# Occultation Newsletter

Volume III, Number 9 November, 1984

Occultation Newsletter is published by the International Occultation Timing Association. Editor and compositor: H. F. DaBoll; 6 N 106 White Oak Lane; St. Charles, IL 60174; U. S. A. Please send editorial matters, renewals, address changes, and reimbursement requests to the above, but for new memberships, new subscriptions, back issues, and any special requests, write to IOTA; P. O. Box 3392; Columbus, OH 43210-0392; U.S.A.

## FROM THE PUBLISHER

For subscription purposes, this is the third issue of 1984.

When renewing, please give your name and address exactly as it appears on your mailing label, so that we can locate your file; if the label should be revised, tell us how it should be changed.

*O.N.*'s price is $1.40/issue, or $5.50/year (4 issues) including first class surface mailing. Back issues through *Vol. 2*, No. 13 still are priced at only $1.00/issue; later issues @ $1.40. Please see the masthead for the ordering address. Air mail shipment of *O.N.* back issues and subscriptions, if desired, is 45¢/issue ($1.80/year) extra, outside the U.S.A., Canada, and Mexico.

IOTA membership, subscription included, is $11.00/year for residents of North America (including Mexico) and $16.00/year for others, to cover costs of overseas air mail. Observers from Europe and the British Isles should join IOTA/ES, sending DM 20.-- to Hans-J. Bode, Bartold-Knaust Str. 8, 3000 Hannover 91, German Federal Republic.

---

## IOTA NEWS

David W. Dunham

This year's meeting of the International Occultation Timing Association will be held at the Lunar and Planetary Institute in Houston, TX, on Saturday, October 20th, starting at 10 am. More details were given on p. 157 of the last issue. Unfortunately, my schedule has prevented me from sending my material to the editor early enough for this issue to reach most subscribers before the meeting.

Planning for the three IOTA expeditions to observe the total solar eclipse on November 22-23rd is nearly complete, and if you have not already joined one of the expeditions, it may be too late by the time you receive this. Paul Maley is leading an expedition of about two dozen observers from North America; they plan to observe just inside the northern limit near Port Moresby. David Herald and Byron Soulsby are leading an Australian expedition, departing from Sydney on November 21 for six days. Arrangements have been made to observe near the southern limit in Papua New Guinea. Hans Bode's European expedition will cost 5970 DM (a little under $2000), including all expenses for 12 days, some of which will be in Bali (a shorter duration may be possible). The round-trip air fare from Amsterdam to Djakarta is about 1500 DM, included in the total price. They hope to observe near the southern limit in West Irian. Alan Fiala and I expect to compute and distribute detailed predictions of the path, taking the lunar profile into account, in October. We also hope to reduce a small amount of data from the May 30th eclipse to estimate an empirical correction to the prediction. We now have a preliminary master record of the central two or three minutes of several video records of the May 30th eclipse, which has been (or soon will be) distributed to those who sent us videotapes; others who want a copy can obtain one by sending one of us a blank videotape cassette, preferably VHS format. See page 165 of the last issue. We may have a more complete version ready in time for the IOTA meeting, and will distribute it back to those who sent us tapes, unless they need the preliminary version sooner for a presentation. We apologize for the delay in producing this, and the expanded profile plots which will be needed in order to analyze the data.

I understand that IOTA/ES has applied to become a tax-exempt scientific organization in the Federal Republic of Germany, as IOTA has done in the U.S.A. Forms for validating tax-deductible travel expenses to make scientifically useful observations of occultations and eclipses will be distributed to IOTA members in the U.S.A. (and to anyone else who requests them) with the next issue, targeted for late November or early December (it will include prediction lists for 1985 planetary and asteroidal occultations). At least a preliminary version of the form will be available at the IOTA meeting.

Peter Manly, 1533 W. 7th Street, Tempe, AZ 85281, telephone 602,966-3920, has prepared a package of information, including circuit diagrams and brochures from some companies, describing equipment and connectors to be used with video cameras or VCR's. The equipment inserts time to the nearest 0.01 second, and a bar which varies in length according to the amplitude of the audio signal. The bar jumps at clear time signal seconds beats, and therefore can be used to calibrate the time display. The package weighs 8 ounces, and Peter will send a copy to anyone who sends him the necessary postage ($1.39 for first class in North America). Sending a large (9 by 12 inches) self-addressed manila envelope will help. Paul Maley notes that JVC now has a simple 0.01-second timer for use with JVC equipment for about $100, and it apparently can be used with RCA Ultricon cameras with one or two simple connections. An article by Manly about astronomically useful video equipment will appear in the November issue of *Astronomy* magazine, and the December issue will contain another article presenting some video observational results, including occultations.

Again, the article on graze expedition results has had to be postponed; some graze information has been included (see pp. 188 and 190). I apologize for the delay. Even more neglected have been reports of progress with double stars relating to occultations. But David S. Evans has published a definitive article on double stars discovered with photoelectric observations of lunar occultations in *Lowell Observatory Bulletin* No. 167, "Current Techniques in Double and Multiple Star Research" edited by R. Harrington and O. Franz, p. 63. This bulletin is actually the 296-page proceedings of the I.A.U. Colloquium No. 62 held at Lowell in 1981. Evans' article, "The Discovery of Double Stars at Occultations," includes a 16-page catalog of all photoelectric observations of stars, for which at least one of the observers has claimed possible duplicity, obtained from the literature. Negative observations of the same star are included. The catalog is arranged in order of SAO number. Another useful recent publication is "Fourth Catalog of Orbits of Visual Binary Stars," by C. Worley and W. Heintz, *Publications of USNO* Second Series Vol. XXIV — Part VII (1983). I do plan to publish an article about new doubles discovered during occultations, not in the next issue but, I hope, in *O.N.* *3* (11), early in 1985.

WWV was off the air on all frequencies on August 20th from 5:25 to 6:02 UT and on August 22-23rd from 23:49 to 0:08 UT, according to the National Bureau of Standards' *Time and Frequency Bulletin* No. 322 (Sept. 1984). So if you had trouble timing some occultations then, now you know why. WWVH had no outages during August. I recommend wearing a digital watch with an alarm. If you can't receive time signals and are using a tape recorder, set the alarm to go off a minute or two before the predicted event, and record the alarm. With the tape recorder still recording, set the alarm again to go off at the first available minute after the observing period, and record it. [Ed: Alternatively, you could leave the watch in minute-alarm-set mode, pushing the reset button shortly after the alarm sounds the minute, leaving it ready to announce the next one. This would limit the tape recorder drift to that which could occur in a single minute.] Then calibrate the watch a few times (such as by recording the alarm and accurate time signals) as soon as possible after the event, doing this for a period of time longer than the time from the event to the first calibration. North Americans can telephone 900,410-TIME if they can't receive any of the shortwave time signals.

The experience with the occultation by (47) Aglaja demonstrated the need to remain flexible (see page 182). Near the times of observationally promising events, even ones nominally predicted to occur far from your location, avoid scheduling important activities. Budget the time for less-urgent work, which could be postponed if astrometric updates show that the path will be over, or within travelling distance of your location. Try to keep informed about updates (remind the coordinator for your region that you want to be informed. Even if no astrometric observations have been made, plan to monitor the star around the predicted time of closest approach, weather permitting. Isolated observations of secondary occultations continue to be reported; these will be confirmed only by greater efforts by more observers, including attempts at separated pairs of stations. Plan to spend much more time than you think necessary to find the star; practice during previous nights, and a good finder (preferably at least 8 × 50), facilitate this. Frequently check the weather (both the latest forecast and the latest observations), no matter how pessimistic it seems; fronts often move faster or slower than predicted.

Offices are being changed again at Computer Sciences Corporation, where I work. My daytime telephone number is now 301,589-1545, ext. 392 (no longer 603). If you can't reach me at my extension, you can have me paged or leave a message that you called. Or you can call my home telephone, 301,585-0989, where a recording machine will take your message if nobody can answer it.

## ANYONE FOR VISA OR MASTERCARD?

Brian Loader, Blenheim, New Zealand, has suggested that we could have an arrangement to charge IOTA dues or *O.N.* subscription and back issue payments via VISA or MasterCard. This might be of advantage, especially to foreign residents, as it might avoid some rather substantial bank charges for foreign exchange, and probably would avoid much of the hassle of getting a bank draft. However, such charge service is not free. IOTA would have to pay 4% to the bank for each such charge. U. S. lawmakers tend to legislate against increasing prices only for card users, but do not object to giving discounts to those not using the cards. It would be necessary for us to raise all rates by 4%, but anyone not using the charge could take a 3.846% discount from the new rates, bringing the effective rates back to the current rates. Individuals could authorize the charge by letter, but should not expect us to return a standard receipt, which would not show anything but the U. S. funds amount, anyway; the local currency amount would have to be determined from the monthly statement. Each individual would have to determine whether or not the charge arrangement would be advantageous to him.

This is an item for discussion at the IOTA annual business meeting, and for approval or disapproval by the Board of Directors of IOTA. The result will be announced in *O.N.*, either in the next issue, or as a last-minute addition to this one. (See p. 190.)

## ANALYSIS AND PUBLICATION OF OBSERVATIONS REPORTED TO IOTA

David W. Dunham

When occultation or eclipse observations are reported to me, or to others who are designated to collect the observations for IOTA (such as Jim Stamm in the case of asteroidal appulse observations, see page 185), it is assumed that I am, or someone working with me is, free to analyze and publish the observations, unless the observer states some restrictions when he submits his report. Usually, only approximate information and preliminary results are published first in *O.N.* Final analyses of important events observed from several locations, such as total solar eclipses and asteroidal occultations, usually will be submitted for publication in refereed professional journals. My general guideline for the author list of such articles is to include all who participated in the analysis, those who accurately recorded the observations with automatic equipment (such as photometers and video cameras), regional coordinators who reported useful visual observations made by others as well as by themselves, and professional astronomers who make especially significant visual observations. All observers, visual or automatic, whose data are included in the article will be credited by name in the article. I believe this policy is fair; let me know if you have any questions about it.

## UPCOMING PLANETARY OCCULTATIONS

David W. Dunham

Information about three occultations during December is given here in tables like those used and described in *O.N. 3* (6), 120 and following. Some data about the occultations by (4) Vesta and (717) Wisibada were given on pages 158 and 159 of the last issue, but the December 30th date of the Vesta occultation was omitted. The errors in Landgraf's occultation calculations described on p. 160 of the last issue turned out to be due to the fact that he used ephemeris data at ten-day intervals, which is all right for the calculation of asteroid orbits, but is too coarse for occultation calculations. When he generated his ephemeris data at one-day intervals, his occultation calculations were in good agreement with mine. Some notes about particular events, some of which were listed in *O.N. 3* (6), are given below.

Table 1

| 1984 DATE | UNIVERSAL TIME | PLANET NAME | $m_v$ | Δ,AU | STAR SAO No | $m_v$ | Sp | R.A.(1950) | Dec. | OCCULTATION Δm | Dur | df | P | Possible Area | El SUN | MOON EL | %SNL | Up | EPHEM. SOURCE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dec 1 | $4^h35^m$-$54^m$ | Wisibada | 14.8 | 1.65 | 75930 | 9.0 | F8 | $3^h23^m.8$ | 21°17' | 5.8 | $4^s$ | 27 | 64 | Iberia,seCanada,wUSA,HI | 165° | 66° | 58+ | w 65°W | LANDGRAF |
| Dec 29 | 12 23-34 | Winchester | 10.2 | 1.22 | | 12.3 | | 6 27.3 | 5 17 | 0.2 | 19 | 20 | 8 | Hawaii?n,Japan?s;seSiberia | 162 | 96 | 43+ | w160°E | LANDGRAF |
| Dec 30 | 12 15-18 | Vesta | 7.7 | 2.29 | | 11.6 | | 13 25.5 | -1 37 | 0.03 | 22 | 12 | 6 | Hawaii?s, Mexico | 78 | 171 | 53+ | none | APAENAXX |

Table 2

| 1984 DATE | MINOR PLANET Name | km-diam. | -" | RSOI | Type | MOTION °/Day | PA | STAR SAO No | DM No. | S | COMPARISON DATA AGK3 No. | Shift | Time | APPARENT R.A. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dec 1 | 717 Wisibada | 38 | 0.03 | 78 | CMEU | 0.186 | 254° | 75930 | +20° 568 | XA | N21° 314 | +0".25 | $-0^m.0$ | $3^h25^m.8$ | 21°24' |
| Dec 29 | 747 Winchester | 208 | 0.24 | 839 | C | 0.298 | 310 | | KL955947 | H | | | | 6 29.2 | 5 16 |
| Dec 30 | 4 Vesta | 555 | 0.33 | 3876 | U | 0.362 | 104 | | | H | | | | 13 27.3 | -1 48 |

*Oct. 6, (365) Corduba:* According to an improved orbit for this asteroid calculated by. W. Landgraf, this occultation did not occur, the path missing the earth's surface by over 3". A finder chart was given on p. 176 of the last issue, but no regional map for the U.S.A. was generated, since we knew that the EMP 1982 orbit was inaccurate. If the path from Landgraf's data had been more favorable, we would have tried to distribute a shorter version of this issue earlier, or otherwise to have notified potential observers before the event.

*Nov. 19, Venus:* The regional map published on p. 178 of the last issue did not extend far enough east, so a revised version is published in this issue. See also p. 160 of the last issue.

*Dec. 1, (717) Wisibada:* Normally, we would not bother with an asteroid this small. However, otherwise observing circumstances and the path for this occultation are very favorable, so observations are encouraged. If astrometry half as good as that for the September 16th occultation by (47) Aglaja (see pg. 182) is obtained for Wisibada, the narrow path could be predicted accurately enough to target mobile observers. The good accuracy of the 18-inch Lowell astrograph may force us to reconsider the lower limit of asteroid sizes used in occultation search programs. Wisibada could serve as a good test case. Information about the occultation, including a finder chart, will be published in the November issue of *Sky and Telescope*. The stellar diameter parameters are 0.17 milli-arc seconds, 205 meters, 22 milliseconds, and 0.8 fringe.

*Dec. 16, (184) Dejopeja:* The diameter of Dejopeja could be anywhere from 36 km to 132 km, depending on whether it is in the E, M, or P class. Observations of this occultation, potentially visible from Europe and Asia, could settle the issue.

*Dec. 29, (747) Winchester:* This occultation was identified during plate scans at Lowell Observatory; see p. 162 of the last issue. Since the AGK3 field covering this event is shown in the middle of p. 176 of the last issue, only the A.C. field identifying the star is published in this issue.

## PROPOSED CHANGES FOR ASTEROIDAL OCCULTATION PREDICTIONS FOR 1985

David W. Dunham

Several observers have complained about the length of the prediction lists, making it hard to decide which events they should attempt to observe. Many of the events involve faint stars with small magnitude drops in bright moonlight. Those in North America and Europe should concentrate mainly on events for which finder charts are published. The list of events for which astrometry is planned, such as on p. 160 of the last issue, can also serve as a guide.

For 1985, I plan to be more selective in the events I list, considering angular diameter and duration as well as the observational circumstances noted above. In addition, events which likely can be detected only photoelectrically will be included neither in *O.N.* nor in the local circumstance predictions distributed by Joseph Carroll, but instead will be distributed separately to the smaller number of observers who can use them. The "visual" events will be restricted to $\Delta m$'s greater than 0.4 for 7th-magnitude stars, 0.6 for 9th-mag., 0.8 for 11th mag., and 1.0 for 13th mag.; no stars fainter than 13.0 will be included, although occultations of them might be seen with very large telescopes, most of which are outfitted with photometers, anyway. These $\Delta m$ restrictions will not be applied for occultations by planets which have a significant dark side (defect of illumination exceeding 1"0). Predictions for occultations with smaller $\Delta m$'s will be published in a separate Supplement for photoelectric observers. It will be sent free to IOTA members whom I know to have a photoelectric capability, or who request it from the editor-treasurer (see address in masthead). *Occultation Newsletter* subscribers who are not IOTA members will have to pay $1.00 per year to subscribe to the photoelectric Supplement, and overseas subscribers in this category will need to pay an additional amount to cover airmail postage. Except for special objects, occultations with $\Delta m$ less than 0.05, or involving stars fainter than magnitude 14.0, will not be included in the Supplement. Also, the Atlas-Coeli parts of the finder charts will not be included for these events, since virtually all photoelectric observers have access to these or more detailed charts, and usually don't need them since they normally work with well-calibrated setting circles.

