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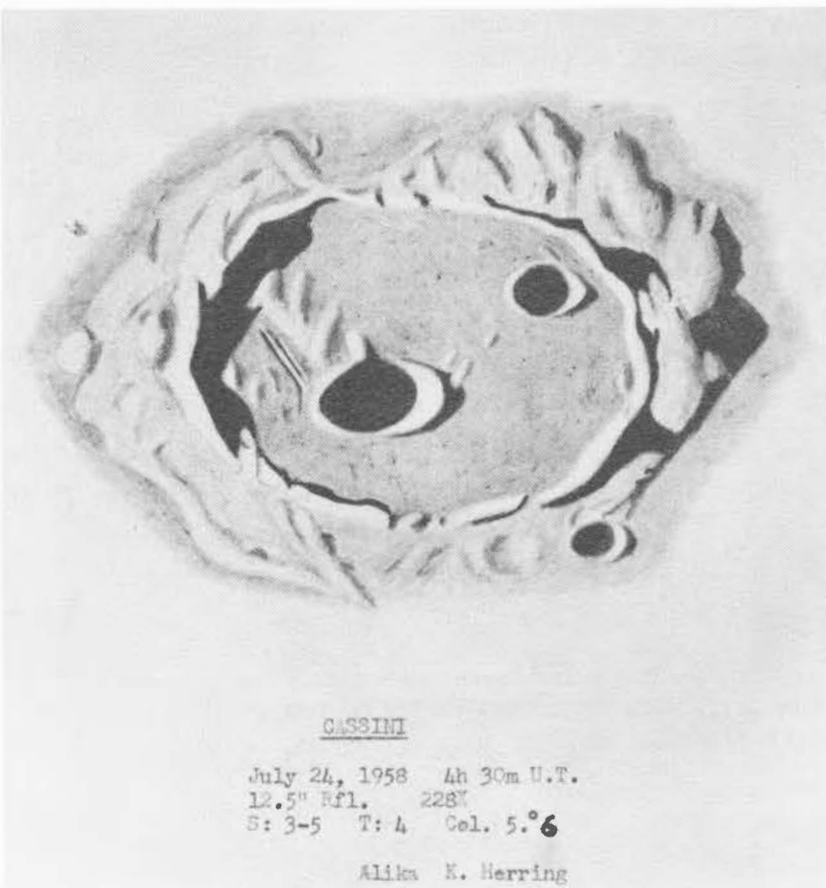

THE STROLLING ASTRONOMER
1835 Evans Place
Las Cruces, New Mexico

Drawing of the lunar crater Cassini by Alika K. Herring on July 24, 1958 at 4 hrs., 30 mins., Universal Time. 12.5-inch reflector at 228 X. Seeing poor to fair, sky clear. Colongitude $=5^{\circ}.6$.

In This Issue

ANNOUNCEMENTS

Request for Data on Radio Amateurs. We have long spoken of the possibility of speeding up the transmission of urgent lunar and planetary news by employing amateur radio, but little enough has yet actually been done in this direction. Mr. Carlos Jensen of Salt Lake City, Utah, has suggested that we request each A. L. P. O. member who also has an amateur radio station to report to us his name, address, call letters, and the bands in which he is active. We heartily endorse this request. Please send this information soon on a postcard with no other messages to the Editor at 1835 Evans Place, Las Cruces, New Mexico. A. L. P. O. members who are not themselves radio amateurs but who have friends with stations and with a desire to promote radio communication within the A. L. P. O. may send the same data about such willing friends. The information received will be published in a future issue of The Strolling Astronomer and may thus guide our equipped members in arranging radio schedules to compare observing notes and techniques. An eventual possibility might be a radio net within the A. L. P. O. Some initial efforts at such schedules were made on January 11 and 18, 1959 with the aid of Mr. Walter LaFleur of State College, New Mexico, Mr. Robert Leasure of Galloway, Ohio and Messrs. Dennis Milon and Frank Olson of Houston, Texas.

The A. L. P. O. Library: A Reminder. We would again direct the attention of our members to our library. Books on hand have been listed in these issues: November-December, 1957, pp. 139-140; January-March, 1958, pp. 31-32; and July-September, 1958, pp. 110-111. The Librarian is Mr. E. Downey Funck, 256 N. E. 11th St., Delray Beach, Florida. Any A. L. P. O. member in the United States may borrow books for a period of 30 days for a charge of 50 cents and the return mailing costs.

We Hope to See You All at Denver. Plans are rapidly developing for the Nationwide Amateur Astronomers Convention at Denver, Colorado on August 28-31, 1959. The Fifth Convention of the A. L. P. O. will be held at this joint meeting, along with meetings of the Astronomical League, the Western Amateur Astronomers, and the A. A. V. S. O. Beyond doubt this gathering of amateurs will be the largest ever in this country, and we urge every reader who can to try to make vacation and travel plans to include a noteworthy Convention. The General Chairman is Kenneth W. Steinmetz, 1680 W. Hoye Place, Denver 23, Colorado. Excellent and convenient campus facilities at the University of Denver will be available to attendees from noon on Thursday, August 27 to noon on Tuesday, September 1. There will be numerous sessions for papers; and a number of outstanding speakers are promised, both professional and amateur. Tentative field trips include ones to the National Bureau of Standards installation and the radio telescope on Gun Barrel Hill in Boulder and to the Air Force Academy and Planetarium near Colorado Springs. There will be extensive exhibits, including many commercial displays. There will be two banquets and one star party - the nights will be enjoyably busy as well as the days. Perhaps most important, however, there will be opportunities for astronomical fellowship, for talking shop with kindred spirits, for renewing old friendships and for making new ones.

We want a fine A. L. P. O. Exhibit at Denver, principally drawings and photographs. We invite readers to begin thinking right now about suitable contributions to this exhibit. A definite announcement will be made in the next issue.

Mr. Steinmetz and his co-workers are engaged in planning for a unique and herculean meeting of all amateur astronomers in this nation. Their effort is worthy of our earnest support. May we hope to make your acquaintance or to renew it at Denver next August?

INTRODUCTION TO SELENOMORPHOLOGY

by Ernst E. Both

(Paper read at the Third A. L. P. O. Convention at Ithaca, New York. July 5 and 6, 1958.)

Prof. Hopmann, director of the Observatory of Vienna, in a very important article in 1952 (1), divided lunar studies into four branches: a) selenography, the study of lunar topography; b) selenophysics, the field of photometry, spectral analysis, etc.; c) selenology, the study of the formation of the lunar globe and of its crust; d) selenodesy, the investigation of lunar rotation, of libration, the measurement of positions, etc. (2). Yet a fifth branch may be called "selenomorphology", and can be defined as that study of the Moon which attempts to classify lunar features according to a variety of qualitative as well as quantitative characteristics. It uses the methods of selenography on the one hand, and selenodesy on the other; and its purpose is to provide the student of selenology with a scientifically sound basis for theoretical discussions.

The selenographers of the 19th century attempted to classify lunar formations according to superficial appearances, and perhaps the classification of Neison (3) is the best example of such endeavors. However, later investigators felt the need for a more empirical study of the problem; and the investigations of Ebert (4), Fauth (5), and MacDonald (6) are especially noteworthy. Aside from these, few students have devoted much time to morphometric studies. Yet it is precisely this field of lunar research, the field of selenomorphology, which to the serious student of the Moon offers nearly unlimited scope for research. Its vital importance is immediately apparent; for only on a detailed and exact morphological basis can be built a successful theory of selenology, and only the possession of such a knowledge will lead to a better understanding of our neighboring world.

During the last few years several important selenological discussions have appeared, of which two are specifically interesting, because they are diametrically opposed in their main postulates, primarily because both lack a sound morphological basis: Baldwin's Meteoritic Impact Theory, as expounded in his The Face of the Moon, on the one hand, and Spurr's Igneous Theory, elaborated in four volumes entitled Geology applied to Selenology, on the other. Both investigations make use of morphological material which is open to question, and both thereby provide eloquent testimony for the need of readily useable data. Baldwin bases his approach on purely quantitative material which lacks considerably in completeness and which is, moreover, in need of a thorough revision. Spurr again goes to the other extreme and uses purely qualitative data which, although on the whole sound, lack the quantitative support. Consequently, neither of the two approaches can be considered entirely valid, even though Baldwin's theory seems to carry more weight in certain professional circles.

It should be realized by now that the lunar crust owes its present appearance to a variety of causes (7), and it is one of the tasks of selenomorphology to provide the theorist with enough data so that he can decide what formations are most likely to have been caused by impact and which are due to some type of igneous action or of other forces. A dichotomy of either meteoritic or volcanic should no longer be seriously considered. In view of this situation, certain areas of selenomorphology, which are in great and immediate need of research, are discussed here. Originality cannot be claimed for this discussion, since Fauth, as long ago as 1895, implied much of what follows!

Selenomorphology may be approached in two ways, each supplementing the other:

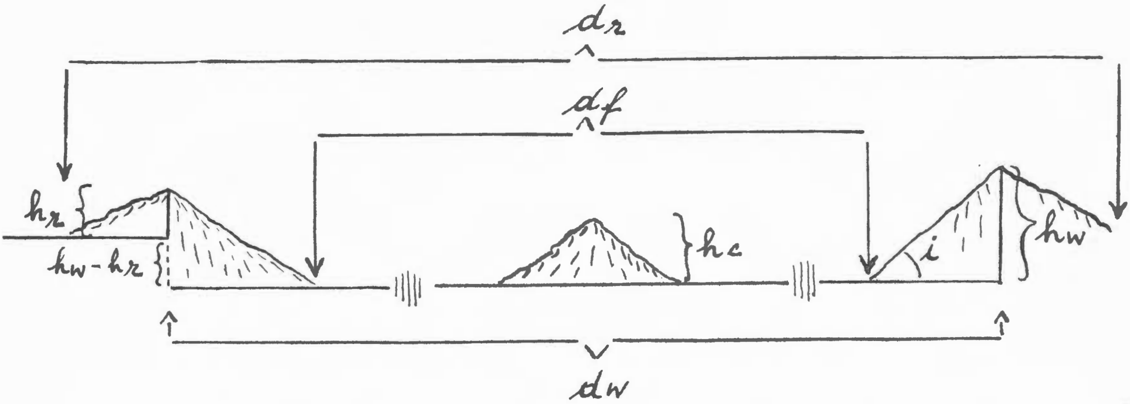

Figure 1. Cross-section of an idealized lunar crater with graphical definitions of terms used in article by Ernst E. Both in this issue.

A. The Quantitative Approach: This consists mainly in gathering and evaluating a large number of morphometric values which may be classified under the following headings:

1. The diameter of formations. For craters this is most commonly measured from wall-rim to wall-rim (the terminology employed here departs somewhat from the usual, and reference should be made to Figure 1 for a graphic definition of the terms) in an east-west direction. For large or irregular formations it should also be measured from north to south (dw). Beyond this, a knowledge of the diameter of the floor is necessary, measured from wall-base to wall-base (df), as well as the diameter of the outside rim (dr). From these measurements the "diameter relation" (dr:dw:df) can be obtained. Since the value of (dw) is known for most formations, the other values may easily be measured on photographs or specially prepared drawings on a scale of 1:1, 000, 000, where 1 mm. equals 1 km. In addition, similar values should be obtained for parasitic craters appearing on the floor, wall, or rim, and these should in turn be compared with those of the "host" crater.

2. The heights of formation components. Among these, the following need to be measured: a) Height of the wall above the floor and its peaks (hw), measuring as many points as possible to derive the profile of the wall. Several years ago such a study was carried out in relation to Theophilus (8), in which the motion picture camera proved its usefulness in lunar studies of this type. In this connection it should be remembered that the values usually given for "wall" heights are in reality maximum values for isolated peaks. The true wall heights are, on the average, considerably lower. b) The height of the wall rim above the surrounding area (hr). c) The height of the central mountain or mountains (hc). A comparison of these values gives the "height relation", namely (hw:hr:hc). The difference beyween (hw) and (hr) gives the depth of the crater relative to the surrounding area.

3. The angle of slope. This morphometric value is extremely important for any selenological discussion, but unfortunately it is known only for a relatively small number of slopes. The method of determining it is based upon the consideration that at the moment when the shadow, which the wall throws on the crater floor (or on the surrounding area), retreats to the wall base, the angle of slope of that wall must be equal to the angular height of the sun. In other words, the observation

involves only the exact timing of the moment when the floor becomes free of any shadow. This method was discussed in a monograph by the Austrian selenographer Josef Gürtler (9), who derived the following simple expression for it:

sin i equals sin (T - long.) . cos lat.

where "i" represents the angle between the crater floor and the line: wall-base to wall-rim, "T" the longitude of the terminator at the moment of observation, "long." the selenographic longitude of the feature and "lat." the selenographic latitude of the formation under concern. Reasonably accurate values can be obtained from an average of repeated timings of this moment and the subsequent derivation of the Sun's altitude. If, for example, Apianus still has floor-shadow at distances of 12° and 15° from the terminator, but none at 19° and 20°, the angle of the slope may be taken as 19.5° as a reasonably accurate estimate (Fauth).

Once we are in the possession of these morphometric values for a greater majority of at least the larger formations (ideally for formations with a diameter of 10 miles and more), we must proceed to classify them in various ways to determine what relations exist among them. The most common classification, that of MacDonald, considers the relation of the diameter to the height of the wall (dw:hw), and divides craters into four classes (10):

class 1: Normal craters - Copernicus, Picolomini, Tycho, Hercules.

class 2: Continental craters - Boguslawski, Maurolycus, Clavius, Casatus.

class 3: Normal walled plains - Maginus, Sacrobosco, Legendre, Mersenius.

class 4: Continental walled plains - Petavius, Ptolemaeus, Plato, Gassendi.

The work of Baldwin is based on this classification. In this connection the relation between the height of the wall and that of the outside rim (hr:hw) was examined for 100 craters with diameters of over 10 miles in order to determine what different relations could be found. The resulting evidence seems to point to a strikingly different type of grouping into again four classes:

<u>class a</u>: the relation of (hr:hw) is 1:1, that is, both values are about the same. Members of all four of MacDonald's classes are represented. The slopes are, generally, between 9° and 13°; the height of the central mountain, where present, is less than that of the rim (hr). Representatives are Tycho, Cichus, Calippus of class 1, Barocius of class 2, Phocylides of class 3, Walter, Archimedes, and Gassendi of class 4.

<u>class b</u>: here the relation is as 1:2. Again we find examples of all four of MacDonald's classes present. The slopes lie most commonly between 12° and 15°; the central mountain is of about the same height as the rim (hr). Agrippa, Stevinus of class 1, Hainzel of class 2, Cyrillus, Arzachel of class 3, and Posidonius of class 4 are good examples.

<u>class c</u>: the relation in this class is as 1:3, slopes generally between 14° and 20°, central mountains on the average twice as high as (hr). Significantly only members of MacDonald's classes 1 and 2 are represented, such as Theophilus, Copernicus, Piccolomini of class 1, Jacobi, Stoefler, and Clavius of class 2.

<u>class d</u> finally shows a relation of 1:4, that is the value for (hw) is four

times as large as that of (hr). Only members of class 1 seem to be represented, such as Reinhold, Mösting, König, and Langrenus.

It should be pointed out that because of the fragmentary nature of the material examined, these four classes may well have to be revised considerably once more detailed information is available. Especially class d, by far the smallest, is in need of more data. Again the insufficient knowledge of the heights of central mountains prevents the pursuit of what look like interesting relations. On the other hand, the classification presented here may well turn out to be only an apparent one, and these relations may actually follow a certain curve without clearly defined memberships. Finally, it should be noted that the maria, and mare-like structures are not considered, primarily again because of the lack of data. From the spurious information available it seems that structures on the order of Ptolemaeus (hr:hw is 1:2, MacDonald class 4) are closely related to the smaller maria, for example Mare Crisium (1:2 or 4). At any rate it should be apparent that relations other than those considered by MacDonald exist, and that they should be investigated.

B. The Qualitative Approach: Beyond a purely quantitative classification, the lunar formations need to be investigated and typed according to common morphological features. Again a number of possibilities suggest themselves, all of which must be considered carefully. Starting from broad features which certain craters have in common, they may be arranged as follows (11):

Normal craters: walls intact and continuous, central mountain present, no parastitic structures of note. Tycho, Copernicus, Piccolomini, Theophilus, Manilius, Autolycus.

Craters with smooth interiors: walls intact and continuous, relatively smooth floor, no central structures. Plato, Archimedes, Billy, Herodotus.

Open craters: walls are partially submerged into the mare, but still intact where present. Central mountain either sunken or still evident. Fracastorius, Lemonnier, Letronne, Doppelmayer.

Craters with parasitic intrusions: walls more or less continuous, parasitic craters on the walls, sometimes rills on the floor. Posidonius and Gassendi.

Crater ruins and almost completely sunken craters: Ancient Torricelli, Flamsteed, Fra Mauro, but also structures like Schroeter's Newton south of Plato, the "ghost" to the east of Thebit, and others. Also continental ruins such as Julius Caesar, Sacrobosco, Hörbiger (Hell-plain).

Craters associated with bright rays: Tycho, Copernicus, Kepler, Aristarchus, Proclus, etc.

Craters associated with rills: Triesnecker, Hyginus, Sabine-Ritter, Ramsden, Aristarchus-Herodotus, etc.

