a.m.
Feb. 9	3:17 a.m.	Eclipse immersion	
Feb. 9	5:25 a.m.	Occultation reappearance	

Date, 1949	Time(E.S.T.)	Phenomenon	Remarks
Feb. 10	1:56 a.m.	Shadow transit ingress	Egress near 3:50 a.
Feb. 10	2:01 a.m.	Satellite transit ingress	Egress near 4:03 a.
Feb. 11	12:35 a.m.	Eclipse immersion	
Feb. 11	2:42 a.m.	Occultation reappearance	
Feb. 11	11:14 P.M.	Shadow transit ingress	Egress near 1:08 a.m. Feb. 12
Feb. 11	11:19 P.M.	Satellite transit ingress	Egress near 1:20 a.m. Feb. 12
Feb. 12	9:54 P.M.	Eclipse immersion	
Feb. 12	11:59 P.M.	Occultation reappearance	
Feb. 13	8:33 P.M.	Shadow transit ingress	Egress near 10:28P.
Feb. 13	8:37 P.M.	Satellite transit ingress	Egress near 10:37P.
Feb. 14	7:12 P.M.	Eclipse immersion	
Feb. 14	9:16 P.M.	Occultation reappearance	
Feb. 15	7:46 P.M.	Shadow transit egress	
Feb. 15	7:54 P.M.	Satellite transit egress	
Feb. 16	6:32 P.M.	Occultation reappearance	
Feb. 22	8:27 a.m.	Eclipse immersion	19 hrs. after opposition
Feb. 23	7:06 a.m.	Shadow transit ingress	
Feb. 23	7:07 a.m.	Satellite transit ingress	
Feb. 24	5:45 a.m.	Eclipse immersion	
Feb. 24	7:43 a.m.	Eclipse emersion	
Feb. 25	4:24 a.m.	Shadow transit ingress	Egress near 6:23a.m.
Feb. 25	4:26 a.m.	Satellite transit ingress	Egress near 6:18a.m.
Feb. 26	3:05 a.m.	Occultation disappearance	
Feb. 26	5:03 a.m.	Eclipse emersion	
Feb. 27	1:43 a.m.	Shadow transit ingress	Egress near 3:43a.m.
Feb. 27	1:44 a.m.	Satellite transit ingress	Egress near 3:34a.m.
Feb. 28	12:23 a.m.	Occultation disappearance	
Feb. 28	2:22 a.m.	Eclipse emersion	
Feb. 28	11:01 P.M.	Shadow transit ingress	Egress near 1:02 a.m. March 1
Feb. 28	11:02 P.M.	Satellite transit ingress	Egress near 12:51 a.m. March 1
March 1	9:41 P.M.	Occultation disappearance	
March 1	11:41 P.M.	Eclipse emersion	
March 2	8:20 P.M.	Shadow transit ingress	Egress near 10:21 P.M.
March 2	8:20 P.M.	Satellite transit ingress	Egress near 10:07 P.M.
March 3	6:59 P.M.	Occultation disappearance	
March 3	9:00 P. M.	Eclipse emersion	
March 4	7:40 P.M.	Shadow transit egress	
March 4	7:25 P.M.	Satellite transit egress	

OBSERVATIONS AND COMMENTS

Note. All dates and times in this periodical are given by Universal Time, unless the contrary is explicitly stated.

Several readers have been paying some attention to Uranus in recent months. Perhaps others have shared the experience of L. T. Johnson of La Plata, Maryland, who used a 10-inch reflector at 288x and 480x on November 28, 1948. "The seeing was fairly good, and Uranus was nearly overhead. I was quite sure that I could see surface detail, but it was not definite enough to draw."

However, T. Cragg of Los Angeles, Calif., has been more successful. He obtained five drawings of Uranus between November 11 and December 1, 1948, with a 6-inch reflector at 208x or 260x. A long vertical (hence north-south?) dark band is strongly present on every drawing. A bright band of width similar to that of this dark one and intersecting it at right angles was depicted on November 29 and 30, and possibly on December 1 too when the lower limb was shown brightened. Cragg's drawings include some other bright and dark spots, the former usually on the limbs. W. H. Haas drew the planet on December 30, 1948, near $9^h 15^m$ with a 6-inch reflector at 188x. The easiest mark for him was a dark belt near the northwest limb and running in a southwest-northeast direction. (Directions are given relative to the east-west drift of Uranus in the telescopic field of view.) Fainter dark bands were also seen. Haas further found the northwest limb to be the brightest part of the planet and the northeast and south limbs to come next to it in intensity. On January 5 near $4^h 45^m$ a poorer view suggested to him a similar over-all appearance. E. Pfannenschmidt wrote on January 13: "Some of our group have done minor work on Uranus during November-December, 1948. The Stuttgart observers frequently noted a bright equatorial band on the disc, vertical to the line of motion [the drift mentioned above]. This band was also observed by Dr. Ruegemer at Neustadt-Waldnaab. The Stuttgart observers noticed also that the north cusp [limb] of the planet was somewhat darker than the south one, and Dr. Sandner reports from Munich that he observed a brighter south-and darker north-cusp also." Is Cragg's bright band the same as the Ruegemer-Stuttgart band?

