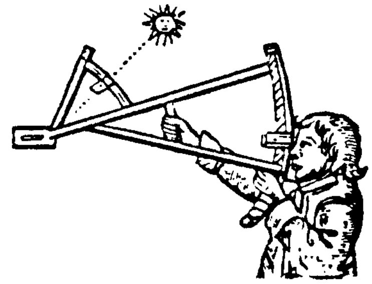
THE NAVIGATOR'S NEWSLETTER



FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION ISSUE ONE

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

The first year of the Foundation has been spent largely in the bureaucratics of getting organized including a long but successful debate with the IRS regarding our tax-exempt donations. During this period the President gave a lecture on celestial navigation at a joint meeting of the Franklin Institute and the Philadelphia Maritime Museum. The talk was given in the Planetarium of the Institute and had a record attendance, which encouraged an official of the Institute to initiate a course in celestial navigation.

The Navy League supports a nationwide organization know as the Sea Cadets in which youths interested in the sea have a chance to learn the maritime skills by experience. We have made initial contact there with a view to sponsoring a celestial navigation course as an award for excellence, to a cadet selected by the Navy League.

We have done some work on a project to establish a race (with a cup) in which the winner will be the navigator with the best precision in his celestial sights, while sailing (or cruising) an actual course. We expect to be contacting an appropriate group shortly about organizing and conducting such a race.

NAVIGATION NOTES

POWER OF SEXTANT TELESCOPES

Many sextant purchasers are offered an "extra" monocular for the sextant of their choice -- which usually comes equipped with a Galilean Telescope of about 3 power as standard. The extra cost monocular is usually 5 or 6 power. The choice turns on some simple physics not always available, but given here in simple form.

First, better precision goes with higher power; your average error with the sextant "clamped" in laboratory conditions, will be cut in half if you double the power. The underlined words, however, are the problem. There is the natural tremor of human hands, even under the best conditions. At 6 power this is exaggerated 6 times, so it is harder to keep the star in the field and get a match with the horizon. However, this motion alone is not prohibitive at 6 power. When an average boat motion is added, only the most professional and experienced celestial navigator can really use that instrument. Most users will find that they simply cannot keep the star in the field and get a reasonable match. The motion degrades precision more than the power improves it. The sun is harder to lose than a star but you will probably find 6 power too much even there. Usually the 6 power accuracy will be no better than the 3, even on the sun. Lower powers are frequently available in the monoculars and are to be preferred. Five power or four power are usable and under some conditions of motions will reduce your errors.

The Galilean telescope is often downplayed by sextant salesmen, perhaps to generate an interest in the monocular. In fact it is an excellent optical instrument that will get more light into your eye (where it counts) because of its fewer glass surfaces. Light-gathering power of any scope is often misunderstood. The night-adapted human eye has an opening (iris) of about seven millimeters maximum and all of the light gathered by the scope must pass through that opening to be used. This constrains the telescope power for any given objective diameter and vice versa. Thus, for a 4 power glass, an objective diameter of 7 x 4 = 28mm is the maximum useable size. Larger objectives will gather more light but they cannot get it into your eye. Smaller objectives will not give you as much light as they should. A 3 power scope should have an objective (front) lens of about 21mm.

Actually, there is another reason for a larger front lens in the Galilean scope, because its Angular Field is limited by its front lens F-ratio, which is the ratio of its focal length to its diameter. For a good angular field the scope then becomes "fat"-- that is, the front lens diameter is large compared to the length of the tube.

Finally, a word about weight. The monocular adds considerable weight to an already heavy instrument. There are many who say that weight is essential to steadying the sextant and therefore, useful. There is some merit to that argument but in many cases it is overwhelmed by the simple labor of holding up a brass sextant under conditions of considerable ship motion. Many who have tried the plastic sextant have found that elimination of the fatigue factor gives them good results.

NOTE ON USING THE SPLIT-SILVERED MIRROR

The normal sextant has a horizon mirror which is half silver and half clear for viewing the horizon. There are now other options and I will discuss some of these later. To get the most out of your split-silvered mirror you should understand the following simple ideas. While the split appears as a clear sharp line to the eye, one of the advantages of using even a low power telescope is that this line of demarcation is de-focussed. This means that some of the horizon view can overlap the sky or star viewed in the silvered portion; and similarly some of the sky (including the star) can overlap the horizon view. Although the light reflected is reduced in the overlap area , as is the light transmitted, nonetheless this area is the optimum place to match the star with the horizon. The width of this area is a significant portion of the entire field and you can get best results if you keep the star in this area according to this rule:

When the star is bright but the horizon is dim, keep the star to the left side of the area of overlap and vice-versa.