Craters with rills on the floor: Alphonsus, Arzachel, Gassendi, Pitatus, Posidonius, etc.

This list could be continued practically ad infinitum. Important in this respect, however, is the fact that classifications such as these are usually set up without quantitative correlations. As it was stressed earlier, the two approaches must supplement each other. It is vitally important that this fact be kept in mind and that constantly data of both approaches be used when lunar formations are analyzed.

A close investigation of Gassendi, for example, reveals its similarity to Posidonius. Both formations are of approximately the same size. Both are situated at the edge of a mare; and part of the wall of each formation has sunk into the mare, that of Gassendi in the south, that of Posidonius in the north-east. Each of the two exhibits parasitic craters on its wall, and in each case there is a relatively large one in the northern wall. Gassendi exhibits a multiple central mountain and a nearly central craterlet, features which are closely shared by Posidonius, although here the central crater is considerably larger while the group of "central" mountains is much lower and less impressive. Finally, both structures exhibit an intricate system of rills on their floors which tax the skill of the most experienced selenographers. Now according to MacDonald's classification both formations belong to class 4, i.e. continental walled plains, whereas according to the classification outlined above, Gassendi is a class a (1:1), while Posidonius belongs to class b (1:2). In this connection it is interesting to note that Spurr considers Gassendi to be older than Posidonius (Middle Mesoselene against Middle-late Mesoselene).

There can be no doubt that a more detailed classification will indicate new and interesting relations, and that eventually it will be possible to assign to each crater a short, characteristic type-formula. However, beyond a detailed analysis of the individual formations it is necessary to investigate the distribution of like structures (12). Some questions that need to be answered in detail are: Do similar formations appear in similar surroundings? Do certain crater-types prefer certain locations? Do they prefer a general direction or are their locations at random? It is a well-known fact that craters with level floors appear generally in the neighborhood of the maria. Rills, likewise, show a tendency to place themselves around the dark plains; and the question arises whether there are other structures which show similar preferences.

Groups like De la Rue, Endymion, Messala, Cleomedes, (Mare Crisium), Mare Spumans, Langrenus, Vendelinus, Petavius, and Furnerius should be investigated in terms of qualitative as well as quantitative characteristics. Or consider the interesting, though not too obvious, double arc of craters extending from the NW to the SE and including Kirchhoff, Newcomb, Stephanides, Römer, Littrow, Maraldi, Vitruvius, Dawes, Janssen, Plinius, Ross, Maclear, Arago, Sosigenes, Manners, Tempel, D'Arrest, Agrippa, Godin, Dembrowski, Rhaeticus, and perhaps its more impressive north-eastern counterpart with Aristoteles, Eudoxus, Alexander, Cassini, the Caucasus Mtns., Aristillus, Autolycus, Archimedes, the Apennines, Eratosthenes, and Copernicus - these arcs then curving towards the SW in five parallel chains:

1. Ptolemaeus, Alphonsus, Arzachel, Purbach, Regiomontanus, Walter, Stoefler.

2. Blanchinus, Werner, Aliacensis, Maurolycus.

3. Hipparchus, Albategnius, Klein, Parrot, Krusenstern, Apianus, Poisson, Gemma Frisius.

4. Descartes, Abulfeda, Almanon, Sacrobosco, Wilkins, Zagut, Rabbi Levi, Riccius.

5. Theophilus, Cyrillus, Catharina, the Altais, Piccolomini.

Such groups of craters must be carefully investigated in terms of their individual members to establish in what respects they are organically related.

In conclusion it may be said that the field of selonomorphology needs a large number of the most varied investigations. The importance of such investigations is so great that it is hoped that a number of observers will undertake some of them. It is necessary to know a great deal more about the Moon, but such a knowledge can only be obtained in a coöperative effort of serious and determined selenographers.

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2. For a discussion of this branch of lunar studies see Ashbrook, Joseph, "Surveying the Moon, "Sky and Telescope, XV, 1956, 452.

3. Neison, Edmund, The Moon, London, 1876, 51-79.

4. Discussed by K. Graff, "Der Erdmond", Handbuch der Astrophysik, vol. IV, Berlin, 1929, 405.

5. Fauth, Philipp, Neue Beiträge Zur Begründung einer modernen Selenographie und Selenologie, Kaiserslautern, 1895, 29-39, and Unser Mond, Breslau, 1936, 13-27.

6. Discussed in detail by R. Baldwin, The Face of the Moon, Chicago, 1949, 117-127, where the investigations of Ebert and Fauth are also treated. For MacDonald's later views see his article "The Depression of Lunar Craters", Journal of the Royal Astron. Soc. of Canada, vol. 36, 1942, 159-162.

7. Alter, Dinsmore, Introduction to the Moon, Griffith Observatory, 1958, preface: "In so far as past experience may be taken as a guide, it would appear probable that when the final truth is established (perhaps by actual exploration of the surface), each of the /selenological/ studies mentioned will have contributed to our knowledge".

8. MacMath, Sawyer, and Petrie, "Relative Lunar Heights and Topography by means of the Motion Picture Negative", Publications Michigan Observatory, vol. 6, 1937, 67-74.

9. Gürtler, Josef, "Böschungswinkel von Mondformationen, "Astronomische Rundschau (Sondernummer), Nov. 1946, 4-8.

10. This relation is given for a large number of formations in Fauth's Unser Mond.

11. As long ago as 1895, Fauth developed a very detailed outline for a qualitative approach. See his Neue Beiträge (cited above), 57-59.

12. Moore, Patrick, "Some Lunar Crater Problems, "Sky and Telescope, XV, 1956, 201-203.

AN APPARENT VOLCANIC ERUPTION IN THE LUNAR CRATER ALPHONSUS

by Walter H. Haas

On November 4, 1958 the Russian astronomer, Dr. N. A. Kozyrev, made one of the most important physical observations of all time of the lunar surface. He witnessed what was apparently volcanic activity from the central peak of the crater Alphonsus.

Our information here rests upon an account by Dr. Zdenek Kopal, "Volcano on the Moon?", The New Scientist for November 27, 1958. Dr. Kozyrev was making spectrograms of the moon with the 50-inch reflector at the Crimean Astrophysical

Observatory. He was taking successive 30-minute exposures of the same region, dispersion 50 angstroms per mm. It is surmised that he was using the well-defined central peak of Alphonsus as a kind of guide-star. Between $3^h\ 0^m$ and $3^h\ 30^m$, Universal Time, on November 4 Dr. Kozyrev noticed that the outlines of the central peak of Alphonsus became blurred and appeared to be engulfed in a reddish cloud, shifting by about two seconds of arc toward the setting sun. (We here assume with Dr. Joseph Ashbrook of the Sky and Telescope staff that the times given in Dr. Kopal's paper are by Universal Time.) This extraordinary appearance was apparently of brief duration. It later turned out that the spectrogram taken between $2^h\ 30^m$ and $3^h\ 0^m$, U.T. shows the violet part of the spectrum greatly weakened and that the one taken between $3^h\ 0^m$ and $3^h\ 30^m$ reveals a whole sequence of the Swan bands of the diatomic carbon molecule in emission. There was no sign of these emission bands on another spectrogram taken half an hour later. Dr. Kopal plausibly explains the initial weakening of the violet end of the spectrum by a large-scale stirring of dust on the floor of Alphonsus and the later emission spectrum by the release of a considerable mass of gas, which quickly dissipated. The carbon emission lines might be the result of either high temperature or of excitation by sunlight. A more detailed interpretation should be possible when the Russian scientists have announced the results of their studies of the spectrograms.

Alphonsus is located in Section VIII of the Wilkins map of the moon, lunar latitude 13°S. and lunar longitude 3°E. It is the middle member of a north-south chain of three imposing lunar formations, with Ptolemaeus the northern member and Arzachel the southern. The diameter of Alphonsus is about 70 miles. It is best known to amateur lunarians for the three prominent dark spots on its floor under high solar lighting. Recently Dr. Dinsmore Alter has found evidence of the existence of occasional lunar gases here on the basis of comparative differences in appearance between Alphonsus and Arzachel in infrared and in blue-violet photographs (Publications of the Astronomical Society of the Pacific, Vol. 69, No. 407, April, 1957).

The early reports which reached us through the popular press of this remarkable and important observation were somewhat incomplete and incorrect. Of course, a number of our observers were immediately interested in examining Alphonsus to determine whether the volcanic outburst had produced any changes in appearance. There was, however, the handicap usual in such lunar matters: few or none of these observers had previously made any special study of Alphonsus. They were hence obliged to depend upon memory and to compare the appearance in the telescope to photographs. The search was spurred by the exciting possibility of a second volcanic outburst, for on the earth we know that one eruption is often followed by a series of others. Dr. James Bartlett, Jr., the Venus Recorder, further suggested that neighboring lunar peaks should be watched too; for on the earth we may have chains of volcanoes, of which first one will erupt, then another, than a third, etc.

We next catalogue such observations of Alphonsus made between November 10, 1958 and January 10, 1959 as have been reported to us. We apologize for any omissions; they are accidental. At 3^h, U.T. on November 4, 1958 the colongitude was 181°.3, Alphonsus thus being only three or four hours inside the sunset terminator.

November 13, 1958. James C. Bartlett, Jr. 4 1/4-inch refl. at 50X and 120X. 23^h to $23^h\ 20^m$, U.T. Colongitude = 301°.3. The earthshine was carefully examined with the assistance of color filters, but no speck of light was discernible in the position of Alphonsus.

November 16, 1958. Craig L. Johnson. 4-inch refl. at 65X and 167X. $0^h\ 55^m$ -$1^h\ 40^m$, U.T. Colongitude = 326°.7. Nothing unusual was seen on the earthshine in the area of Alphonsus.

November 19, 1958. Walter H. Haas. 12.5-inch refl. at 303X. $3^h\ 20^m$

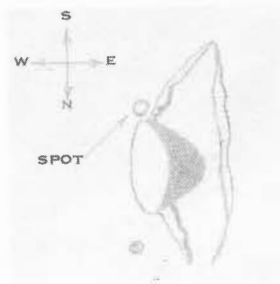

Figure 2. Alphonsus Central Peak and Vicinity. November 19, 1958. $21^h\ 15^m$, U.T. 15 1/4-inch refl. 500X. H.P. Wilkins. Colong. = $13\overset{\circ}{.}4$. Seeing excellent. Arrow points to spot regarded as a new lunar feature by Dr. Wilkins.

Figure 3. Alphonsus Central Peak and Vicinity. December 20, 1958. $6^h\ 0^m$, U.T. 12.5-inch refl. 367X. Walter H. Haas. Colong. = $22\overset{\circ}{.}7$. Seeing poor.

$-5^h\ 20^m$, U.T. Colongitude = $4\overset{\circ}{.}3$ to $5\overset{\circ}{.}3$. The crater was examined at intervals, but nothing unusual or not in agreement with photographs was observed. At $3^h\ 20^m$ little but the central peak was visible in the sunrise shadow. By $5^h\ 20^m$ most of the floor was in sunlight.

November 19, 1958. H.P. Wilkins. 15 1/4-inch refl. at 500X. 21^h $-21^h\ 30^m$, U.T. Colongitude = $13\overset{\circ}{.}4$. Aided by excellent atmospheric conditions, Dr. Wilkins observed "a faint dusky reddish patch, about 2 miles in diameter" immediately south of the bright central peak (Figure 2). On the same evening J. Wall and F.D. Brewin in England saw in the same position a dusky patch with a 12-inch telescope. Writing on December 10, Dr. Wilkins mentions several more confirmatory observations in the British Isles and in Hungary. He concludes: "The spot is certainly new and does not appear on any photograph". These observations fill much of Bulletin No. 7 of the International Lunar Society, where the new spot is said to lie on the south flank of the central peak and to be invisible in small instruments. The Editor would suggest that more evidence is needed to prove this spot to be a new lunar feature. One may recall the great difficulty, indeed the seeming utter impossibility, of determining the detailed appearance of such well-studied lunar regions as Maedler's Square and O'Neill's Bridge. The absence of the spot from photographs will mean little unless the photographs were made under similar solar lighting to the visual studies and unless the photographs showing no spot <u>do</u> reveal features now more difficult than this spot.

November 20, 1958. James C. Bartlett, Jr. 5-inch refl. at 110X and 180X, 4 1/4-inch refl. at 120X and 240X. $0^h\ 40^m$ $-1^h\ 40^m$, U.T. Colongitude = $15\overset{\circ}{.}1$ to $15\overset{\circ}{.}6$. A long and careful scrutiny gave completely negative results.

November 20, 1958. Charles M. Cyrus. 10-inch refl. at 323X. About 2^h, U.T. Colongitude near 16°. Alphonsus appeared normal.

November 20, 1958. Walter H. Haas. 12.5-inch refl. at 303X and 367X, $3^h\ 50^m$ $-5^h\ 0^m$, U.T. Colongitude = $16\overset{\circ}{.}7$ to $17\overset{\circ}{.}3$. Alphonsus was examined at intervals and appeared to be completely normal and in full agreement with photographs.

November 21, 1958. James C. Bartlett, Jr. 4 1/4-inch refl. at 120X and 240X. $2^h\ 10^m$, U.T. (middle time). Colongitude = $28\overset{\circ}{.}0$. A one-hour study both with and without several color filters and with the help of excellent atmospheric conditions gave absolutely negative results.

November 22, 1958. Craig L. Johnson. 4-inch refl. at 375X. Colongitude about 40°. Alphonsus was examined carefully in excellent seeing. The north, west, and northwest walls were suspected of a changed aspect; but Mr. Johnson was later doubtful of the correctness of this impression.

November 24, 1958. Walter H. Haas. 12.5-inch refl. at 303X. $5^h\ 35^m$, U.T. Colongitude = 66°.2. Alphonsus looked normal.

November 25, 1958. Walter H. Haas. 12.5-inch refl. at 367X. $5^h\ 16^m$, U.T. Colongitude = 78°.2. Alphonsus again looked ordinary and normal.

November 27, 1958. James C. Bartlett, Jr. 4 1/4-inch refl. at 120X and 240X. $2^h\ 30^m$ -$3^h\ 20^m$, U.T. Colongitude = 101°.0 to 101°.5. The central peak was strongly suspected of marked variations in intensity when compared with the very bright spot in the southeastern part of the floor. At $2^h\ 55^m$, U.T. the central peak to fade, at $3^h\ 2^m$ it was almost invisible, and when observations ended at $3^h\ 20^m$ it had not yet regained its original brightness.

December 3, 1958. Walter H. Haas. 12.5-inch refl. at 303X. $9^h\ 47^m$, U.T. Colongitude = 177°.6. With low lighting but bad seeing, it was again impossible to find any peculiar or unusual aspects.

December 19, 1958. Alika K. Herring. 12.5-inch refl. at 228X, 310X, and 465X. 3^h, U.T. Colongitude = 9°.0. With excellent seeing but poor transparency, Mr. Herring searched long and carefully but vainly for anything out of the ordinary. Possible obscurations were looked for, but the floor details in Alphonsus were equally clear with those in Arzachel and Ptolemaeus. Neither could any anomalous colors be found, though the poor transparency might have hidden them.

December 19, 1958. Walter H. Haas. 12.5-inch refl. at 303X. $5^h\ 27^m$, U.T. Colongitude = 10°.2. Alphonsus looked normal, and a sketch of the central peak showed no dusky patch on its south flank.

December 20, 1958. Walter H. Haas. 12.5-inch refl. at 367X. $6^h\ 0^m$, U.T. Colongitude = 22°.7. The central peak and its surroundings were drawn (Figure 3). Is the darker knot in the slight floor shading to the south of the central peak Dr. Wilkins' "new" spot?

December 22, 1958. Walter H. Haas. 12.5-inch refl. at 303X. $5^h\ 23^m$, U.T. Colongitude = 46°.6. The aspect seemed normal, and the dark patch just south of the central mountain was not recovered.

December 23, 1958. Charles M. Cyrus. 10-inch refl. at 323X. $3^h\ 30^m$, U.T. Colongitude = 57°.8. Central peak appeared normal.

December 24, 1958. Walter H. Haas. 12.5-inch refl. at 303X. $8^h\ 6^m$, U.T. Colongitude = 72°.3. Handicapped by haze which reduced contrasts, the observer saw no dark spot south of the central peak nor anything else unusual.

In addition, Mr. David P. Barcroft several times in November and December could find nothing peculiar about Alphonsus.

We thus may have a fair case that the volcanic activity on November 4, 1958 did not alter the appearance of Alphonsus to an extent readily observable with ordinary telescopes. The dark spot observed by Dr. Wilkins and others may refute this point of view, however; and we hence urge our readers to search carefully for this spot, employing Figure 2 as a guide.

This example of lunar vulcanism can hardly fail to influence our ideas about the cause of the lunar surface formations and about the physical nature of the moon. In recent years the meteoritic impact theory has probably been more popular than the volcanic theory among professional astronomers as an explanation of how the moon's surface was molded to its present appearance. Kozyrev's observation may restore the balance between the two interpretations or even cause a strong swing to vulcanism. In fact, Professor A. A. Mikhailov of the Soviet Academy of Sciences has been quoted as having said "we are now able to rule out as entirely erroneous the present views that the peculiarities of the lunar relief are the results of hits by meteors". This opinion seems to go too far; for it is surely possible that someone will one day witness the creation of at least a tiny craterlet by meteoritic impact, and we ought not then in similar fashion to announce that vulcanism has played no role in cuasing the lunar craters. If analysis proves that the carbon in the spectrum of Alphonsus was at a high temperature, then we must accept at least one pocket of hot materials in the lunar crust. The gases released by this outburst must contribute to a lunar atmosphere for a period of time depending upon their molecular weights, and perhaps the extremely tenuous lunar atmosphere can even be gaining in density from such releases of gases.