Unhappily, it appears difficult to interpret any of the bright or dark bands mentioned above as lying parallel to the equator, and hence as analogues of the better-seen Jovian and Saturnian cloud-belts. Presumably the equator of Uranus is in the plane of the orbits of the satellites. A glance at pg. 456 of the 1949 American Ephemeris and Nautical Almanac will show that their apparent orbits are now almost circular. This result means that the pole of Uranus is now near the center of the disc and hence that the limb approximates the equator.

Only one drawing of Venus has come to hand during the last month; it was made by W. H. Haas on January 6. Both cusp-caps were seen, with the south one the brighter and the north one unnotable. The north cusp-band was broad, dark, and conspicuous. A dark band near the south limb was also strong. Two long, very faint, dusky streaks may well correspond to the belts drawn by Cragg, Reese, and German observers. Cragg points out that such belts are apparently seen best when Venus is gibbous and wonders why the crescentic Venus should comparatively lack them.

A note by E. Pfannenschmidt on the changeability of Venusian features may interest other readers: "I have seen Venusian details change extremely rapidly during 1948 and then again have found others remain somewhat constant during three to six days. Generally, however, I think--because of their atmospheric nature--that such details do change quickly."

We have spoken in past issues of T. Cragg's drawings of large protrusions from the bright Venusian cusp-caps and of our conjecture that they may represent cold polar air-masses flowing toward the equator of the planet. Though other American observers have apparently not seen these features, they are evidently familiar to E. Pfannenschmidt's group of German observers. We note with interest a passage in No. 14 of his Planeten Beobachtungs Blatt (Planetary Observation Leaflet); a rough translation follows: "Relatively frequently (6 times) 'noses' (i.e., sharp local protrusions) were clearly observed at the south pole; they extended toward the north, toward the presumable equator. Cragg in the U. S. A.(6-inch refl.) likewise perceived such a 'nose' on September 2 [1948] ; it is perhaps identical with a feature drawn by Sandner at Munich with a 4.5-inch [refractor] on August 31 and September 1."

Since we last went to press we have received observations of Saturn from J. C. Bartlett (3.5-inch reflector), T. Cragg (6-inch reflector, 12-inch refractor), R. S. Ellwood (8-inch reflector), W. H. Haas (6-inch reflector), E. E. Hare (7-inch reflector), L. T. Johnson (10-inch reflector), and W. Sandner (4.5-inch refractor).

We urge observers to watch the two Saturnian shadows closely on all possible dates during February and to report to us what they see. The shadow of the ball on the rings will presumably be invisible for a time near opposition on February 21. If we may rashly predict from past experiences, we should expect to find on that date two "false shadows"; in other words, a dark band will border the limb on each side of the ball. Farther from opposition the band beside the limb where true shadow exists will be darker, or wider, or both than the other band. These dark bands may well be nothing but contrast-caused illusions; nevertheless, we recommend careful estimates of their widths and intensities. The shadow of the rings on the ball which was so prominent last autumn will vanish near the middle of February. It should by all means be followed to total invisibility, and its breadth and darkness should be carefully noted. The shadow may look too wide and too light when it has become extremely thin. Observations of this shadow may supply indirect evidence about a possible dusky ring outside of Ring A.

Dr. Bartlett, perhaps our most attentive student of lunar and planetary colors, has examined the hues visible on Saturn since early November with the aid of color-filters. He stresses that the colors are more subdued and nearer to gray than during the 1947-8 apparition. The South Equatorial Belt now usually looks brownish gray to him and is only occasionally reddish brown. Other belts are gray. The shaded South Polar Region is ordinarily gray or greenish gray, though sometimes brownish gray. The North Polar Region is often gray, though decidedly chocolate-colored on November 8. The brighter parts of the ball are pale whitish yellow, except that the Equatorial Zone may be white. Observations by Haas, also using color-filters, in December and January accord with such a relative lack of colors. Haas finds Ring A, Ring B and the brighter parts of the ball white. The South Equatorial Belt is most frequently brownish gray, though sometimes sensibly gray and once red-brown. The South Polar Band is nearly gray, although called bluish gray on December 19. The North Temperate Belt once looked brownish gray but is too faint for good judging. In the editor's opinion the two observers agree on colors about as well as can be expected.

