Occultation Newsletter

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IOTA BUSINESS MEETING

Paul J. Newman

During August 8 through 13, the International Occultation Timing Association met jointly with the National Amateur Astronomers, Inc., the Astronomical League, the Association of Lunar and Planetary Observers, and the Western Amateur Astronomers, at the University of Colorado, in Boulder. [Ed: Proceedings of the convention will include most of the scientific papers presented. Extra copies were to be printed. While they last, U.S. residents can obtain copies @ $5.50, postpaid. Make checks payable to National Amateur Astronomers, Inc., and send to Derald Nye, 5604 Bowron Place, Longmont, CO 80501.] On Friday night, August 12, in Lecture Room 0-30G of the Duane Physics Building, IOTA held its first general business meeting. There were twenty-two members and three guests present, representing Denmark, Republic of South Africa, and the United States.

The meeting began at approximately 20:35 MDT, with IOTA President and Scientific Director David W. Dunham giving a brief welcome and a description of the agenda. The first items of business were the offficers' reports. Secretary Berton L. Stevens, Jr. announced that an updated roster is forthcoming, and that by the middle of September, all members will have received predictions for the October 12 solar eclipse for their respective locations as indicated on observer information forms. He advised observers who have new observing stations or other related changes in their circumstances to request new observer information forms (see FROM THE PUBLISHER for Stevens' address). In closing, he expressed the gratitude of the Executive Committee for all the volunteers who have helped IOTA in providing services to its members. Treasurer Homer F. DaBoll reported a balance of $981.50, but noted that IOTA had made commitments for goods and services for which reimbursement had not yet been requested.

The next item on the agenda was the election of officers. Dr. Dunham presented the slate of officers proposed by the Executive Committee: President and Scientific Director, David W. Dunham; Vice President, Homer F. DaBoll; Secretary, Berton L. Stevens, Jr.; and
(Continued on next page, bottom)

LUNAR OCCULTATIONS OF THE HYADES CLUSTER

David W. Dunham

[Paper presented 1977 August 12, at the Fourth Nationwide Amateur Astronomers Convention, Boulder Colorado]

During the next five years, the moon will pass through the main part of the Hyades Cluster each month. Careful observations during these passages can lead to the discovery of very close double stars. Duplicity of even bright members may have been previously overlooked. For example, δ Tauri was only recently found to be a spectroscopic binary. When a star is found to be double, its position changes on the color-magnitude (Hertzsprung-Russell) diagram since the components are fainter than the combined light of the system. A number of newly discovered doubles can shift the cluster main sequence, crucial in the case of the Hyades, since its main sequence has been used to establish the galactic and extra-galactic distance scales. Numerous timings of occultations during these passages will also be valuable for detailed studies of Watts lunar limb correction data. Since the moon's latitude libration has nearly maximum values during the Hyades passage, studies of the observations will nicely complement the Pleiades passage studies, when latitude librations had large negative values.

The Hyades is not as dense a cluster as the Pleiades. About 40 members are spread over a roughly circular area with a diameter of 7°. It takes the moon half a day to cross the diameter. A few bright stars are superimposed on a rather ordinary background of faint stars. But starting next year, the series becomes more interesting as the moon occults all the stars along the southern arm of the Hyades "v", the last of which is the non-member Aldebaran, at magnitude 1.1, the brightest star which can be occulted by the moon. Figures 1 and 2 are charts showing the main part of the Hyades. Positions of stars as faint as mag. 11.5 have been obtained from the Bordeaux zones of the Astrographic Catalog. Occultation predictions for all of these stars are being computed at the USNO for occultation observers with large telescopes.

The map in Figure 3 shows all northern and southern limits of occultations of Aldebaran which cross the contiguous United States and southern Canada during the upcoming series. For completeness, graze paths for Regulus and Venus which occur during this Aldebaran series are also plotted. I hope the planners of astronomical conventions will avoid meeting dates near the dates of the events shown on this map. Unfortunately, most of the grazes of Aldebaran occur during the daytime or on the bright side of a highly gibbous moon. But the star is bright enough that good observations can be made with small telescopes under these adverse conditions. These grazes will give data that will be important because they cannot be obtained with fainter stars. The best graze which crosses a large city will be the 1980 June 18th graze of Regulus, which might be seen without optical aid from parts of New Orleans. After 1981, there will be no occultations of first magnitude stars until 1986.

The graze prediction format has been designed to ease the job of plotting graze paths on topographic maps. Plotting scales have been designed to further simplify and speed the plotting needed for expedition planning. A fairly simple correction for height above sea level needs to be applied to graze paths in areas such as Colorado, but can be ignored for prediction purposes in areas less than 1000 feet above sea level (prediction uncertainties are then greater than the elevation correction). The path of a graze can be plotted over a considerable distance quickly on a 1:250,000 scale map, which is often sufficient for all prediction purposes. In highly developed areas, mere inspection of a more detailed map can quickly decide the suitability of a site shown on a 1:250,000 scale plot. With only a little advance planning, astronomical society bulletins can be used to distribute graze expedition meeting times, places, and a phone number for a weather go/cancel decision to many potential observers, one of whom may live near the graze site and could make a site survey to check for adequacy. A survey is almost always needed for low altitude grazes, to be sure of an adequate horizon. In most areas, most grazes are clouded out, so the expedition leader wants to minimize preparation time for each, but to be ready when clear skies do occur, perhaps only a few hours before the graze.
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Last-minute addition - For latest information on Uranian ring occultation predictions, see page 130 or *IAU Circular #3108*.

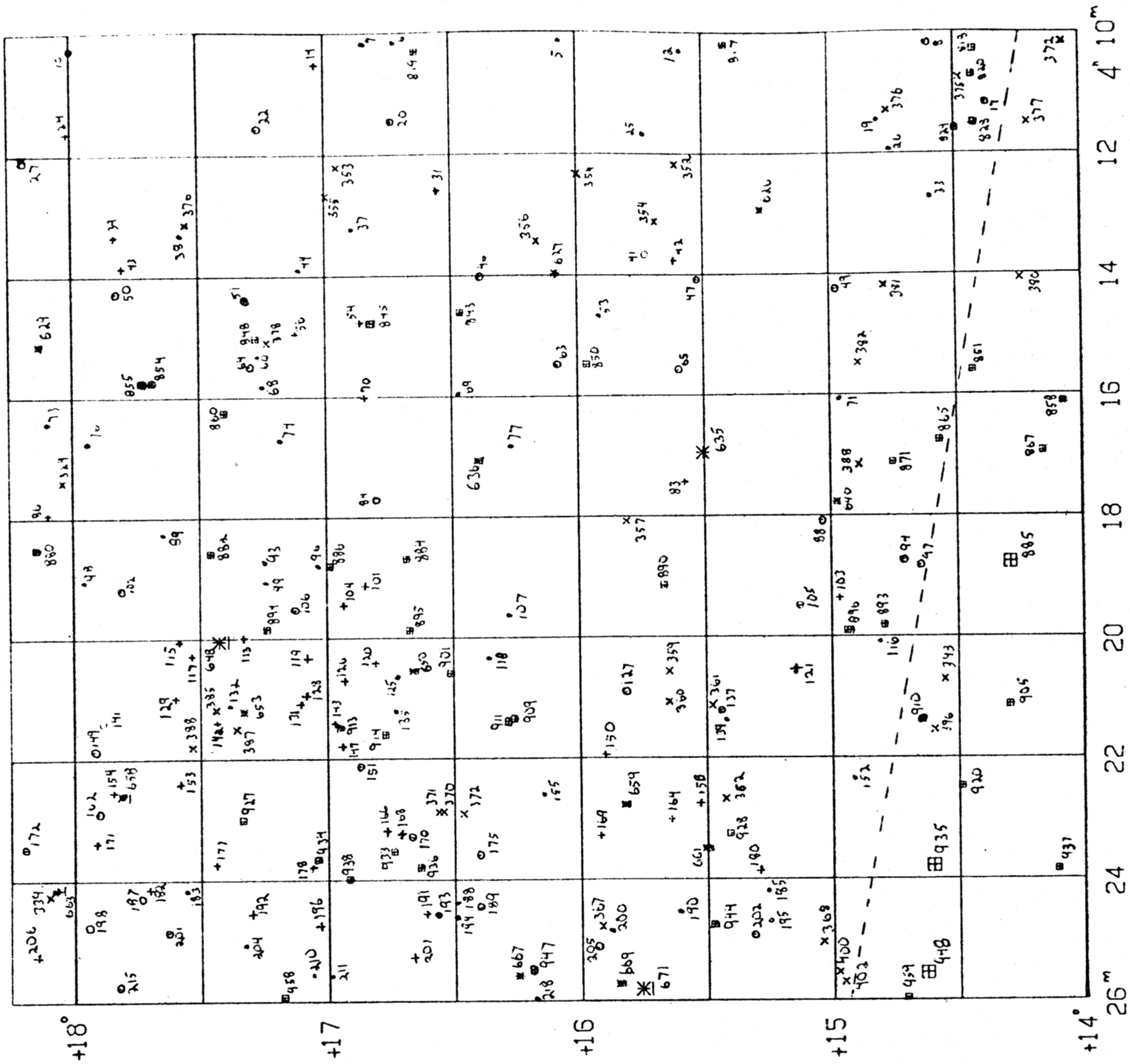

Figure 1
The Western Part of the Hyades Cluster

Key to Figures 1 and 2:

Known double stars in the occultable zone are underlined. δ Tauri is ZC 648 at RA 4^h 20^m, Dec +17°.4. Aldebaran is ZC 692 at RA 4^h 33^m, Dec +16°.4. Note that the moon moves from west to east across the cluster. The chart was produced at USNO with a computer program written by Vincent Sempronio; the star numbers were added by Rick Binzel.