It is interesting to speculate upon how common such examples of lunar volcanic activity are. Kozyrev's observation is unique, but then spectrograms of the moon are by no means taken frequently. Dr. Alter's photographs mentioned above would strongly hint at other outbreaks of activity in Alphonsus. This November 4 affair would also give inferential support to the many examples of apparent obscurations of lunar surface detail reported by reliable visual observers. One thinks at once of the many records of a veiling of Plato floor detail and wishes that the evidence had been more conclusive.

We might also reflect upon the fact that, to the best of present knowledge, only Kozyrev observed this Alphonsus phenomenon. Nevertheless, the shifting reddish cloud briefly present between $3^h\ 0^m$ and $3^h\ 30^m$ would surely have been a striking object in even 4 - to 6-inch telescopes. The moon was at Last Quarter near 14^h, U.T. on November 4 and hence at 3^h would have been well placed for observation over a sizeable portion of the earth's surface. Even so, others seem to have seen nothing. The incident emphasizes just how fragmentary and incomplete is our coverage of the lunar panorama. All sorts of important and exciting lunar events could occur undetected by us, and perhaps some actually do. We may hope for improved coverage in the future with the Lunar Missile Survey; but we are still far short of what we ought to have, namely, a continuous patrol of the moon.

SOME STATISTICAL NOTES ON THE AUXILIARY PHENOMENA OF THE CUSP CAPS OF VENUS

by James C. Bartlett, Jr.

In a previous paper in the April-June, 1958 Str. A. quantitative aspects of the apparent polar caps of Venus were considered, as derived from 830 observations during the years 1944-1956. In the present paper we shall consider two closely associated phenomena; the dark cusp bands around either cap and the two cusp indentations, peculiar one to the south and one to the north cusp. As in the previous paper the observations have been organized into three groups; those of the writer, those of O.C. Ranck, and those of 32 other A. L. P. O. observers. The reason for this division is that the first two observers are represented by long periods of consistent observations, whereas the observers in the second group are represented individually by fewer, more scattered observations, though collectively by a greater number. The numerical data will be considered in order of descending number of individual observations, for which reason the writer has ventured to play the first but by no means the leading role. Also, as in the previous paper, percentages are rounded off to avoid fractions.

Of the 830 observations upon which this survey is based, no less than 451 were contributed by the following workers to whom the writer is correspondingly indebted:

Leonard Abbey, Jr.; R.M. Adams; D.P. Avigliano; Ray Berg; R.M. Baum; Lee Bellot; Phil Cluff; Thomas Cragg; Charles M. Cyrus; W.H. Haas; W.K. Hartmann; Lyle T. Johnson; A.P. Lenham; A. Longton; Eugene A. Lizotte; Charles P. Martens; David D. Meisel; Richard Miller; Patrick Moore; T. Osawa; Cecil Post; Tsuneo Saheki; C.J. Smith; C.B. Stephenson; H.P. Squyres; J.E. Thrussell; Frank Vaughn; Howard Le Vaux; Brian Warner; William Weaverling; John A. Westfall; and René A. Wurgel.

The reduction of the observations for this paper was considerably easier, because here one was dealing with features having high contrast and in regard to which the drawings were never doubtful. Accordingly it is believed that such errors of interpretation as may have crept into the reductions for the bright cusp caps do not apply here. Certainly it can be said that the drawings of the various observers were completely honest, and accurate to the extent that the observer depicted the phenomena as they appeared to him.

It now remains to be seen whether the mass of data herein considered shows any substantial agreement in fundamentals, which would indicate that something more than illusion is involved. To this end we shall first examine the cusp bands.

The cusp bands of Venus, as their name implies, are the two dusky collars often - but not invariably - found bordering the two apparent polar caps. Like the caps they delimit they have been known for many years, and also like the caps they have been regarded by many as illusions and by many as real features. Among the classical observers, Percival Lowell left no doubt as to his views. Said Dr. Lowell: "Of the markings to be made out upon the disk there are two kinds. The nicks in from the terminator, the collar around the south pole, and the two spots upon it, like beads upon a necklace, belong to the first and most obvious class. Of them I have never entertained the suspicion of a doubt...." The two dusky spots which Lowell observed on the south cusp band he named Astoreth and Ashera. To Lowell, the south cusp band and its two associated spots were objective features; but it must also be remembered that he used those same spots to measure the rotation, deriving therefrom a period of 225 days now generally abandoned. For this and other reasons many careful observers have been inclined to regard the cusp bands as being purely subjective; as contrast effects but nothing more. Among A.L.P.O. observers W.H. Haas leans to this view, though there are not wanting champions of the opposite opinion. The question of their true nature is tied in with that of the cusp caps themselves; know the one and you will know the other.

All depends upon the true nature of the bright caps. If only illusions themselves then the cusp bands are probably the same; but in a previous paper we have seen that there is respectable reason to regard the caps as objective realities. It follows that if the caps are true polar accumulations of snow and ice, then the cusp bands follow as necessary sequellae.

Somewhere I have seen the suggestion that these features are melt bands, similar in nature to the melt bands around the Martian caps. This conception has much merit, though it should be clearly understood that melt bands around hypothetical Venusian caps would arise from entirely different causes. The difference in causes is an important one and has considerable bearing on the observational evidence; for it means that if the cusp bands of Venus are really melt bands then we should expect to see them consistently and in every part of the planet's orbit. If it is shown that they are so seen, then the possibility of their being real features is strengthened. The Martian caps, like those of our own planet, are subject to melting (though the degree of melting is much greater for Mars than for earth);

but this melting is periodical. It arises out of the circumstance that the axis of Mars has an inclination of some 25° from perpendicularity to the orbit, which gives to the sun a north-south movement in the Martian sky resulting in the same kind of seasons familiar to us - though the Martian seasons are considerably longer and the winter ones considerably more rigorous. As on the earth, during the winter season of a given hemisphere the Martian polar cap is obscured in a long night. With the return of the sun in the vernal season activity begins around the fringes of the cap, and as the sun daily mounts above the Martian polar circle the whole cap begins to shrink away. When this melting has progressed far enough a dark band begins to appear around the cap, often of a beautiful blue color. This is the melt band.

An important superficial difference between the Martian melt bands and the cusp bands of Venus is in the greater conspicuousness of the former, which follows naturally from the greater contrast with the Martian background. A much more important and fundamental difference lies in the fact that whereas the Martian melt bands are visible only in season, the cusp bands of Venus are visible to some degree at all times. Now this circumstance points to an entirely different modus operandi in the production of the Venusian cusp bands; and while the one fact cannot prove the other, it is nevertheless significant that if the cusp bands of Venus are truly melt bands, then their behavior is exactly what is required by theory.

This follows from the fact that if the cusp bands are melt bands, then the cusp caps are real polar caps; and if this is so, then the inclination of the axis of Venus is close to zero. Once these relations are thoroughly grasped the pieces of the puzzle immediately fall into place.

Assume that the inclination is zero, maybe plus or minus a degree or two. Now this would mean that the sun would forever be on or very close to the equator of Venus; but whereas on the equator the sun would forever have a zenith distance, at culmination, equal to 0°, at the pole the sun would forever have a zenith distance of 90°. In short, at the equator the sun would always be in the zenith at meridian passage; but at the pole the sun would always be on the horizon - and it is important to notice that the sun would forever be on the horizons of both poles simultaneously. This condition is so foreign to our experience that its cause may not at first be clear. On any planet the pole of rotation must always lie 90° from the equator. Therefore, at the pole itself, the equator is always on the horizon. But if the axis of Venus is perpendicular to the orbit, then the sun has no north-south movement as seen from Venus. Consequently its position in the sky is always on the equator as seen from any point on the surface; and since the equator lies in the polar horizon, it follows that the sun will always be seen on the horizon from either pole.

This state of affairs does not mean that in such case Venus would have no seasons. What it does mean is that Venus would have no seasonal change. To put it another way, in such case the seasons of the planet would be determined not by time but by latitude; and each climatic zone between given parallels would perpetually enjoy the season peculiar to its distance from the equator. For example; eternal summer at the equator balanced be eternal winter at the poles; and midway between, eternal spring.

Now in this circumstance we have an explanation both for the persistence of the apparent polar caps in all parts of the orbit, and equally for the similar persistence of the cusp bands. Assuming that appearances correspond to realities, and that the sun is always upon or very close to the equator of Venus, it follows that there would be an equable gradation of temperature, falling slowly, from equator to poles and alike in both hemispheres. Now it is obvious that there must be two points at which the temperature will always be at a minimum; and the two points will be those which lie 90° from the equator, i.e. the poles. Here then, granting the presence of water and a degree of cold sufficient to freeze it, we could expect to find permanent polar caps. Now it is also clear that at some point close to the polar regions the temperature gradient, though low, would be just above freezing. Here there would be interaction with the permanent snow of the cap, and here there would be a degree of melting; but since this zone, like all other climatic zones, would be fixed the net advances and retreats of the melting edge of the cap would have a mean value close to zero. In other words one would have a permanent melt band surrounding each polar cap; a permanent polar marsh remaining more or less always of the same area and occupying more or less always the same position.

It is entirely possible therefore that the cusp bands of Venus are melt bands of this nature; dark and narrow polar marshes not affected by any seasonal change.

Of course the reader will realize that the picture just drawn is an ideal one, and Nature rarely works in ideal fashion. For instance, we cannot really know that the temperature gradient would have an equable fall from equator to pole even if the axis is perpendicular to the plane of the orbit. Many local factors could seriously affect it; e.g. the proportion of land to water surface and the mean elevation of one part of the surface as compared to another. Finally it must be said that we cannot be sure that the points of minimum temperature, i.e. the poles, would have a temperature at or below the freezing point. The dense atmosphere of the planet, especially as it contains much carbon dixoide, might result in polar temperatures much higher than 32^{o} F.

All that can be said with any certainty is that the persistence of bright caps some 90^{o} from the apparent equator strongly suggests an inclination close to zero, and the existence of permanent snow areas, implying that surface conditions are such as to permit the accumulation of ice and snow at the polar points. On this view the existence and permanency of the cusp bands can find a physical explanation as noted above.

Let us now proceed to an inquiry into the statistical aspects of the cusp bands, beginning with:

Table 1

interval	no. of observations		observer
1944-1956	221		Bartlett
S. band alone visible	74	34%	
N. band alone visible	10	5	
Both bands visible	29	13	
Both bands invisible	108	48	
	221	100 %	

Table 2

interval	no. of observations		observer
1951-1956	158		Ranck
S. band alone visible	43	27%	
N. band alone visible	11	7	
Both bands visible	19	12	
Both bands invisible	85	54	
	158	100 %	

Table 3

interval	no. of observations		observers
1951-1956	451		all others
S. band alone visible	56	13 %	
N. band alone visible	11	2	
Both bands visible	48	10	
Both bands invisible	336	75	
	451	100 %	

Table 4

interval	no. of observations		observers
1944-1956	830		all observers
S. band alone visible	173	21 %	
N. band alone visible	32	4	
Both bands visible	96	12	
Both bands invisible	529	63	
	830	100 %	

Among the safe general conclusions to be drawn from these four tables are the following:

That in those observations in which only one cusp band was visible it was predominantly the south cusp band; that the north cusp band is not so consistently visible; that both bands together were visible for a smaller percentage of time than the south cusp band alone; that with the single exception of the writer's series, both bands were invisible more often than visible. Now this last has an important bearing on the question of illusion; particularly when we understand that invisibility of the cusp bands by no means always coincided with invisibility of the bright caps. In many of the writer's observations, for instance, the caps were obviously brighter than the adjacent surface and by this means alone were rendered visible. Yet if the cusp bands are purely contrast effects, then we should expect them to be prominent whenever the contrast is great. Such has not been found to be the case.

It is also noteworthy that in the observational series of both O.C. Ranck and the writer the percentage of invisibility hovers close to the half-way mark; 2 points below for Bartlett, 4 points above for Ranck. This is probably due to the fact that with both observers there were long periods of consistent observation, daily insofar as weather or other factors permitted. It is therefore a reflection of another fact, namely that, like the caps themselves, the cusp bands are visible more frequently between Superior Conjunction and either elongation than between either elongation and Inferior Conjunction. Now the same relation was found for the bright caps, and the cause is undoubtedly the same; the greater area of surface illuminated between Superior Conjunction and an elongation than between an elongation and Inferior Conjunction.

The other observers, collectively, had more observations than both O.C. Ranck and the writer; but individually there were fewer. This difference is reflected in the somewhat different percentage figures, reaching a maximum difference in the percentage for invisibility. On the whole, however, the general agreement is so good that the illusion theory would appear to be greatly weakened - at least it seems so to this observer.

If the cusp bands are not illusions, perhaps they are only phase effects. If so, then we should find them closely related to phase, and we would not expect them to be visible in all parts of the orbit. In the following tables we see the fruits of an investigation into the relation between visibility and phase; as measured by the quantity, k, taken from the tables of the Illuminated Disk of Venus in The American Ephemeris and Nautical Almanac. The values of k, for all intermediate dates, are interpolations and have been rounded off.

Table 5

Earliest appearance of one or both cusp bands as related to k, Superior Conjunction to Greatest Elongation East

k	date	observer
0.982	March 17, 1954	O.C. Ranck
0.946	Sept. 2, 1952	Thomas Cragg
0.930	Nov. 27, 1955	W.H. Haas
0.882	March 12, 1951	J. C. Bartlett
0.881	Jan. 29, 1956	Frank Vaughn
0.855	March 23, 1951	R.M. Baum
0.855	May 31, 1954	D.P. Avigliano
0.841	Jan. 13, 1956	Richard Miller
0.805	Nov. 11, 1952	A.P. Lehham
0.701	March 1, 1956	D.D. Meisel
0.594	March 27, 1956	A. Longton

Table 6

Latest appearance of one or both cusp bands as related to k, Greatest Elongation East to Inferior Conjunction

k	date	observer
0.466	April 20, 1956	Brian Warner
0.448	April 23, 1956	W.H. Haas
0.370	Feb. 24, 1953	A.P. Lenham
0.351	July 18, 1951	R.M. Baum
0.250	March 11, 1953	O.C. Ranck
0.157	May 29, 1956	D.D. Meisel
0.148	March 21, 1953	J.C. Bartlett

Table 7

Earliest appearance of one or both cusp bands as related to k, Inferior Conjunction to Greatest Elongation West

k	date	observer
0.101	Sept. 21, 1951	Thomas Cragg
0.362	Jan. 31, 1955	O.C. Ranck
0.457	Aug. 24, 1956	William Weaverling

Table 8

Latest appearance of one or both cusp bands as related to k, Greatest Elongation West to Superior Conjunction

k	date	observer
0.557	Nov. 25, 1951	Phil Cluff
0.735	Jan. 9, 1952	R.M. Baum
0.810	Sept. 10, 1953	O.C. Ranck
0.875	Oct. 5, 1953	H.P. Squyres

The primary fact apparent in these tables is the visibility of the cusp bands in all parts of the orbit. They are, therefore, like the bright caps, permanent features and certainly not phase effects. A secondary fact is their easier visibility between Superior Conjunction and an elongation, not so well shown in the morning observations because these are too few but abundantly clear in the evening observations. In this too they agree with the aspects of the cusp caps. The above observations do not, of course, number all the observations made of the bands; but simply the maximum and minimum dates of their visibility as reported by the several observers. The range is sufficiently great, however, from 0.982 to 0.101, to show conclusively that when visible at all they may be expected at any point in the orbit and for any phase. We are justified therefore in regarding them as permanent features. For permanent illusions to show such a range seems very unlikely. Some readers may object to the single observation of Cragg, with a k value of only 0.101, as being highly improbable. Nevertheless Cragg's drawing for that date definitely shows a dark section of band-like nature at the position of the south cusp cap, and so was included in accordance with the regulations adopted for qualification. But even if this observation is rejected the results are in no way invalidated.

We now turn to two other features associated with the cusp caps and which also have been treated as illusions by some observers; I refer to the prominent indentations which from time to time are seen at both cusps. Of these the more prominent is the South Cusp Indentation. The North Cusp Indentation is smaller and is also less frequently seen. There is also some reason to suppose that the North Cusp Indentation represents more than one such feature as seen at different times.

The South Cusp Indentation, when well seen, appears to result from an irregularity, presumably a depressed surface relative to the South Cusp Cap, of considerable size. When favorably placed it is so conspicuous that few who see it could seriously entertain the idea that it is wholly illusory. Moreover when intermittent observations of this feature are made, striking changes are observed strongly suggesting the effects of rotation. Figures 4 and 5, from the writer, illustrate this point.

The North Cusp Indentation - or possibly indentations - appears to result from a similar cause, i.e. a depressed area relative to the cusp cap. In both cases, however, the apparent depression may actually be caused by a sharp elevation of the cusp cap at a particular point. All that can be said with any certainty is that both cusp indentations appear either to be depressions filled with shadow, or shadow effects from nearby elevations.