If you have any comments or objections to the proposed changes, write to me at P.O. Box 7488, Silver Spring, MD 20907, U.S.A. There will be no changes until November, when I will produce the 1985 predictions for the next *O.N.*

I plan to give the positions of the stars to more accuracy, to the nearest second of time in R.A. and to 0:1 in dec., to help identify faint stars in crowded fields. This will be done only for the 1950 positions, unless someone can give me a good reason for also giving the apparent positions to greater accuracy.

I plan to create a large catalog including all AGK3 and SAO stars, as well as many from other catalogs. I plan to use it for producing the finder charts which are now generated with either SAO or AGK3 data. This should eliminate the problem of missing bright stars from my AGK3 data (some stars in the printed AGK3 are not in the magnetic tape version obtained from the Astronomisches Rechen Institut, and vice versa) and the 10° declination zone boundaries of my SAO data. These problems now are taken care of manually for the charts published in *O.N.*, but observers outside of North America and Europe often rely on the raw computer-produced charts which I distribute.

## THE SEPTEMBER 16TH OCCULTATION OF SAO 146599 BY (47) AGLAJA

David W. Dunham

Regional maps and a finder chart for this occultation were published on pages 170 and 171 of the last issue. Astrometric observations were made at Lowell Observatory during the nights before the occultation using the newly mounted 18-inch telescope described on pages 161 and 162 of the last issue. The path predicted by Bob Millis and Ted Bowell from their eleven exposures had a shift value of 1"05 south and time correction of 2.8 minutes early, placing the path across the southern U.S.A., England, northern Germany, and southern Denmark. Larry Wasserman's preliminary solution from a few of the observations of the occultation show that the prediction from the astrometric observations was in error by only 0"004, probably the best-predicted asteroidal occultation to date!

When Millis telephoned me on the 13th with the first prediction, we coordinated efforts to notify as many potential observers as possible. Since the long-range weather forecast was pessimistic in the U.S.A. east of Texas, efforts were concentrated more in the western part of the path. With help from Wolfgang Beisker, we got word to European coordinators. Unfortunately, it was cloudy in Germany, Holland, and Belgium. Some miss observations reported from Denmark might constrain the northern limit, whose location is known only poorly from the American data.

Several astronomers left Lowell Observatory on the 14th, heading for southeastern New Mexico to deploy their three portable photoelectric systems. I made reservations to fly to Texas for the event, but cancelled these plans when I learned that the weather forecast, as of 12 hours before the occultation, was that a cold front would be along or just south of the path from Arizona to the Carolinas, with no good clearing until a few hours after the event. This also discouraged my notification effort. But six hours before the occultation, checking with the weather office indicated that the front was moving faster than expected, with mostly clear skies expected from northern Georgia to Mississippi and west of central Texas. With help from my wife, Joan, I was able to pack observing equipment and catch a flight to Atlanta, GA, to attempt an observation. Just before boarding the flight, I called Joan; she read me some observations which Arnold Klemola had just phoned from Lick Observatory. Three exposures had been taken on Sept. 11, but the plate measurements could not be reduced earlier due to computer problems. I had known about the observations and had computed a list of topocentric positions, which I had with me. Using a pocket calculator during the flight, I computed the paths from Klemola's data. Two were in good agreement with the Lowell results, but the third path was over an arc second farther south. In any case, Atlanta was near the center of the predicted path, and I only had time to drive to Riverdale, a suburb just far enough south of the city to avoid serious light pollution. The occultation lasted 13½ seconds. I timed a "probable blink" a few seconds before the (main) disappearance. Aglaja seemed a little brighter than predicted, since I could see it with my 20-cm telescope during the occultation.

Around Atlanta many miles north and south of Riverdale, R. Williamon at Fernbank Science Center and H. Landis at Locust Grove photoelectrically recorded the occultation. Of the three Lowell stations, one was clouded out, one had a miss, and the other recorded the occultation. Several other chords were obtained near Phoenix to south of Tucson, AZ, including an image-intensified video record by Peter Manly. Ben Hudgens timed a 5½-second occultation at Clinton, MS, apparently near the southern limit. Roger Harvey saw no occultation at Concord, NC, apparently the American closest to the northern limit to see a miss (he saw Aglaja approach the star, centrally as well as he could tell. Bob Melvin reports that several others in the Carolinas were clouded out.

Unfortunately, it was cloudy over much of the path in Texas. But Paul Maley found a large clearing at Mt. Enterprise, and saw a miss. At a location 5 miles farther north, Chuck Herold timed two brief occultations of the star, the first lasting two seconds and the other lasting only 0.5 seconds starting 0.7 second after the first reappearance. The first disappearance was gradual, lasting a full second. Chuck said the star turned red as it faded. Wasserman's preliminary analysis gives a smaller-than-predicted diameter of about 135 km for Aglaja, and it shows that Chuck Herold's site was near the southern limit of the occultation. But his timings disagree by about half a minute with the other timings of the event, and the discrepancy still is being investigated.

Was the extreme accuracy of the prediction from the new Lowell telescope a fluke, attributable to beginner's luck? I think not. The telescope characteristics are similar to those of the Lick astrograph. These two astrographs are the only ones with a generous plate scale and with a large-enough field so that only the accurate Perth70 and AGK3R reference stars are needed for the plate solutions. The statistics from large numbers of exposures measured automatically (and therefore accurately) virtually guarantees accuracies much less than 0".1. The only astrometric observations of known comparable accuracy for asteroid events have come from very long-focus smaller-field telescopes where secondary star positions measured from Lick plates were used for the local plate reductions; and from the photoelectric transit telescope at Bordeaux, France (see page 168 of the last issue). The positions of SAO and AGK3 stars are often now in error by an arc second or more, and are often systematically in error with discontinuities near the edges of the plates used for the Yale and AG catalogs. For asteroid occultation astrometry, this often results in errors of 0".5 or more, even though the internal accuracy of 3 or 4 exposures may be much less. At the moment, it is not possible to assess the accuracy of plates taken with the Astrographic Catalog camera at the Cape Observatory. Secondary star positions reduced from wide-field plates (taken with another telescope at Cape) using accurate data from the Southern Reference Star program (SRS; the Perth70 catalog is part of the SRS) have been used. None of the occultations predicted with astrometry from this telescope have been observed due to bad luck with weather and the paths often ending up over the ocean.

We all hope for a long and productive future for the new Lowell astrographic telescope. It is now somewhat difficult to use, with a wooden plateholder and Plexiglass filter slide. The success with Aglaja certainly shows that it deserves better accessories to facilitate routine use. Robert Millis plans to present preliminary results from the September 16th occultation at the meeting of the American Astronomical Society's Division of Planetary Science in Kona, Hawaii, this month, and it will certainly also be mentioned at the IOTA meeting in Houston on the 20th.

## ASTEROIDS AND THE GRAVITATIONAL CONSTANT

David W. Dunham

Articles about the gravitational constant derived from analysis of the very accurate range measurements to the Viking landers on Mars have been published in *O.N. 3* (6), 118 and p. 158 of the last issue. An article, "Determining Asteroid Masses from Perturbations on Mars," by J. G. Williams, *Icarus 57* (1), 1, sheds more light on the matter, and urges that good diameters be determined from occultation observations of several asteroids which affect Mars' orbit the most.

Williams notes that determination of $\dot{G}/G$ to accuracies better than $10^{-11}$ from the Viking data requires solving for improved masses for the three largest asteroids and good modeling for the accelerations due to the smaller ones. There is some controversy over the best way to do this. Although the accuracy of the result by Hellings *et al.* given in *O.N. 3* (6) was $0.4 \times 10^{-11}$, an accuracy of $3 \times 10^{-11}$ using a different asteroidal model is given for $\dot{G}/G$ by R. Reasenberg in "The Constancy of G and Other Gravitational Experiments" in *Philos. Trans. Roy. Soc.* Part A, in press when Williams' article was published. Reasenberg's uncertainty is a little larger than that from lunar occultations given in *O.N. 3* (8) 158.

Williams describes how the masses of the outer planets can be improved from analysis of the Viking data. The data also are sensitive to more distant objects which have been the subject of speculation during recent years. Williams says that the current analyses of the Viking data rule out the possibility of an undiscovered planet as large as the earth to a distance of about 100 A.U., and of a star as massive as the sun to a distance of about 40,000 A.U.

Williams states, "If future missions to Mars are to have the capability of testing $\dot{G}/G$ at levels below about $0.3 \times 10^{-11}$, it will be necessary to improve on our present knowledge of asteroidal densities and diameters." He stresses that physical information, especially accurate diameters, be determined for all of the asteroids in Table III of his paper, noting: "Clearly, the objects of the table are prime targets for occultations." The asteroids in Table III have the following numbers: 1, 2, 3, 4, 6, 7, 8, 9, 10, 13, 14, 15, 16, 18, 19, 20, 22, 24, 29, 31, 41, 45, 51, 52, 65, 78, 97, 111, 324, 372, 405, 409, 511, 532, 704, and 747.

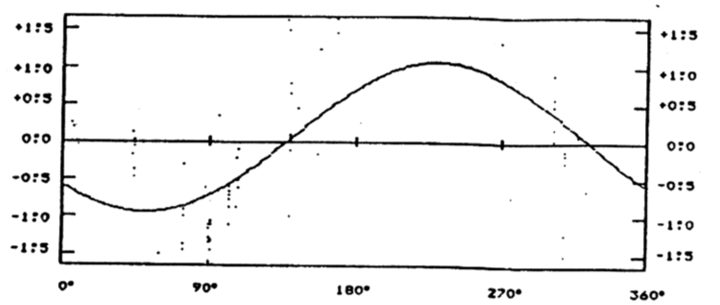
## OCCULTATIONS DURING TOTAL LUNAR ECLIPSES

David Herald, David W. Dunham, and Paul Maley

Herald has analyzed visual occultation timings made during the past five total lunar eclipses in Australia and New Zealand, as reported in Circular

C84/9 of the Occultation Section of the Royal Astronomical Society of New Zealand. Plots of the residuals as a function of position angle show the best-fit sine curve representing solutions for corrections to the lunar right ascension (not longitude, as printed below the plots), declination (not latitude), and radius. Actually, the radius used by Herald in his calculations was 0".05 smaller than that usually used for occultation work, in good agreement with the average radius correction of +0".06 from all

ANALYSIS OF OCCULTATIONS OBSERVED DURING THE LUNAR ECLIPSE OF 1978 March 24

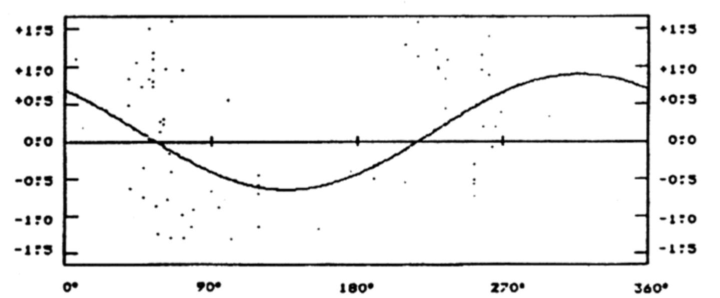



Correction to the Moon's longitude = -.78 : .12

Correction to the Moon's latitude = -.62 : .15

Correction to the Moon's radius = .04 : .09

ANALYSIS OF OCCULTATIONS OBSERVED DURING THE LUNAR ECLIPSE OF 1978 September 16

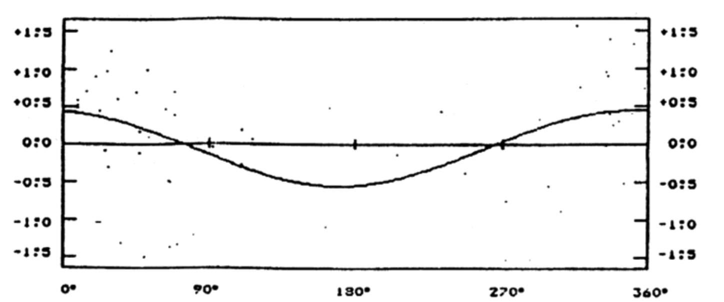



Correction to the Moon's longitude = -.51 : .13

Correction to the Moon's latitude = .56 : .18

Correction to the Moon's radius = .11 : .09

ANALYSIS OF OCCULTATIONS OBSERVED DURING THE LUNAR ECLIPSE OF 1979 September 6




Correction to the Moon's longitude = -.07 : .15

Correction to the Moon's latitude = .49 : .20

Correction to the Moon's radius = -.05 : .15

eclipses. The plots for only the first three are reproduced here. Those for the 1982 eclipses will be published later, after Dunham has time to go through his records and send Herald the numerous timings he has received from North Americans and others. A few observations of the 1982 eclipses made in the Soviet Union were received recently. If there are still some unreported observations of the 1982 eclipses, please send them to Dunham at P.O. Box 7488, Silver Spring, MD 20907, U.S.A. He still has no reports from Japan, and few timings from other observers in Asia. We hope that when we publish the results for the 1982 eclipses, we also can list all observers who contributed, ranked according to the number of valid timings used in the solutions (with reappearances weighted extra).

The plots show a concentration of observations near position angle 90° due to a paucity of graze data and reappearances. The scatter is rather large due to visual timing, star position, and Watts limb correction errors. The star positions can be improved by good astrometric observations, such as those made at Lick Observatory of the 1982 eclipse fields. Timing errors could be eliminated by using photoelectric or image-intensified video observations, and attempts using the latter are encouraged during future eclipses.

The next total lunar eclipse is on 1985 May 4th, visible from the Eastern Hemisphere. Sometime before the eclipse, Dunham plans to distribute extended-coverage total occultation predictions to observers there, but Astrographic Catalog star positions for the star field in Libra need to be generated first. Herald can generate plate constants for the A.C. measurements with SAO data. Dunham can use the plate constants to generate right ascensions and declinations of all the stars from the x-y measurements given in the A.C. We may need someone to volunteer to punch the x-y data for us, either on cards or to floppy disk (using a microcomputer; the data then could be transferred to the IBM 4341 at USNO).

This eclipse will be unusual because 2.9-mag. Zubenelgenubi (Alpha Librae) will be occulted during totality. This will not happen again for 19 years (one Metonic cycle later, during the eclipse of 2004 May 4), according to G. P. Konnen and Jean Meeus in their article, "Occultations of Bright Stars by the Eclipsed Moon," *J. Brit. Astron. Assn. 85* (1), 17 (1974). The only other occultation of a star brighter than mag. 3.9 by a totally eclipsed moon before 2004 will be an occultation of 3.5-mag. Delta Geminorum on 2001 January 9 (during a small partial eclipse on 1994 May 25, Beta Scorpii will be occulted by the eclipsed part of the moon for some areas). Zubenelgenubi is a triple star. 5.3-mag. Alpha 2 Librae is about 3' away (this star itself may be a close double). The magnitudes of the close components of Alpha 1 Librae are 3.4 and 3.8; their separation likely varies due to orbital motion, but was 0".01 during a previous occultation.

IOTA's plans for an expedition to observe the May 4th eclpse have stalled due to other more urgent matters. We would like to observe at the northern limit of the graze of Zubenelgenubi; plans have been made to observe at the southern limit by members of the Astronomical Society of Southern Africa. We wanted to observe from the Seychelles, but the northern limits of both Alpha 1 and 2 missed all the islands there. The paths also cross Algeria, Libya, the Sudan, Ethiopia, and Somalia, which all have either political or suitable mapping problems. The path for Alpha 2 Librae passes less than 10 km from the center of Addis Ababa and about 50 km to the southwest of that for Alpha 1. The best possibility may be Alpha 1 about 50 km south of Khartoum, where there is a network of irrigation canals. The eclpse will occur very high in the sky in the Seychelles. Unfortunately, no grazes of SAO stars cross any of the accessible islands. The Alpha Librae paths pass near some of the islands, but central graze is on the penumbra there, not in the umbra during totality, as is the case for Africa. Hans Bode notes that it is possible to arrange trips from the German Federal Republic to the Seychelles, staying for 2 weeks for DM 1500, all expenses included. Weather prospects and other information about these areas still need to be determined. We are trying to contact a member of the British Astronomical Association who recently observed a lunar occultation of Mars in the Sudan.