You may already do this to some degree instinctively, but it is better to plan to do it, particularly when "dipping" the star where it is sometimes allowed to depart from the correct position.

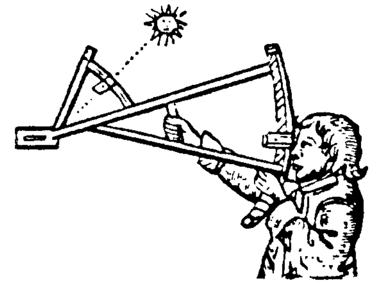
PLANNING PRECOMPUTED SIGHTS

In setting up the times for sights in advance, it is better if the assumed sighting times are about two or three minutes apart. The times should also be sequenced to allow for the sequence in which the stars appear. In a clear sky, as twilight progresses, the first stars will appear overhead or at relatively high altitudes, about 50° or better. The next star appearances will be the hemisphere opposite the Sun's bearing. Finally, the last stars will appear in the direction of the sunset and that will also usually be the last available horizon. When picking your stars to precompute, note their altitude and azimuth to permit sequencing the time for this anticipated visibility. If clouds obscure some areas of the sky, you will still find what stars are available will be in this sequence and so you will get them with minimum time wasted.

FUTURE ISSUES

Items for future issues include hints on navigational techniques, book reviews, some interesting footnotes to navigation history, and a READER'S FORUM. Send questions/suggestions to: Foundation for the Promotion of the Art of Navigation, P.O. Box 1126, Rockville, MD 20850.

THE NAVIGATOR'S NEWSLETTER



FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION ISSUE TWO

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

Of course our most important activity since the last Newsletter has been the membership drive which was kicked off with a bulk mailing by which you received your first issue of the Newsletter. The membership is off to a good start with enough revenue from donations to keep the Newsletter going for the remainder of the year. However, our other activities to promote navigational interest and expertise will generate a need for revenue growth. To meet this we are:

a) Organizing a second mailing to stimulate additional interest.

b) Getting articles about the Foundation published in appropriate magazines.

c) Asking each of you current members to make an effort to enroll some others. If you prefer to simply send us names and addresses of good prospects, we will contact them by mail. Extra membership forms are enclosed.

d) Seeking donors who would be willing to donate larger amounts than the minimum $25 suggested.

READERS FORUM

One of the pleasing results of our mailing was the substantial number of you who wrote letters with your membership requests. These letters were too numerous to reproduce in full, but I will try to summarize them here, providing answers where appropriate.

With one exception (from a famous source of electronic navigation R&D), all letters were enthusiastic about the idea of our Foundation, noting that the preponderance of electronic navigation devices created a need for a focus on the individual and the basic skills which must always be in the background of anyone who ventures to sea. Several writers teach courses in navigation in various parts of the country which suggests that it would be useful for the Foundation to publish an index of such courses for the convenience of members who may be asked where one can go to learn navigation. We propose to start such a list with our next Newsletter.

A number of members recommended that the Foundation adopt a shorter name for business purposes. We agree with this and after some consideration we have decided to have a short title, "The Navigation Foundation," which can be used on checks or wherever the members desire. This short title will appear in quotes on our stationery under our full name which is registered with the IRS in connection with our tax-exempt status. This status makes gifts and donations fully tax deductible.

One of our members, Capt. Shuffelt, has long been a distinguished expert in navigation and takes exception to some of my notes on the sextant telescopes as follows:

"First, as to sextant weight -- the heavier, brass framed sextant tends to dampen out tremor more than the lighter aluminum model. For years, professional navigators almost unanimously bought the heavier model from C. Plath.

"As to telescopes, I cannot overstress the importance of a well-fitting rubber eye cup, which serves to tie the sextant into the bony structure of the skull, and also keeps out cold air. As to magnification, as Professor Smiley, of Brown, pointed out in his report to ONR, a 6x is the least with which one can hope to discriminate to 0.1 minutes. Smiley also stressed the importance of much practice -- observers continuing to improve after taking 2,000 sights.

"I am convinced that the greatest difficulty besetting the competent observer is the horizon."