Right ascensions and declinations are epoch 1950. The dashed line crossing the lower part of the chart marks the southern limit of the occultation zone, below which a star cannot be occulted as seen from the earth's surface. The star symbols and numbers are as follows:

- ✳ - Zodiacal Catalog, mag. 1.1 - 3.9
- ✱ - Zodiacal Catalog, mag. 4.0 - 7.0
- ⊞ - SAO Catalog, mag. 4.0 - 6.4 The number given is the SAO number minus 93000.
- • - SAO Catalog, mag. 6.5 - ca. 9
- × - AGK3 Catalog, mag. ca. 8½ - 10½. The AGK3 # is the declination zone (such as +17°)

Treasurer, John D. Phelps, Jr. He then solicited nominations from the floor. As there were none, Dr. Dunham moved that the proposed officers be elected by acclamation. The motion was seconded and unanimously approved. The only difference in the Executive Committee was that DaBoll and Phelps exchanged offices. DaBoll will remain the editor of *Occultation Newsletter*.

The remainder of the meeting consisted of discussion of several subjects related to IOTA and occultation observing. For example, the desirability and feasibility of producing regional maps for grazes or special events, by computer, was acknowledged. Derald Nye volunteered to work on this project. DaBoll announced that Volume I of *O.N.* will be closed-out sometime during the summer of 1978, and requested the help of someone, preferably with library experience, in producing an index. Robert Sandy agreed to get necessary computer program rewriting done so that the IOTA roster can be updated and distributed. A graze observer's manual, being written by the Dunhams, with assistance by DaBoll, Phelps, Sandy, et al., is projected to be completed by the end of 1977.

Concerning personal equation, Dr. Dunham related the results of tests conducted by T. Mori and other Japanese observers. In these tests, which involved simultaneous visual and photoelectric observations of lunar occultations, none of the p.e.'s obtained were less than 0.s3; in fact, only a small percentage were 0.s3. The bulk of the p.e.'s obtained for bright stars were at least 0.s4 or longer, and tended to increase for fainter stars. M. D. Overbeek, an IOTA member from the Republic of South Africa, reported that he had conducted similar tests,
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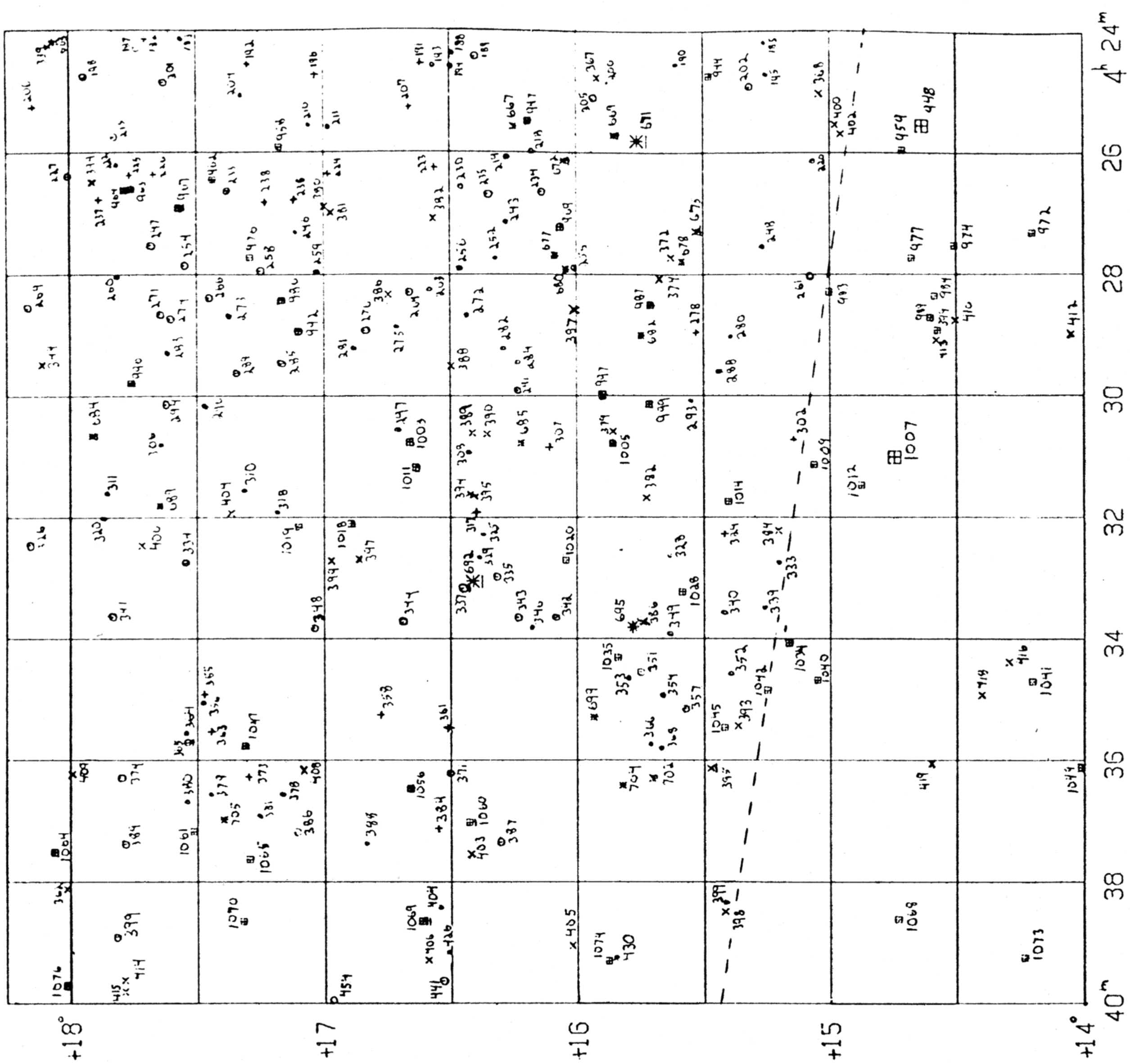

Figure 2
The Eastern Part of the Hyades Cluster

and a number which increases in RA order, as in the BD.

o - BD Catalog, mag. ca. 9 - 10 The number given is the USNO "J" number.

+ - Astrographic Catalog, mag. 8.5 - 11.5. The "J" number is used.

· - Astrographic Catalog, mag. 10.6 - 11.5. The "J" number is used.

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and that the data he gathered were in close agreement with those obtained by the Japanese. It was also noted that the physical and psychological condition of an observer, as well as environmental circumstances, affect personal equation.

Dr. Dunham mentioned that the Japanese have succeeded in developing the equipment and technique for consistently observing total lunar occultation reappearances photoelectrically. After a general discussion of the problems involved in photoelectric observations of occultations, such as achieving and maintaining good signal-to-noise ratio and the use of a small diaphragm, he described the equipment and the "wrap-around" computer data processing technique used at McDonald Observatory. Stevens then reported that his photoelectric system, which will utilize "floppy disk" technology for increased data storage and processing, is near completion.

Concerning grazes, it was pointed-out that, while observation by several observers is desirable, a solitary observation is, nevertheless, valuable, especially if the event occurs in a Cassini region. Also, several people mentioned occasional errors in their reports of residuals from HMNAO. It was emphasized that discrepancies that appear on reports of residuals need to be checked-out and resolved.

Robert Sandy next made a statement expressing the gratitude of the IOTA membership for Homer DaBoll's fine job as editor of *Occultation Newsletter*. The last item discussed was future IOTA meetings. Dr. Dunham concluded by saying that, while national meetings are desirable every few years, regional meetings, perhaps in conjunction with the Astronomical League, might be appropriate on a yearly or more frequent basis. The meeting was adjourned at 23:04 MDT.