---

## OBSERVATIONS OF ASTEROIDAL APPULSES AND OCCULTATIONS

Jim Stamm

Observations of appulses and occultations of stars by asteroids should be sent to me at Route 13, Box 109, London, KY 40741, U.S.A., telephone 606,864-7763. Send a copy of the report to David Dunham, P.O. Box 7488, Silver Spring, MD 20907, U.S.A., only if an occultation has been observed which could use some analysis for comparison with others, and indicate to whom copies have been sent on the report. Dunham prefers not to have to send me copies of numerous reports sent only to him. Alternatively, you can send your report to a local or regional coordinator who then can send the results on to me. Europeans can send their reports to R. Boninsegna; Rue de Mariembourg, 33; 6381 Dourbes, Belgium; he has been sending good summary reports to us. In the accounts of individual events below, a reference to a previous preliminary *O.N.* account of the event, if any, is given in parentheses following the date.

*(9) Metis and SAO 184440, 1981 Jun 14:* An occultation was observed photoelectrically in the USSR according to L. Kristensen in his article about the February 19, 1984 event discussed below.

*(106) Dione and SAO 80228, 1983 Jan 19:* (*O.N. 3* (5) 104). From *Astron. Nachr. 305* (4), 207-211 (1984); Final results from the data of 12 amateur astronomers and one professional in Denmark, Germany, and the Netherlands show this asteroid to be egg shaped with a mean diameter of 147 ±3 km. Final results, computed by L. Kristensen.

*(683) Lanzia and SAO 117317, Nov. 5:* J. Pinson, using a 35-cm telescope at La Seyne-sur-Mer, France, saw no occultation between $5^h30^m$ and $5^h50^m$ U.T., while G. Leonis and L. Zimmermann used a 10-cm at Charneusc, Belgium, to record a negative observation from 5 39 50 to 5 49 50 .

*(199) Byblis and SAO 78120, Nov. 20:* Under cloudy skies, J. F. Petrucci and T. Lesnes managed to observe from $5^h18^m$ to $5^h21^m$, $5^h23^m$ to $5^h28^m$, and $5^h33^m$ to $5^h35^m$, with a 30-cm scope at Hyeres, France, without detecting any occultation.

*(1467) Mashona and AGK3 +50°0390, Dec 5:* No occultation was observed from about 20h45m to 21h04m by R. Boninsegna with a 30-cm at Dourbes, Belgium, and from 4 French stations: Dubois and Florsch Halbnachs with a 49-cm at Strasbourg Observatory, J. Pinson with a 35-cm at Seyne-sur-Mer, B. Candela with a 20-cm at Lollies-Pont, and J. F. Petrucci with T. Lesnes using a 30-cm at Hyeres.

*(208) Lacrimosa and SAO 78799, Dec 14:* J. Aloy at Barcelona, Spain (*O.N. 3* (8), 168), and 7 stations in Belgium all reported no occultation from about $23^h20^m$ to $23^h40^m$: J. Bourgeois with a 25-cm at Furfooz, G. Leonis with a 25-cm at Uccle Observatory, A. Sorro and L. Zimmerman with a 28-cm at Brussels, P. Poitevin with a 25-cm at Herk-de-Stad, P. Van Cauteren with a 25-cm at Aartsclaar, A. Lheureusc, Y. Thirionet, and M. Decominck with 15- and 20-cm scopes at Brussels, and C. Bactens at Boechout.

*(91) Aegina and SAO 76615, 1983 Dec 30:* Twelve stations reported on this event, with the only probable occultation (80% certainty) being observed by D. Barbany at Granolless, Spain. Using an 8-cm instrument, he timed a 1-sec. extinction at $22^h56^m43^s$. Others reporting timings from Belgium were P. Louis and R. Boninsegna with 30 cm at Dourbes ($22^h40^m$ to $23^h00^m30^s$), A. Worro with 16 cm at Brussels ($22^h40^m$ to $23^h00^m$), and C. Kint and G. Leonis at Uccle Observatory $22^h40^m39^s$ - $22^h47^m$ and $22^h49^m43^s$ -$23^h01^m 49^s$). L. Louys monitored from $22^h45^m$ to $23^h00^m$ with 50 cm at Tenerife in the Canary Islands. French observers included L. Bellotto with 30 cm at La Seyne-sur-Mer ($22^h30^m$ - $23^h05^m$), B. Candela at Lollies-Pont using 20 cm ($22^h30^m$ - $23^h05^m$), T. Lesnes at Hyeres with 30 cm ($22^h38^m$ - $23^h01^m$), and J. F. Leborgne with 16 cm at Brest ($22^h44^m$ - $23^h00^m$).

*(154) Bertha and 13 mag. star, 1984 Jan 12:* P. Poitevin used a 25-cm telescope from $18^h00^m$ to $18^h 02^m$ at Herk-de-Stad, Belgium, to monitor the star, but there was no event, and it clouded up after two minutes of observing, according to a report of European observations received from R. Boninsegna.

*(194) Prokne and SAO 117122, Jan 20:* (*O.N. 3* (8), 168). At London, KY, I monitored the star from $6^h 55^m$ to $7^h13^m45^s$ with a 20-cm SC, observing no extinctions longer than $0^s5$, except for a $1^s5$ loss of the star at $7^h09^m45^s$, probably due to fatigue, a warm scope, and -21° C temperature. Michael Crist, at Burns, TN, had clouds as well as -16° C temperature to hinder his observations with a 36-cm SC. He monitored from $7^h03^m$ to $7^h12^m$ with breaks at $7^h07^m 19^s$ to $7^h07^m42^s$ and $7^h10^m37^s$ to $7^h10^m44^s$. Benny Roberts and Ben Hudgens, using 33-cm and 25-cm Newtonians, respectively, saw no events from $6^h55^m$ to $7^h20^m$ at Jackson, MS.

*(41) Daphne and SAO 112434, Jan 26:* R. Burchi, A. Di Paoloantoni, *et al*, at Teramo, Italy, monitored the star with photometers from $18^h$ to $20^h$, with no extinction, while 5 other astronomers in Belgium al-

so recorded no occultation: L. Zimmermann at Brussels with a 16-cm refractor ($18^h20^m$ to $18^h39^m$), G. Leonis at Brussels using 28 cm ($18^h19^m05^s$ to $18^h39^m21^s$), P. Poitevin with 25 cm at Herk-de-Stad ($18^h31^m$ to $18^h40^m$), F. Van Soo ($18^h28^m$ to $18^h42^m$) with 25 cm at Wagem, and P. Van Eauteren ($18^h26^m30^s$ to $18^h41^m$) with 25 cm at Aartsclaar.

*(46) Hestia and AGK3 +3°1471, Jan 29:* (*O.N. 3* (8), 168). C. Gualdoni and M. Cavagna observed from $4^h14^m$ to $4^h45^m$ with no event detected at M. Bornia, Italy. J. F. Leborgne at Toulouse, France, used a 20-cm from $4^h16^m$ to $4^h40^m$ with no occultation observed. A. Maury monitored the star at Grasse, France, with a refractor and photometers from $4^h27^m$ to $4^h47^m$ and $4^h47^m$ to $5^h01^m$ without any extinctions. Also no occultation was seen in France by B. Candela at Lollies-Pont, T. Lesnes at Hyeres, D. Bockelee and J. Lecacheux with photometers at Haute-Provence Observatory, and J. Pinson at Seyne-sur-Mer; and by A. Estela and J. Fabregat at Valencia, Spain.

*(194) Prokne and 12.2 mag. star, Jan 30:* Ferruccio Ginelli observed a $13^s.2$ extinction beginning at $22^h20^m37^s$ U.T.C., from Fortaleza, Brazil. He used a 32-cm Newtonian under good skies, and was sure of the event. This observation shows a shift of $0''.8$ north, placing the path also over southwest South Africa, but no reports of this event have been received from there yet. This is the first observation of an asteroidal occultation of an Astrographic Catalog star not in the SAO or AGK3.

*(12) Victoria and 11.8 mag. star, Feb 15:* I monitored the star with an 8-inch SC from $0^h48^m$ to $1^h02^m$ at London, KY. No event was detected, in less than average seeing. After significant separation at $1^h15^m$, Victoria seemed brighter than the star.

*(9) Metis and SAO 119464, Feb. 19:* (*O.N. 3* (8), 168). The chords of observers at Bech, Larsen, Klinting, Aarhus, and Esbjerg, Denmark, and at Kiel and Lübeck, German Federal Republic are plotted by Kristensen in *Astronomi & Rumfart*, May-June 1984, p. 76. He fitted the data with a 170-km by 210-km ellipse. Wolfgang Beisker also noted that the Lübeck observation was photoelectric, and gave details for visual timings made at Rathe and Kalauc, German Democratic Republic. A. Figer at Paris monitored the star from $1^h25^m$ to $1^h42^m$ with a 26-cm scope without observing an occultation. R. Boninsegna used a 30-cm at Dourbes, Belgium, from $1^h29^m20^s$ to $1^h41^m$ without observing an occultation greater than 1 second in length.

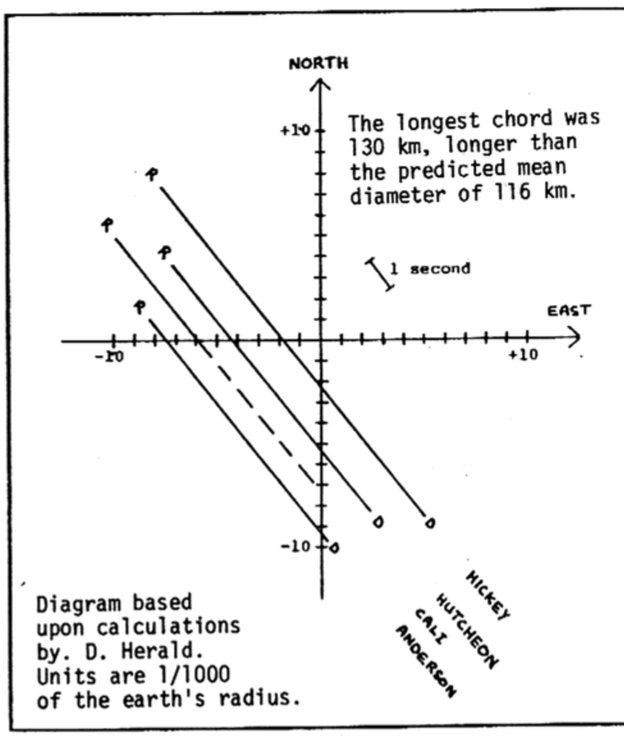
*(9) Metis and BD +8°2579, Mar 15:* (*O.N. 3* (8) 169). S. Maksymonire observed from $4^h10^m$ to $4^h30^m$ with an 11-cm instrument, without an event, from Asernes, just north of Conde-sur-Noireau, France.

*(114) Kassandra and SAO 169989, Mar 23:* Buffet Mazalrey, using a 28-cm scope at Vernon, France, observed no occultation from $4^h23^m$ to $4^h43^m$. P. Barufetti at Massa, Italy, saw no event from $4^h08^m49^s$ to $4^h41^m44^s$ with a 31-cm glass.

*(324) Bamberga and 12.3 mag. star, Apr. 3:* Peter Anderson observed from Brisbane, Australia, and reports that the asteroid seemed to merge with the star 10 minutes later than the predicted time.

*(128) Nemesis and SAO 139402, May 2:* Six members of the Southern Cross Astronomical Society reported a "no event" for this event. M. C. Mooney used a 36-cm SC, and R. Scott Ireland used 80-mm binoculars from $1^h35^m$ to $1^h50^m$, at the Southern Cross Observatory. The other 4 members, spread around Dade County, FL, were R. Riefes ($1^h31^m$ to $1^h45^m$), W. T. Douglas ($1^h38^m$ to $1^h45^m$), Don Parker ($1^h31^m$ to $1^h49^m$), and R. Grant ($1^h35^m$ to $1^h51^m$). Jose Izaguirre and Domingo Sanchez, observing in Venezuela with 15-cm and 25-cm telescopes, respectively, reported no occultations from $0^h00^m$ to $2^h40^m$. Observations with the Bordeaux transit telescope over several nights from Apr 11 to 26 showed a south shift of $0''.19 \pm 0''.12$, and a time shift of 2.2 ±0.5 minutes early. This placed the path over southern Brazil and the south coast of South Africa.

*(230) Athamantis and SAO 158162, May 11:* Observations at Bickley Observatory in Perth, Australia, on May 9 showed a one arcsecond south shift, placing the path between Sydney and Canberra. These updates were phoned to a number of coordinators, including Peter Anderson in Brisbane, resulting in nine stations that monitored the event visually. Four of the stations obtained positive results: S. J. Hutcheon, J. Cali and G. Bond, T. and D. Hickey, and P. E. Anderson. The chords obtained give a rough idea of the size and shape of the asteroid. The results are detailed in Circular C84/6, the April 1984 publication of the Occultation Section of the Royal Astronomical Society of New Zealand, from which the diagram is reproduced.




*(326) Tamara and SAO 226130, May 15:* Based on plates obtained by Joe Churms at Cape Observatory, South Africa, on May 10, a shift of $2''.26$ north and 1.9 minutes early (mostly due to the asteroid ephemeris) was predicted by David Dunham. This would place the path over southern Chile, central Argentina, central Africa, and southern Saudi Arabia.

*(21) Lutetia and SAO 158714, May 16:* Arnold Klemola obtained plates for this event on Apr 24, and Dunham sent updated predictions to Mexico, Hawaii, and Japan; predicting a shift of 0".48 north ±0".15, and 1.5 minutes late ±0.3 minute.

*(19) Fortuna and 12.0 mag. star, May 25:* Peter Anderson, observing from Brisbane, writes that the asteroid seemed brighter than the star.

*(326) Tamara and SAO 225520, Jun 2:* Churms obtained plates on May 28. Because of the May 30 eclipse, Dunham was not able to compute shifts until after the event, so there was no notification. In any case, the resulting 3".0 north shift, due primarily to the error of Tamara's ephemeris, took the path of the event off the earth's surface. Likewise, the Jun 4 occultation of SAO 225478 by the same asteroid almost certainly missed the earth.

*(602) Marianna and SAO 227909, Jun 2:* The same plates and computation as mentioned above gave a 2".5 south shift, placing the path south of South Africa, but possibly catching the southern part of New Zealand. C. Frick, at Como, Australia, and C. Bembrick, at Queenscliffe, Australia, observed the appulse, with no occultation occurring.

*(624) Hektor and AGK3 +7°46, Jun 2:* C. Bembrick also observed this event without seeing an occultation.

*(386) Siegena and AGK3 +5°2112, Jul 16:* Marco Cavagna observed from $0^h20^m$ to $0^h44^m$ near Como, Italy, with a 25-cm reflector, seeing no occultation.

*(110) Lydia and SAO 211065, Jul 18:* B. Loader, at Blenheim, New Zealand, S. G. Ryan, at Christchurch, N. Z., and P. E. Anderson, at Brisbane, Australia, all report no extinction for this event.

*(94) Aurora and SAO 211730, Jul 28:* Australian observers S. J. Hutcheon at Sheldon, and P. E. Anderson at Brisbane, observed this appulse without event.

*(451) Patientia and L 931708, Aug 5:* P. E. Anderson observed at Brisbane, but saw no occultation.

*(704) Interamnia and L 944324, Aug 5:* Jim Young, at Table Mountain Observatory in California, photoelectrically recorded a 10% drop with a 61-cm telescope from $6^h41^m45^s$ to $6^h42^m12^s$. Plates taken at Lick Observatory were analyzed at Lowell Observatory, and yielded a south shift of 0".7 and a time shift of 1.5 minutes early, placing the path over Los Angeles and most of southern California. The observation showed the event to be 1.0 minute early. At Mt. John, N. Z., A. C. Gilmore and M. Clark monitored the star without detecting any event.

*(704) Interamnia and L 941608, Aug 8:* On Aug 5, Klemola obtained plates, and a telegram was sent to Graham Blow in New Zealand, since the predicted path would cross New Zealand and southeast Australia. However, the low magnitude drop for this event prevented most of the potential observers from getting any results.