The following tables give the statistical relations:

Table 9

S. Cusp Indentation

interval	no. of observations		observer
1944-1956	221		Bartlett
visible	42	19%	
invisible	179	81	
	221	100 %	

Table 10

N. Cusp Indentation

interval	no. of observations	observer
1944-1956	221	Bartlett

Table 10 (Con't)

visible	18	8%
invisible	203	92
	221	100 %

Table 11

S. Cusp Indentation

interval	no. of observations		observer
1951-1956	158		Ranck
visible	7	5 %	
invisible	151	95	
	158	100 %	

Table 12

N. Cusp Indentation

interval	no. of observations		observer
1951-1956	158		Ranck
visible	1	0.6 %	
invisible	157	99.4	
	158	100 %	

Table 13

S. Cusp Indentation

interval	no. of observations		observers
1951-1956	451		all others
visible	40	9%	
invisible	411	91	
	451	100 %	

Table 14

N. Cusp Indentation

interval	no. of observations		observers
1951-1956	451		all others
visible	22	5 %	
invisible	429	95	
	451	100 %	

The salient single fact to emerge from this tabulation is the more frequent visibility of the South Cusp Indentation as compared to the visibility of the North Cusp Indentation, a fact agreed upon by all the observers. Another fact - entirely natural- is the lesser visibility of both indentations as compared to either the cusp caps or the cusp bands. The reason is not mysterious. If the cusp indentations are real

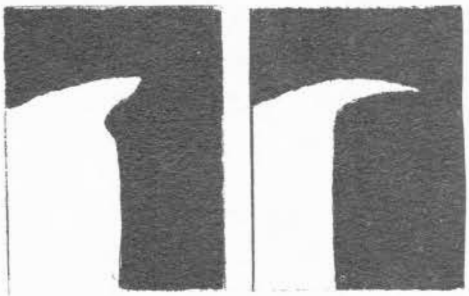

Figure 4. Change of aspect in the South Cusp Indentation. June 20, 1951.
Left - at $0^h 16^m$, U.T.
Right - at $1^h 00^m$, U.T.
3.5 in. reflector, 100x.
James C. Bartlett, Jr.

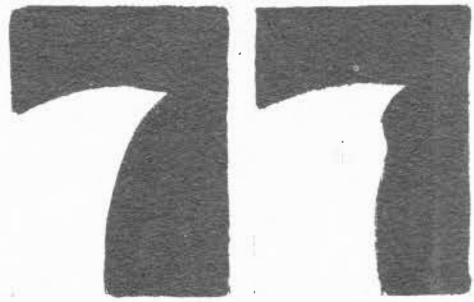

Figure 5. Change of aspect in the South Cusp Indentation. July 8, 1951.
Left - at $0^h 37^m$, U.T.
Right - at $1^h 12^m$, U.T.
3.5 in. reflector, 100x.
James C. Bartlett, Jr.

features, then they would be seen only occasionally when they chanced to be upon the terminator. The caps and bands, on the other hand, being features not depending upon position for visibility, would be generally visible.

This brings us to the most important aspect of the cusp indentations, their relation to phase; for if it can be shown that their visibility is completely independent of phase then we have positive indication of a short rotation period, though the value of the period cannot be established by this relation alone. This follows from the fact that if Venus almost turns one face constantly to the sun, as the moon does precisely to the earth, then any irregularities in the surface would become visible as the terminator passed over them. This behavior is exemplified monthly by the moon. Now assume a surface feature on Venus - a depression or elevation - whose visibility would depend entirely upon shadow relief. It is clear that we should expect to see it only when the terminator passes over it; but if the planet's axial rotation is almost synchronized with its orbital revolution, then, since the advance of the Venusian terminator is assumed comparatively slow, we should expect to see the feature for some days in succession. But if the planet is rotating upon its axis in a period much shorter than the year, then the position of the feature relative to the terminator would usually be different for each succeeding observation. Unless we knew the period of rotation, and thus could plan our observations accordingly, observations of the feature would be random and by chance. This circumstance is strongly indicated by the comparatively few sightings made in 830 observations.

Furthermore the feature would certainly be seen for any and all positions of the terminator, though less easy for the gibbous than for the crescentic phase. Let us now see if the visibility related to phase, as expressed by the quantity k, supports such a view.

Table 15

Earliest appearance of both cusp indentations as related to k, Superior Conjunction to Greatest Elongation East

South Cusp Indentation

k	date	observer
0.838	Sept. 30, 1953	Eugene Lizotte
0.704	Feb. 23, 1956	O.C. Ranck

Table 15 (Con't)

k	date	observer
0.689	March 5, 1956	D.D. Meisel
0.675	July 26, 1954	J.C. Bartlett
	North Cusp Indentation	
0.704	Dec. 19, 1944	J.C. Bartlett
0.671	Dec. 26, 1952	R.M. Baum

Table 16

Latest appearance of both cusp indentations as related to k,
Greatest Elongation East to Inferior Conjunction

South Cusp Indentation

k	date	observer
0.261	March 10, 1953	A.P. Lenham
0.261	March 10, 1953	Patrick Moore
0.230	August 2, 1951	J.C. Bartlett
	North Cusp Indentation	
0.261	March 10, 1953	Patrick Moore
0.261	March 10, 1953	A.P. Lenham
0.206	August 5, 1951	J.C. Bartlett

Insofar as observation is concerned it is apparent that the cusp indentations, like the cusp caps and cusp bands, are not related to phase. Quite obviously they are visible for all positions of the terminator. Therefore the rotation must be much shorter than the orbital revolution. What its value is will long be a matter of dispute; but measurements made on certain bright spots by the writer, in 1951, gave a period of $22^h\ 33^m\ 2^s.2$ about an axis perpendicular - or sensibly so - to the plane of the orbit. Perhaps it is only coincidence, but this is remarkably close to the 22 hr. radio period found by Dr. Kraus. Time measurements made between successive apparent returns of the South Cusp Indentation yielded periods ranging from $23^h\ 54^m$ to $24^h\ 15^m$, as determined by the writer in 1951. It is clear that the physical extent of this feature, naturally unknown, will have an important effect on any estimates of rotation based upon successive returns, particularly those on dates some days or weeks apart. But such indications as one can gather, taken with the visibility of the feature for all positions of the terminator, strongly suggest a rapid rotation. Unfortunately I have not found it possible to predict the next appearance at the terminator with any degree of accuracy, basing myself upon any of these periods. This may be due to error in the estimated periods, but it may with equal plausibility be due to the state of the Venusian atmosphere at the time of observation. All other things being equal, it is this factor which chiefly appears to determine whether a Venusian feature will be visible or invisible, even if on the terminator. Given a massive cloud ceiling and your feature is invisible, however great its relief relative to the surface. To such atmospheric tricks is certainly due the many disappearances of both cusp caps and their associated bands.

Returning to the above tables the phenomena agree in kind, though not in degree, with those of the cusp caps and bands; i.e. visibility in all parts of the orbit. But there is one striking difference. There are no morning apparitions of either cusp indentation. How is this lack to be explained? Given the random nature of the cusp indentations' appearances, the many fewer morning observations (almost confined to O.C. Ranck) are probably competent alone to explain it; but there is possible also a physical explanation of considerable interest.

We have seen that the general conformation of these indentations, especially the larger South Cusp Indentation, is very suggestive of a hollow depression which at times seems filled with shadow. Figures 6, 7, 8, and 9 give representative views from different observers. Now from the absence of wall shadows, such a depression would not be like one of the walled lunar ring plains but rather in the nature of a sink, i.e. the rim would be at surface level. The floor of the sink apparently merges with the plane of the surface to the east; hence there would be no eastern rim. Now between Superior and Inferior Conjunctions the solar rays are coming in from the west. It is clear from the schematic diagram (Figure 10) that the floor of the depression would then be in shadow. Between Inferior and Superior Conjunctions the solar rays strike from the east. It is clear from Figure 11 that the floor would then be illuminated. Consequently we should expect to see the feature between Superior and Inferior Conjunctions, but not between Inferior and Superior Conjunctions. A little thought will show that the same relations would maintain if the assumed depression were merely the shadow effect of an elevation of the cusp cap toward the east. These views will have to be modified if subsequent morning appearances of either cusp indentation turn up; but only to the extent of converting the sink to a basin, i.e. a depression rimmed all around.

Before concluding these remarks attention should be drawn to two "parallel" observations of March 10, 1953; one by A. P. Lenham and the other by Patrick Moore. Actually the observations are timed 30 mins. apart; but both show a prominent South Cusp Indentation, and both show a much less conspicuous irregularity at the north cusp (Figures 6 and 7). Incidentally on Lenham's sketch an unknown hand (was it W.H. Haas?) has pencilled the following in relation to the South Cusp Indentation: "Should interest J.C.B.!" It did indeed.

Lenham's observation was at $17^h\ 30^m$; Moore's observation at 18^h. Now it is interesting to note that also on March 10, 1953, but at $23^h\ 13^m$, a prominent South Cusp Indentation was also visible to this observer; but the north cusp appeared perfectly smooth. Accordingly it is tempting to believe that by this time the north cusp irregularity had rotated out of sight. But how explain the continuing visibility of the South Cusp Indentation some 5 hours after Moore's observation? One thing is obvious. Such a prolonged visibility of the feature cannot be accommodated to a short rotation, even one as long as $24^h\ 14^m$. Assuming 24 hours for convenience, then in 5 hours Venus would have rotated through 75^o of longitude. If the feature is the same, then we should have to imagine an irregularity extending through at least this width of longitude, which seems very doubtful; though not altogether impossible, since the northern coast of the Soviet Union extends through no less than 140^o of terrestrial longitude.

The South Cusp Indentation therefore may be only part of a considerable complex of irregularities surrounding the South Cusp Cap. It may be not one but several features separated by appreciable intervals in longitude. This interpretation would go far towards explaining the contradictions in rotation periods derived from observations of this feature when assumed to be a single structure. Elsewhere I have remarked that there is some reason to believe that the North Cusp Indentation is really two or more similar features (based upon rather different appearances of what is assumed to be the same feature). But one thing seems assured: these cusp indentations are real and not illusory.

To sum up these researches they appear to establish beyond reasonable doubt the following facts:

That the bright caps, the cusp bands, and the cusp indentations have been

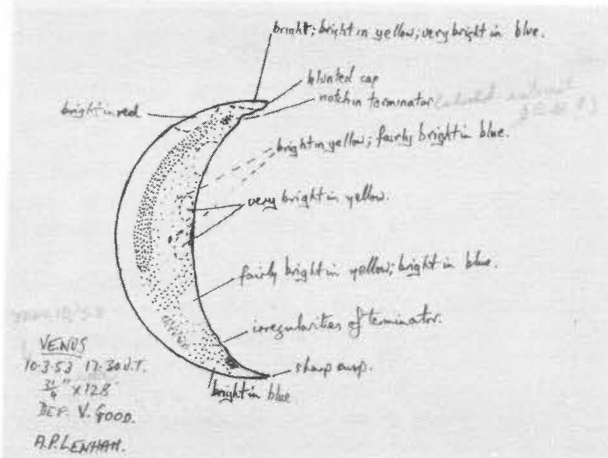

Figure 6. Venus
March 10, 1953,
$17^h\ 30^m$, U.T.
3.25 in. refr., 128x
A. P. Lenham

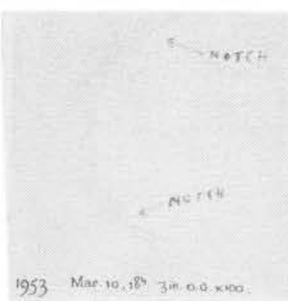

Figure 7. Venus.
March 10, 1953,
18^h, U.T.
3-in. refractor, 100x
Patrick Moore

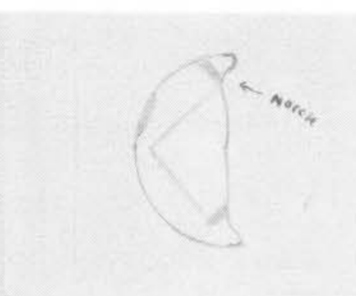

Figure 8. Venus.
August 31, 1954,
19^h, U.T.
6-in. reflector, 150x
Leonard Abbey, Jr.

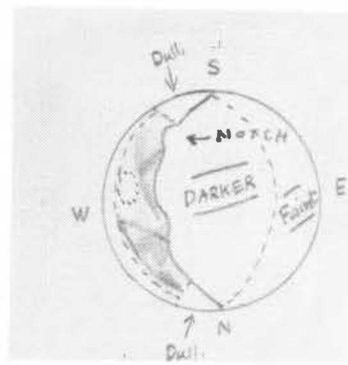

Figure 9. Venus.
May 23, 1956,
$22^h\ 30^m$, U.T.
4-in. refractor, 120x
C. C. Ranck

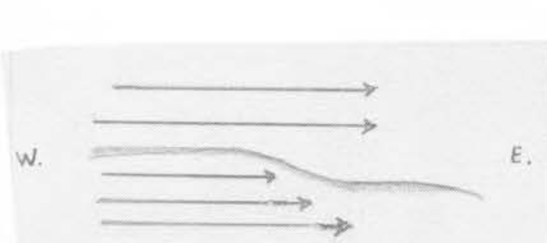

Figure 10. Diagram of possible conformation of the South Cusp Indentation. Solar rays incident from west.

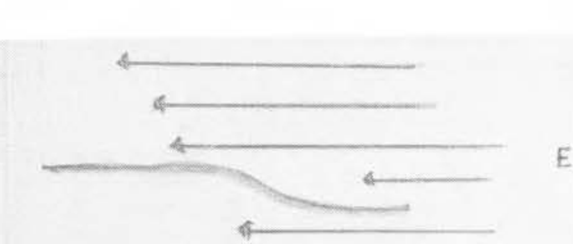

Figure 11. Diagram of possible conformation of the South Cusp Indentation. Solar rays incident from east.

independently observed by too many observers to be dismissed as illusions; that the observations agree too closely with respect to fundamentals to be the result of random coincidence; that all observers agree on the visibility of these features in all parts of the orbit, saving only that the cusp indentations appear to be visible only from Superior Conjunction to Inferior Conjunction; that all observers agree on lack of specific relation to phase for any of the features herein considered.

Finally it may be stated that entirely plausible physical explanations may be found for them; explanations which violate nothing definitely known about the planet - which is precious little.

ON THE 1949 APPARITION OF JUPITER

by Elmer J. Reese

Rotation Periods

Fifteen observers contributed a total of 3449 transits in 1949 of spots on Jupiter. When plotted on graph paper, 2110 of these transits form usable drifts for 111 Jovian spots. Of these 111 spots, 53 had an observed life of 30 to 90 days; 25 spots persisted for 90 to 150 days; 17 spots lasted from 150 to 210 days; 16 spots lasted for more than 210 days. No attempt has been made to ascertain how many spots lasted less than 30 days; however, it is certain that most of the 1339 unused transits were of such short-lived spots.

The names of the observers who have contributed transits for the 1949 apparition of Jupiter follow:

Observer	Station	Telescope	Transits
Bartlett, J.C.	Baltimore, Md.	$3\frac{1}{2}$-in. refl.	6
Bevis, P.D.	Santa Monica, Calif.	6-in. refl.	1
Brinckman, F.E.	Long Beach, Calif.	6-in. refl.	7
Cragg, T. A.	Los Angeles, Calif.	6-, 12-in. refls.	17
Ebisawa, S.	Tokyo, Japan	8-, 12-in. refls.	19
Haas, W.H.	Albuquerque, N.M.	6-in. refl.	549
Hare, E.E.	Owensboro, Ky.	7-in. refl.	1075
Howard, W.	Portsmouth, Va.	$3\frac{1}{2}$-in. refl.	1
Johnson, L.T.	La Plata, Md.	10-in. refl.	29
Monger, D.R.	Larned, Kansas	6-in. refr.	5
Murayama, S.	Tokyo, Japan	8-in. refr.	47
O'Toole, D.	Vallejo, Calif.	6-in. refl.	59
Reese, E.J.	Uniontown, Pa.	6-in. refl.	1570
Stephenson, C.B.	Chicago, Illinois	6-in. refr.	17
White, E.K.	Chapman Camp, B.C., Canada	7-in. refl.	47

In the tables which follow, the first column gives an identifying number or letter to each object. The second column indicates whether the object was dark (D) or bright (W) and whether the preceding (p), center (c) or following (f) end was being observed. The third column gives the first and last dates of observation; the fourth column, the longitudes on those dates. The fifth column gives the longitude at opposition, July 20, 1949. The seventh column indicates the number of degrees in longitude that the marking drifts in 30 days. The last column gives the computed rotation period of the object.