IOTA NEWS

David W. Dunham

The first IOTA special publication, a list of all named and specially designated stars in the Zodiacal Catalog (and some non-Z.C. variable stars), has been distributed to IOTA members. Michael Pine, a member of the National Capital Astronomers, wrote the program to produce the list according to my specifications during a weekend at the U.S. Naval Observatory. This list is especially useful now that HMNAO is not including a list of these names with the predictions which they publish. It was duplicated at low cost to (Continued on next page, bottom)

1978-1981 GRAZING OCCULTATIONS - ALDEBARAN, REGULUS, VENUS

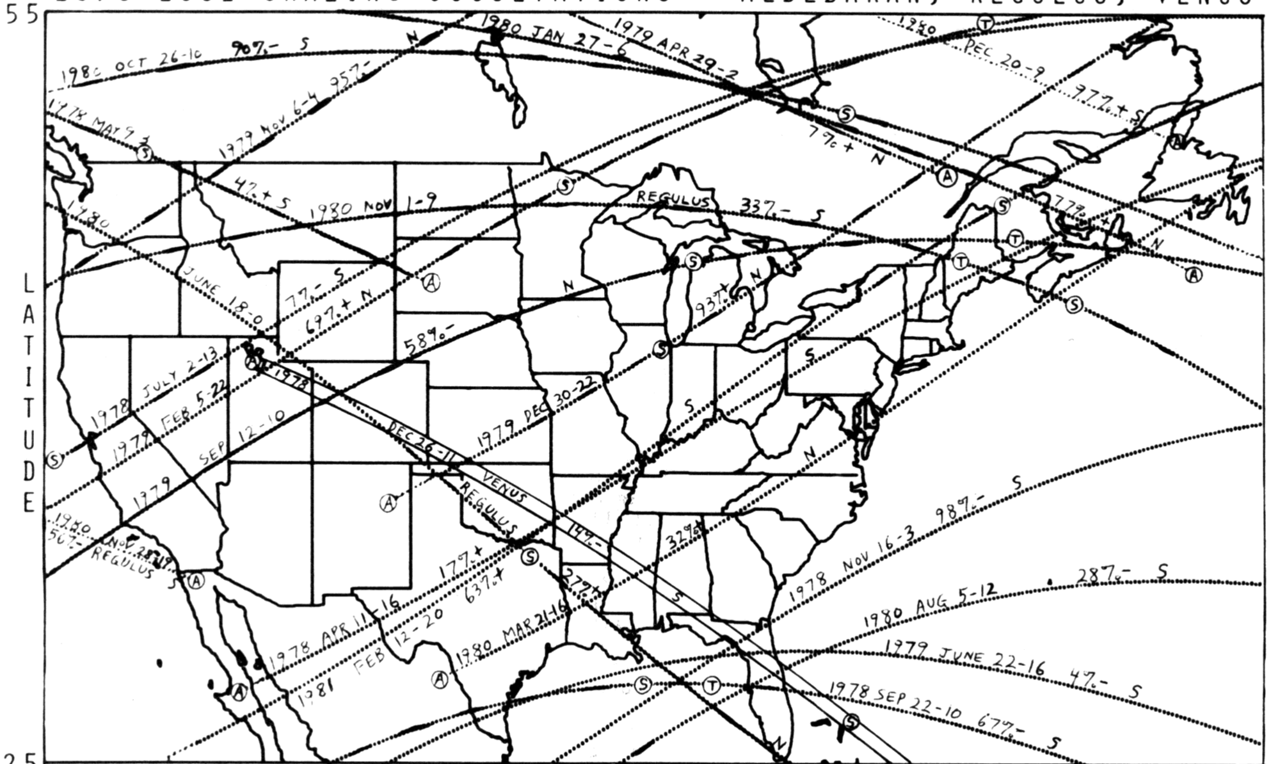

Figure 3

The northern and southern limits of occultations of first magnitude stars and of Venus through 1981. Unless otherwise indicated, the star grazed is Aldebaran. The Universal Time, year, month, day, and hour at the west end of the track are given, followed by the % of the moon sunlit (+ for waxing and - for waning) and an N or S indicating northern or southern limit. Note the lunar shadow sweeps from west to east taking as long as two hours to cross the continent. Ⓐ indicates moonrise or moonset, Ⓢ indicates sunrise or sunset, and Ⓣ indicates central graze at the terminator. All lines are plotted as series of dots at $^1/_4°$ intervals of longitude. A superimposed solid line indicates possible naked-eye visibility, superimposed dashes show binocular visibility, and a small telescope probably will be needed for the rest. The graze of Venus actually will be a partial occultation in the 43-mile-wide band shown on the map. Coordinates of points in the graze paths were computed at USNO and written onto magnetic tape by Rick Binzel and David Dunham. This tape was read by another computer program which produced the basic plot by Fred Espenak. Dunham manually added the final information for the map. Berton Stevens computed the data for the 1978 December 26 partial occultation of Venus. Derald Nye prepared the table using data supplied by Dunham.

TABLE OF CONDITIONS AT THE ENDS OF THE GRAZE PATHS PLOTTED ON THE MAP

				WEST END OF PATH						EAST END OF PATH				
YEAR	MO.	DAY	OBJECT	U. T. h	m	MOON ALT.	SUN ALT.	CUSP ANGLE	U. T. H	M	MOON ALT.	SUN ALT.	CUSP ANGLE
1978	Apr	11	Aldebaran	16	33	4°0	43°0	8°8S	17	55	55°8	38°9	6°5S
1978	May	9	Aldebaran	3	14	18.0	4.5	6.1S	3	21	0.5	-13.0	5.5S
1978	Jul	2	Aldebaran	13	08	20.5	-0.3	3.4S	15	04	46.7	57.7	10.9S
1978	Sep	22	Aldebaran	10	43	74.0	-31.0	-7.9S	12	40	33.7	35.4	5.5S
1978	Nov	16	Aldebaran	3	19	35.1	-51.8	-25.3S	4	58	66.5	-59.5	-18.6S
1978	Dec	26	Venus	11	23	0.5	39.5	-0.3S	12	01	43.0	4.0	-5.1S
1979	Feb	5	Aldebaran	22	33	17.6	31.6	-3.8N	23	59	51.6	-24.6	0.4N
1979	Apr	29	Aldebaran	2	06	16.2	-3.4	-4.6N	2	12	0.5	-19.0	-3.8N
1979	Jun	22	Aldebaran	16	23	71.9	54.4	4.9S	18	25	28.3	50.0	19.1S
1979	Sep	12	Aldebaran	10	05	41.1	-45.0	9.9N	12	09	37.8	31.5	-2.1N
1979	Nov	6	Aldebaran	4	51	21.4	-40.8	17.8N	5	23	39.8	-49.3	17.1N
1979	Dec	30	Aldebaran	22	16	1.5	15.3	4.3N	22	59	39.6	-28.3	3.8N
1980	Jan	27	Aldebaran	6	09	40.0	-51.1	4.0N	6	39	3.0	47.0	8.1N
1980	Mar	21	Aldebaran	16	54	1.0	50.0	-8.9N	17	45	46.9	34.0	-9.7N
1980	Jun	18	Regulus	0	26	54.7	36.0	1.7N	2	03	27.4	-21.8	3.5N
1980	Aug	5	Aldebaran	12	06	66.5	6.7	-9.0S	13	45	50.6	61.2	2.2S
1980	Aug	11	Regulus	15	09	5.8	16.3	6.3S	16	32	71.6	79.6	-7.1S
1980	Oct	26	Aldebaran	10	58	53.4	-35.1	-11.6S	12	02	8.2	18.2	-3.9S
1980	Nov	1	Regulus	9	42	8.1	-53.7	-9.2S	11	20	62.0	14.1	4.1S
1980	Nov	28	Regulus	19	48	8.4	33.6	-0.2S	19	49	0.5	36.6	-0.8S
1980	Dec	20	Aldebaran	9	20	16.1	-32.9	-16.1S	9	26	1.7	-19.2	-17.1S
1981	Feb	12	Aldebaran	20	41	3.7	50.6	7.2S	22	08	53.9	-14.7	5.7S

IOTA at the Dayton Museum of Natural History, as has been done for some of the recent issues of *o.n.* Copies of the Z.C. names list are available to non-IOTA members by sending $0.50 to Berton Stevens, IOTA Secretary, 4032 N. Ashland Ave., Chicago, IL 60613.