His expertise in this area far exceeds that of the average navigator including most professionals, however, I stand on my view of power for all but the real expert. Other members' experience would be interesting to hear about.

Navigators David and Elsie Nelson asked about how to apply a Venus "phase" correction that appears as a small table in the Nautical Almanac (page 259-1983) and seems to require an angle θ which is not readily available. Paul Janiczek of the Nautical Almanac Office advises that the correction is essentially zero in 1984 and will be folded into the Venus Daily GHA and Dec Tables by 1985.

Another of our expert members, Dr. Allan Bayless, disagreed with my remarks upon the light-gathering power of telescopes, citing the typical 6 inch objective of an amateur astronomer's telescope as an indication that objectives larger than 28mm are useful. Of course my statement referred to a <u>4x power</u> telescope which cannot get any more light than from a 28mm objective into the pupil. In the case of the 6" scope, the power of the eyepiece must be at least 22x in order to get all of the light into the pupil. That is, 7 x 22 = 154mm which is about 6 inches. To make the point once again: a 7x glass cannot usefully employ an objective larger than 7 x 7 = 49mm. (Hence, the well-known 7 x 50 binocular, rated as a "night glass.") Thus to determine the optimum size of objective we multiply the power (in diameters) by 7mm, the nominal aperture of the night-adapted human eye.

Capt. Norman Cubberly also disagrees with the remarks about the virtues of the Galilean telescope. He cites a very extensive and impressive experience in taking sights, both navigational and surveying (marine) and feels that he could never have done these with a 3 power Galilean, but used a 6.5x on a German sextant. As mentioned before, my comments were more oriented toward the average yachtsman than the expert professional, and the limitation the non-professional will find in the high-power glass is from hand-tremor and ship's motion. These can be minimized by extensive training but never eliminated.

Incidentally Capt. Cubberly says he never expects better than 1 arc-minute accuracy, and then gives some excellent rules for increasing expertise in using the sextant:

"Training is required. I trained myself, then I trained others.

"Never hold the sextant up for more than 60 seconds.

"Use shade glasses or the astigmatiser on stars. <u>Light gathering power is not the problem as the bright star obscures a weak horizon.</u> "

Capt. Michael Iacona, Sr., writes that he considers celestial navigation only a part of the "Art" of navigation and urges that we consider other aspects as well. He also brings up an interesting point on the use of "Electronic Bulletin Boards" to provide technical data to computer users via telephone line.

A member has asked how to get a copy of Ageton's table (H.O. 211). The book reviewed in this issue is one answer. Another would be to write to Weems & Plath in Annapolis who sell a spiral bound reprint of Ageton. Finally, Donald J. Pegg of 1122 South 7th Street, Fort Pierce, Florida 33450 tells me that he has several original copies of Ageton's and may be willing to part with one.

NAVIGATION NOTES

PACKING THE SEXTANT FOR SHIPMENT

These remarks are from a note from Dale Dunlap.

The sextant is a delicate instrument which can be damaged quite easily in shipment if not properly packaged. The instrument case in which all high quality sextants are supplied is intended primarily for hand carrying and for storage of the sextant. It is not sufficient to fasten the sextant in the case, and expect it to survive the rough handling of shipping. By observing the following precautions sextants can be shipped safely by common carrier:

1. Release the tangent screw from the gears on the frame and secure the release mechanism in this position. If this is not done the precision gear teeth will be damaged.
2. Secure the index arm to the sextant frame so that it will not swing along the arc.
3. Fasten the sextant in the holder in the instrument case.
4. Pack all extra space in the instrument case with crumpled tissue paper or newspaper. The retaining unit in the box will not always hold if the shipping case is dropped or thrown and this inner packing prevents the mirrors from hitting the lid of the box.
5. Place the instrument case in a large new cardboard shipping carton so that there will be at least three or four inches of packing on all sides. The cardboard shipping carton will cushion more shocks than an outer wooden box.

FILTERS

Every sextant comes equipped with optical filters for observation of the Sun and to permit use of very bright horizons associated therewith. It is worth a little time to examine these, particularly when considering the purchase of a sextant.

First of all, they should be of glass or of special plastic to ensure your eye is protected from the harmful effects of the Sun's very intense ultraviolet (U.V.) light. It is this U.V. which causes sun damage to the skin, plastics, paint, etc., and it can be devastating to the eye.