S. S. Temperate Current (SSTB), System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
						o	h m s
1	Dc	Jul. 7 - Jul. 24	16° - 5°	7°	4	-19.4	9 55 14

S. S. Temperate Current (SSTB), System II (Cont)

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period		
2	Dc	Jul. 5 - Aug. 3	36 - 8	22	6	-29.0	9	55	1
3	Dc	Jul. 23 - Aug. 9	238 - 220	241	3	-31.8	9	54	57
4	Dc	Jul. 12 - Aug. 27	2 - 322	355	6	-26.1	9	55	5

Mean rotation period $9^h\ 55^m\ 4^s$

S. Temperate Current (S. edge STB, STeZ), System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period		
						o	h	m	s
1	Dc	Jun. 23-Jul. 24	32^o - 5^o	7^o	5	-26.1	9	55	5
2	Wp	Jul. 28-Nov. 9	7 - 281	(12)	12	-24.8	9	55	7
3	Dc	Jun. 23-Jul. 24	46 - 18	21	5	-27.1	9	55	4
F	Wp	May 18-Dec. 9	108-318	60	15	-21.9	9	55	11
A	Wf	May 6 - Dec. 9	145 - 341	88	23	-22.7	9	55	10
B	Wp	May 14-Oct. 23	251 - 140	205	30	-20.6	9	55	13
7	Wc	Jul. 4-Aug. 21	233 - 200	221	6	-20.6	9	55	13
C	Wf	May 12 - Nov. 6	285 - 155	235	31	-21.9	9	55	11
9	Dc	Jul. 4-Aug. 24	251 - 216	239	7	-20.6	9	55	13
D	Wp	May 12-Oct. 11	316 - 200	263	22	-22.9	9	55	9
11	Wc	Jul. 3- Sept. 10	297 - 245	283	9	-22.6	9	55	10
E	Wf	Mar. 27 - Oct.26	28 - 227	304	40	-22.7	9	55	10

Mean rotation period $9^h\ 55^m\ 9\overset{s}{.}3$

The letters in the first column designate the terminal ends of the long-enduring bright areas along the south edge of the STB.

Middle of the S. Temperate Belt, System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period		
						o	h	m	s
1	Df	Mar. 28-Nov. 10	158^o - 324^o	60^o	10	-24.3	9	55	8
2	Wp	Mar. 19-Nov. 27	247 - 36	145	39	-25.0	9	55	7
3	Wc	May 26-Jul. 11	199 - 158	(149)	10	-26.7	9	55	4
4	Wf	May 28-Jul. 11	203 - 165	(157)	7	-25.9	9	55	5
5	Wf	Aug. 9-Oct. 22	162-103	(178)	9	-23.9	9	55	8
6	Df	Jun. 24-Nov. 6	225 - 146	209	7	-17.6	9	55	17
7	Dp	Aug. 3-Oct. 9	348 - 293	(0)	5	-24.6	9	55	7
8	Wc	Oct. 10-Nov. 10	345 - 329	(28)	4	-15.5	9	55	19
9	Wf	Oct. 10-Nov. 10	350 - 335	(29)	3	-14.5	9	55	21

Mean rotation period (without Nos. 8, 9) $9^h\ 55^m\ 8^s$

Red Spot and Hollow, System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period		
						o	h	m	s
	RSHp	Mar. 14-Dec. 20	219^o - 232^o	224^o	111	+ 1.4	9	55	43
	RSHc	Mar. 14-Dec. 16	232 - 246	240	71	+ 1.5	9	55	43
	RSHf	Feb. 18-Dec. 27	246 - 259	255	82	+ 1.2	9	55	42
	RSp	Apr. 10-Oct. 16	223 - 239	227	59	+ 2.5	9	55	44
	RSc	May 9-Oct. 2	238 - 251	241	47	+ 2.7	9	55	44
	RSf	May 9-Oct. 21	250 - 265	254	56	+ 2.7	9	55	44

Mean rotation period of RSH $9^h\ 55^m\ 42\overset{s}{.}5$

Mean rotation period of RS $9^h\ 55^m\ 44\overset{s}{.}2$

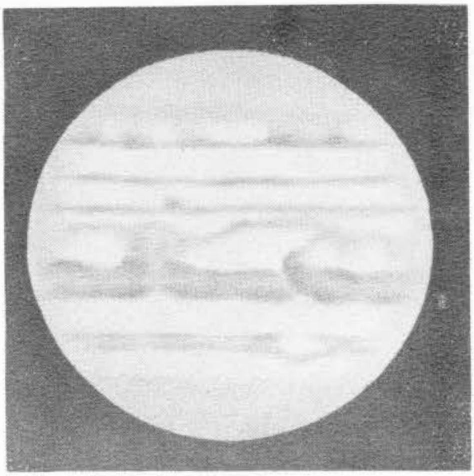

Figure 12. Jupiter.
Sadao Murayama.
8-inch refr. 180X.
July 23, 1949. $14^h 5^m$, U.T.
C.M.$_1$ = 13° C.M.$_2$ = 164°
Seeing good. Small dark projection in SEB_n a little left of C.M. marks initial outbreak of 1949 SEB Disturbance.

Early in the apparition the Hollow was much more prominent than the Red Spot. During June, July and August the Red Spot was dark and conspicuous while the Hollow became less prominent. As the SEB darkened in September under the influence of the great Disturbance in that belt, the Red Spot began to fade. By early October, about 74 days subsequent to the outbreak of the SEB Disturbance, the aspect of the Red Spot region had completed its transition from Spot to Hollow.

The Red Spot and Hollow were decelerated at opposition or very shortly thereafter. Prior to opposition, the center of the Red Spot had a rotation period of $9^h 55^m 42^s.3$; subsequent to opposition, the period was $9^h 55^m 46^s.2$. The Red Spot maintained this very large drift in increasing longitude until October when it faded from view. The Hollow, however, was accelerated near mid-September and drifted in decreasing longitude until early November after which it resumed a motion in increasing longitude.

South Tropical Zone, System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
						°	h m s
1a	Dc	Aug. 19-Nov. 13	183° - 22°	(239°)	4	-56.2	9 54 24
2b	Dc	Sep. 8-Nov. 10	273 - 292	(258)	7	+ 9.1	9 55 53
3b	Dp	Sep. 18-Nov. 27	307 - 314	(302)	5	+ 3.0	9 55 45
4b	Dc	Sep. 18-Dec. 9	314 - 320	(310)	6	+ 2.2	9 55 44

Mean rotation period of Nos. 2, 3, 4 $9^h 55^m 47^s$

a. Identification is uncertain. The object is included in the table because similar rotation periods were found in 1947 and 1948 for dusky markings in the STrZ in longitudes preceding the Red Spot region.

b. These dusky markings were situated in longitudes following the Red Spot region. They had periods similar to those found for similarly placed markings in 1947 and 1948.

S. edge SEB_s, System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period
						°	h m s
1	Dc	Jun. 6-Oct. 10	11° - 31°	17°	21	+4.8	9 55 47

SYSTEM II

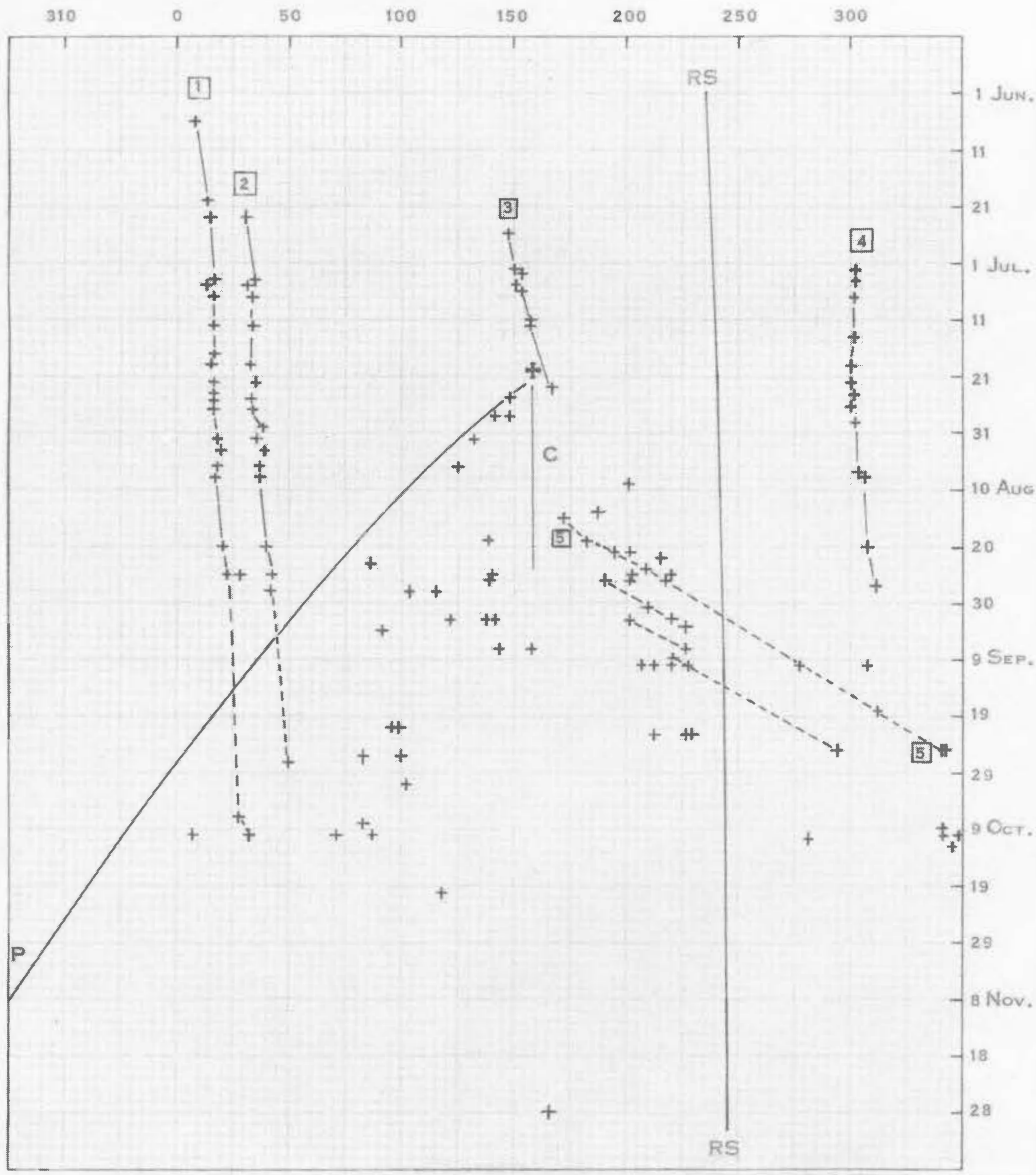

FIGURE 13

LONGITUDE - TIME GRAPH OF DARK SPOTS ON THE SEBs OF JUPITER IN 1949. REFER TO ARTICLE BY ELMER J. REESE IN THIS ISSUE.

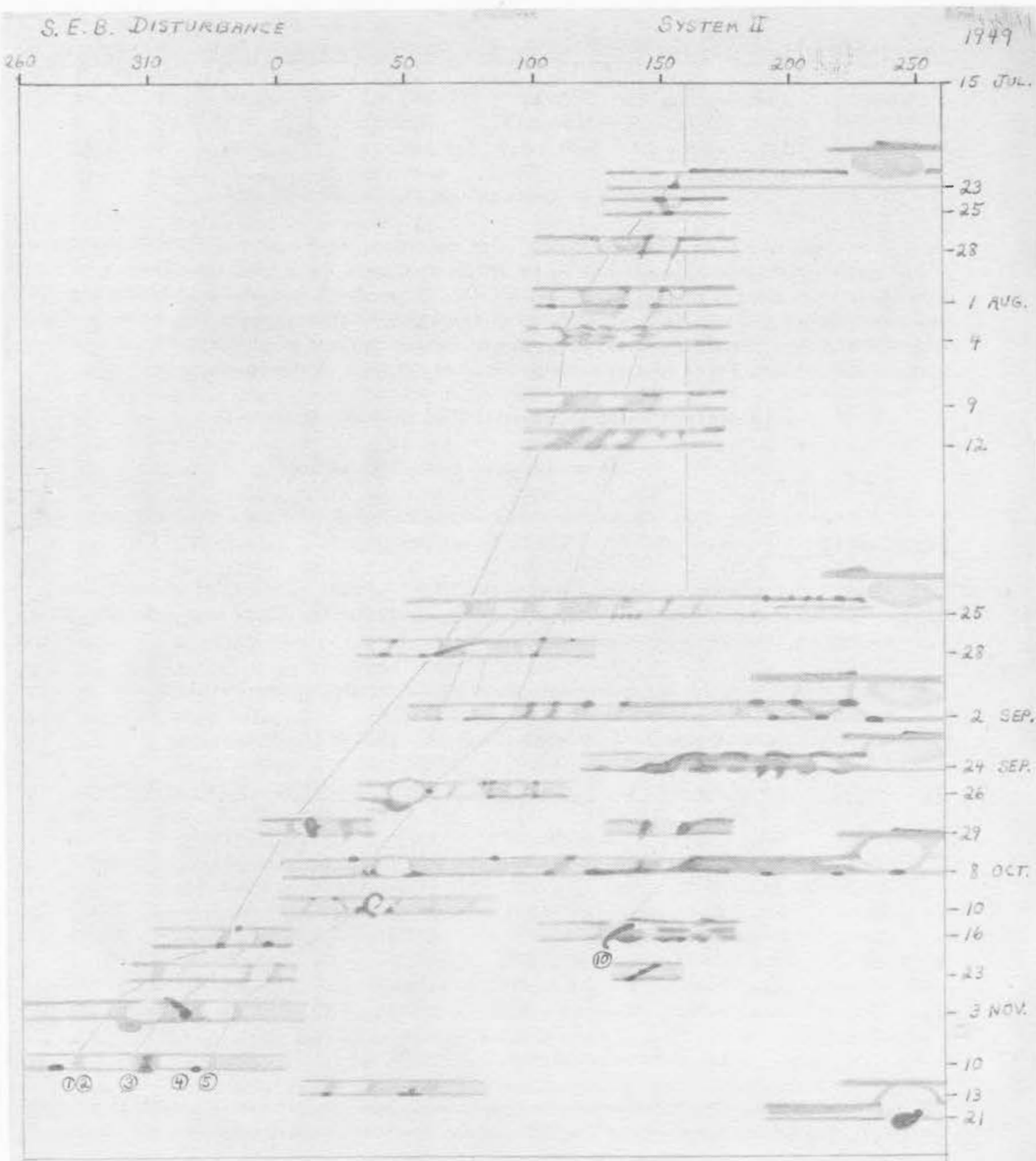

Figure 14. Strip - sketches of 1949 SEB Disturbance on Jupiter. Refer to article by Elmer J. Reese in this issue.

S. edge SEB_s, System II (Cont)

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period		
						°	h	m	s
2	Dc	Jun. 23-Aug. 28	32 - 43	35	17	+5.0	9	55	48
3	Dc	Jun. 26-Jul. 23	148 - 163	(183)	8	+16.7	9	56	4
4	Dc	Jul. 2-Aug. 27	304 - 312	301	13	+4.3	9	55	47

Mean rotation period (without No. 3) $9^h\ 55^m\ 47^s$

The objects listed above probably were not associated with the SEB Disturbance. Many spots which probably did belong to the Disturbance were observed from late July to mid-October; however, these spots did not produce well-defined drifts when plotted on graph paper. One possible drift belonging to the retrograding branch of the Disturbance (No. 5 on Figure 13) indicates a rotation period of $9^h\ 58^m\ 31^s$. For further comments, refer to a special section on the SEB Disturbance.

Middle of South Equatorial Belt (SEBZ), System II

Mean rotation period $9^h\ 54^m\ 27^s$

A table and chart for spots observed in the SEBZ during 1949 have already been published (Strolling Astronomer, Vol. 9, Nos. 5-6, pg. 68).

Spot No. 1 was the preceding end of the SEBZ branch of the SEB Disturbance. This is the spot whose drift is marked P on the chart for the SEB_s accompanying this report (Figure 13).

Spot No. 9 was the following end of the SEBZ branch of the Disturbance.

South Equatorial Current (SEB_n, S. part EZ), System I

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period		
						°	h	m	s
1	Dc	Sep. 2-Nov. 7	349° - 318°	(9°)	9	-14.1	9	50	11
2	Dc	Aug. 24-Oct. 28	14 - 350	(27)	13	-11.1	9	50	15
3	Dc	Aug. 20-Nov. 26	31 - 359	(41)	16	-9.8	9	50	17
4	Dc	Aug. 25-Oct. 10	150 - 123	(171)	7	-17.6	9	50	6
5	Dc	Aug. 25-Oct. 1	164 - 150	(177)	9	-11.4	9	50	15
6	Dc	Aug. 28-Oct. 10	185 - 154	(212)	11	-21.6	9	50	1
7	Dc	Aug. 3-Oct. 11	283 - 272	(285)	7	-4.8	9	50	24
8	Dc	Aug. 3-Nov. 21	308 - 294	(310)	10	-3.8	9	50	25

Mean rotation period $9^h\ 50^m\ 14^s$

Many of the spots listed above were probably associated with the SEB Disturbance. However, the advancing front of the SEB_n branch of the Disturbance was not recorded.