Progress is being made with faint star catalog data for various clusters occulted by the moon, although the progress has been slower than I would like, due to other more important commitments. The results of some of this work are discussed in Wallentine's and my article about asteroid passages through clusters on p. 126. I can now produce these data rather routinely for clusters north of declination +4° using the Astrographic Catalog data described on page 97 of [issue #10], and in particular, have compiled a catalog of over 2000 stars brighter than magnitude 10.5 in the moon's current path, between right ascensions 5^h and 7^h (which includes the northern Milky Way). David Herald's project for the southern Milky Way using A.C. data is described on p. 113. The data for the -17° zone have already been prepared and keypunched at USNO, as have data for M23, M24, M25, and the 1978 March and September total lunar eclipse star fields. After a few discrepancies are resolved, this information will be combined to produce extended USNO predictions for the most active total occultation observers for the rest of this year. In the mean-time, predictions for passages through specific clusters, such as the Hyades, are being computed and distributed when appropriate, with Richard Binzel's list (p. 117) serving as a guide. Michael Pine wrote programs which converted David Herald's data into the form needed for occultation predictions, as well as a program which read the Yale Catalog tape to produce a catalog of several hundred occultable stars not in the SAO, some 7th mag. (see p. 101 of issue #10).

PLANETARY OCCULTATIONS

David W. Dunham

[Ed: Space limitations in #11 necessitated postponing parts of the Planetary Occultations article to #12, which explains the apparent anachronism of some of the material.]

Robert Harrington, USNO, obtained plates of Pallas in February and March. These indicated cross-track ephemeris errors of +1".0 and -0".7 during the respective months, emphasizing the lesson learned with the Hebe occultation discussed [on p. 114]. An earlier plate of another minor planet shows SAO 99401; Harrington's measurements of it indicate that the star currently is 0".2 south of its SAO position, which was used for the July 8 occultation prediction discussed in [#10]. Of course, the ephemeris uncertainties are much greater than this. Astronomers at Lick, Lowell, and U. S. Naval Obse4vatories have said that they will try to obtain plates 2 or 3 nights before July 8, so that a last-minute improved prediction can be issued. Jorge Polman, Recife, Brazil, has written a special bulletin about the occultation in Portuguese and has sent it to observers in 23 Brazilian cities. The sphere of influence, within which the attraction by Pallas is greater than that by the sun, has a radius larger than 5000 km.

Gordon Taylor has predicted that an occultation of a 10.1-mag. AGK3 star by 8.6-mag. Vesta will occur on July 24. He has notified occultation observers in the possible area of visibility, although the magnitude drop during an occultation will be so small that photoelectric equipment will be needed to record it. Taylor predicts that a 9.5-mag. star will be occulted by Pallas east to west across the U.S. A. shortly after 5^h U.T. of 1978 May 29 (Memorial Day weekend). Observers throughout the country should keep this date in mind, in case subsequent astrometric observations indicate that they are likely to be within the approximately 600-km-wide occultation zone. Pallas' magnitude will be similar. However, the AGK3 gives 10.6 for the magnitude of the spectral type A0 star, in which case, the magnitude drop at disappearance would be 0.3, which would be a little difficult to detect visually.

In a letter published on p. 197 of the Feb. issue of *J. Br. Astron. Assoc.*, J. van Maanen, Holland, notes the next planetary occultation of a star brighter than mag. 3.5: Nunki (σ Sgr., mag. 2.1), 1981 Nov. 17, at 15^h U.T. It will be visible from the U.K. half an hour before sunset, and probably from central and eastern Europe, the Mideast, and most of Africa in a relatively dark sky.

The accurate astrometric ephemerides of minor planets mentioned on p. 97 of [Vol. I, No. 10] have been computed up to 2000 May for the objects whose numbers are: 1-16, 18, 20-22, 25, 26, 29, 31, 32, 34, 37, 39, 40-42, 44-46, 52, 56, 59, 65, 68-71, 75, 79, 80, 89, 92, 97, 103, 105, 110, 128-130, 139, 146, 148, 164, 192, 196, 198, 258, 324, 349, 354, 356, 381, 387, 405, 471, 511, 516, 532, 563, 584, 624, 679, 694, 704, 737, 925, and 927. Joe Jordan, Jr. helped check my ephemerides with the approximate ones published by the Leningrad Institute of Theoretical Astronomy (I.T.A.), and discovered that my original data for 192 Nausikaa were greatly in error. The problem was caused by an error in the accurate osculating orbital elements published in I.T.A. Bulletin 152 (1974), which had been used. The semi-major axis was given as 3.4025800 A.U., when it should have been 2.4025800. Astrometric ephemerides for all major planets except Mercury have also been computed, and ephemerides for more minor planets with relatively large expected diameters will be computed as accurate orbital elements for more objects become available from the minor planet centers in Cincinnati and Leningrad. Transfer of the ephemeris data by magnetic tape to Gordon Taylor at HMNAO has begun. A computer program to compute apparent-place ephemerides from the astrometric data has been successfully tested. It will soon be used to generate data needed for the prediction of lunar occultations of minor planets at USNO. Astrometric ephemerides of the minor planets listed above, printed at 5-day intervals only when the object's V-magnitude is brighter than 11.0, have been sent to Jean Meeus for publication.

A working meeting on planetary occultation predictions was organized by James Elliot, Cornell University, and held May 13 at USNO, Washington, D.C. Gordon Taylor reported the status of his searches, which are complete for the major planets for SAO and AGK3 stars to 1980 Dec. 20. The only events not yet reported are by Mars, including a 6.8-mag. star 22° from the sun in 1978 and a 6.3-mag. star in 1979. Special plates have been taken to scan the path of Pluto to mag. 17 to 1978 October, with negative results. SAO and AGK3 searches well into 1979 have been accomplished for the first four asteroids, and twelve events beyond 1977 have been found. Searches for 26 other minor planets through the end of 1977 have also netted several possibilities; Taylor informs occultation observers in the possible area of visibility as plates can be taken to establish the current offset from the object's ephemeris reasonably well. Searches for occultations of SAO and AGK3 stars by the main satellites of Jupiter, Saturn, Uranus, and Neptune are complete for about two years in advance, with negative results. The same is true for special plates taken for Saturn's satellites down to 3 magnitudes fainter than the satellite. Elliot said that he would provide realistic magnitude limits for useful photoelectric work based on expected background light levels at different wavelengths, to ascertain, for example, whether the 3.5-mag. limit for Mercury is too conservative. Elliot also noted that, during the lunar occultation of β Scorpii [July 1976], he was able to record the diffraction pattern photoelectrically at both immersion and emersion. With these data, he was able to determine the diameter of the moon to an accuracy of 5%, by comparing the observed rate (fringe spacing) with the predicted fringe spacing for a central event. This determined the position angles of the events, assuming a circular moon, and the difference in time between the two events and the known lunar velocity established the scale. This illustrates what could be accomplished with with only one high-speed photoelectric observation of an occultation by a minor planet or by any other solar system body with no atmosphere.

Otto Franz (Lowell Observatory) and Brian Marsden discussed astrometric capabilities at their institutions. An extensive collection of planetary search plates, down to about 16th magnitude, and with 1" positional accuracy, has been collected at Lowell. A wide range of latitudes from the ecliptic has been covered twice, with an epoch difference of about 40 years. This allows a determination of those faint stars which have large proper motions. Marsden complained that he widely distributed some predictions of occultations by comets (radio astronomers had expressed some interest in these), but didn't receive a single response. As Director of the I.A.U. Central Bureau for Astronomical Telegrams, he provided useful information about the logistics of distributing last-minute information. For those with the service, TELEX seems to be the best form of rapid international communication.

Peter Shelus (Texas) and Edward Bowell (Lowell) described their plate-scanning techniques. Bowell's method is essentially a semi-manual version of the University of Texas system. Reference stars and an astrometric ephemeris are computer-plotted on transparent overlays. The stars on the overlay and the plate are matched visually, and the path examined for possible occultations. The method involves little computer time, and the visual scan is quick and efficient. Bowell has provided me with updated physical information for several minor planets, and I am providing him with ephemeris data to generate his overlays.

I described my occultation work and the resources of IOTA. Van Flandern reported progress at USNO to improve individual star positions with analysis of total lunar occultation observations, about 100,000 of which are now available since the atomic time scale became available in 1955. Van Flandern expects that, by the end of this year, good improvement can be obtained for the positions of about 5000 stars, and some improvement for another 5000. It seems that graze observations could be valuable for improving stellar declinations, especially needed for an accurate planetary occultation prediction, for a smaller number of stars. But if a planetary occultation of a certain SAO star is predicted, we currently have no organized record by star number to even tell if a graze of that star was ever seen.