The filters should each have plane-parallel surfaces so that they do not introduce errors into the sight. The horizon is viewed through one set and the Sun through another and a wavy surface on either can generate an error in the sight.

Many sextants provide several colors in the filters for those who believe that so doing aids in picking out the Sun in a broken sky. Because most sextant telescopes are not completely color-corrected it is important that whatever color is used produces a nearly monochromatic image. Some blue filters are notorious for passing red light as well -- which accentuates any lack of color correction in the scope and produces a Sun image with color fringes on the edges.

EVENING VS. MORNING STARS

As several of our letters noted, the problem in a celestial sight is usually the horizon more than the star. As a result, evening star availability terminates with the disappearance of the horizon -- usually before you realize it. On the other hand morning stars can be held and used (once located) on into almost broad daylight -- while the horizon is getting better and better. Therefore start your evening stars early, use precomputation to locate them. When there is a choice between evening and morning stars, always choose the latter.

BOOK REVIEW

COMPACT SIGHT REDUCTION TABLE
(MODIFIED H.O. 211, AGETON'S TABLE)
Allan Bayless. 32 pp. Cornell Maritime Press, Centreville, MD 21617. 1980
$4.50

One might subdivide the community of users of celestial navigation tables into those who prefer compendia of answers or solutions of the celestial triangle, from which they select the relevant solution for their specific sight, and those who prefer the compact type of table which simply provides the mathematical tools to reduce the sight but requires substantial table-entries, somewhat complicated rules and addition and subtraction of multidigit numbers. Certainly this latter group will be pleased and intrigued by Dr. Bayless' excellent little book. His argument for the use of his table is based upon the need for a fall-back system to cover the possibility of failure of computers or electronic navigation systems. He argues that for such an eventuality the navigator should be satisfied with the most compact, effective method.

It has been argued that the multiple digit additions, table entries etc., of the compact table appeals to a type of navigator who is basically more meticulous than the average and whose inclination towards precision and orderliness (a desirable trait in any navigator) may well compensate for these opportunities for error. Precision is further improved by the use of DR position rather than a position assumed to generate integral degree hour-angle and latitude.

Dr. Bayless has taken an old (but still used) method developed by Arthur Ageton in the early 1930's, instituted some simple but effective improvements and corrected a few errors resulting from the original calculation with six-place logarithm. The result has been neatly packaged by Cornell Maritime Press and yields a clear, easily readable table of only nine pages. The instruction and ancillary pages outnumber the tables. Table entries are reduced from those required by the old H.O. 211. The one-half minute entries have been eliminated with a slight loss in precision of the solution, but one which the author contends is unnecessary, considering the precision of the sextant sight.

I find myself agreeing very much with the author on this latter point, recognizing the several observational errors that need to be combined with any table errors. Finally by doubling up on the argument headings, Dr. Bayless has eliminated a duplication resulting from the symmetry of secants and cosecants around 45°. The "rules" for the method are rendered somewhat more complex by these changes, and thereby compound the reasons why some may find this method less than optimum. One is led to wonder whether the reduction from 36 pages to 9 pages is worth the added complexity since the difference in thickness and weight is hard to detect. Overall, however, I find the tables well done and useful.

For order information call Cornell Maritime Press at 800-638-7641.

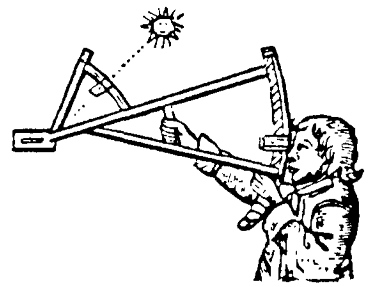
FUTURE ISSUES

In future issues we will continue our navigation notes and expect continued participation by correspondents. Our Awards Program will be outlined shortly and we will furnish details of a Race for navigators we are now planning. We also have several historical footnotes associated with navigation which I hope that we can squeeze in soon.

Finally, an urgent request for recruiting more members. Please send in names and addresses of interested parties -- or best of all have them write in with their contribution. Also note that contributions are not limited to $25, perhaps there are some who would like to give more. Extra forms are included.

Address all correspondence to:
Foundation for the Promotion of the Art of Navigation, P.O. Box 1126, Rockville, MD 20850.