J. C. Bartlett adds his opinion to that of Cragg, White and Haas that the South Equatorial Belt is fainter than in 1947-8. Perhaps this belt is now easier to split into two components than a few months ago; anyhow, it has been so resolved by Cragg, Ellwood, and Haas during the last month. Haas sometimes finds the north component slightly the darker, Reese having called it darker last November 18. Haas finds a broad and diffuse South Polar Band to be the second most conspicuous belt. Johnson, Bartlett, and Sandner do not see this Band but instead observe a shaded South Polar Region. Cragg's drawings indicate a darkening of this shading from December 28 to January 15. Cragg and Haas show a small white cap on the extreme south limb. It is all a bit mystifying! According to Haas, the thin North Temperate Belt in early January lay 1/5 of the way from the north edge of the shadow of the rings to the north limb. Bartlett agrees with Reese that this belt is darker than the S. E. B. though much narrower, a remark suggesting that his 3.5 -inch reflector must define very well. Bear in mind that Johnson found the N. T. B. to be a mere streak in his 10-inch reflector on two dates and saw nothing of it on other occasions. Cragg sees the N. T. B. to have an intense core and fainter, hazy "wings" on each side. We spoke in our January issue of Cragg's thin South South Temperate Belt about midway between the S. E. B. and the S. P. B. and of the narrow brighter zone beside this S. S. T. B. Cragg found this belt faint and very narrow on December

28 and 29 and completely invisible in a view of comparable quality on January 15; the adjacent zone was distinct on December 28, narrower on December 29, and much dimmer on January 15. Though most observers quite failed to see the S. S. T. B. in the autumn of 1948, Bartlett and Sandner perceived it regularly. The latter almost always drew it to be extremely thin and to be broken into separate sections. From late December to mid-January Cragg and Haas recorded a faint, diffuse, and sometimes fairly broad North North Temperate Belt near the north limb. Perhaps it should instead be regarded as a North Polar Band, for in its lack of sharpness and suggested complex structure it was like the South Polar Band. Here again Johnson, Bartlett, and Sandner observe no Belt but instead find a shaded North Polar Region. On January 18 only Haas observed an Equatorial Band at the extreme limit of visibility near the middle of the bright Equatorial Zone.

In October-November, 1948, the North Tropical Zone, the space between the projected rings and the N. T. B., was notably bright and even rivalled the E. Z. It is no longer distinguished. On December 28 and 29 Cragg found it dull and much the same tone as the ball north of the N. T. B. From December 19 to January 18 Haas concordantly usually saw the N. Tr. Z. and the ball north of the N. T. B. equally bright. Hare recently finds the N. Tr. Z. so filled with murkiness extending southward almost to the shadow of the rings that he wonders whether one has a broad North Equatorial Belt of which the N. T. B. is a dark north edge. Hare's implied less dusky southern border of the N. Tr. Z. looked so bright to Cragg on January 15 that he opines that it is really part of the Equatorial Zone, thus now visible north of the rings.

The Crape Ring has been observed in the ansae of the fairly narrow rings by Hare, Cragg, Sandner, and Johnson. We congratulate these observers on their success! Johnson on December 27 estimated that Ring C extended inward 4/10 of the way from the inner edge of Ring B to the globe and thus exactly confirms E. K. White's estimates of last autumn. The Crape Band just south of the inner edge of Ring B as seen projected upon the ball was described as follows by Hare on January 20: "The Crape Band was much darker than any belt but was not so black as the shadow of Ring A. It therefore appeared to be narrower. I judge it to be nearly as wide, however. The seeing was only fair to good." Some tabulated calculations kindly submitted to us by Hare make the width of the shadow of A 0".33 on January 20. Johnson on December 27 described the Crape Band as "barely visible as an extremely thin line which was narrower than Cassini's at the ansae." Cragg on December 28 made the Band between 1/4 and 3/10 as wide as Cassini's at the ansae, the seeing being fairly good. Up to and including January 18 Haas failed to see the Crape Band at all, and on January 6 he felt confident that it was less than 1/2 as wide as Cassini's at the ansae, perhaps much less. The angular value of this unit employed for the comparisons was about 0".58 on the dates in question. Hare's computations mentioned above give 0".22 for the width of the shadow of C on December 27 and 0".31 for the width of the C projection then. On January 20 the corresponding values were 0".29 and 0".35, all assuming 9600 miles as the width of Ring C.

The article "Concerning the Ring C Puzzle" on pp. 5-7 of the January issue should at least have convinced readers that determining the width of Ring C by observing the width of the Crape Band is greatly complicated by the presence of the shadow of C! This systematic error is eliminated, however, when the earth and the sun are the same angular distance from the ring-plane, as will be approximately true from February 14 to 24. We recommend that especially careful estimates of the width of the Crape Band (sometimes loosely termed the Ring C projection) be made in that 10-day period. Perhaps those colleagues having access to professional instruments will even carry out some valuable micrometrical measures.

We were surprised to remark Encke's Division on a drawing by Johnson on November 12. However, Cragg's view of ring-detail with the Griffith 12-inch refractor on January 15 surprised us still more. In order of decreasing conspicuousness he saw Cassini's, the Third Division near the inner edge of Ring B, Encke's somewhat outside the middle of Ring A, and the Fourth Division in the outer part of Ring B. On this lofty note we shall be wise to conclude.

S U B S C R I P T I O N R A T E S

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S T A F F

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