*(87) Sylvia and SAO 211985, Aug 8:* Astrometry by Churms on Aug 6.9 led to a predicted shift of 2".14 south ±0".2 and 5.2 minutes late ±0.5 minute. Dunham telephoned Blow 6 or 7 hours early, and Blow relayed the astrometry to several observers. Mike Clark at Mt. John Observatory monitored photoelectrically from $17^h43^m$ to $17^h59^m$, while Carlsson Chambliss and Jim Bruton at Black Birch did the same from $17^h27^m$ to $18^h24^m$. No events were recorded. Several other photo-monitor attempts were unsuccessful due to equipment and the bright background problems. Steve Hutcheon in Queensland confirmed that the planet seemed to have passed south of the star. Others observing from New Zealand were S. G. Ryan and L. Hussey (Christchurch), G. L. Blow and J. Priestley (Wellington), and R. R. D. Austin (New Plymouth). P. E. Anderson also monitored at Brisbane. [Note added early October:] M. D. Overbeek tells us that a 12-second occultation was reported by an observer in Port Elizabeth, South Africa, 4 minutes later than the nominal time. The observer did not know about the astrometry. The observation is consistent with the time from the astrometry, but the implied path is 0.3 arc second north, which would pass entirely north of Australia. Graham Blow reports that Peter Anderson, at Brisbane, Australia, believed Sylvia passed north of the star at his location, which is consistent with an occultation at Port Elizabeth. Since the predicted central duration was 24 seconds assuming a diameter of 275 km, Port Elizabeth probably was close to one of the occultation limits.

*(51) Nemausa and 12.3 mag. star, Aug 15:* P. E. Anderson observed this appulse from Brisbane without any occultation occurring.

*(704) Interamnia and L 941618, Aug 19:* Klemola got plates in early August showing a path shift to central Texas, the western plains, and up to Saskatchewan. This was, however, another low magnitude drop, and no observations have been reported.

*(104) Klymene and SAO 185260, Aug 25:* R. R. D. Austin at Plymouth, N. Z. saw no event during this appulse.

*(704) Interamnia and L 941624, Aug 29:* Klemola's early August plates showed a path through Patagonia, off the coast of Chile, and southern Peru. Also a low magnitude drop.

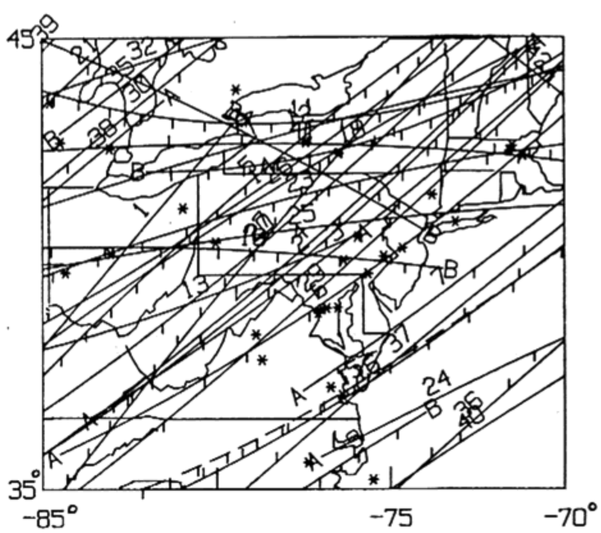
*(747) Winchester and BD +4°978, Sep 2:* Under excellent skies, Benny Roberts at Jackson, MS, with a 33-cm Newtonian; Tony Freeman just east of Prineville, OR, with a 20-cm SC; and I, at London, KY, with a 20-cm SC, all obtained negative observations. I began monitoring at $10^h13^m$ when I still could see separation, and watched the asteroid skim the northern edge of the star with 120 power. Roberts began at $10^h00^m$, and watched the asteroid approach, merge, and recede, until $10^h25^m$, with 125 power. Freeman used 111 power, and detected Winchester about 3 arc seconds due east at $10^h00^m$. He was unable to tell whether the asteroid passed north or south of the star, and observed until $10^h20^m$.

*(704) Interamnia and BD -19 4924, Sep 2:* Klemola's early August plates indicated a path through western India and western China, and Lowell Observatory sent telegrams to Uttar Pradesh State Observatory on Manora Peak, Naini Tal, and to Kovalur Observatory, Bangalore, India, since there was a good drop in magnitude for this event.

*(209) Dido and SAO 188498, Sep 4:* Plates obtained by Klemola on Aug 27 led to a predicted shift of 2".0

SW ±0".3, and 10 minutes late ±2 minutes, while astrometry by Churms led to a predicted shift of 2".9 west, and 9 minutes late. The main reason for the large shift was an error in the declination of the star. The path was shifted to the Pacific Ocean in daylight.

GRAZES. 1984 JULY 20 TO DECEMBER 31




| NO. | | YEAR | MO | DAY | USNO # | SAO | MAG. | STAR NAME | PLACE | D | % SUNL | | LIMIT | W.U.T. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | S | 1984 | JUL | 21 | 300 | 110295 | 7.8 | | KY-Ont. | V | 48 | WAN | NORTH | $9^{h}32^{m}.0$ |
| 2 | | 1984 | JUL | 23 | 517 | 93494 | 6.4 | 26 B. TAURI | TN-ME | | 29 | WAN | NORTH | 7 12.2 |
| 3 | | 1984 | JUL | 24 | X5728 | 76609 | 7.5 | | TN-ME | J | 20 | WAN | NORTH | 7 07.5 |
| 4 | | 1984 | JUL | 24 | 665 | 76618 | 5.7 | 247 B. TAURI | TN-ME | U | 20 | WAN | NORTH | 7 50.7 |
| 5 | | 1984 | AUG | 18 | 372 | 92991 | 7.6 | | KY-Que. | | 64 | WAN | NORTH | 9 22.5 |
| 6 | | 1984 | AUG | 19 | X4181 | 93331 | 7.6 | | TN-MA | | 56 | WAN | NORTH | 4 32.2 |
| 7 | | 1984 | AUG | 21 | X6335 | 76853 | 7.7 | | VA-DE | | 35 | WAN | NORTH | 5 16.1 |
| 9 | S | 1984 | AUG | 22 | X8235 | 77932 | 8.0 | | NC | | 24 | WAN | NORTH | 10 05.1 |
| 11 | | 1984 | SEP | 3 | 2459 | 185049 | 7.2 | | MI-ME | | 56 | WAX | NORTH | 0 49.6 |
| 12 | | 1984 | SEP | 22 | 1435 | 98742 | 6.6 | 57 B. LEONIS | IN-ME | | 11 | WAN | NORTH | 9 42.4 |
| 13 | | 1984 | SEP | 29 | X21720 | 183833 | 7.8 | | KY-PA | | 20 | WAX | NORTH | 0 30.2 |
| 14 | | 1984 | OCT | 1 | 2558 | 185779 | 6.2 | 4 G. SAGITTARII | IN-Que. | | 41 | WAX | SOUTH | 1 06.5 |
| 15 | | 1984 | OCT | 2 | 2721 | 187239 | 3.3 | PHI SAGITTARII | SC-VA | X | 51 | WAX | NORTH | 0 17.9 |
| 16 | | 1984 | OCT | 2 | 2723 | 187246 | 6.7 | | SC-VA | | 51 | WAX | SOUTH | 0 28.8 |
| 18 | S | 1984 | OCT | 4 | X29678 | 190337 | 7.3 | | L.ERIE-ME | | 79 | WAX | NORTH | 23 12.7 |
| 19 | | 1984 | OCT | 13 | 531 | 93557 | 5.5 | 13 TAURI | IN-NJ | V | 90 | WAN | NORTH | 10 41.7 |
| 20 | | 1984 | OCT | 14 | 634 | 76551 | 5.3 | 56 TAURI | KY-VT | | 85 | WAN | NORTH | 2 00.1 |
| 21 | | 1984 | OCT | 14 | 656 | 76601 | 4.4 | KAPPA TAURI | MI | V | 84 | WAN | NORTH | 5 07.3 |
| 23 | | 1984 | OCT | 17 | X10949 | 79316 | 7.9 | | IN-MA | | 55 | WAN | NORTH | 8 25.5 |
| 24 | | 1984 | OCT | 19 | 1373 | 80702 | 6.1 | 90 H1. CANCRI | NC | | 34 | WAN | NORTH | 5 46.9 |
| 25 | | 1984 | OCT | 21 | X16870 | 99505 | 7.9 | | IN-L.I. | | 14 | WAN | NORTH | 8 52.0 |
| 26 | | 1984 | NOV | 2 | 3242 | 0 | 7.8 | | KY-ME | | 65 | WAX | SOUTH | 4 15.4 |
| 27 | | 1984 | NOV | 4 | 3480 | 146799 | 7.3 | 352 B. AQUARII | TN-Que. | | 81 | WAX | SOUTH | 1 55.6 |
| 29 | | 1984 | NOV | 11 | 742 | 76858 | 6.0 | 99 TAURI | NC-ME | A | 95 | WAN | NORTH | 1 02.3 |
| 30 | | 1984 | NOV | 12 | 900 | 77775 | 4.9 | 139 TAURI | MI-Ont. | | 89 | WAN | NORTH | 3 07.1 |
| 32 | | 1984 | NOV | 14 | 1211 | 79869 | 6.2 | 4 CANCRI | MI-Ont. | C | 71 | WAN | NORTH | 6 24.0 |
| 33 | | 1984 | NOV | 20 | X19474 | 139403 | 6.0 | S VIRGINIS | | | 9 | WAN | SOUTH | 9 13.7 |
| 34 | S | 1984 | NOV | 20 | 1951 | 139447 | 7.1 | 81 VIRGINIS | MI-NJ | M | 8 | WAN | SOUTH | 11 32.2 |
| 35 | S | 1984 | NOV | 24 | 2575 | 185900 | 6.8 | 11 B. SAGITTARII | MI-Ont. | K | 5 | WAX | SOUTH | 22 16.6 |
| 36 | | 1984 | NOV | 26 | 2910 | 188722 | 4.8 | OMEGA SAGITTARII | ATLANTIC | | 18 | WAX | SOUTH | 23 07.0 |
| 37 | | 1984 | NOV | 26 | X27771 | 188749 | 8.0 | | NC-VA | | 19 | WAX | SOUTH | 23 49.3 |
| 38 | | 1984 | NOV | 27 | 2914 | 188778 | 5.0 | 60 SAGITTARII | IN-Ont. | V | 19 | WAX | SOUTH | 0 31.7 |
| 39 | | 1984 | NOV | 27 | 3052 | 189801 | 6.4 | 86 B. CAPRICORNI | MI | M | 27 | WAX | SOUTH | 23 33.0 |
| 40 | | 1984 | NOV | 29 | X30071 | 164654 | 7.9 | | ATLANTIC | | 37 | WAX | SOUTH | 1 58.8 |
| 41 | | 1984 | DEC | 14 | X15882 | 99202 | 7.7 | | MI-MA | | 65 | WAN | SOUTH | 6 14.8 |
| 42 | | 1984 | DEC | 18 | X20068 | 158405 | 7.5 | | VT-ME | | 19 | WAN | SOUTH | 10 57.1 |

## IOTA GRAZING OCCULTATION MAPS

David W. Dunham

I have set up a system to produce maps of the northern and southern limits of occultations using the same USNO input data used by the computors to generate IOTA's detailed grazing occultation predictions. The Meeusmap program, which is being distributed to all of the computors along with the graze input data for 1985, generates a magnetic tape containing the path data for specified input longitude and latitude boundaries. The magnetic tape is read by my Grazemap program which actually produces the plot, including asterisks at stations whose longitudes and latitudes are specified. An example is shown at left, covering most of the northeastern part of the U.S.A. and including 36 grazes of stars brighter than mag. 8.1 from late July to the end of this year. Time tick marks, at integral 2-minute intervals of Universal Time, are on the north side of southern limits and are south of northern limits, that is, on the side where a total occultation occurs. Grazes on the dark limb are drawn as solid lines, and those on the sunlit side are dashed lines. Graze paths end with A (altitude too low), S (twilight too bright), and B (bright side interferes), if they do not go to the edge of the map. The maps produced by Grazemap are false projections, where both the longitude and latitude scales are linear (the longitude scale is compressed relative to the latitude scale by the cosine of the latitude of the map center). Hence, it is relatively easy to plot the position of a location whose longitude and latitude are known, or to measure the coordinates of a point on the map. An index number in the middle of the track identifies the graze in the table.

Most of the column headings of the table are self-explanatory. The star's double star code is given under "D," and the sunlit percent of the moon is given under "% SUNL." "W.U.T." is the Universal Time of central graze at the westernmost point of the path on the map. On this map, there was a program error which resulted in "B" being written at the ends of paths with bright twilight, instead of "S." An "S" has been written between the number and date in the table for these cases. The "PLACE" column was written in manually to identify the states (by two-letter postal abbreviations) and Canadian provinces in which the western and eastern ends of the graze paths on the map are located. Grazes in the tape generated by the Meeusmap program can be removed from the plot by specifying their number in a "deletion list" input for the Grazemap program. This has been done for 6 grazes in the example, because they only crossed ocean or occurred under quite unfavorable conditions in the area of the map. The information needed to select which grazes to reject is available in the printed output from the Meeusmap program. I plan to add a more sophisticated observability rejection code which should minimize the need for manual deletion. If a limit for a bright star passes only over the ocean, it may be useful to keep it if a total occultation is visible from land, as a reminder and to help estimate the circumstances at various locations.

This map is reproduced only as an example. Since these maps are primarily of only local interest, I do not intend to publish them regularly in *O.N.* The map here was distributed with information about planned expeditions from the Washington, DC, area to about 150 observers, most of them in the Mid-Atlantic states and most of whom have participated in past expeditions which I have organized. I also send these notices to most IOTA members in the region shown, but not to some, especially in the more northern and western areas of the map. If you want to receive my semiannual expedition mailings, which now will include these graze maps, write to me at P.O. Box 7488, Silver Spring, MD 20907.

For future maps, I plan to correct the "B" error noted above, and probably will limit them to 25 paths or less (for maps covering a region of this size) to reduce clutter. I plan to rearrange the table, adding some information, yet making it more compact. The stations shown on the map are observatories with photoelectric capabilities (except for Cape Hatteras); in the future, I plan to plot instead the stations for those receiving the detailed graze predictions. Similar maps can be produced for other parts of the world. However, our resources are limited, so I do not want to duplicate maps being produced by the ILOC. The IOTA maps are intended primarily for regional publications. If you are interested in including such maps in a regional publication, contact the computor who normally sends you the detailed IOTA graze predictions, specifying the faintest magnitude wanted, the desired map boundaries, and stations for which asterisks should be plotted. Try to request maps at least two months before they need to be sent to the publisher. If possible, maps should be included entirely within one of the 1000-mile-wide "super standard station" prediction regions which have been assigned letters and are used for the graze predictions generated at USNO. At present, if a map for a larger region is wanted, the graze data for the different super standard station regions have to be merged manually before being input to the Meeusmap program. This was actually done for the first IOTA graze map which I produced, the one of the contiguous states of the U.S.A. published on pages 52 and 53 of this month's issue of *Astronomy* magazine. In that case, the merging was not a large job, since only relatively bright stars were selected.

The database of physical and political boundaries which I use for these maps is the same as that used for the regional maps for asteroidal occultations published in *O.N.* It is too coarse for maps with scales expanded much more than the example shown here. Unfortunately, the database does not include the boundaries of the provinces of Canada, the states of Australia, nor the republics of the Soviet Union. I know the format of the database, and with some trouble, can update it. I hope to obtain the coordinates of the boundaries of the Canadian provinces from the National Weather Service, since they include them on their gridded geosynchronous satellite weather photoes.

The Meeusmap program gets its name from the method it uses to compute grazes, by calculating the latitude and time for a series of equally spaced longitudes, which has advantages for producing paths to be plotted on maps. This method was developed by Jean Meeus and published in his 1967 article, "Le calcul des occultations rasantes," *Ciel et Terre 83* (1), 3. I programmed the method over a dozen years ago, and Berton Stevens modified my program to read the USNO graze data and generate IOTA-format predictions. My Meeusmap program is a further modification of Stevens' version. Rather than giving TANZ, its tabular output lists sin(D) × TANZ, which is the dimensionless elevation factor by which heights above sea level must be multiplied to tell how far north or south the sea-level limit given in the predictions must be shifted in the direction perpendicular to itself. The factor is negative if the path is to be shifted southward, which is the case for most grazes in northern temperate latitudes.