THE NAVIGATOR'S NEWSLETTER



FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION ISSUE THREE

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

Since the last Newsletter we have recontacted our original mailing list to try to bring in additional members. At the same time we expanded our list of potential interested persons. That mailing was delivered to the Post Office on 26 July 83. While the final results are not yet available - membership requests are continuing to come in from our original mailing, the second mailing and from the announcement in Yachting Magazine (July issue, page 53). We should have announcements in a large number of maritime magazines as well shortly.

Meanwhile we hope that our members are finding time to interest others in applying, using the forms sent out in the last Newsletter. Our efforts to find donors who were willing to donate longer service have produced some early results with several more prospects ahead.

It is a great pleasure to welcome to our Board of Directors three distinguished experts in the field.
Capt. Henry H. Shufeldt, an original associate of P.V.H. Weems in the navigation business, has enjoyed a worldwide reputation in navigation and sailing for a very long period. Commander Dale Dunlop, also a long associate of Capt. Weems in the navigation business, currently operates an antique scientific instrument business in Annapolis.

Both Capt. Shufeldt and Dunlop are best known as the Editors of Dutton's "Navigation and Piloting," 12th edition.

Dr. Allan E. Bayless, our third new Director, has been a sailor, navigator and yachtsman for many years. He has long been active in the U.S. Power Squadrons as vice commander and also as chairman of the Navigation Committee. Most recently Dr. Bayless has published a revised and substantially improved version of Arthur A. Ageton's sight reduction tables (H.O. 211).

This array of expertise and talent will greatly strengthen the Foundation and result in stronger efforts at stimulation of interest in the Art in the near future.

Through the efforts of Director Roger H. Jones we have committed to our initial academic award for navigation. It will be a suitably engraved prize for award to a student at the U.S. Merchant Marine Academy at Kings Point, NY. The winner will be selected by the faculty of the Department of Navigation at the Academy. It is expected that approval from the Merchant Marine Academy will be forthcoming in September. It is hoped other academic awards will follow - with the purpose of inspiring students in the maritime fields and stimulating interest there. We also plan awards in non-academic areas.

Here is our initial index of navigation schools operated by our members. Thus far we only have 3 such schools but as membership increases we should have more. The list should be helpful to individuals who wish to start in navigation or refresh old skills.

1. Starpath School of Navigation
   2101 N. 34th
   Seattle, Washington 98103

   David F. Burch, PhD., Director

2. Land Celestial Navigation School
   1521 West Main Street
   Norristown, Pennsylvania 19403

   William O. Land, Director

3. C. Plath, North America
   (Formerly Weems and Plath)
   Navigation Division
   222 Severn Avenue
   Annapolis, Maryland 21403

   Ed Bergin and Jack Buchanek, Directors

NOTE: Since our membership list is now on a computer we can supply interested members with names of other members in the same area if we have such requests.

READERS FORUM

Letters from new members continue to come with ideas and suggestions. Stafford Campbell of Yachting who does the Practical Navigator department adds his commendation on our efforts and says that he will take note of our activities in his writing. He adds:

"In passing, may I add my comment to two of your articles. I have found after thousands of sights that the Plath 6 x 30' scope represents about the best all-'round compromise, and most certainly, for yachtsmen who attempt star sights, morning stars are much easier than evening - you also have the advantage of working them out in daylight. As for H.O. 211, I always support carrying tables as a back-up, but, for the yachtsman-navigator, I have found Pub. No. 249 to be much easier to learn and use, far less prone to operator error, and not that much more bulky to stow. If space were really at a premium, it would be possible to Xerox the few pages a yachtsman would need on any projected cruise. Vol I., of course, also serves as a convenient star finder, often all that is needed by a small-boat navigator. I'm surprised that the virtue of its compact size continues to keep H.O. 211 alive, overriding its cumbersome procedural requirements."

J. Herbert Watson who heads the Sea Cadet program of the Jacksonville/Mayport Navy League, writes with a list of items he would like to see covered in Newsletter articles:

DLO
Left vs Right Eye Sighting
Theory on both eyes open or one closed for sighting
H.O. 211 vs H.O. 249
Care and Cleaning of Arcs

These items will be covered starting in this Newsletter. Other members with specific requests are invited to send them in and we will do our best to dig out information on them. Finally we have a suggestion from R. J. Mudd that we issue the Newsletter punched for a 3 ring binder.