Central Equatorial Current (EB), System I

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period		
						°	h	m	s
1	Dc	Jun. 23-Aug. 27	34° - 12°	23°	11	-10.2	9	50	16
2	Df	Jul. 3-Sep. 2	263 - 263	263	17	0	9	50	30
3	Df	Jul. 4-Aug. 3	300 - 310	306	7	+10.0	9	50	44

Mean rotation period $9^h\ 50^m\ 30^s$

North Equatorial Current (S. edge NEB, N. part EZ), System I

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period		
						°	h	m	s
1	Wp	Jul. 28-Sep. 16	4° - 354°	(5°)	10	-6.0	9	50	22
2	Dc	Mar. 27-June 8	39 - 23	(14)	11	-6.6	9	50	21
3	Dc	Aug. 6-Sep. 7	16 - 2	(23)	7	-13.5	9	50	12
4	Wc	Aug. 6-Oct. 16	18 - 350	(25)	13	-11.9	9	50	14
5	Dc	May 3-Dec. 12	50 - 338	30	37	-9.7	9	50	17
6	Dc	May 24-Dec. 1	65 - 3	46	10	-9.7	9	50	17
7	Dc	Apr. 20-Nov. 13	89 - 23	59	36	-9.6	9	50	17
8	Wc	Jun. 2-Sep. 26	86 - 42	68	8	-11.4	9	50	15
9	Dc	Apr. 6-Dec. 6	127 - 32	85	33	-11.7	9	50	14
10	Wc	June 2-Oct. 9	113 - 68	96	14	-10.5	9	50	16
11	Dc	Feb. 19-Dec. 4	168 - 75	118	49	-9.7	9	50	17
12	Wc	Apr. 29-Oct.14	155 - 103	129	15	-9.3	9	50	18
13	Dc	June 26-Oct. 26	142 - 107	135	13	-8.6	9	50	19
14	Dc	Mar. 19-Nov. 9	192 - 124	156	42	-8.7	9	50	18
15	Dc	July 3-Nov. 27	175 - 130	170	13	-9.2	9	50	18
16	Dc	July 5-Oct. 8	183 - 162	179	8	-6.6	9	50	21
17	Wc	July 3-Sep. 20	188 - 174	185	10	-5.3	9	50	23
18	Dc	Mar. 24-Nov.30	222 - 164	195	57	-6.9	9	50	21
19	Dc	July 3-Nov.7	213 - 186	209	8	-6.4	9	50	22
20	Wc	May 2-Oct. 8	232 - 188	210	15	-8.3	9	50	19
21	Dc	June 20-Sep.22	223 - 214	220	7	-2.9	9	50	26
22	Dc	Apr. 7-Nov.7	255 - 205	232	49	-7.0	9	50	21
23	Wc	Apr. 23-Sep.24	269 - 232	248	24	-7.2	9	50	20
24	Dc	July 6-Aug. 26	258 - 244	254	7	-8.2	9	50	19
25	Dc	Mar. 31-Aug.3	284 - 260	263	25	-5.8	9	50	22
26	Wc	May 7-July 20	293 - 272	272	6	-8.5	9	50	19
27	Dc	May 23-Nov.7	296 - 220	280	27	-13.6	9	50	12
28	Wc	Apr. 7-June 8	312 - 296	(286)	8	-7.7	9	50	20
29	Wc	July 25-Sep.25	287 - 247	(290)	16	-19.4	9	50	4
30	Dc	Mar. 20-July 11	334 - 301	(298)	24	-8.8	9	50	18
31	Dc	Aug. 26-Nov.21	283 - 248	(298)	21	-12.1	9	50	14
32	Wc	July 31-Nov.14	301 - 265	(304)	15	-10.2	9	50	16
33	Dc	May 12-Nov.10	338 - 274	312	33	-10.5	9	50	16
34	Dc	June 23-Nov.24	336 - 293	333	18	-8.4	9	50	19
35	Dc	Apr. 10-Nov. 8	1 - 333	353	54	-4.0	9	50	25

Mean rotation period $9^h\ 50^m\ 18^s$

No. 3 may have been a revival of No. 2.

No. 5. This object was sharply decelerated near May 31 and accelerated near Sept. 3.

No. 27. This object was suddenly accelerated near July 24 and was very well observed until Sept. 27. (Drift: Jul. 24 - Sept. 27, 279° - 238°, -18° .9/30 days, $9^h\ 50^m\ 5^s$.)

No. 29. This object may be identical with No. 28. No. 29 drifted very rapidly from Aug. 19 to Sept. 25 (280° - 246°, -27° .6/30 days, $9^h\ 49^m\ 53^s$).

No. 31. Probably a continuation of No. 30 which was obscured from July 11 to August 26. A remarkable deceleration occurred near Sept. 25. (Aug. 26 - Sept. 25, 283°-257°, -26°.0/30 days, $9^h\ 49^m\ 55^s$). (Sept. 25 - Nov. 21, 257° - 252°, -2°.6/30 days, $9^h\ 50^m\ 27^s$).

Middle of North Equatorial Belt, System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period		
						°	h	m	s
1	Wc	Aug. 10-Oct. 10	114° - 15°	(149)	5	-48.7	9	54	34

Middle of North Equatorial Belt, System II (Cont)

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period		
						°	h	m	s
2	Wf	Aug. 26-Oct. 10	103 - 19	(173)	5	-56.0	9	54	24
3	Wc	Sep. 2-Oct. 10	98 - 35	(174)	8	-49.8	9	54	33
4	Wp	Jul. 2-Jul. 28	284 - 183	208	8	-116.7	9	53	2
5	Wf	July 2-July 28	305 - 193	227	5	-129.2	9	52	45

Mean rotation period $9^h\ 53^m\ 51^s$

North Tropical Current (N. edge NEB, NTrZ), System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period		
						°	h	m	s
1	Wc	Apr. 10-Nov. 21	212° - 133°	178°	37	-10.5	9	55	26
2	Wc	July 14-Nov. 9	285 - 272	285	22	-3.3	9	55	36
3	Dc	Mar. 27-Oct. 23	346 - 304	322	39	-6.0	9	55	33

Mean rotation period $9^h\ 55^m\ 32^s$

North Temperate Current (NTB, NTeZ), System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period		
						°	h	m	s
1	Dp	June 23-Oct. 3	89° - 153°	106°	15	+18.8	9	56	6
2	Df	May 6-Sept. 22	135 - 207	177	22	+15.5	9	56	2
3	Wc	July 3-Sept. 10	171 - 206	183	22	+15.2	9	56	1
4	Dp	July 4-Sep. 10	179 - 211	190	13	+14.1	9	56	0
5	Wp	Aug. 7-Nov. 26	248 - 327	(236)	12	+21.4	9	56	10

Mean rotation period $9^h\ 56^m\ 4^s$

N.N. Temperate Current (NNTB, NNTeZ), System II

No.	Mark	Limiting Dates	Limiting L.	L.	Transits	Drift	Period		
						°	h	m	s
1	Df	July 22-Sep. 21	34° - 39°	34°	4	+2.5	9	55	44
2	Dp	July 3 - Sep. 21	49 - 50	49	9	+0.4	9	55	41
3	Df	July 20-Sep. 2	90 - 86	90	8	-2.7	9	55	37
4	Df	May 9 - June 14	193 - 194	(195)	3	+0.8	9	55	42
5	Dc	May 26 - July 4	216 - 216	(216)	4	0	9	55	41
6	Dp	May 9-Nov. 14	234 - 258	246	36	+3.8	9	55	46
7	Df	May 12 -Nov. 10	293 - 311	321	22	+3.0	9	55	45
8	Dp	May 5 - Oct. 10	336 - 338	337	17	+0.4	9	55	41
9	Dc	July 2-July 22	350 - 356	355	4	+9.0	9	55	53

Mean rotation period $9^h\ 55^m\ 43^s$

SEB Disturbance of 1949

The most remarkable development on Jupiter in 1949 was a violent Disturbance in the South Equatorial Belt which began near the date of opposition and was still very active at the end of the apparition. Interim reports on the Disturbance can be found in the following back issues of The Strolling Astronomer: Vol. 3, No. 9, pg. 13; Vol. 3, No. 10, pg. 9; Vol. 4, No. 2, pg. 7.

During April and May of 1949 the wide and dark SEB became divided into two thinner component belts, the SEB_s and SEB_n, separated by a bright zone, the SEBZ.

By mid-July the SEB_n was quite faint, the SEBZ was very bright with a clear yellow tint, and the SEB_s was narrow but very dark - especially preceding the Red Spot. Now this was the aspect of the SEB just prior to the outbreak of the Disturbance. The appearance of the SEB_s was not typical for such an occasion since it was dark and active. Four dark condensations were being observed on the south edge of the belt. These spots were drifting slowly in the direction of increasing longitude with a "normal" rotation period of $9^h\ 55^m\ 47^s$. They are numbered 1 to 4 on the chart for the SEB_s accompanying this report (Figure 13).

Before continuing, it might be well briefly to describe the chart for the SEB_s. The large cross indicates the probable location of the initial outbreak of the Disturbance. The drift of the preceding end of the SEBZ branch of the Disturbance is marked by the large letter, P. The following end of dark, disturbed matter in the SEBZ is marked C. It will be noticed that C remained fixed near the longitude of the initial and subsequent eruptions of the Disturbance. The center of the Red Spot region is marked RS.

The great Disturbance was first observed by R. A. McIntosh of New Zealand using a 14-in. reflector (JBAA., Vol. 60, No. 8, pg. 247). On July 19 McIntosh recorded a small bright spot on the SEB_s at longitude 163°. Within 10 days it had expanded to completely fill the SEBZ. The Disturbance was next seen on July 23 by E. E. Hare in America, and by S. Murayama in Japan (Figure 12). Hare recorded the transit of a small, dark hump on the south edge of the SEB_n at 154° and a thin column in the SEBZ at 156°. A transit by Murayama placed the dark hump at 151°.

The chart shows that the Disturbance broke out very near the SEB_s spot No. 3. However, there seems little reason for associating this spot with the subsequent development of the Disturbance. (The SEB Disturbance of 1943 broke out very near a similar spot on the SEB_s that had been recorded from time to time for several weeks prior to the outbreak. BAA Memoirs, Vol. 35, Part 4, pg. 19).

Subsequent to the initial outbreak of the Disturbance, many dark spots appeared on the SEB_s in those longitudes which were under the influence of the ever-expanding Disturbance. When plotted on graph paper, these spots did not produce well-marked drifts as did spots 1, 2, and 4 which presumably were not associated with the Disturbance. Unfortunately transit observations of the spots were not quite numerous enough to verify the rapid retrograding motion recorded during the Disturbances of 1928 and 1943. Drift No. 5 on the chart indicates a rotation period of $9^h\ 58^m\ 31^s$; however, the objectivity of this drift is not very convincing. An inspection of the chart reveals two ways in which the spots can be reasonably connected. One way would result in small drifts relative to System II; the other, rapid drifts towards increasing longitudes. This problem of identification of the SEB_s spots presented itself during the Disturbances of 1943A, 1943B, 1952, and 1958. F.R. Vaughn recently suggested that the dual nature of these SEB_s drifts might result from rapidly retrograding dark spots being seen intermittently through openings in a higher cloud layer - these openings remaining nearly stationary in System II. This idea, which has several variations, is certainly worthy of further investigation.

The strip-sketches of the SEB Disturbance (Figure 14) will give some idea of the development of the Disturbance. The time scale of Figure 14 is not uniform, hence straight drifts do not appear straight. Most of the sketches show only portions of the SEB_s, SEBZ, and SEB_n. The Red Spot region and a portion of the STB are included on some. The strip-sketches are based on observations by the following: E.E. Hare (July 23, July 28, Aug. 9, 25); D. O'Toole (Aug. 1, Sept. 29, Nov. 21); S. Ebisawa (Aug. 4, Sept. 24, Oct. 16); S. Murayama (Aug. 12); E.J. Reese (all other dates).

SOME REMARKS UPON THE TOMBAUGH-SMITH SEEING SCALE

by Walter H. Haas

The estimation of the atmospheric steadiness, or seeing as it is often called, has long been an essential part of every serious lunar and planetary observation. The reason, of course, is that this seeing greatly influences the amount of detail which our telescopes reveal on a planetary disc or in a lunar crater. Various seeing scales have been used at different times by different observers; but almost all A.L.P.O. members, and many others, now employ a scale of zero (worst) to ten (perfect). Although seeing ten may then be theoretically (but hardly ever practically!) defined as the lack of any perceptible atmospheric tremor with even a high magnification, seeing zero as the worst possible seeing has long been realized to be a loose and vague concept. The whole scale thus becomes subjective. I have several times been in a group of experienced observers in which each of us would in quick succession independently estimate the seeing on the same object in the same telescope and with the same eyepiece. Differences of two or three grades on the zero-ten scale were sometimes found. It may well be that a new observer working with another person can learn to make estimates consistent with his teacher's; but it is also true that many of the leading lunar and planetary observers work alone and learn without help to estimate the seeing, surely often in only rough agreement with other observers.

It is in this general context that we should evaluate a paper called "A Seeing Scale for Visual Observers" by Messrs. Clyde W. Tombaugh and Bradford A. Smith in Sky and Telescope, Vol. XVII, No. 9, July, 1958. The authors here relate seeing to the observed diameter of the "confusion disc" or "image blur" of a star. When they compared the sizes of this "confusion disc" in different grades of seeing on the zero-ten scale, as Mr. Tombaugh had been using it for many years, they discovered that the diameter of this disc is an exponential function of the seeing, just as the brightness of a star is an exponential function of the stellar magnitude. They used this principle to work up a table of seeing as related to image diameter, most of which is given here:

Seeing	Image Diameter
-1	12."6
0	7.9
+1	5.0
+2	3.2
+3	2.0
+4	1.3
+5	0.79
+6	0.50
+7	0.32
+8	0.20
+9	0.13

The authors suggest that a way for independent observers to make objective and accurate estimates of the seeing is to estimate the diameter of the "confusion disc" by taking double stars of known separations. They supply a list of such double stars in large northern declinations. The seeing is then determined, of course, by the estimated image diameter.

The relationship employed by Messrs. Tombaugh and Smith may be considered to be of the form:

$$d = K \cdot r^s ,$$

where d is the image diameter, s is the seeing, and K and r are constants. For the

Tombaugh-Smith Seeing Scale K is 7."9 and r is the fifth root of one-tenth or 0.631. Thus the table above can be represented by the formula:

$$d = 7''.9 \ (0.631)^s.$$

A graph can easily be drawn for this formula and can facilitate the quick selection of the s corresponding to a given observed d.

One could, of course, construct other seeing scales with other values of K and r. For example, we might keep the same r but arbitrarily define seeing 5 to correspond to a confusion disc with a diameter of one second. We would then get slightly easier arithmetic with the relation:

$$d = 10'' \ (0.631)^s.$$

The Tombaugh-Smith Seeing Scale has several advantages and must be considered a definite improvement over most earlier and contemporary seeing scales. It is certainly more objective and less subjective than scales which depend largely or wholly on impressions of how much detail is visible on the moon or on a planet. This objectivity could be especially advantageous in A. L. P. O. projects involving fairly large numbers of widely scattered observers, such as the Lunar Missile Survey or our observations of the 1959 apparition of Jupiter. The Tombaugh-Smith scale has a definite physical meaning; to show that the estimating of the seeing is analogous to the estimating of stellar brightness, both involving the same kind of physiological response, is a definite advance. The ease of extension at both the upper and lower ends as compared to the zero-ten scale is attractive, though we hope for no flood of lunar and planetary observations made in negative grades of seeing! The new scale is determined by what a telescope is actually resolving at a given moment; a larger aperture with its greater resolving power will create smaller stellar discs, corresponding to better seeing, if the atmosphere is not too turbulent, while an optically inferior telescope will give larger discs leading to poorer seeing estimates. It should be noted that perfect seeing is a function of aperture on the Tombaugh-Smith scale. When the atmosphere is perfectly calm, observed diameter of the "confusion disc" will approximate the Dawes Limit for the aperture, Dawes being affected to some extent by color and brightness of the stars. For a 6-inch telescope, for example, the image diameter could not be less than about 0."75, the Dawes Limit for this aperture; and hence the seeing should never be estimated as better than about +5. In a 16-inch the limit would be between +7 and +8.

There is still, of course, the little matter of making the image diameter estimates, from double stars for example. It would be preferable to be able to use the object under actual observation, but planetary features of accurately known dimensions are not always available for such estimates: consider the near-blank face of Venus and the ever-varying visible surface of Jupiter, for example. It will be inconvenient to turn the telescope from object to double star and back when the seeing is varying rapidly, nor will it always be easy to find double stars of the proper separations at the same altitude above the horizon as the object being observed. With experience the observer may learn to calibrate his scale from the amount of detail visible on a lunar or planetary subject, having first carefully correlated the visibility of detail with seeing estimates determined by double star observations of "confusion disc" diameters; but there may then be a threat of a return to the old more subjective seeing estimates, unless there are re-calibrations at suitable intervals with the help of double stars. Mr. Craig L. Johnson has suggested that a micrometer wire of known angular breadth in the field of view might aid considerably in estimating the image diameter. Several wires of known breadths over a suitable range would be an obvious extension of this idea.

We urge our readers to experiment with using this new seeing scale and to report to us what they find. Of course, estimates made on the Tombaugh-Smith scale should be identified as such. Let us hear your comments, criticisms, and suggestions.

BOOK REVIEWS

The Moon, by Dr. H.P. Wilkins and Patrick Moore. The MacMillan Company, New York. 1955. 388 Pages. $12.00.

Reviewed by Alika K. Herring

For a number of years, Dr. Wilkins was Director of the Lunar Section of the British Astronomical Association. Following his resignation from this position, he was largely instrumental in organising the International Lunar Society, the first truly world wide association of Lunarians, and was honored by being elected its first president. In addition to many important papers on the moon published in the Journal of the B.A.A. and elsewhere, Dr. Wilkins has written several popular books on observing and the moon.