A few invited participants were unable to attend, including Thomas Gehrels and William Hubbard, both in Tucson, AZ, and both of whom sent letters expressing their viewpoints. Gehrels mentioned that a few minor planets have been observed recently by speckle interferometry, which confirmed the sizes determined by polarimetry and radiometry. Therefore, he felt that a program to determine the sizes of minor planets by their occultations of stars was not justified. Nobody else at the meeting agreed with this, feeling that a dozen or so diameters could be more accurately determined by occultations of stars than by any other method during the next several years; this would be essential for validating the indirect polarimetric and radiometric results for all classes of minor planets. Gehrels did note that occultations by asteroids could perhaps be useful for determining the diameters of stars. I don't think that this point was emphasized strongly enough at the meeting. The resolution obtained with a planetary occultation is of the order of 0".0001, over an order of magnitude smaller than what can be obtained during a lunar occultation. Therefore, I feel that a continuing prediction service is justified, at least until the diameters of a couple of dozen stars of spectral type and angular size not reachable by other methods are determined by photoelectric observations. Some indefinitely continuing program might be useful to find occultations of stars and objects of special interest, such as 3C-273. It was agreed that the effort should be limited to the larger minor planets, since the probability of seeing an occultation at the predicted path is directly proportional to the object's size and inversely proportional to the positional uncertainty before the event, which is rarely less than 0".1. Elliot noted that use of the Kuiper Airborne Observatory would not be justified unless the probability of seeing the event was at least 95%. 100 km seemed to be a reasonable limit. I pointed out that over 200 minor planets are expected to be larger than 100 km in diameter, based on the polarimetric and radiometric scales for the most numerous C-type objects. So a higher limit, such as 150 km was suggested. It was more-or-less agreed to consider some dozens of the larger minor planets for which accurate orbital elements were available. Bowell will likely be the main source for finding observable occultations of non-SAO and non-AGK3 stars. In spite of the early epoch, I think that searches against Astrographic Catalog data eventually will be useful, since the searches can be completely computerized. Although the A.C. positions are not very good due to the early epoch, searches using A.C. data would still be useful, for recent plates of the occulting object and the star must be taken in any case to make any sort of reliable prediction. Marsden mentioned a bad experience with the A.C. positions of the faint stars near Uranus' path in late May (see p. 114), but Uranus is much more sensitive to small positional errors than minor planets, which are generally about ten times closer to the earth. However, occultations by minor planets as small as 798 Ruth (see p. 127) are not the type of event we want to predict. Gordon Taylor warned of the danger of calling "wolf" too often, and urged that no predictions be issued until some recent astrometric observations are made to improve the prediction. This is hard to reconcile with the long-term planning needed for such events (i.e., for submitting funding proposals, requests for observing time, and avoiding conflicting meeting dates). When any planetary occultation prediction is issued, it should include an estimate of the possible area within which the event might occur, the probability of seeing the event in that area, and what last-minute improvement might be possible. Maley's observation (p. 115-117) indicates that valuable observations might be made far from the predicted occultation path. Taylor, as president of the I.A.U. Commission 20's working group on planetary occultations, agreed to distribute information about upcoming events found by him and by others, in order to obtain astrometric data to improve the predictions enough for distribution to observers.

PASSAGES OF MINOR PLANETS ACROSS GALACTIC CLUSTERS

Derek Wallentine and David W. Dunham

Wallentine has used the approximate (accurate to about 1') ephemerides of minor planets published by the Institute of Theoretical Astronomy in Leningrad to find passages across galactic (open) clusters, where the probability for an occultation by the asteroid is enhanced. Since most clusters are near the galactic plane and since the ephemerides of most minor planets are published only within a month of opposition, most of the passages occur during June and December, and the preceding and following months. Wallentine has submitted details about the passages he has found to the *Minor planet Bulletin*, published by Prof. Richard G. Hodgson, 316 S. Main Ave., Sioux Center, IA 51250 (like *O.N.*, a year's subscription to *M.P.B.* costs $4). Included is an ephemeris around the time of the cluster passage, with separation and position angle from the cluster center, and approximate predictions of appulses to SAO stars within 6'. In the list below, the dates of cluster entrance and exit are given, along with an estimate of the minor planet's diameter, the probability of an occultation of a cluster member visible somewhere from the earth's surface, and the estimated maximum duration of an occultation. A small letter after the cluster name indicates the part traversed.

1977 Dates (UT)	Minor Planet	phot. mag.	Diam.	Cluster	Prob.	max. dur.
June 5.0 - 5.5	115 Thyra	12.5	93 km	NGC 6400 sw	0.83	8 seconds
June 22 - 24*	1904 1972 JM	16.2	20	M-25 nw	0.09	2
July 16 - 18	79 Eurynome	12.5	76	M-17 s	0.29	8
Sep. 20-Oct. 10	228 Agathe	15.4	11	Pleiades	0.34	13
Oct. 25-Nov. 4	604 Tekmessa	13.3	63	Pleiades n	0.32	9
Nov. 13 - 15*	789 Lena	16.3	24	NGC 1647 se	0.10	2
Nov. 22.2-22.8*	798 Ruth	14.8	66	NGC 2169 n	0.69	7
Dec. 5 - 14*	1232 Cortusa	16.2	38	Pleiades n	0.17	3
Dec. 9.2 - 9.7	726 Joella	14.9	27	NGC 2194 se	3.56	2
Dec. 10 - 12	1737 Severny	16.1	27	M-38 n	0.77	2
Dec. 18.7-18.8	816 Juliana	14.9	38	NGC 2259 ne	0.42	4
Dec. 21.2-21.8	1551 Argelander	16.3	13	NGC 1647 n	0.01	2
Dec. 19 - 31	910 Anneliese	15.8	40	Pleiades s	0.23	4
Dec. 23 - 27	1305 Pongola	15.8	35	NGC 1746 n	0.26	3

The ephemeris of 115 Thyra is indicated as especially poor, with errors as large as 30' possible. 228 Agathe reaches her stationary point in R.A. near the center of the Pleiades.

Wallentine suggests that observers with suitably large telescopes monitor the passages and alert as many observers as possible if an actual occultation of a cluster member appears likely. Dunham expects that few observers with large telescopes would be willing to devote much time to this effort, and the logistics of notifying large numbers of observers of a possible occultation probably only a few hours before the event would be formidable and expensive. When possible, it is better to identify occultations beforehand, using an accurate ephemeris for the minor planet and accurate positions for many non-SAO (as well as SAO) stars in and near the cluster. As mentioned in IOTA NEWS and in [issue #10] of *O.N.*, Dunham has developed computer programs to extract all Astrographic Catalog stars (to about 12th mag.) in certain regions of the sky between declination +4° and +31°, to compute accurate astrometric ephemerides of minor planets when accurate orbital elements are available, and to combine the two to automatically search for and compute occultations (A.C. data for the vicinity of the southern clusters M23, M24, and M25, which are being occulted by the moon, have also been provided by David Herald). These were used for the Pleiades passage of 22 Kalliope and the Praesepe passage of 44 Nysa mentioned in [issue #10]. No occultations by Kalliope were found. Two occultations by Nysa were found, including the known (predicted by Gordon Taylor) occultation of an AGK3 star in north Africa and that of an 11th-mag. star in Japan on Feb. 22, a week before the calculations were done. A plate taken by Robert Harrington showed that a near miss (Arctic) on March 26 would in fact miss the earth's surface.

Asterisks following some dates in the above list indicate four passages for which both accurate minor planet orbital elements and A.C. positions for the faint non-SAO stars are available. Dunham used the search program mentioned above to compute details of any possible occultations. None were found involving 789 Lena or 1232 Cortusa. The first event in the list below implicates a star in the M25 field which may have been occulted by 1904 1972 JM. All the others involve 798 Ruth, which will occult a bright double star in NGC 2169, as well as several other stars in the rich surrounding Milky Way field of northern Orion. Due to the uncertainty in Ruth's and the star positions, the locations given in the list are as specific as can be said at the moment, and there would be some possibility that the event could occur just outside the area indicated. The chances are about 1 in 50 that an occultation will occur even at the predicted path. These odds could be improved by a factor of about 5 by current astrometric observations of the stars and the minor planet. The prediction could be improved somewhat more by last-minute astrometry, as was done for the occultation of γ Ceti A by 6 Hebe, but at least for most of the events, the chances of getting observations of the occultation would be so small that a last-minute effort to improve the prediction would not be justified. In the list below, "0" under closest topocentric separation indicates that the predicted path is on the earth's surface, while a number indicates the miss separation as seen from the optimum polar location if the path misses the earth (but with an uncertainty large enough that an occultation could actually happen in the polar area indicated). Due to the small size of these minor planets, observers should realize that the possibility of actually seeing an occultation is very small, so that a large effort to obtain observations is not justified. Locations are listed in the chronological order in which the occultation will occur.