FORMAT ERROR IN USNO TOTAL OCCULTATION PREDICTIONS

David W. Dunham

A new printer for the IBM 4341 computer at the U.S. Naval Observatory was installed in September, in the middle of the computer runs which generated the 1985 USNO total occultation predictions. Unknown to Marie Lukac and me at the time, some of the format statements which originally were keypunched with BCD keypunch machines result in some incorrect characters being printed by the new printer. Specifically, in the GRAZING OCCULTATION NEARBY and VARIABLE STAR messages in the USNO total occultation predictions, "#" should be "=" and "%" should be "(." With the new printer, a typical "graze nearby" formula prints as follows:

LAT. # 30.50 - 0.68%WEST LONG. - 95.15),

which doesn't make any sense; it should be

LAT. = 30.50 - 0.68(WEST LONG. - 95.15),

which is the way it printed with the old printer. Similarly, the "#" following "MINIMUM MAGNITUDE" in the variable star message should be "=." We don't remember exactly where in the 1985 predictions the printer change was made, but think that all of the predictions for overseas observers, and for those in regions XB and XR, as well as some of the North American observers (especially those with address region codes at the beginning of the alphabet, particularly A and B), were printed with the old printer and are all right. But other North American predictions were printed with the new printer and include the error, which was first pointed out to me by Don Stockbauer in the E region (address code

AE230). Marie Lukac and I will soon try to change the program so that the correct characters print with the new printer.

The "graze nearby" messages giving the linear formula for the limit normally are printed only if the limit passes within 3 miles of the location for which the predictions are computed. However, if the third option is 4 (extended graze option), the message is printed for all limits which pass within 40 miles of the station, and if it is 6, the radius is extended to 60 miles. The specific calculation is for the distance of a line from the observer to the star above or below the moon's surface at the time of closest approach to the center, this distance being .003, .040, and .060 lunar radii for standard option, option 4, and option 6, respectively. Hence, projection onto the earth's surface can give the message for much greater distances from the station. The four option numbers are printed to the left of the address code on the top of each page; the first option is the minimum observability code included in the predictions.

## LAST-MINUTE ADDENDUM TO IOTA NEWS

David W. Dunham

The IOTA meeting was held on October 20, as planned. Chuck Herold's report about the meeting will appear next time.

Although this issue contains a couple of articles about grazes, an article summarizing expedition results again has had to be postponed. We hope that it will appear in the next issue, about a month from now. Recent observations of northern-limit grazes favor the 78A prediction version, which is used for generating the profiles, but observers are cautioned that even many bright stars currently have errors of ½ second of arc or more in declination.

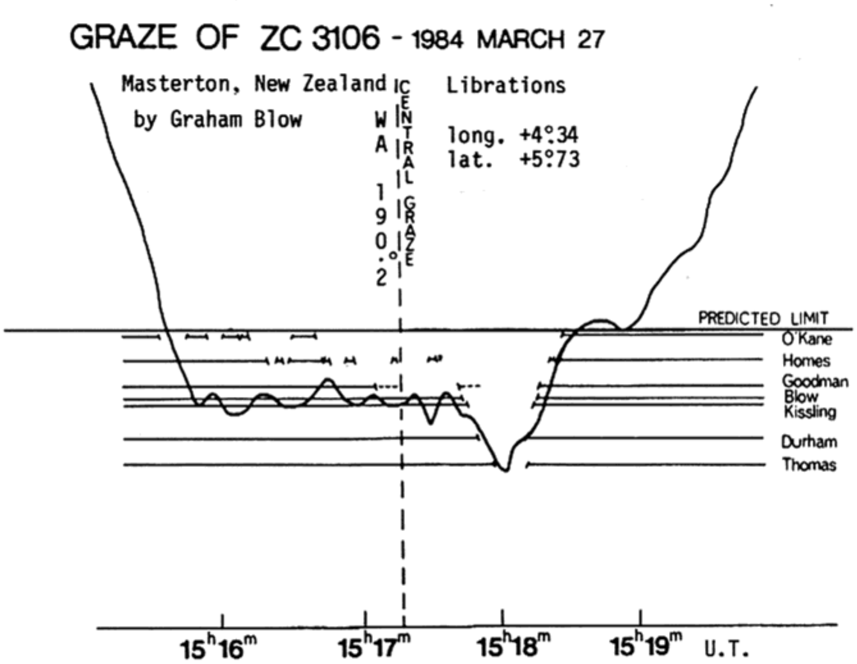
## LAST-MINUTE ADDENDUM — CHARGE CARDS

The IOTA Board of Directors has approved the charge-card arrangement (see p. 180) conditional only on our not having to pay more than a nominal annual fee in addition to the standard 4% charge on purchases. Our banker assures us that as we will be using our own typewriter rather than renting an imprinter, there will be no additional charges. You now may use your VISA or MasterCard for payments to IOTA if you find that to be to your advantage; when you write, specify which card you are using, and include your signature and all the information in the raised lettering. Card users must pay the full prices, which are shown below, followed by the discount prices in brackets for the use of those paying by cash, check, or money order.

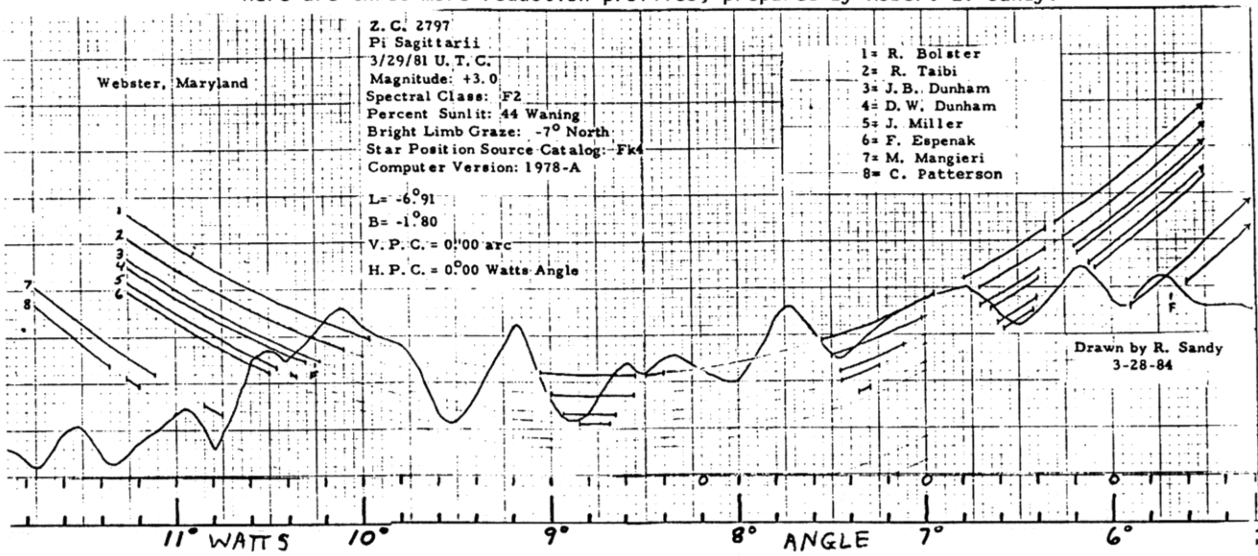
*o.n.*'s price is $1.44[1.40]/issue, or $5.72[5.50]/year (4 issues) including first class surface mailing. Back issues through *Vol. 2*, No. 13 still are priced at only $1.04[1.00]/issue; later issues @ $1.46[1.40]. Air mail shipment of *o.n.* back issues and subscriptions, if desired, is 47¢[45¢]/issue ($1.87[1.80]/year) extra, outside the U.S.A., Canada, and Mexico. IOTA membership, subscription included, is $11.44[11.00]/year for residents of North America (including Mexico) and $16.64[16.00] for others, to cover costs of overseas air mail. For IOTA members, graze predictions and the photoelectric Supplement are available without extra charge; non-members pay $2.08[2.00]/graze prediction, and $1.04[1.00] for the photoelectric Supplement.

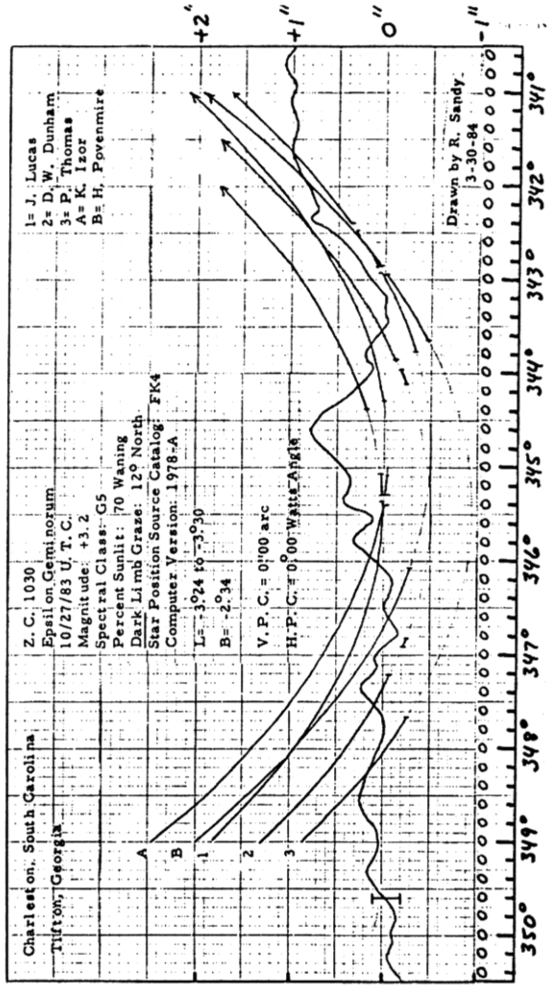
## OBSERVED PROFILES OF GRAZING OCCULTATIONS

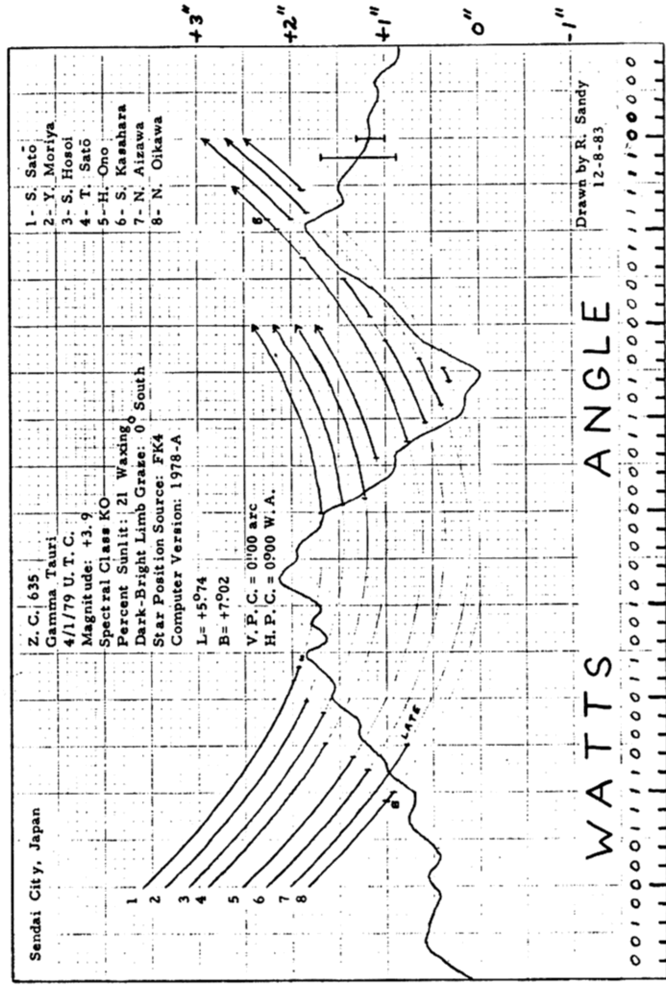
Prepared by Graham Blow



Here are three more reduction profiles, prepared by Robert L. Sandy.

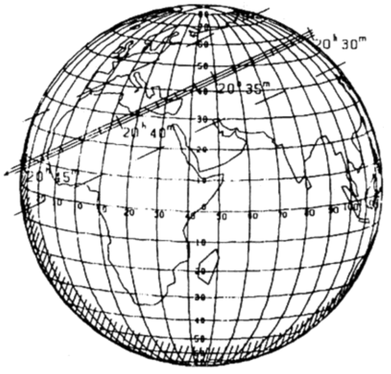


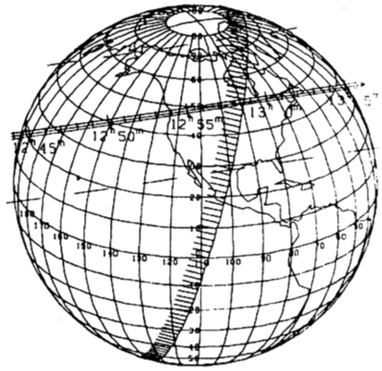




## PLANETARY OCCULTATIONS DURING 1984-5

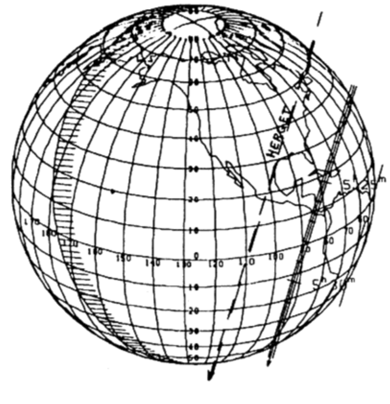
[The remainder of this issue is a continuation of the article "Planetary Occultations During 1984," by David Dunham, which began in *O.N.* *3* (6), pp. 119-146, and was continued in *O.N.* *3* (7), pp. 151-156, and in *O.N.* *3* (8), pp. 170-178. World maps are by Mitsuru Sôma. Regional maps and finder charts are by David Dunham.]