Patrick Moore has served as Secretary of the Lunar Section of the B.A.A. He has also been a very prolific writer; his "Guide" series on the moon and planets should be familiar to every amateur. Along with Dr. Wilkins he has long been engaged in serious lunar research, and both observers have been privileged to use some of the largest telescopes in Europe for this purpose. They are therefore eminently qualified to co-author a work of this type.

The Moon is based upon a newly revised and up to date edition of the well known 300-inch map of the moon which was first published by Dr. Wilkins in 1946. This has been reduced to a scale of approximately 33 inches for the lunar diameter, and in accordance with long established precedent, has been presented in the usual 25 sections. These unquestionably comprise the most detailed lunar charts in existence, since no less than some 90,000 separate bits of detail are plotted! Of these, approximately 800 craters, mountains, and seas are named; the text is concerned chiefly with the description of these features, which it does in considerable detail. Observations made at Meudon with the 33-inch refractor and elsewhere have been freely utilized in the compilation of this descriptive material. Some excellent photographs from Pic Du Midi, Greenwich and Mount Wilson Observatories have been included, in addition to a number of drawings made by the authors of relevant detail. The maps are augmented by extra charts of the limb and libratory regions.

Other material included in The Moon is a short introductory history of selenology. The appendices include a valuable section on lunar photography by E.A. Whitaker, and indices to the named formations, of which nearly 100 are newly named. Also included is a comprehensive list of lunar observers of the past and present.

The Moon has been clearly intended by the authors to supplement, not supplant, previous works of this type. While this in itself may be a laudable intention, it perhaps tends to be self-defeating, since the earlier classics compiled by Neison, Elger and Goodacre have long been out of print and are no longer readily available. Each new observer therefore has no ready means of determining what has previously been done on the particular formation under study, and a bibliography or list of references to previous material would have been an extremely valuable addition. The reduced scale of the maps occasionally results in severe crowding of detail with some loss of legibility, particularly in the very complex southern regions of the lunar surface. With the exception of a simplified method of determining lunar heights, no formulae are given for the reduction of lunar observations. The drawings in many instances are highly stylized and often fail to convey a sense of reality.

However, these omissions and inadequacies do little to detract from the great value of the book as a whole. In the opinion of this reviewer, The Moon will be the "standard" of reference for many years to come. It should therefore be in the hands of every student of the moon as well as constitute an indispensable component of every lunar reference library.

Der Sternenhimmel 1959. Edited by Robert A. Naef. Published by H.R. Sauerlaender and Co., Aarau, Switzerland. 123 pages. Available from Albert J. Phiebig, P.O. Box 352, White Plains, New York.

Reviewed by Ernst E. Both

"Der Sternenhimmel" certainly should need no introduction to American amateurs. For 19 years this little observing handbook has been a favorite with amateurs and professional astronomers in Europe.

The familiar arrangement has been retained: explanation of use (13-20); general review of special phenomena in 1959, according to planets, asteroids, and periodic comets (21-34); this is followed by a celestial calendar for each month with many useful charts and diagrams, information about meteor showers with brief historical notes, variable stars, etc. Important or interesting events are set off in bold type (35-95). The editor devotes considerable space to the solar eclipse of October 2, 1959 (79-85), and to the rare occultation of Regulus by the planet Venus on July 7, 1959 (64-66). Both of these events* are carefully illustrated with diagrams and charts.

The celestial calendar is followed by information concerning the giant radio telescope at Jodrell Bank (96), data of the positions of sun, moon, asteroids, and planets (97-105), a list of Swiss observatories (106), a very clear general map of the moon (107-108), a list of interesting objects such as stellar clusters, variable stars, double stars, and other useful information (109-126).

As in previous years there is an excellent map of Mars by Switzerland's leading planetary observer, Dr. M. Du Martheray (from personal observations 1941-1952), which compares rather favorably with the new I. A. U. map (Ashbrook, Sky and Telescope, XVIII, No. 1, November 1958, 23-25). Unfortunately the nomenclature on Du Martheray's differs considerably from the I. A. U. map; perhaps there was not enough time to correct this. The most conspicuous deviations are (I. A. U. designations in parentheses): Sinus Furcosus (Sinus Meridiani), Thaumasia north (Sinai), Aethiopis (Amenthes), Nepenthes - Thoth (Nepenthes); in addition a number of "canals" are listed which are omitted in the I. A. U. map (i.e. Indus, Ganges, Gorgon, Scamander, Titan). For the sake of uniformity it would be advisable to adopt the new nomenclature in future issues. There are also drawings of Saturn (apparent size and ring position 1944 - 1974) and Jupiter.

Although only an observer familiar with German can use this handbook to the greatest advantage, it is nevertheless to be recommended very highly. Those who know only a little German might find that they can learn many astronomical expressions easily from this helpful booklet.

The Air, by Edgar B. Schieldrop. Philosophical Library. New York. 1958. 256 pages and many photographs. Price $12.00.

Reviewed by Charles A. Haas

At the present time Man is turning his mind to the art of conquering space and to what value it will have for the human race. Dr. Schieldrop has given us a vast amount of information along this line in his book, The Air. He deals with this subject from the early attempts at flying to the present time. The text is divided into five chapters, each one a unit of its own. The description of each topic can be readily grasped by the reader. Many failures arose, and many problems have had to be solved.

* (visible in the eastern United States only).

In chapter one the author starts out with the fairy stories of Man's attempts to fly. He describes early actual efforts and their failures. As the final result the Wright Brothers succeeded in producing a machine that could fly.

In chapter two the author gives in detail the problems involved in flying this machine. Each effort gave rise to new problems. The subject of aerodynamics was evolved. The aircraft engine was developed, with many problems. The petrol engine, the gas turbine, and the propellorless turbo-jet are compared. The jet engine has passed all barriers.

Large scale aviation has brought forth many problems: the organization of large companies, the construction of huge airports, the development of numerous safety devices, and the evolution of devices for the convenience of passengers. These are fully treated in chapter three. It has been necessary to study the weather and to maintain wireless communication with the pilot. Passenger travel has greatly increased. The development and structure of airplanes are fully discussed.

The ultimate speed to be reached by jet propulsion is not yet known. We have made many wonderful advances. Many new and difficult problems arise. The book is interesting and instructive and has a place in any science library.

AN AMATEUR VIEWS THE TOTAL ECLIPSE OF THE SUN

by Dave Morrison

An eclipse of the Sun is not only one of the most beautiful, but also one of the most rarely seen celestial events. Although the paths of Earth and Moon cross and recross, and their impenetrable shadows sweep for hundreds of thousands of miles through space, only once on the average in 350 years does the black needle of the Moon's umbra pierce the Earth at any one spot; and but seconds after the Sun is obscured, the swift shadow moves on, and the drama is past. Yet so much can be learned during those seconds of totality that for the past century and more astronomers and physicists have traveled all over the world to place their instruments within the narrow shadow path.

The total solar eclipse of October 12, 1958, falling during the IGY and being of long duration, promised to provide the opportunity for detailed analysis of the solar atmosphere near time of peak solar activity. Japanese, British, and American expeditions were all sent to the central Pacific, the only place the eclipse could be observed with the Sun reasonably far above the horizon. The shadow path crossed only about eight small islands, and the American expedition chose Motu Kotava in the atoll of Pukapuka (Danger Islands), in the Northern Cook Islands.

Organization of the U.S. Expedition

Eclipse paths, although thousands of miles long, have an unpleasant habit of avoiding populated and accessible areas - - perhaps a measure of how little of the Earth's surface we have tamed. Pukapuka atoll, three islands with a total area of about two square miles, is one of those oft-sung-of South Sea Islands, almost completely cut off from the world. The girdling barrier reef, offering neither harbor or anchorage, has helped keep the Polynesian society most primitive and interesting but offered a serious problem to the U.S. expedition.

The entire logistics of erecting a shore camp and keeping it supplied was handled by the U.S. Navy. All units, which included Marine, Seabee, Under Water Demolition Team, and Helicopter Utility Squadron, operated from the Landing Ship Dock U.S.S. Point Defiance, LSD-31, which was assigned to the expedition. The ship left Long Beach, California, in mid-August and arrived at the islands on the 26th. By September 1, 375 tons of equipment had been moved ashore and the camp set up,

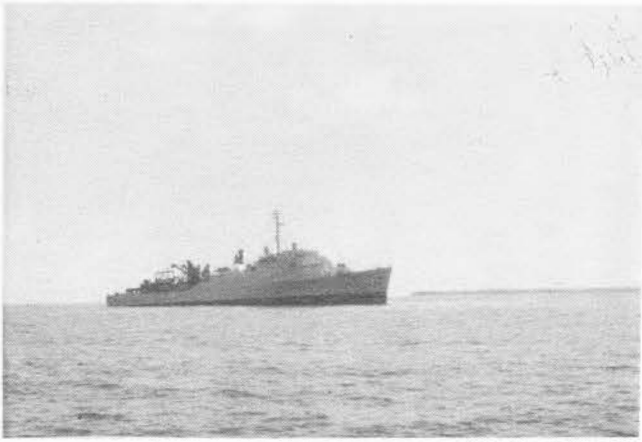

Figure 15.
The U.S.S. Point Defiance, LSD-31, headquarters for the U.S. expedition, off Pukapuka atoll in the South Pacific. This photograph and also Figures 16, 17, and 18 by Dave Morrison.

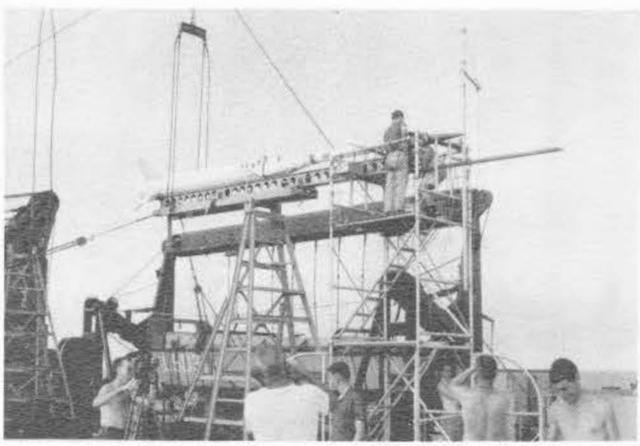

Figure 16.
One of the two-stage Nike-Asp high altitude research rockets being readied for firing from shipboard by an NRL crew.

where it would serve as home for much of the expedition until completion of back-loading on October 18.

I, an eighteen year old junior astronomer, accompanied the expedition from 19 September through 24 October under the auspices of the National Academy of Sciences and upon the recommendation of the Astronomical League. It was an unprecedented opportunity for a young amateur to see the professionals at work and to participate in a major IGY project. I hope I can pass on some small part of what I have learned to my fellow A. L. P. O. members.

Rocket Program

Dr. Herbert Friedman, now supervisor of the Atmosphere and Astrophysics branch of Naval Research Laboratory (NRL), directed the 13 man rocket team which remained on board the Point Defiance. Their goal was to get accurate measurements of the total solar energy flux in three wave length bands which are blocked from reaching the surface of the Earth by the atmosphere, by measures from rocket-borne detectors above the filtering atmosphere. Such observations outside the narrow spectral range which the atmosphere will transmit had never been made during total eclipse, and this promised to provide valuable new data on the ultra violet and X-ray emissions of the solar corona.

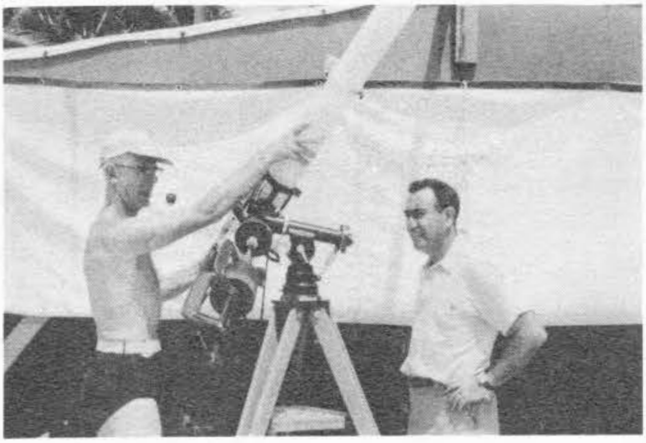

Figure 17.
Dr. John Evans, leader of the shore party, demonstrating an H-Alpha monochromator to Dr. Herbert Friedman, head of the NRL rocket team. (Left to Right: Evans, Friedman)

Figure 18.
Primitive Polynesian village on the island of Pukapuka in the South Pacific.

Eight two-stage Nike-Asp rockets were used to lift the 40-pound instrument payloads to a peak altitude of 150 miles. Data recovery was by an FM-FM telemetry system employing four subcarrier channels; the instrument sections themselves were not recoverable. On most rockets the four channels consisted of one for aspect to determine the position of the rocket and three carrying data from detectors for Lyman Alpha emission in the ultraviolet, and X-ray bands 8-18 A and 44-60 A.

These rockets had never before been fired from shipboard, and the first of the two test shots, on September 28, established a record altitude for shipboard launchings. Six rockets were scheduled for firing during the eclipse itself. On the day before the eclipse they made a beautiful sight, six slender white needles rising 20 feet above deck, gently rolling against the deep blue sky. Five were actually fired eclipse morning, while the sixth was held for a background shot the following day. During the four minutes of totality two rockets were in the air simultaneously, having been successfully fired within less than 30 seconds of each other. Data recovery was excellent; and the results of the experiments, certainly the most spectacular part of the expedition, should soon be published by NRL.

Shore Based Experiments

The optical and radio experiments were based on the island of Motu Kotava, smallest of the three which make up the atoll. Roughly 50 persons, including about 20 scientists, lived for a month and a half in temporary structures on the coral beach facing the calm lagoon, with the graceful palms of the island rising behind them. Dr. John Evans of Sacramento Peak Observatory headed the shore party.

A number of varied experiments were planned by several sponsoring organizations. High Altitude and Sac Peak Observatories installed an extremely complex flash spectograph. Their observations were to consist of a rapid sequence of medium and high dispersion spectrograms of the light of the whole chromosphere extending above the limb of the moon. The University of Wisconsin group planned spectral analysis of the corona during totality, while one of the projects of the California Academy of Sciences was determination of the white light polarization of the corona. The other was a project to study the "shadow bands". National Bureau of Standards sponsored two groups, one to measure the intensity of airglow in the emission line of atmospheric oxygen at 6300 A, the other to record developments in the ionosphere by radio soundings.

Those on shore who could take time off from their work found the islands most fascinating. Swimming in the 80 degree water was always excellent, and the underwater views of gracefully branching coral and the hundreds of blue and green and gold fishes never ceased to charm. The Polynesian natives were friendly, although apparently incapable of grasping what was going on most of the time. They rode happily on the DUCK, however, gleefully watched the movie each night, and traded their handicraft for cigarettes, clothes, and mosquito netting.

At night the southern stars shone down with a glory undimmed by smoke or dust. Centaurus and Crux, Canopus and Achernar, the pearly Clouds of Magellan, all filled the tropical night with splendor. The bright band of the Zodiacal Light streamed up from the horizon as darkness fell each night, while overhead the galactic center in Scorpius and Sagittarius displayed in clouds of stars and dust an incomparable glory.

Eclipse Observations

The morning of October 12 dawned clear and beautiful on shore, and hopes for complete success ran high. Rain squalls were approaching, however, by time of first contact, and when totality occurred at 8:47 A.M. the Sun was totally obscured by heavy clouds. Only two minutes after totality the thin solar crescent broke into clear skies, but by then it was too late. Only the ionosphere and airglow experiments produced successful data on shore.

The Point Defiance was 40 miles away, and happened to be under clear skies during totality. While the rockets thundered upwards from her deck, observers saw the last thin crescent disappear and the round white corona leap into view in the darkened sky. On the lower limb of the Sun a great red prominence licked down, clearly visible. Jupiter and Venus shone brightly, while Alpha and Beta Centauri and the Southern Cross twinkled to the south. In four minutes it was all over; the shadow swept on to the west, the stars winked out, and the light of the crescent Sun once again glittered on the long Pacific swells.

A great deal of the expedition was successful. For those who had come so far and worked so hard only to be completely thwarted by clouds it was, of course, a bitter disappointment. But the very fact that astronomers are not totally dependent on the whims of the atmosphere and the limited wave lengths which it can at best pass is evidence of the new emancipation which is sweeping through astronomy today, making its proper domain not just visible light, but the whole span of electromagnetic radiation.

ARTIFICIAL PLANET ONE AND THE A. L. P. O. LUNAR MISSILE SURVEY

by Walter H. Haas

On January 2, 1959, the U. S. S. R. launched a space probe, which, passing within about 5, 000 miles of the moon, is now in an elliptical orbit around the sun, the first man-made object to escape from the earth' s gravitation. The last stage of the vehicle weighed 3, 245 pounds and included a payload of scientific instruments weighing about 795 pounds. A cloud of sodium vapor was released at $0^h\ 57^m$, U. T. on January 3 to facilitate optical tracking; the probe was then below the horizon in the United States. Radio transmitters sent back data to earth for two and a half days, until they ran out of power. Harvard Announcement Card 1422, dated January 8, 1959, carries the following preliminary geocentric positions for the probe from Russian sources. We also give the moon' s simultaneous geocentric coordinates.