1977 Date	U.T.	m_{pg}	R.A. (1950)	Decl.	Closest topocentric separation
June 22	8^h43^m	11.0	$18^h28^m32^s.4$	-18°59'56"	0".47, Antarctic
Nov. 10	20 08	10.1	6 11 01.4	+14 40 16	0, western Australia
Nov. 22	12 03-6	8.6	6 05 40.2	+13 58 46	0, Siberia
Nov. 22	12 02-18	7.9	6 05 40.0	+13 58 46	0, Canada, Japan, Philippines
Nov. 30	2 05-19	13.5	6 00 43.5	+13 34 28	0, n. Europe, U.K., east U.S.A.
Dec. 1	15 25	13.5	5 59 35.8	+13 29 48	0".68, Spitzbergen Islands
Dec. 2	20 56	8.7	5 58 40.6	+13 26 11	2".78, northern Canada
Dec. 5	3 16	13.5	5 56 55.9	+13 19 49	1".76, Alaska
Dec. 6	19 39-52	11.6	5 55 35.5	+13 15 19	0, U.S.S.R., Europe
Dec. 7	14 44-48	13.5	5 54 57.1	+13 13 19	0, Australia (Queensland to west)
Dec. 15	0 44	11.5	5 48 42.7	+12 55 44	0".21, Alaska

A 91% sunlit moon will be above the horizon west of long. 120° W. on Nov. 22; it will be 84% sunlit and up east of 80° W. on Nov. 30; 71% sunlit on Dec. 1; and 21% east of long. 105° E. on Dec. 6. The respective stars (A.C. designations if not otherwise specified) are as follows: -19° 51227 on June 22; +15°6^h12^m286; SAO 95282 B; SAO 95282 A; +14°6^h00^m411; +13°5^h-56^m744; SAO 95131; +13°5^h56^m364; +13°5^h56^m181; +13°5^h56^m75; and +13°5^h-48^m539 on Dec. 15. The SAO catalog shows that SAO 95131 is moving south, so that it is virtually certain that no occultation of it will be visible from the earth's surface on Dec. 2. The magnitudes for it and for the components of SAO 95282 are visual. The mean position for SAO 95282 was computed using the recent AGK3 position (the AGK2 position is not usable) and combining it with the G.C. position computed at the G.C. epoch as taken from the SAO to determine proper motions (which should thereby be improved over the significantly different, but poor due to short time base, G.C. proper motions). Double star data from the Lick Observatory Index Catalog were used to compute the component positions from the mean position. The I.D.S. lists some other components, which are all given separately in the A.C.; the closest approach to any of these other stars is 6".15 (topocentric) for the 11th-mag. C component at 12^h46^m U.T. of Nov. 22. Due to the faintness of these minor planets, a substantial drop in brightness will be seen for any of these events if an occultation does occur.

USING WATTS ANGLES IN OBSERVING REAPPEARANCES

David Herald

In past issues of *O.N.*, various devices have been described for assisting in knowing where to look for stars at the reappearance phase. These devices all have their respective advantages, but generally require making some form of diaphragm to fit in the eyepiece. In contrast to this there exists quite a precise method which requires no more than a map of the moon, and the Watts angle of the event, which is one of the angles listed in the USNO predictions.

The advantage of the Watts angle is that it relates the position of an occultation directly to the surface features of the moon. Watts angles start at zero at the north lunar pole, and increase to 360° through east, south, and west (Mare Crisium is near WA 260°). Thus, in principle, all one has to do is to mark on a map of the moon the Watts angles 0° through to 360°. Then noting the the WA of an event, ascertaining from the map the lunar features in the vicinity of the event, and locating these features at the telescope, will direct one's attention to the location of the event.

Obviously, the method is most advantageous when one can see features close to the limb. It is thus extremely useful near full moon, when the CA is of little value, and also at phases when the dark limb is visible due to earthshine. It can still be used at other phases by using sunlit features and estimating (e.g., by imagining a line drawn between two craters) where the event should occur. Here, of course, part of the estimation must be to establish where the dark limb of the moon is, as well as the position along that limb where the event will occur, but with a little practice, one should be able to concentrate his attention on a region about the area of the crater Clavius, with almost total confidence. Like all observational techniques, a little practice is needed, but the simplicity and accuracy of the method soon will be apparent.

There is a refinement which, when an observer is familiar with the method, he may find advantageous to use. When using the basic method, it may be noted upon studying the position of the star after reappearance, that it is not exactly where one would expect it to be. In fact, several observers have written to IOTA, querying such situations, and suggesting errors in the predicted PA or WA, even though the event occurred on time. In fact, there is no error in the predictions. What has not been taken into account is the effect of the lunar librations on the apparent positions of the lunar features on the moon's surface at the time of the event (the librations are listed in the USNO predictions). The effect of the librations is as follows:

Libration in longitude: all features are moved in selenographic longitude by the amount of the lunar libration. When the libration is positive, all features are moved eastward (Mare Crisium gets farther from the limb).

Libration in latitude: to a good approximation for our purpose, features are moved by the amount of the libration in latitude times the cosine of the feature's longitude. In practice, no great accuracy is required in determining the exact amount. A rule of thumb is: if on the moon's meridian, the shift is the full value of the libration; if on the limb, there is no shift; if the lunar longitude is ±60°, the shift is half the libration value. When the latitude libration is positive, features are moved southward.

While this may sound a bit complicated to use, no great accuracy is required. All that is generally needed at the telescope is a rough idea of how much one's chosen reference features are displaced by the librations. As an example, let us assume that an occultation is scheduled to occur with a Watts angle of 260°. With a map of the moon, it will be seen that this event should occur close to the southern extremity of Mare Crisium, and, in the event that the limb is not visible, the limb is approximately 3/4 of the length of Mare Crisium away from the southern extremity thereof.

Since the map is almost undoubtedly

drawn for mean librations, i.e., librations in longitude and latitude both zero, the event will occur in the position predicted above when the librations are both zero. However, if the libration in latitude is +7°, Mare Crisium will appear to have been shifted southward 3½° in latitude (7° × cos 60°). The result of this is that now the event will occur 1/3 of the way northward along Mare Crisium. Conversely, if the libration in latitude is -7°, Mare Crisium will appear to have been shifted northward, and the event will now occur midway between Mares Crisium and Foecunditatis.

In this instance, the libration in longitude will affect the estimation of where the limb is (if it is not visible), but toward the poles, it will also affect the position along the limb. Thus, in this example, the limb is spaced 3/4 of the length of Mare Crisium from the southern extremity. If the libration in longitude is +7°, Mare Crisium is farther from the limb, its longitude having changed by 7°. In effect, the limb is now apparently the full length of Mare Crisium from the southern extremity. Conversely, if the longitude libration is -7°, Mare Crisium is closer to the limb, which is now apparently less than half the length of Mare Crisium from the southern extremity.

In this example, I have used figures close to the maximum librations possible, to show the magnitude of the largest shifts that can be expected. In practice, I find no need to worry about these corrections except when a libration is greater than 2 or 3°. For reappearances when the dark limb is visible by earthshine, I have found the full method to be extremely accurate, and can confidently expect to train my attention very close to the actual location of the event, and can thus be confident of reappearance timings even of events approaching the observability limit of my telescope.

VALUES OF k FOR OCCULTATION REDUCTION

In the *Explanatory Supplement to the A.E.* (p. 297), there is a description, "The value used for k, the ratio of the radius of the Moon to that of the Earth, is 0.2724 953 and is the value adopted by R.T.A. Innes (*A.J. 35*, 155, 1924) for occultation reductions." In fact, Innes gave a value k = [9.43536] (where brackets indicate common logarithms), which corresponds to the range k = 0.2724 928 to 0.2724 990, while [9.435360]= 0.2724 959. It seems worthwhile to make clear the origin of the specific value k = 0.2724 953.

0. As usual, σ and π stand for the moon's semi-diameter and equatorial horizontal parallax, respectively. Then, k is defined by the relation: $\sin \sigma = k \sin \pi$. For the mean values od σ and π, $^1/_6\sigma^3$ = 0″0032 and $^1/_6\pi^3$ = 0″157. Hence, the above relation can be approximated by $\sigma = k(\pi - 0''16)$.

1. Innes (1924) used Newcomb's (1912) value of σ = 932″58 and Brown's (1919) value of π = 3422″54 to derive k = [9.43536], by which the moon's semi-diameter can be calculated through σ = [9.43536] (π - 0″16). Although the above value of k can be calculated through $\frac{\sin 932''58}{\sin 3422''54}$ = 0.2724 934 = [9.4353 560], Innes might derive it in logarithmic form, presumably through $\frac{932''58}{3422''54 - 0''16}$ = [2.9696 86]-[3.5343 28] = [9.4353 58].