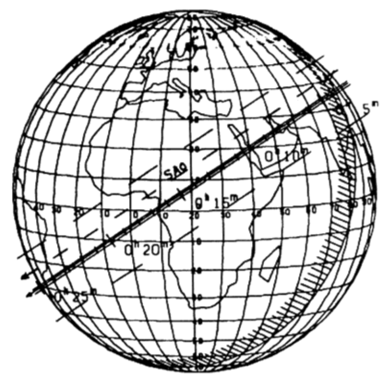

Anonymous by Doris 1984 Nov 2



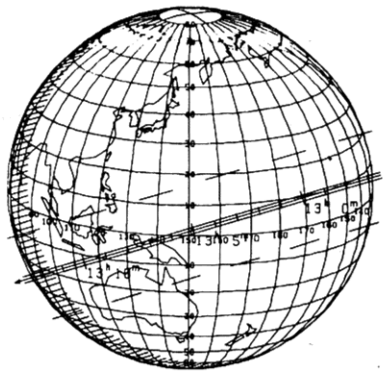

Anonymous by Hermione 1984 Nov 4



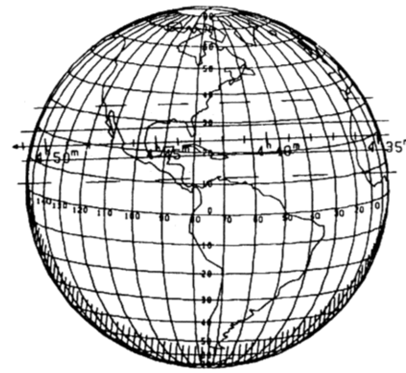

DM +23° 6 by Pretoria 1984 Nov 8



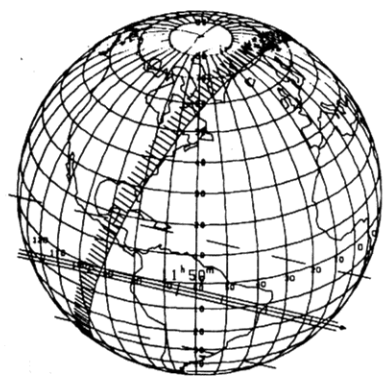

SAO 112399 by Hypatia 1984 Nov 12



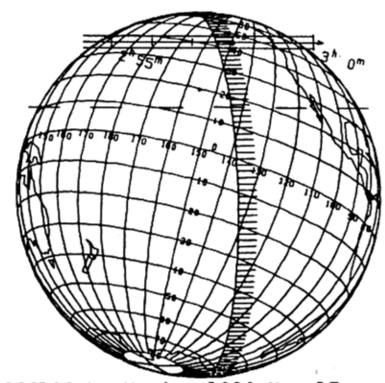

Anonymous by Themis 1984 Nov 12



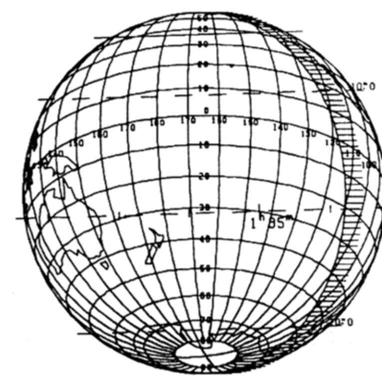

DM +08° 471 by Ceres 1984 Nov 13



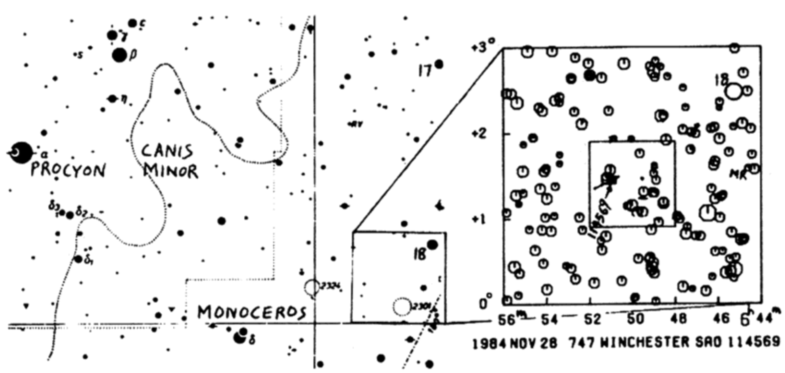

Anonymous by Euphrosyne '84 Nov 15



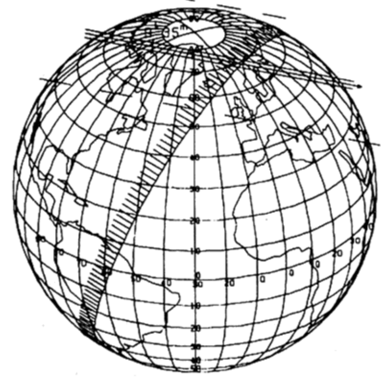

L946104 by Hygiea 1984 Nov 17




SAO 186841 by Venus 1984 Nov 19



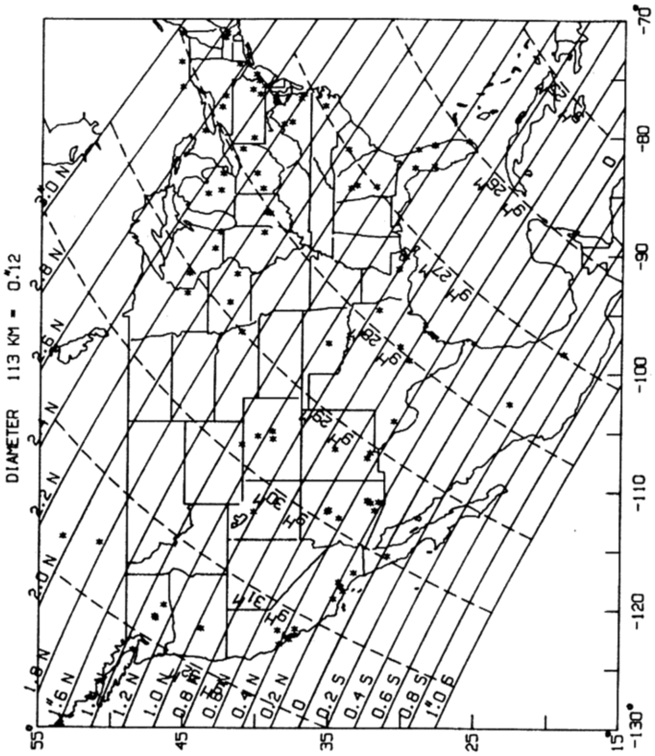

1984 NOV 28 747 WINCHESTER SAO 114569



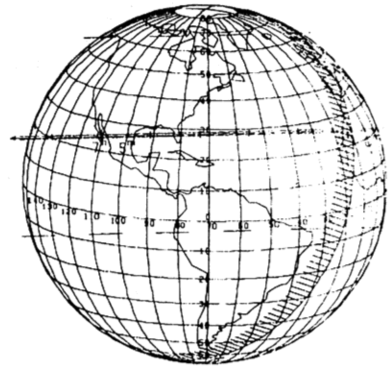
Anonymous by Euphrosyne '84 Nov 22

1984 11 24 (751) FAÏNA 80 +17° 796

DIAMETER 113 KM = 0."12



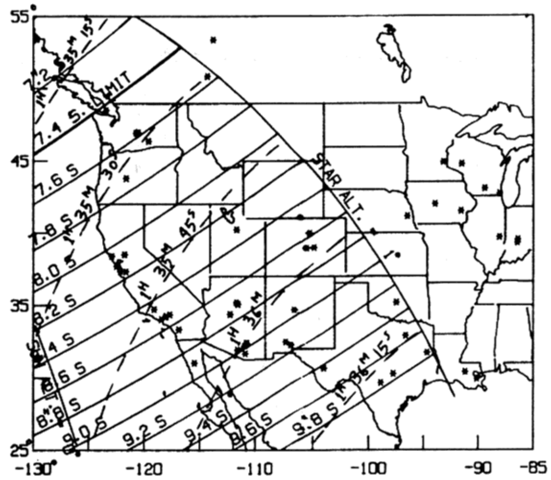

EPHEMERIS SOURCE = EMP 1982



Anonymous by P/Halley 1984 Nov 23

1984 11 19 (2) VENUS SAO 186841

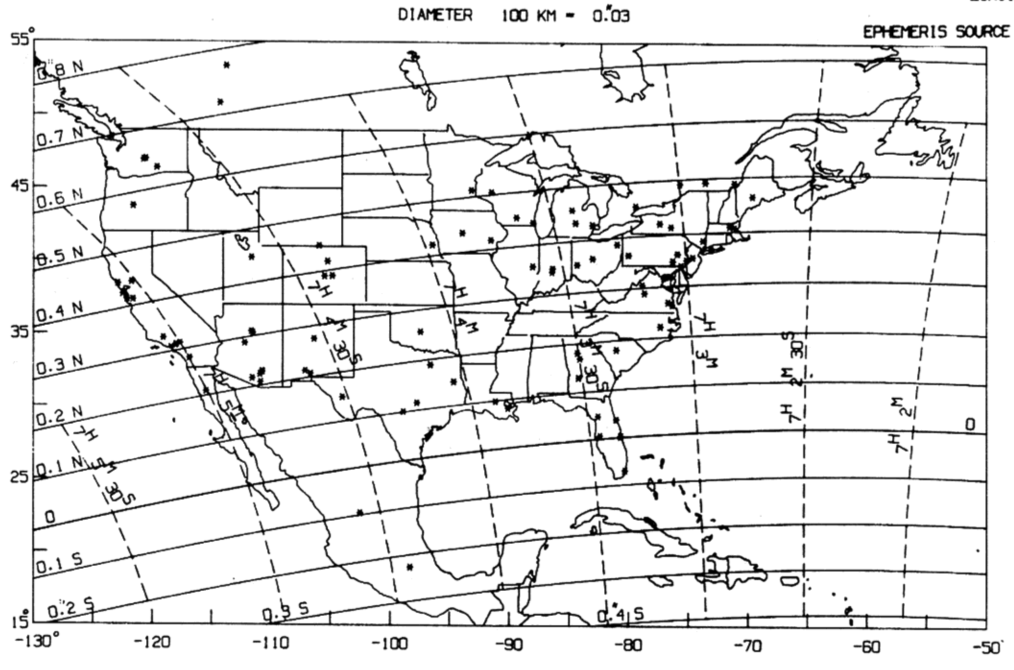
DIAMETER 12220 KM = 14."81



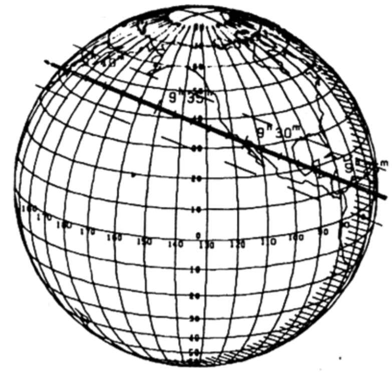

EPHEMERIS SOURCE = NA0001

1984 11 23 (1) P/HALLEY "A" ON FINDER CHART

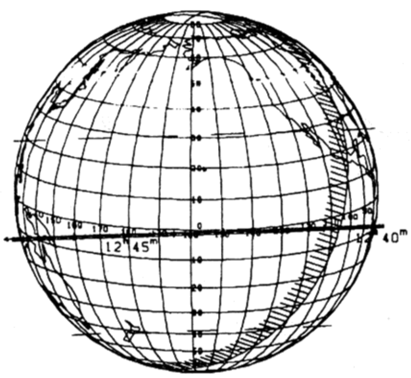
DIAMETER 100 KM = 0."03




EPHEMERIS SOURCE = YEOMANS7



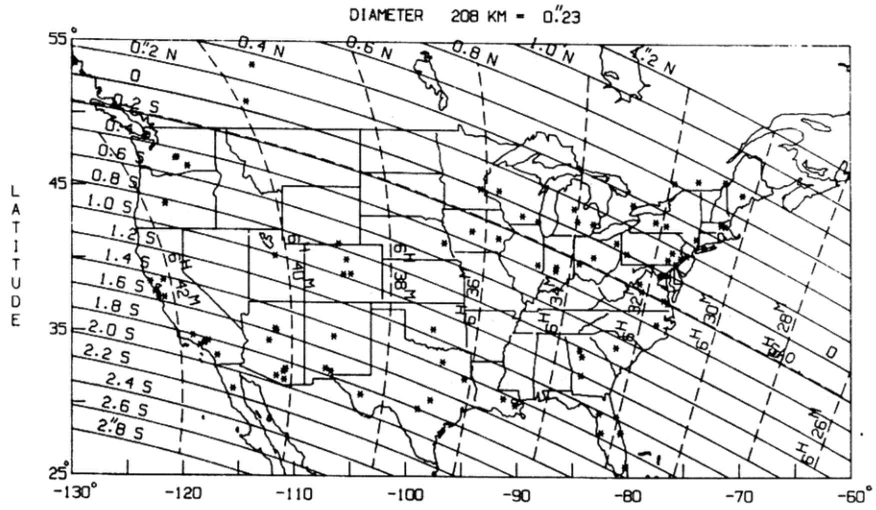
DM +17° 796 by Faïna 1984 Nov 24



Anonymous by P/Halley 1984 Nov 24

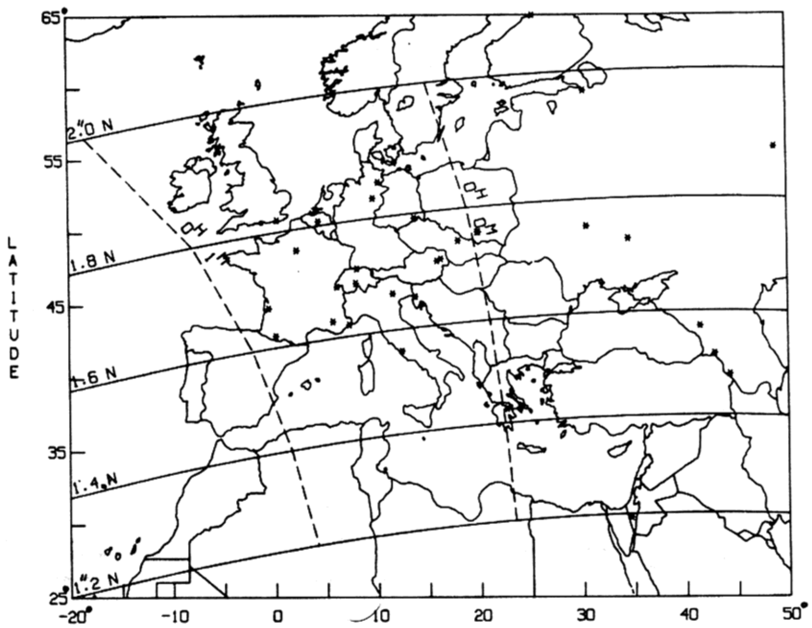
Anonymous by P/Halley 1984 Nov 25

1984 11 28 (747) WINCHESTER SAO 114569
DIAMETER 208 KM = 0."23

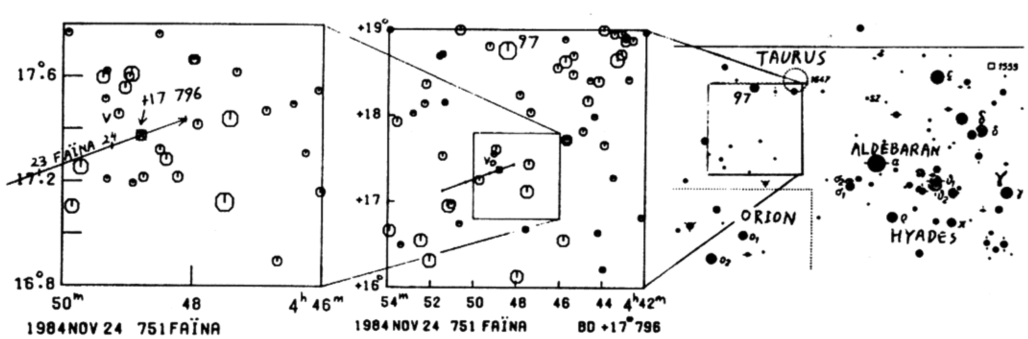


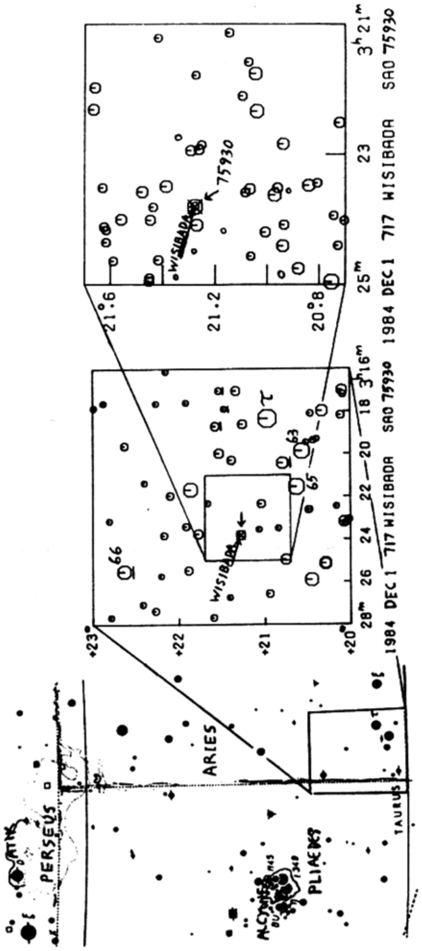

EPHEMERIS SOURCE = HERGET78

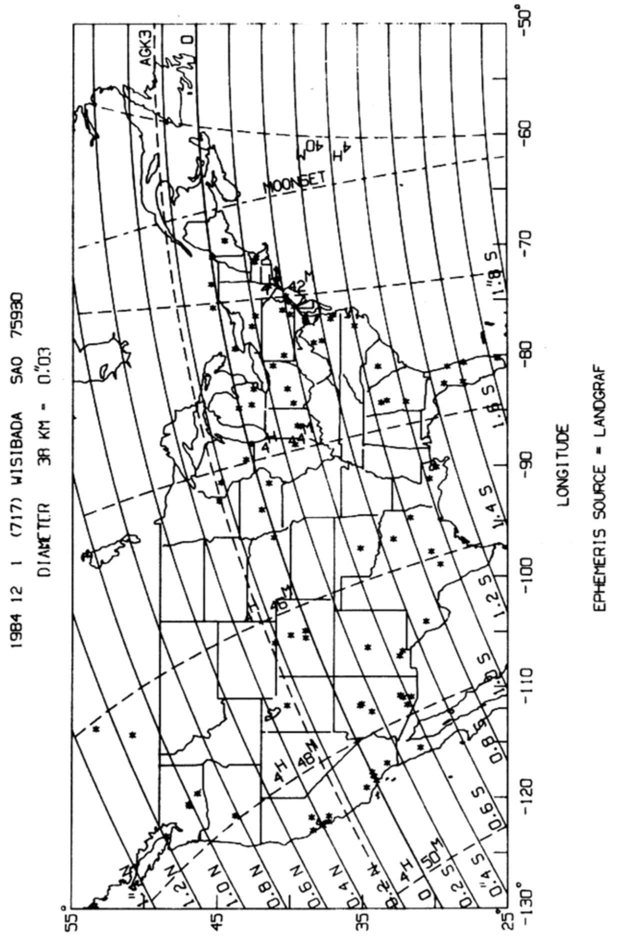
1984 11 25 (1) P/HALLEY FINDER CHART STAR "C"
DIAMETER 100 KM = 0."03




EPHEMERIS SOURCE = YEOMANS7

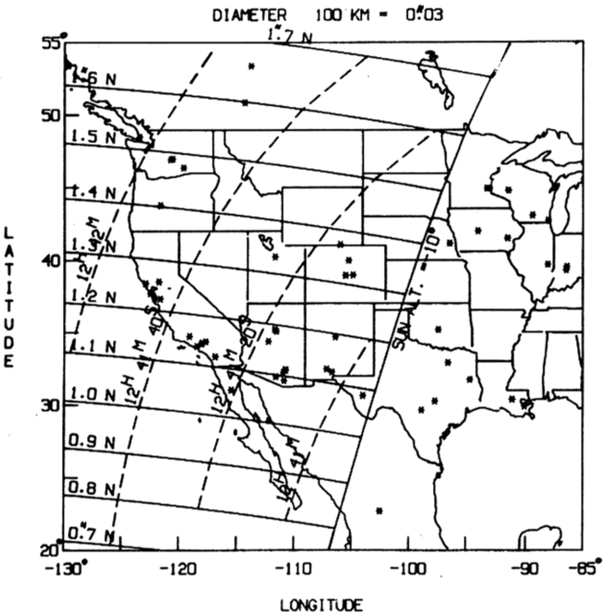





1984 11 24 (1) P/HALLEY FINDER CHART STAR "B"