Capt. Norman Cubberly, Master of R/V Eastwind, writes:

"-Continuing in the controversy over the power of the sextant telescope, I went to the high power when I was no way an 'expert.' I did it because increasing nearsightedness in my right eye made it necessary. My first serious use of it was approaching Bermuda in the 1962 Bermuda Race on the USCG yawl Petrel. The approach was under full moon toward North Rock as a landfall for course change to Kitchen Shoals. I took a Polaris sight every 15 minutes with great ease and crossed the last three with the light for a series of fixes leading to that weakly lit buoy. We were 3rd across the line. I re-did my Polaris corrections only once in 4 hours.

-I agree fully with Capt. Shufeldt as to the value of the heavy brass sextant. Due to the weight, however, I recommend holding it up for as short a time as possible, usually less than a minute.

-Allan Bayless' tables are valuable for several other reasons:

They can be packed into the average sextant box. Many vessels today seem to have lost their sight reduction tables so one must bring his own.

The small boat sailor making all of 100+ miles per day needs room for recreational reading, not massive tables. He can take a running fix around noon every two or three days in the tropics and be quite accurate when far from land.

-I now make a point to all navigators that sextant, chronometer and tables comprise just as much of a 'black box' as does a loran set or satnav. Has anyone silvered a mirror lately in an emergency, or perhaps repaired a chronometer? Celestial Navigation is merely an old fashioned 'black box' requiring a bit more of the navigator than button pushing. One can limp home on meridian transits, even on losing the almanac. When the compass goes, one can do it on the reflection on the thumbnail. The value of Celestial Navigation is that it is inexpensive, requires less repair and relies less on the care of some remote technician to keep the system up. Just don't drop the sextant.

-Whenever travelling with my antique Plath by air, I try to bring it as carry on luggage, sometimes puzzling those at the X-ray machine. I pack it tightly in socks and underclothing, preferably clean, but not necessarily so. I strap the box with a heavy black 3' electronic 'tie-wrap' if I must put it in luggage. Putting the sextant in luggage this way is a fearful but so far successful procedure. (shudder)

-Several comments indicated that the horizon was the real problem when it came to inaccuracies and in learning the sextant. I find this definitely true. I require practice sights after a layoff. I find the high power telescope sorts out the numerous tropical false horizons, that sometimes there is no horizon, that by day when the horizon under the Sun is impossible, it is usually excellent under the Moon or Venus. I calculate the position of the brightest stars for soon after sunset, Sirius 5 minutes after, Capella 8 minutes after, etc. Later they tend to be too bright. It also delightfully confuses the worried scientists on a research vessel who finally spot Venus about when I start working out the fix.

-I am interested in finding persons who have worked night sights with no moon or very little moon. Occasionally I have worked weak stars this way, taking two stars several times. If the plotted lines move correctly across the chart I assume about a 5 mile error. If Polaris is visible, I crank it down to the horizon and then up to the horizon about four times for an average and sometimes good accuracy. Someone else reads the sextant while I keep my night vision. I tend to oppose stars at night rather than taking a 'wheel' feeling that my horizon errors may compensate but being beware of the darker sectors. I once used a 'dipping' running light with fair success and once even tried a calm sea as a artificial horizon but with no luck, even though the two stars I could pick off the water were perfectly reflected.

Keep up the good work."

NAVIGATION NOTES

WHICH EYE?

In sighting each person has a "natural" sighting eye which can easily be determined by the following test. With both eyes open (in daylight), point with whichever hand seems natural or spontaneous, towards some distant landmark.

With your finger still "pointing," close first one eye then the other. With your natural sighting eye open your finger will clearly line up with the object pointed at. With the other eye the finger will be out-of-line.

This simple test will tell you which eye is natural to use in the sextant. To some degree left-handed people tend to point with their left hand and also their left eye; however this is not always true, and this test will give you the best answer. In holding the sextant the left-handed person may have difficulty in getting his coordination organized although the left hand does perform the delicate function of setting the altitude knob.

H.O. 211 VS. H.O. 249

These two tabular methods of sight reduction are really not directly competitive, since they appeal to different types of people. There are many navigators who naturally keep their paperwork meticulous and add and subtract multi-digit numbers with great facility and accuracy. To those of this mind-set the compact table (HO 211) offers advantages of weight, size and ease of handling on the navigator's table. The actual working of the sight takes some increase in time (14 steps to solution), but it can be based on a DR position instead of the "Assumed Position," which generally improves accuracy. Of course its use is not limited to selected stars. Pre-computation for identification, however, takes more time, if that technique is used.