2. Comrie (1937) pointed out that the figure 3422″54 was not Brown's value for π but the value for sin π. He derived a correct value of k to be 0.2724 807 from π = 3422″70 (= 3422″54 + 0″16) and σ = 932″58. (Note) When Brown constructed his *Tables of the Motion of the Moon* (1919), a value 3422″700 was used for the constant term in sine parallax. Later he adopted 3422″540 as the final value and inserted a correction for this change in the *Tables*. Although these figures happen to coincide with those used by Innes and Comrie, Brown's amendment and Comrie's comment are entirely independent of each other.

3. Comrie (1937), however, considered it better not to introduce a discontinuity by correcting the values of k. By retaining Innes' value k = [9.43536], he derived σ = 932″63 inversely, remarking that this value is probably nearer the true semi-diameter of the moon than 932″58. Here various values of $\sigma = \sin^{-1}(k \sin \pi)$ could be derived according as adopted numbers of decimal places for the values of k and sin π, i.e.:

π = 3422″70 →	sin π	0.01659	0.016593	0.01659296
k = [9.43536] → k	0.27250	σ = 932″48	932″65	932″646
	0.272496	932.47	932.635	932.6333

Hence, it is presumed that Comrie employed sin π = 0.0165 9296 and k = 0.2724 96 to derive σ = 932″63. Then from this value of σ and π = 3422″70, he presented k = 0.2724 9529 ≈0.2724 953 = [9.4353 59] ≈ [9.4353 6] = Innes. The meaning of the description in the *Exp. Sup. A.E.*, referred to at the beginning, can thus be understood.

4. The constant No. 21 in the IAU System (1964) of the Astronomical Constants is sin π = 3422″451, which corresponds to π = 3422″608. With this value and σ = 932″63 we obtain k = 0.2725 0261 ≈ 0.2725 026. The last figure was adopted for reduction of occultations (*Exp. Sup. A.E.*, 3rd imp., pp. 514 and 518 = *A.E. 1968 Sup.* pp. 20s and 24s). A more recent value, derived by Van Flandern, using the Watts charts, is 0.2724 994.

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GRAZES REPORTED TO IOTA

David W. Dunham

[Ed: All material in this article was carried forward from #11, where there was insufficient space for it.]

On p. 10 of *Observing Grazing Occultations - VIII*, an article by Jean Meeus, "Le calcul des occultations rasantes," is briefly described. The formulae presented are the most direct for computing the geographic latitude and time of points in an occultation limit at equal intervals of longitude. Meeus has been computing and publishing graze predictions for Belgium, the Netherlands, and Holland using his method since the late 1950's. In 1967, I programmed Meeus' method for an IBM 7094 computer, and developed an option to compute data at equal intervals of latitude, sometimes needed in the polar regions where graze paths can go due north-south. David Laird, Cincinnati, Ohio, also programmed the method and computed some predictions, especially for grazes of bright stars at low altitude, which pose problems for any equal-time-interval prediction method. But I never found time to adapt the 1967 program to read the USNO graze data on which we now depend, nor to print the results in a form suitable to send to observers. Berton Stevens has done this, working from a copy of my 1967 program, and can now use it to compute predictions for individual observers using the small IBM computer to which he has access. This is a big help for IOTA operations, since he can now compute update predictions for new members. The predictions produced by his program are very similar in format to our usual INT4 predictions, but he has added two new items, the bearing (azimuth of the predicted limit = angle G, or angle VAH, of Figure I of *What to do with the Predictions and Profiles*) and a numerical graze rating, which is greater than 6.1 for spectacular events, between 4.2 and 6.1 for favorable ones, and between 2.0 and 4.2 for marginal grazes. Rather than TAN Z, the "elevation factor" = TAN Z times sine D , is printed. Simply multiply this elevation factor by the height above sea level in order to find the amount to shift the limit perpendicular to itself (the distance IH in the above-mentioned Figure I), eliminating the need to measure an angle or make a geometric construction on the map. The elevation factor is positive if the limit should be shifted southward with increasing height above sea level, the usual situation for observers in the north Temperate Zone. The shift of the limit due to height above sea level is not significant for prediction purposes for heights less than about 300 meters or 1000 feet, but for higher elevations, it should be computed. Unfortunately, Stevens' computer does not have the capacity for making detailed scans and computing predictions for several observers at once; it is too slow to compute the predictions for one of the 1000-mile-diameter regions with a typical number of stations. But it should be possible to replace part of, and considerably simplify, our regular INT4 prediction program with Stevens' coding. This could reduce the computing time and storage by perhaps a factor of 3. Completion of the Zodiacal double star file (see NEW DOUBLE STARS) will eliminate much of the manual work now needed. Completion of these two tasks, which should be possible by the end of 1977, will make it possible for only two or three computors to calculate all IOTA graze predictions, and farther into the future than is now possible.

The coordinates of a point in the predicted limit, and the approximate time of graze there, are printed on the ACLPPP profiles. The basic data for the profile were computed for this point, which may be several degrees of longitude west of the point in the predicted limit closest to the observer. This is all right for prediction purposes, since all profile quantities except the position angle of graze change slowly along the limit and affect the profile only slightly. The position angle of central graze is adjusted to its value at the point in the predicted limit closest to the observer's station for all ACLPPP profiles. This can be checked by comparing the POS ANGLE given on the profile with the values for the position angle of graze given in the limit predictions. The computer programs are designed so that the difference in p.a. of central graze at the closest point in the limit and at the point for which the basic profile data were computed is less than 1°; if it is more than 1°, basic data for another point in the limit are computed for that profile.

The site from which I observed the March 27th graze of 9.0-mag., Z04796 was less than ideal. It was along a straight rural road with all turnoffs closed with locked gates and posted "no trespassing." Since the road shoulders were adequate, this normally would pose no problem. However, the road was brightly illuminated with mercury vapor lights its full length at about 200-foot intervals, and there was no time to drive to another road. I set up my telescope nearly opposite one of the lights, so that my head would cast a shadow over the eyepiece at the Newtonian focus. A jacket was used to shield out most of the other light. I had a fairly good view of the graze of the faint star, glare from the bright side of the moon posing more of a problem than the street lights. This shows that, unlike most astronomical observing, lunar occultations are relatively unaffected by rather high levels of artificial lighting, and useful observations can be made in urban areas. However, even for occultations, light pollution is a nuisance, and is especially disconcerting when unexpectedly found in rural areas. Dark skies are a necessity for making reliable observations of planetary occultations of faint stars, and for other types of astronomical viewing which most of us like to do. For this reason, Thomas Campbell, Temple Terrace, FL, has become especially active in the anti-light-pollution campaign of the Astronomical League, which is being assisted in the effort by environmental groups on energy-wasting grounds. Campbell is also using a program which he wrote for his SR-56 pocket calculator to compute predicted shifts for grazes with Yale catalog star positions.

Shortly before the graze of 68 Tauri (ZC 658) on March 25 near Shimada, Japan, Susumu Hosoi photographed the moon and the star with a 400-mm f.l. lens. The photograph also shows the moon's dark limb and two other Hyades stars, δ and 64 Tauri, whose total occultation disappearances and reappearances were timed by most observers in the large expedition.

Observers often complain that it was clear the night before the graze, and/or the night after, but... During late May and June, we have had our usual poor weather, but it happened to be clear for five of our planned expeditions from the DC area in a row. The last, a distant one on a weekday morning, was not observed; the earlier expeditions considerably delayed this issue of *o.n.* Our sixth expedition was cancelled due to mostly cloudy skies.

Do you have trouble finding observers for grazes in your area? Try publishing a short article in your local newspaper. When the USNO planned a cable expedition for a graze at Virginia Beach in 1966, a Norfolk amateur placed an ad in the classified section which produced six responses. Don Stockbauer contacted a newspaper in Victoria, Texas, which wrote a short general article about grazes. Three observers, two in a town 50 km away, contacted him after reading the piece.

NEW DOUBLE STARS

David W. Dunham

Fred Espenak, Greenbelt, MD, wrote a small computer program to read the Wilson radial velocity catalog data on magnetic tape to select spectroscopic binaries which may not be in our lists. About 200 occultable stars were found. He checked the extra notes published in the printed catalog for about 400 occultable stars flagged as having additional notes not included in the magnetic tape version. A couple of dozen of these stars were also spectroscopic binaries. These will soon be matched with the USNO SZ catalog to produce a set of double star cards to be merged with our special double star data file. The computer runs were prepared and run during two Sundays at USNO. Since this is the last substantial data set which needs to be added to our master file of double star data, we finally should be able to publish a comprehensive zodiacal double star list before the end of the year. Some other work described below needs to be done before this will be possible.