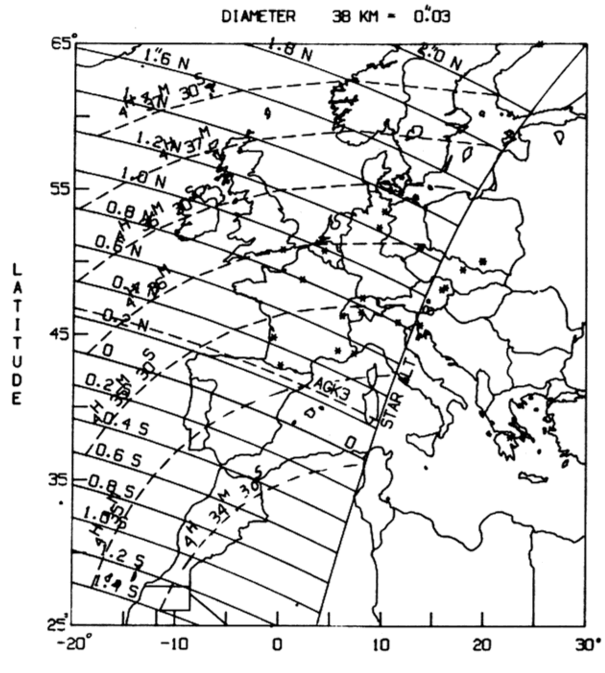
DIAMETER 100 KM = 0".03




EPHEMERIS SOURCE = YEOMANS7

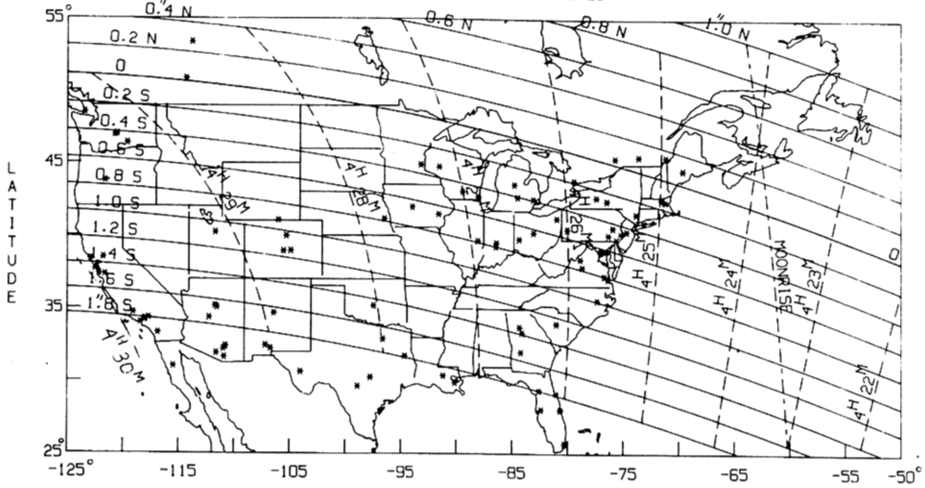
1984 12 1 (717) WISIBADA SAO 75930

DIAMETER 38 KM = 0".03



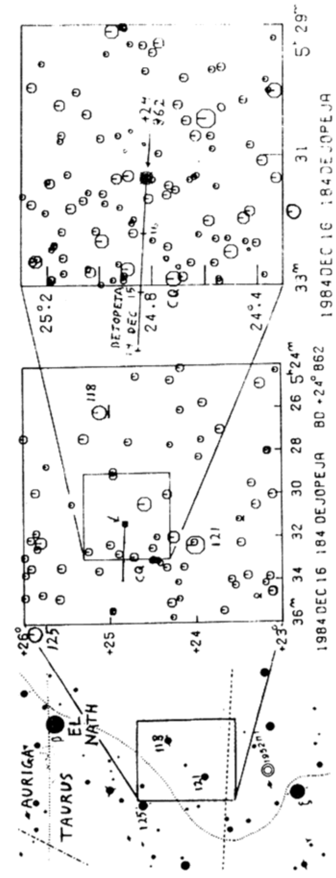

EPHEMERIS SOURCE = LANDGRAF

1984 12 16 (6) HEBE
DIAMETER 186 KM = 0."20

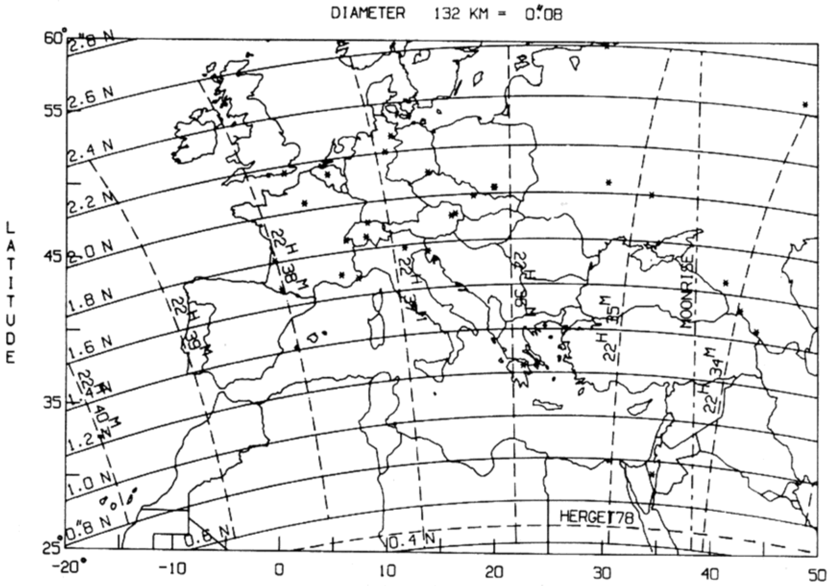



LONGITUDE

EPHEMERIS SOURCE = BRANHAM

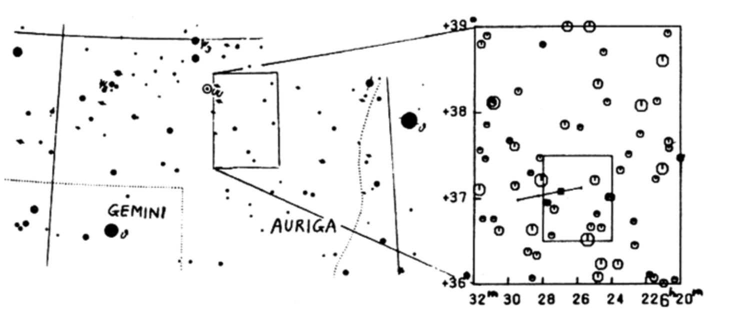



1984 12 16 (184) DEJOPEJA BD +24° 862
DIAMETER 132 KM = 0."08

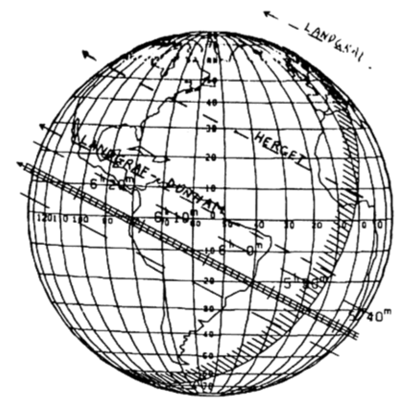



LONGITUDE

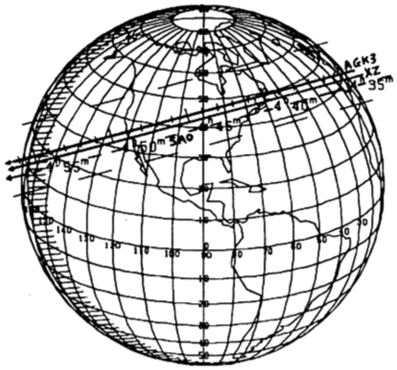
EPHEMERIS SOURCE = EMP 1983




1984 DEC 17 161 ATHOR SAO 59154

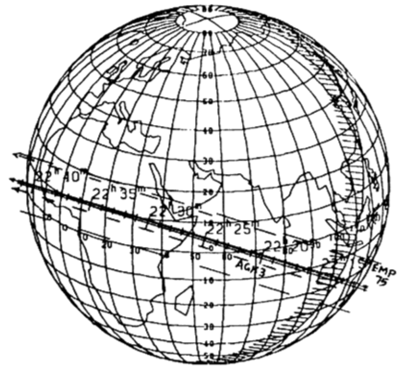



SAO 114569 by Winchester 84 Nov 28



SAO 75930 by Wisibada 1984 Dec 1

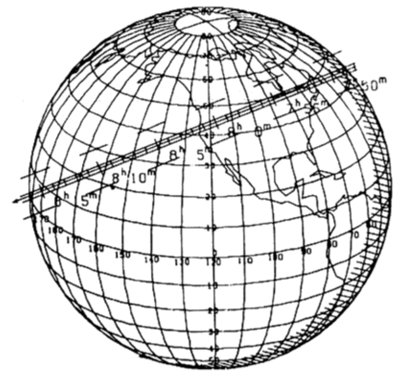
Anonymous by Iris 1984 Dec 1



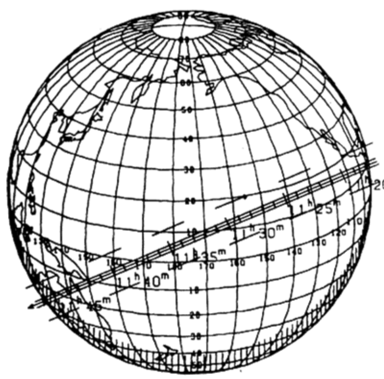
SAO 78926 by Harmonia 1984 Dec 3

Anonymous by Iris 1984 Dec 7

SAO 100286 by Berbericia 84 Dec 10



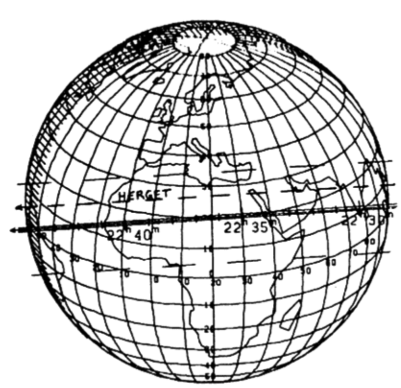
Anonymous by Iris 1984 Dec 13



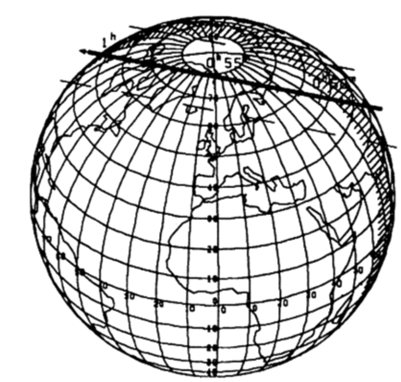
Anonymous by Iris 1984 Dec 14

SAO 109396 by Tercidina '84 Dec 15

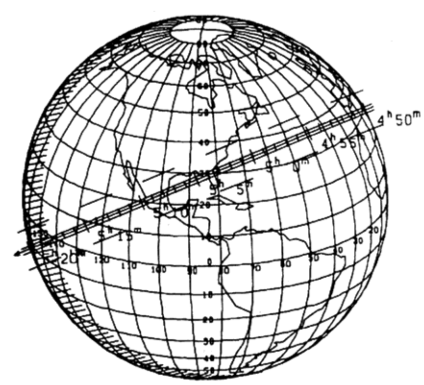
Anonymous by Hebe 1984 Dec 16



DM +24° 862 by Dejopeja '84 Dec 16

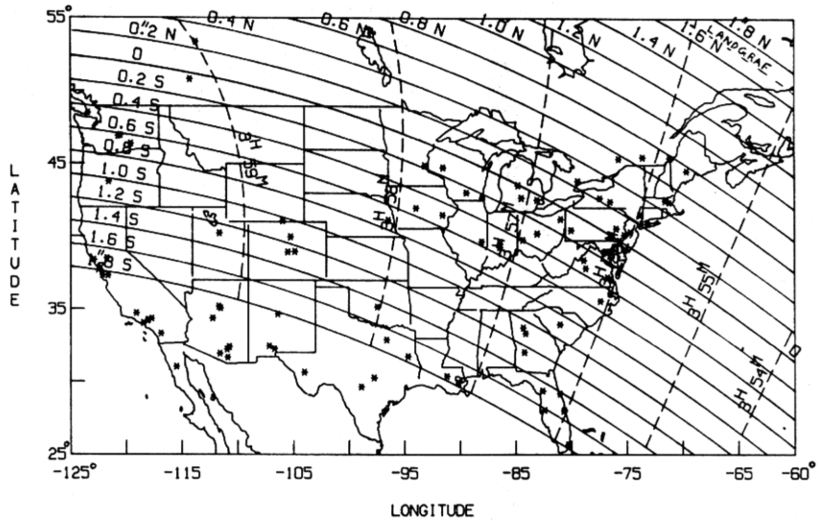


SAO 59154 by Athor 1984 Dec 17



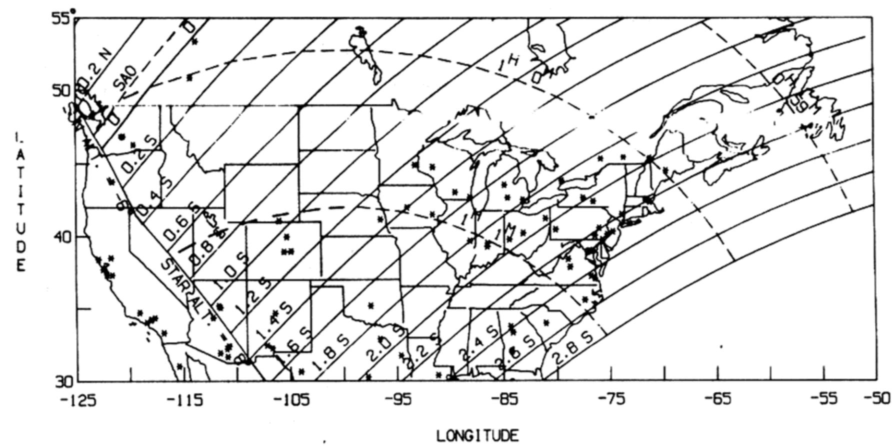
Anonymous by Iris 1984 Dec 20

1984 12 22 (747) WINCHESTER
DIAMETER 208 KM = 0."24



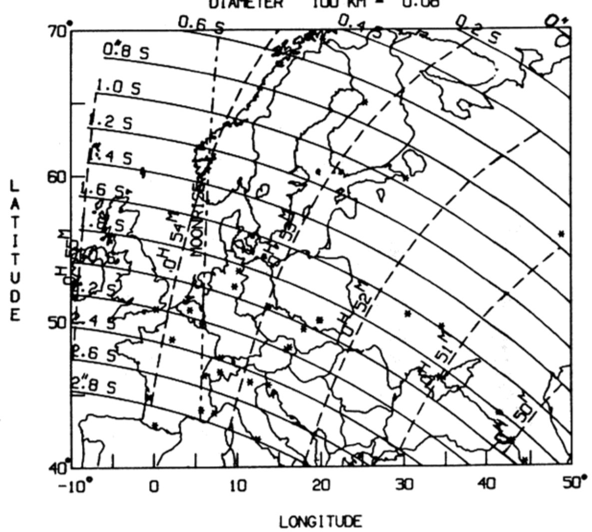

EPHEMERIS SOURCE = EMP 1982

1984 12 17 (161) ATHOR SAO 59154
DIAMETER 100 KM = 0."08

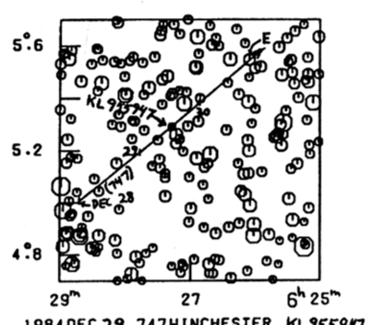



EPHEMERIS SOURCE = EMP 1981