On the other hand while HO 249 is bulky (volumes for sun/planets and stars) it allows reduction of a sight with a minimum of arithmetic and time. For many persons whose addition and subtraction (particularly the latter) is not too reliable - and may be a chore - HO 249 offers an excellent method of sight reduction. It is, however, limited to 7 stars (Volume I) selected from a longer list to be those whose azimuths are such as to give good sight accuracy. Therefore stars used must be identified and available, i.e., not covered by clouds. Identification by pre-computation is made simple - again, if the stars in 249 are indeed visible.

Actually identification many times turns out to be the most difficult problem, and it is required for either method. Pre-computation is easier by 249, but when skies are partially cloud-obscured and only a few stars are visible, even the experienced mariner can have difficulty deciding which is which.

HISTORY OF NAVIGATION

From time to time I propose to cover an item under this heading which I hope will stimulate some interest and discussion of this interesting area. Many of us have wondered how we ended up with a circle that is divided into 360 parts, each of which is divided into 60ths. We can thank (or blame) the ancient Greek astronomer Hipparchus (Second Century BC) for this arrangement which has become so deeply embedded in our mathematics, astronomy, navigation, engineering, etc., that it seems impossible to change. There are other units used in other areas of science, but geography and navigation together with many other disciplines seem stuck with degrees and minutes.

However, when you are cursing Hipparchus for making you subtract degrees and minutes from 360°, remember that he also was responsible for many basic principles in navigation and consequently was a contributor to that art which allowed the spread of civilization from the Mediterranean across the Atlantic and around the world. He proposed determining longitude from the observation of celestial events (eclipses, of planets by the Moon, etc.), a concept later reduced to practice as the method of Lunar Distances.

MARINE INFORMATION NOTES

With this issue we initiate this new department of the Newsletter. From time to time we will advise our readers on discrepancies or sources of confusion in published marine information. Our first items follow below.

(1) A Notice to Mariners contains an erroneous translation of an explanation by the German Hydrographic Institute of the effect of overhead power cables on radar reflections. The correct translation shows that your radar will indicate a target at the foot of a perpendicular dropped from the position of the radar to the power line. Note that this location changes with the movement of your vessel and can give the appearance of another ship on a collision course.

(2) Chart users who wish to make comments or inputs on charts should note that the National Ocean Survey is now called the National Ocean Service and correspondence should be addressed to:

Director, Charting and Geodetic Services
Attn: N/CG22, National Ocean Service
NOAA, Rockville, MD 20852

(Provided by Ernest B. Brown)

BOOK REVIEW

A STAR TO STEER HER BY
Edward J. Bergin, 250 pp., Cornell Maritime Press, Centreville, MD 21617, 1983, $16.50.

Reviewed by Roger H. Jones

Bergin has been teaching and writing about celestial navigation for eight years. He co-authored in the early 1970's the first book published on the application of the hand-held calculator to the solution of celestial navigation problems. He was one of the founders of the Navigation Institute, Inc., and he has co-authored seven correspondence courses in celestial navigation. He earns his living as a policy advisor in the Office of the Secretary of Labor, but also serves as education director of Weems & Plath, Inc. (now C. Plath North America).

Bergin's new book builds upon the work which he and Jack Buchanek have done over the past 6-7 years in developing workforms, concepts, and principles in the teaching of their courses in celestial navigation to new students of the subject. The book is based upon the premise that there is a need for a comprehensive self-study guide, written in plain and easily understood terms, and that the subject really does lend itself to an organized process of self-teaching. The book takes the "classroom" to the reader-student's own home or office, and guides him, step by step, at a realistic pace in mastering the subject.

Its chapters present a logical sequence of learning building blocks, starting with a solid review of piloting and dead reckoning navigation, latitude and longitude, true and magnetic directions, the measurement of arcs by degrees, minutes, and tenths of minutes, and time-speed-distance relationships. Each succeeding chapter is self-contained, but each leads to the next. The flow is from "How Celestial Navigation Works" through "Celestial Timekeeping" to chapters on the Nautical Almanac, the marine sextant, and use of HO 229, which is the most complete and accurate of the inspection tables for sight reduction. There is an especially good chapter on identifying stars and planets, and the explanation of how to use HO 229 for star identification is better than that given in the tables themselves. After a chapter on the noon sight, great circle sailing, and planning a cruise, the book closes with a chapter on the new assumed altitude method of celestial navigation developed by Davies. This is the first discussion of the assumed altitude method in any text or comprehensive book on celestial navigation. The very first assumed altitude tables for sight reduction were published in 1980, and the Bergin book may lead many away from the traditional assumed position approach to the assumed altitude method, especially insofar as star sights are concerned.