U. T. Date and Time	Right Ascension Probe	Declination Probe	Distance Probe from Earth' s Center	Right Ascension Moon	Declination Moon
1959, Jan. 3					
0^h	$14^h 0^m \pm 2^m$	$-3^\circ\ 12'$	115, 000 kms.	$13^h 10^m$	$-7^\circ 23'$
3	14 2 ±2	-4 30	143, 000	13 17	-7 54
10	14 9 ±2	-7 33	215, 000	13 33	-9 6
13	14 6 ±2	-8 20	243, 000	13 40	-9 35
16	14 6 ±2	-8 57	281, 000	13 47	-10 5
18	14 10 ±2	-9 18	290, 000	13 51	-10 24
21	14 11 ±2	-9 45	317, 000	13 58	-10 53
Jan. 4 0^h	14 12 ±2	-10 7	342, 000	14 5	-11 21
6	14 14	-11 25	396, 000	14 20	-12 15
9	14 15	-12	428, 000	14 27	-12 41
16	14 17	-13 42	480, 000	14 43	-13 39

The closest approach to the moon was at $2^h\ 59^m$, U. T. on January 4.

It may be well to note that apparently the right ascensions of the probe are subject to probable errors of two minutes of time, which is half a degree of arc at the celestial equator. It is reasonable to suppose that there is some uncertainty in the declinations as well. At the distance of the moon a half-degree uncertainty is about 2, 000 miles. If we are to accept these figures at their face values, one must wonder about the range of uncertainty of the miss distance; and since the moon' s gravitational force must modify the subsequent orbit very considerably by an amount depending rather sensitively upon the miss distance, one may wonder just how accurate are orbital elements recently given for Artificial Planet One.

The A. L. P. O. Lunar Missile Survey members were keenly interested in this body, and we here report observations made by them. While the vehicle was in flight, an actual impact on the lunar surface was for a time thought possible. We were able to give no instructions for observations to our members; each one guided himself by newspaper, radio, and television releases. Weather conditions were poor over most of the United States and kept many would-be observers idle.

January 3, 1959. Mrs. Dorothy Pickering of Reeds Ferry, New Hampshire observed all of the earthshine with a 3-inch reflector from $8^h\ 0^m$ to $8^h\ 55^m$, U. T., the goal being to see a possible missile impact-flash. Nothing was noticed; the seeing and transparency were both poor. Like the rest of us, Mrs. Pickering then had very limited information on the space probe. Mr. Lyle Johnson of Welcome, Maryland saw the moon for about two minutes through clouds in his 16-inch reflector near 9^h, U. T. Mr. William K. Hartmann of New Kensington , Penna. made a prolonged series of observations with an 8-inch reflector from $10^h\ 2^m$ to $12^h\ 30^m$. Partly he studied the moon itself, including the earthshine; he watched Wilkins Map Section XVIII especially closely. He also scanned the sky within about 20' of the moon in the hope of detecting the probe itself, either as a moving star-like object or as a possible faint flashing (because tumbling?) object. He found nothing, and the table above shows the probe to be then about nine degrees from the moon. Mr. Fred Wyburn in Red Bluff, Calif. had negative results in a search from $12^h\ 30^m$ to 14^h, U.T.

January 4, 1959. Mr. Kenneth Delano at Taunton, Mass. observed the sky west of the moon from the west limb out to a distance of one degree from $8^h\ 0^m$ to $8^h\ 45^m$, U.T., employing an 8-inch reflector. He detected nothing, and the table shows that the probe was already more than a degree away from the moon. Mrs. Dorothy Pickering watched the earthshine from 9^h to $9^h\ 45^m$, U.T., 3-inch reflector and negative results. Mr. Eugene Spiess in Manchester, Conn. observed Section VI from $10^h\ 0^m$ to $10^h\ 30^m$ and then the earthshine from $10^h\ 35^m$ to $11^h\ 43^m$. His telescope was a 5-inch refractor. Results were negative. Mr. Lyle T. Johnson with a 16-inch reflector observed Section XXII and also photographed the moon during these intervals: $10^h\ 15^m$ - $10^h\ 33^m$, $10^h\ 55^m$ - $11^h\ 7^m$, and $11^h\ 20^m$ - $11^h\ 45^m$. He saw nothing; he had not yet developed his film when he wrote. Mr. Philip R. Glaser and Mr. E. E. Bowman observed with the Milwaukee (Wisconsin) Astronomical Society's 13-inch reflector from $9^h\ 0^m$ to $12^h\ 10^m$, a remarkable vigil in view of the temperature of -11^oF. They studied the lunar surface and also searched star fields out to a distance of five to ten degrees, this area thus certainly including the new artificial planet. Several photographs were made. Results were negative, the seeing and the transparency being poor. Mr. D. D. Werdick at Bloomington, Minn. observed with a 6-inch reflector in a temperature of -18^oF. (!) from $9^h\ 0^m$ to $9^h\ 23^m$ and from $9^h\ 45^m$ to $10^h\ 0^m$, U.T. He watched both the earthshine and the sunlit regions but saw nothing. Mr. Paul Nemecek of Whittier, Calif. observed the sky in a 12.5-inch reflector within two or three degrees of the moon from 11^h to 14^h, U.T., seeing nothing. The probe was not in the region watched. Walter H. Haas at Las Cruces, N. Mex. scanned the moon, including the earthshine, with a 12.5-inch reflector from $10^h\ 13^m$ to $10^h\ 39^m$ and from $11^h\ 2^m$ to $11^h\ 13^m$. His results too were negative.

We must naturally feel disappointed that Artificial Planet One, the first eminently successful space probe, supplied nothing observable in ordinary astronomical telescopes. We would, however, feel even more disappointed if our members had reported something which could not have occurred! It is apparently little use to try to observe space probes themselves without fairly accurate information on their positions. In all but one of the searches described above the probe was outside the area examined. Mr. William K. Hartmann has pointed out that press statements of the time at which a probe is above a specified place on the earth's surface give its astronomical position: the latitude of the place, with sign, is the declination; and the sidereal time at the place at the moment of such zenith-passage is the right ascension. For vehicles launched from Cape Canaveral, Florida it is possible that observers in the Southeastern States can secure valuable optical data early in the flight, following the object in their telescopes as long as possible. Each such observation should express the right ascension and declination and the corresponding time. Of course, these records will be useful for finding future positions of the object only if we can also quickly carry out some calculations and can transmit the results to Lunar Missile Survey observers. If probes continue to be launched so as to be close to the moon near perigee, the lunar phase is now becoming very unfavorable for seeing missile impact-flashes. The three next perigees occur on February 26, March 26, and April 23, while the three next full moons are on February 23, March 24, and April 23 (all dates by U.T.). Mr. Hartmann remarks that the magazine Aviation Week Including Space Technology is a good source of advance information on scheduled space probes.

Finally, we would suggest that the Lunar Missile Survey has much value and great interest quite apart from moon rockets and their kin. The volcanic activity in Alphonsus mentioned elsewhere in this issue underscores the need for a continuous, careful patrol of the lunar surface. The Lunar Meteor Search now capably supervised by Mr. Robert M. Adams for several years will benefit greatly from well-planned observing-sessions for possible lunar meteors involving relatively large numbers of Lunar Missile Survey team members. The atlas of lunar domes discussed by Ernst Both and Leonard Abbey on pp. 96-101 of our July-Sept., 1958 issue will be much aided if each Lunar Missile Survey observer will assiduously search his assigned section for these domes - a long-time study, to be sure. Similar searches can also be made for other kinds of lunar objects, such as craters with wall bands (in which Alika Herring and others have long been interested) and very tiny bright crater-spots (William Hartmann and others having pointed out that missile-impacts may produce such features). It is much easier and far more profitable to search one or two Wilkins map sections for such lunar oddities than to undertake to examine the whole moon for them. Interested readers are again invited to join the Lunar Missile Survey, and there is still an acute need for observers outside of the United States.

OBSERVATIONS AND COMMENTS

Lunar Meteor Cooperation. Mr. Robert M. Adams recently contributed this discussion: "During the past two years the best results obtained from observing lunar meteors have been via teams such as the Montreal group, the Manchester, Conn. group, and more recently the groups from the area around Pittsburgh. Indeed, practically all of the observing has been accomplished as a result of the efforts of observers in these teams. We sincerely trust that these groups will continue to send in reports. Spokesmen for any new groups wishing to send in reports should first clear with [me as] the Recorder.

"Another possible observational approach is the cooperation of a few widely separated observers, all reporting directly to the Recorder. Persons interested in setting aside two or three hours a month for this research should contact the Recorder. These individuals would then be assigned hours to observe, probably the fourth and fifth evenings after new moon or the fourth and fifth mornings before new moon. Both negative and positive reports must be recorded. The results would then be included in the yearly report to The Strolling Astronomer. Of course, anyone who sees an apparent lunar meteor at times other than those hours assigned should report all data on it. Such procedures as these should assure a maximum of overlapping in time, the aim of the project.

"All reports sent to Walter Haas as part of Lunar Missile Surveys [but primarily those reports which are observations of the earthshine] should have significant value to the Lunar Meteor Search. Reports of any flashes or light streaks which are verified by others or large accumulations of negative reports or unverified positive observations should be of great significance. Incidentally, since the Russian observers report volcanic activity, perhaps some of our observers should also be aware of the possibility of flashes of longer duration or even light-glows of varying intensity. Here again we may have a chance of verifying or negating a claim."

It should encourage others planning such cooperative lunar meteor searches that Craig L. Johnson in Boulder, Colo. and Walter H. Haas in Las Cruces, N. Mex. achieved an hour of overlapping time on January 13, 1959.

Cassini. Mr. Alika K. Herring offers these remarks on his drawing of the lunar ring-plain Cassini which appears on the front cover of this issue: "Before 'settling down' to the night's work, I usually spend some little time in a preliminary survey of the lunar surface. While so engaged on [July 24, 1958], I was interested to note what appeared to be two rather conspicuous clefts lying west and south of the largest craterlet in Cassini. I had originally planned to sketch another formation at this time; but these features, which I had not seen previously, interested me so greatly that I decided to change my schedule. This drawing was the result.

"As so often happens in instances such as this, the available literature may be inadequate. Elger and Goodacre make no mention of such details in this part of Cassini, although Wilkins in The Moon does make a vague reference to some ridges in this area. However, they appeared to me to be very cleft-like and so that is how I drew them. Of course, ridges can also cast shadows.

"The third craterlet in Cassini, the small one which lies on the floor at the foot of the north wall, was not visible at this time. It is usually a rather easy object under a somewhat higher lighting."

Figure 19. Sketch by Alika Herring of newly discovered lunar cleft south of Plato. See text on pg. 155 of this issue.

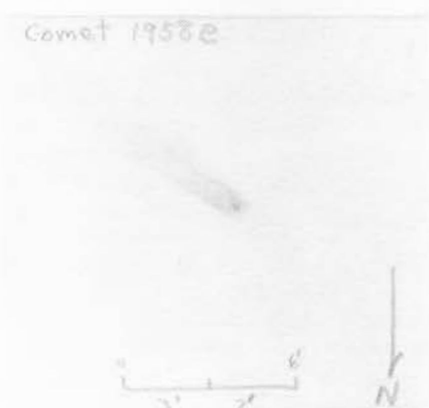

Figure 20. Comet 1958$_e$ (Burnham-Slaughter). December 14, 1958. $4^h\ 1^m$, U.T. Gary Wegner. 10-inch reflector. 184X - 241X. Seeing fairly good. Sky clear.

New Cleft in "Ancient Newton." Figure 19 shows this object, of which Mr. Alika Herring writes: "First discovered on July 26, 1958 at colongitude 30° with 12.5-inch reflector under fairly good seeing. Appeared to extend south and slightly west on the Mare Imbrium from the base of the wall of Plato, curving slightly to the west during its course, until it ended just east of the small crater marked 'C' on the Wilkins map. The cleft was again seen on August 23, 1958 at colong. 11°5. Under this lower lighting two very low ridges were seen to extend southwards from the Plato wall. The cleft was seen to lie in the very shallow valley between these ridges."

One more lunar cleft is not earth-shaking news, but the manner of the "discovery" of this unmapped (to our knowledge) feature may be most instructive and even thought-provoking. Mr. Herring had made a prolonged study of Plato with 8-inch and 12.5-inch reflectors over a period of some years prior to July 26, 1958. He had observed Plato literally hundreds of times, but he had never before noticed this cleft. Now he does not even regard it as a particularly difficult object. Nevertheless, he definitely does not think that the feature is new to the lunar scene; it was merely long overlooked. This question of possible earlier oversights by insufficiently attentive observers almost always exists when "new" lunar features are announced.

Sketch of Comet Burnham - Slaughter. Mr. David Meisel, our Comets Recorder, invites attention to Figure 20, which he regards as a very laudable sketch of Comet Burnham-Slaughter. Mr. Wegner, the observer, estimated the stellar magnitude at 13 for the nucleus, 14 for the whole comet. A short but very faint tail was noticed in the steadier moments of seeing. The angular scale on Figure 20 and the arrow to indicate north in the sky are almost essential if one's sketch of a comet is to be useful. Several articles upon the work of the Comets Section are planned for the next couple issues.

Lunar Color Observation. Mr. Carlos Rost of Santurce, Puerto Rico writes that on one evening, probably in March or April, 1958, he remarked with a 4-inch reflector "a noticeable blue or purple hue", perhaps inside the walled plain Albategnius. Efforts to dispel the color by moving the telescope had no effect so that the color was apparently neither on the mirror nor on the eyepiece. It is unfortunate that Mr. Rost is unable to give more precise data on an interesting observation.

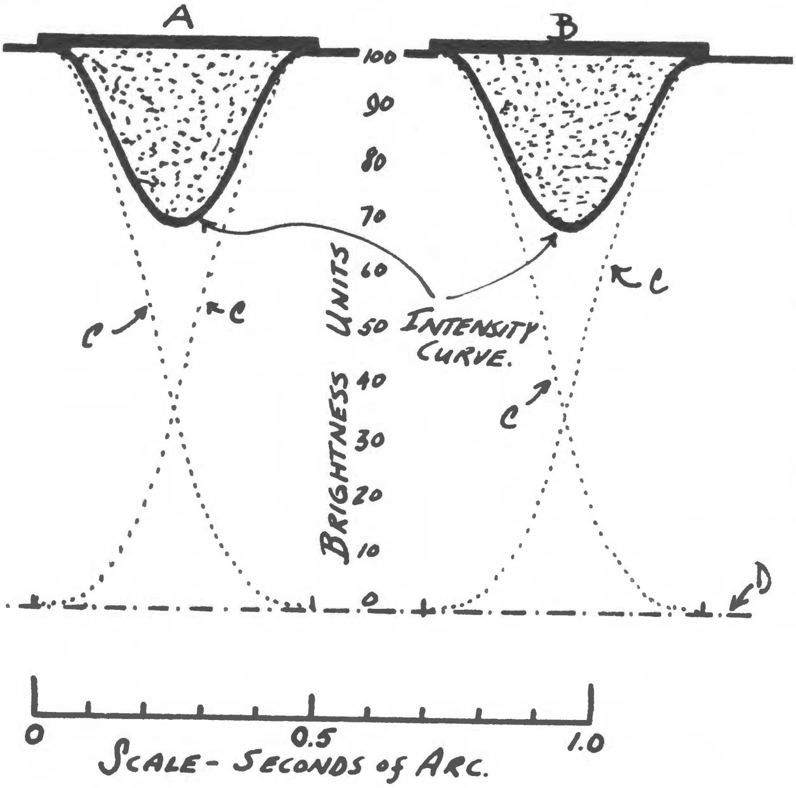

Figure 21. Example of diffraction-patterns with extended surfaces. 5.5-inch telescope, axial image, no spherical or chromatic aberration. A and B are dark areas seen against a light background of 100 brightness units. Contributed by Frank Vaughn.

Notes on Extended Surface Diffraction Theory. Mr. Frank Vaughn offers the following remarks, here slightly edited: "It is perhaps not generally realized that stellar concepts of resolution, visibility, etc. require modification when applied to planetary and lunar surfaces, with their markings of moderate to low contrast. In Figure 21 it will be obvious that A and B will appear as distinct spots of a diameter smaller than real, but separated by their true angular distance. Curiously, a larger perfect telescope would show the spots as larger, but of course more nearly of their true size, and darker, hence more nearly of their true intensity. If the 5.5-inch telescope is not perfect but differs from a true convergence by 1/8 wave, then in Figure 21 we should move the right-hand diffraction curves for each spot-boundary 0.5 seconds to the left and the left-hand diffraction curves 0.5 seconds to the right. It will then be plain that little or no contrast now exists between the spots and the bright background, and they would hence be invisible.

"Extending these ideas to other separations of spots (or lines), with different apertures of telescopes, it should be obvious that it is of the greatest importance for optical systems to be of the greatest perfection attainable, i.e. as in planetary and lunar work, where we are concerned with the delineation of delicate details against a brighter background. For example, where enough surface brightness exists, a perfect 4-inch telescope will reveal darkish details with the same facility as an 8-inch telescope of 1/8 wave correction. This fact may form the greater part of the explanation of why some good observers show as much reliable detail with a 6-inch aperture as others with twice as much. Such has been my personal experience".

The Strolling Astronomer

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