1984 12 17 (161) ATHOR SAO 59154
DIAMETER 100 KM = 0."08

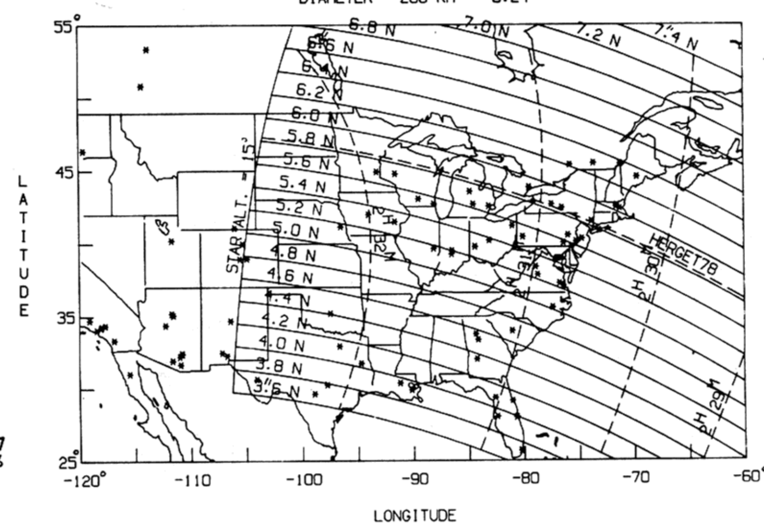



EPHEMERIS SOURCE = EMP 1981

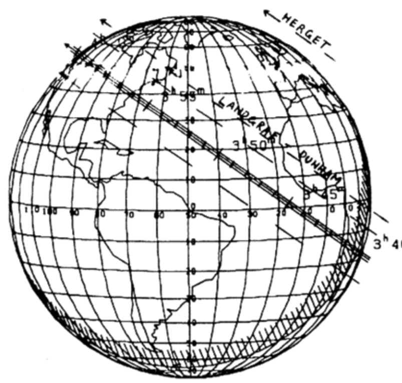



1984DEC 29 747WINCHESTER KL955947
&30 "E" MAG. 10.6

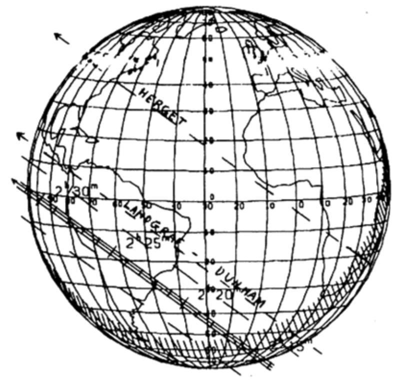
1984 12 23 (747) WINCHESTER
DIAMETER 208 KM = 0."24



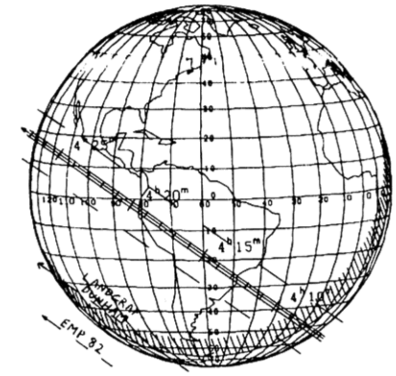

EPHEMERIS SOURCE = EMP 1982



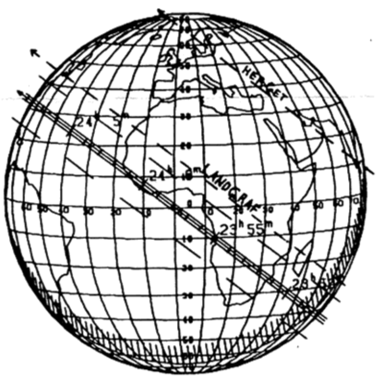

Anonymous by Winchester '84 Dec 22



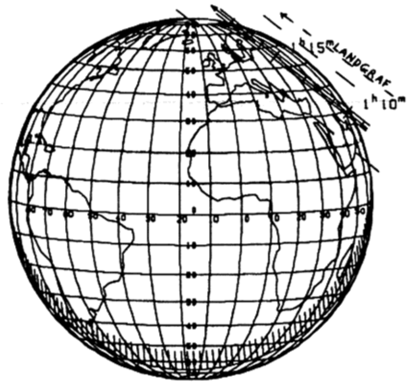

Anonymous by Winchester '84 Dec 23




Anonymous by Winchester '84 Dec 23

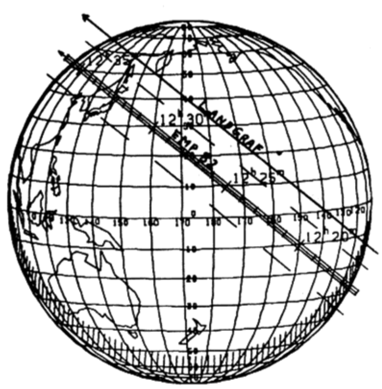



DM +4° 1312 by Winchester Dec 25



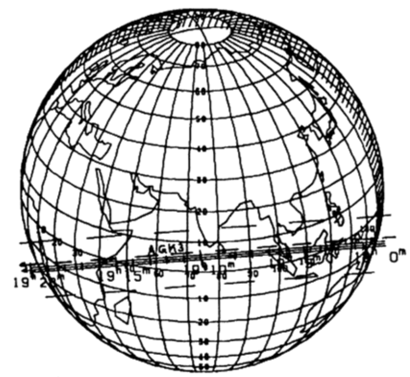

Anonymous by Winchester '84 Dec 27


Anonymous by P/Halley 1984 Dec 27

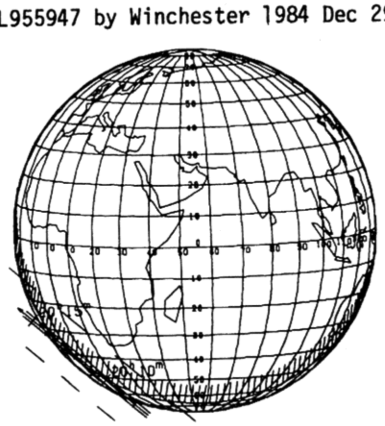



KL955947 by Winchester 1984 Dec 29

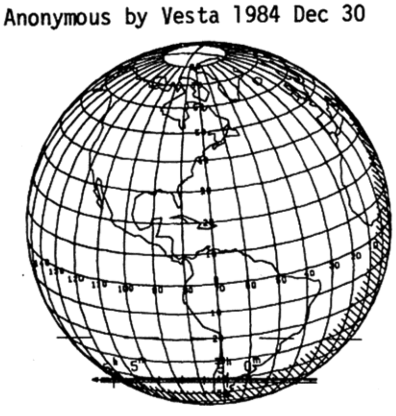
Anonymous by Vesta 1984 Dec 30



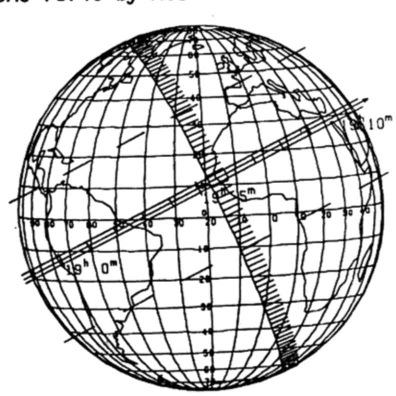

SAO 78743 by Ate 1984 Dec 30



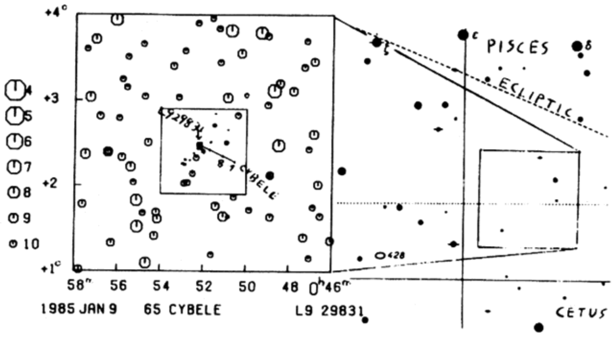

Anonymous by Winchester '84 Dec 30

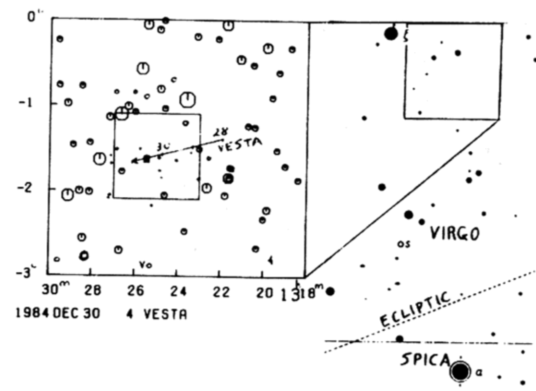



SAO 96300 by Nuwa 1984 Dec 31

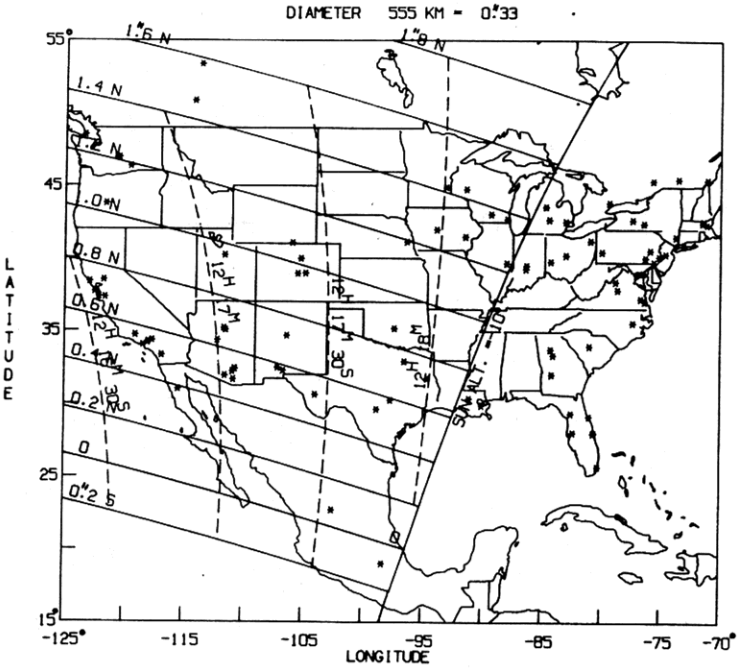



L929831 by Cybele 1985 Jan 9



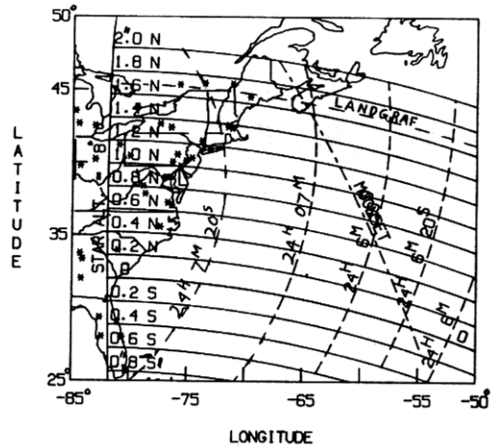




1984 12 30 (4) VESTA
DIAMETER 555 KM = 0".33



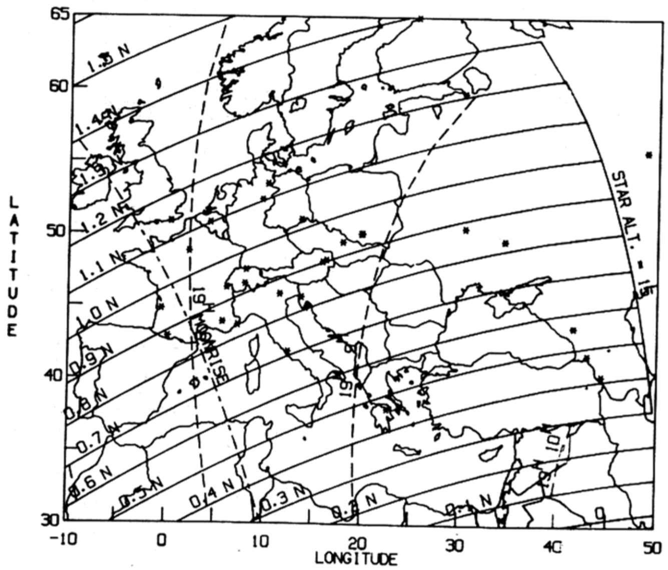

EPHEMERIS SOURCE = APAENAXX

1984 12 25 (747) WINCHESTER BD + 4° 1312
DIAMETER 208 KM = 0".24



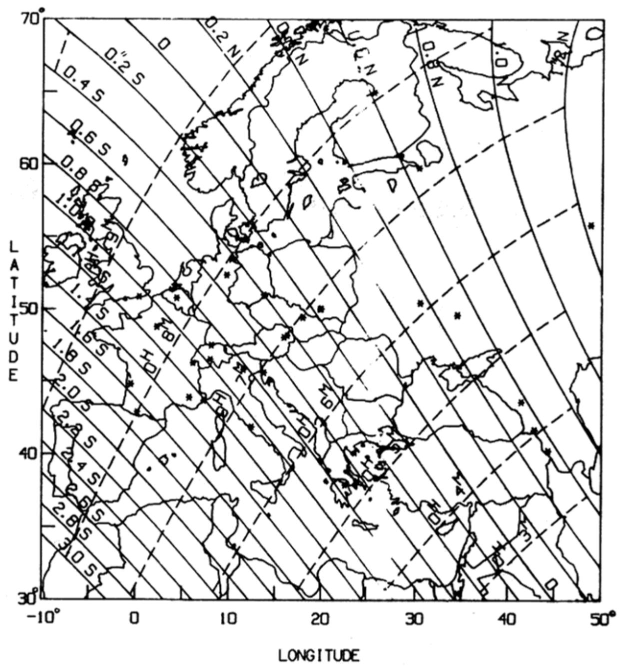

EPHEMERIS SOURCE = EMP 1982

1985 1 9 (65) CYBELE L929831
DIAMETER 311 KM = 0.12




EPHEMERIS SOURCE = EMP 1975

1984 12 26 (747) WINCHESTER BD + 4° 1312
DIAMETER 208 KM = 0".24




EPHEMERIS SOURCE = HERGET78