Vincent Sempronio, Bolling AFB, DC, keypunched and helped me with the development of a small computer program which read the six current separate double star files and printed a comprehensive list of all the included double stars arranged in SAO-number order. Since the formats of the lists differ, a code is given for each star to tell from which original file the data for the star are obtained. Since the list is provisional, copies of it have been sent to only a few of the graze computors. The work was accomplished during a Sunday evening, at USNO. The next step will be to add the spectroscopic binaries from the Wilson radial velocity catalog. All data will then be put into a format similar to that of the Stockbauer list of visual double star data. As discovery information will be included, this also depends on Nolthenius work (see p. 119). Finally, much work needs to be done to resolve discrepancies found during the computer runs which produced the Stockbauer list, and to resolve about 100 double star code discrepancies between the USNO SZ catalog and my double star data. After this work is done, we will bw able to publish a comprehensive list and establish a computer file to automatically insert double star information in occultation (especially graze) predictions.

On 1977 May 26, an occultation of SAO 118289 (ZC 1526) recorded photoelectrically at McDonald Observatory by B. Smith indicated a possible 11.9-mag. companion 0".47 away in direction 75°.6. The star is already in the special list from a McDonald Observatory observation made under good conditions on 1973 March 17, indicating a 10.0-mag. secondary 0".415 in direction 284°.7. Combining the results gives a rather unlikely separation of 1".7 in P.A. 1°. The large difference in magnitude also indicates that the recent observation may be spurious.

ERRONEOUS STAR POSITIONS AND UNPREDICTED OCCULTATIONS

David Herald

The most notable observation reported comes from McDonald Observatory. The central D of SAO 97334 was observed on 1976 March 12, some 24 seconds later than the predicted time. Comparison of the AGK3 with the SAO indicates that the error lies in the SAO (and Yale) declination, to the extent of exactly 1 arc minute. The correct figure is 50', not 51'.

Four nights earlier at McDonald, they also observed the D of 93842. This star was observed on the same night by James Van Nuland, who noted the D 24 seconds late (see p.79 of *o.n.* #8). A comparison of the AGK3 and SAO showed a discrepancy of some 5" in RA, a difference which explained the observation very well. However, the McDonald observers recorded the D at the predicted time. Interesting, though, is the fact that when reducing the McDonald timing, a satisfactory residual was obtained only when the AGK3 position was used. Perhaps the AGK3 position was used for the McDonald predictions. I would like to hear of any timings involving this star at all. Its series of occultations, occurring mainly in 1975 and 1976, is now finished.

On 1977 Feb. 28, Robert Sandy observed the D of 95263 20 seconds later than predicted. Again, an AGK3 comparison indicates discrepancy in the SAO, this time in both the RA and in the proper motion in RA. The net effect is a difference in RA, by 1977, of some 7 arc seconds, providing full explanation of the observation.

Doug Hall, Leicester, England, reports an observation of ZC 684, SAO 94002, which he observed 4 seconds after the predicted time (USNO acc. 2 sec.). When he received the HMNAO reductions, the residual after limb correction was -1".41. He commented "One explanation for the discrepancy would appear to be that the star was coded M in the predictions, a fact that was overlooked at the time. The prediction time being for the mean position of a close double, the timing obtained being possibly of the occultation of the following star of the double". This, in fact, turned out to be the case. Extrapolating the data in Aitken's catalogue to 1977 for this star, which is comprised of two 7th-mag. stars, separation 2", and using the position for the following star relative to the mean position results in a correction to the residual of +1".46. The lesson to be learned here is to watch out for any double star coding in the predictions, and use the appropriate coding columns in the report forms. Apparently HMNAO doesn't make any allowance for the possible effects of star duplicity (at the preliminary reduction stage, at least) unless the duplicity is brought to its attention. This is particularly important in cases where the star is coded M (since the catalog position is for the mean position of the stars, and the stars are of very similar magnitude; if the stars are not distinguished at the telescope, the occultation will be of the following component) or where an occultation of the fainter component is observed (e.g., Antares B, where the catalogue position will refer to the brightest component).

Jean Bourgeois, Belgium, observed the D of an unpredicted star at $17^h23^m43^s$ on 1976 Dec. 26, in PA 105°, magnitude about 9.0. This star is AC 2300-03 128. Using the AC position for the star (epoch 1893) gives a residual, without limb correction, of -0".5 in PA 91°.4.

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DIGITAL STOPWATCH KITS

Emil J. Volcheck, Jr.

These two low-cost digital stopwatch kits are based on the new Intersil ICM 7205 digital stopwatch IC. The IC is crystal controlled, offers both split and Taylor timing modes either with or without running display, and reads to 0s.01. I have built the kit by Adage Electronics ($39.95; see *Popular Electronics*, Dec. 1976) and used it for total occultation timing and analyzing graze occultation tapes. It works like a charm, and has adequate accuracy without the optional trimmer capacitor. The same circuitry is offered by the James Electronics EDS-100 (also $39.95), which has a display unlock to allow observe the running display between events (very helpful if the events are far apart). Though I have not built it, the literature shows it to be a more attractive unit than the Adage, but not as compact. Any electronics magazine describes it. In modifying the Adage unit to include the display unlock, I had to repackage it in a larger (Radio Shack) box to hold the extra push-button switch.

PREDICTED URANIAN RING OCCULTATIONS

IAU Circular #3108 mentions two predicted occultations of stars, in December, by the Uranian ring system. Data for the occulted stars include positions (A. R. Klemola) and visual magnitudes (W. Liller).

1977 UT	α 1950	δ 1950	V
Dec 5.62	$14^h45^m03^s.98$	-15°33'19".2	13.8
Dec 23.31	14 48 44.66	-15 49 47.9	10.4

J. L. Elliot predicts that the drop in magnitude of the integrated planet - star system, in the I-band, will be 0.004 for the first star, 0.14 for the second. B. Marsden's predictions include minimum separation of the star from the center of the planet and UT of occultation by the leading (εA) and following (εB) edges of the ε ring.

Location	Sep	εA	εB
Mauna Kea	3".1	05, 14^h39^m	
Herstmonceux	0.8	23, 06 55	
La Plata	0.1	23, 06 54	23, 07^h46^m
Cerro Tololo	0.1		23, 07 46

Although the second star is 1.2 magnitudes fainter (in the I-band) than SAO 158687, the star occulted on March 10, it is by far the brightest of the 12 predicted to be occulted by the rings during the next 3 years. This star also will be occulted by Uranus, itself, for about 32 minutes, at the 3 stations listed. At Herstmonceux, observations will be somewhat difficult due to morning twilight.

LETTERS

To the Secretary:

I wish to inform the members of your association, through you, that the International Union of Amateur Astronomers will be holding its 4th World General Assembly in Dublin, Ireland in August, 1978. Both professionals and amateurs are invited to attend and contribute to the assembly. It is hoped that delegates from national and regional societies will make representation. Further information can be had by writing to the Secretary for the 4th Assembly at 26 Cedarwood Pk. Ballymun Dublin 11 Ireland. For general information and union business correspondence one should contact the Union's Secretary for the Americas at 135 West 18th Street Hamilton Ontario L9C4G3 Canada.

It would be much appreciated if you would submit the above as a notice in the next issue of your society's publication.

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To the Editor:

On October 10 there will be a solar eclipse that will be widely visible in the Americas. Many occultation observers may want to make timings of the contacts. It might be mentioned that the obvious method of timing contacts, namely, by means of a stopwatch, is not really satisfactory. As I said in a previous note (see *O.N. 1*, 53, #6), a better method is that of Minnaert, which involves making timed measurements of the distance between the cusps of the notch in the sun's limb. That method is made to order for amateur astronomers, and it is strange that the method is not mentioned in other amateur astronomical literature. It might be a nice thing to mention it in *O.N.* again before the eclipse.

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FROM THE PUBLISHER

For subscription purposes, consider this to be the second issue of 1977.

O.N. is priced @ $1.00 per issue, or $4.00 per year (4 issues) including first class surface mailing. Air mail delivery is available at added cost outside the U.S.A.: add 16¢/year in Canada and Mexico; add $1.28/year in Central America, Colombia, Venezuela, the Caribbean Islands, Bahamas, Bermuda, St. Pierre and Miquelon; add $1.76 /year in all other countries. Back issues, #1 thru #9, are available @ 50¢, later issues @ $1.00.

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Please address all subscription, back issue, and IOTA membership requests to Berton L. Stevens, Jr., 4032 N. Ashland Ave., Chicago, IL 60613, U.S.A., but make checks and money orders payble to IOTA, or to International Occultation Timing Association.