The Bergin book is full of well-drawn and easily understood illustrations, and its chapters each present examples and problems supplementing the text. The text passages represent a balanced compromise. They omit a lot of the finer details of celestial theory and the reasons underlying all of the various easy corrections which must be applied to a raw sextant observation of a celestial body, but they present enough of the details to provide fundamental grounding in theory. The book presents definitely much more than a "cook book" approach in which only steps are followed without an understanding of the underlying reasons, but it avoids the tedious detail which is the thing that most often discourages students using other comprehensive texts.

The book does not present material on topics of interest to advanced students, such as how to compute the exact time of passage of a celestial body over the meridian where the vessel will be if it maintains its course and speed, but anyone who masters the celestial art with the aid of the Bergin book will be able to sail anywhere in the world. A student of the Bergin approach will, moreover, have no difficulty using the other sight reduction tables readily available which are not mentioned in the book. The latter include, principally, the HO 249 tables originally developed for air navigation, but now used by many mariners as well as aviators, and even the workforms presented in the book are adaptable to use with tables other than HO 229. It's a good, easily read and logically structured book by a teacher who knows teaching and who knows his subject well.

A Star to Steer Her By is expected to be available in November from Cornell Maritime Press, Centreville, MD 21617.

FUTURE ISSUES

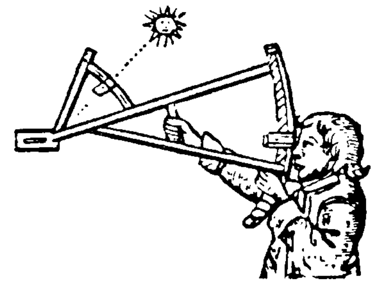
We expect to cover other items suggested by our readers in navigation notes, and we will have additional corrections or clarifications in our maritime information notes. We are also expecting an expanded index of navigation schools.

We are also hoping to approach potential new members suggested by our current membership. We urge your continued efforts to provide interested parties with our literature and, where preferred, provide us with names and addresses.

Address all correspondence to:

Foundation for the Promotion of
the Art of Navigation
P.O. Box 1126
Rockville, MD 20850

THE NAVIGATOR'S NEWSLETTER



FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION ISSUE FOUR, SPRING 1984

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

Our last Newsletter was delayed by "mechanical" difficulties (paste-up and printing); these problems have been corrected so we should be on schedule hereafter. Which brings up the question of schedule. Our Newsletters will still be identified as "Issue Four," but we will now identify the period of issue as Spring, Summer, Fall or Winter. Holding to an exact date is not feasible, but you may expect the Spring issue (this one) early in March, the Summer in June, Fall in September and Winter in December.

At the moment we are preparing information for the Internal Revenue Service who are reviewing our tax-exempt status. We expect no problem in continuing this status in view of our broad public support; however, the operation is time-consuming.

With this fourth issue of the Newsletter we will complete our first year of effective operation. Our efforts have been directed largely towards membership and funding and we will include a financial statment in the next issue of the Newsletter.

Our financial plan is based upon an annual donation of $25 per member, so we request another donation upon the anniversary of your first one. Some members have already done so and we hope that this will continue. Where the anniversary date passes without a response, the Foundation will send a reminder letter.

The Newsletter has been well received and generates an increasing amount of mail from our readers and our enlarged Board of Directors brings a substantial increase in expertise available for dealing with reader's problems. In this regard I should like to correct an error in our last Newsletter. Our Director Mr. G. Dale Dunlop was incorrectly identified as "Cmdr." Dale Dunlop. We apologize for the error.

Several readers have suggested that in each issue we include a celestial sight or navigation problem - The solution to be given in the subsequent issue. You will find a starter problem under Navigation Notes.

We have had two letters from persons who have accumulated out-of-print or early navigation tables and related documents which they feel might properly be preserved by the Foundation in some Archive - where they would be available for reference by interested parties in the years to come. We have such an idea under disucssion with the U.S. Naval Observatory, which maintains an excellent library including a vault of antique astronomy and navigation books of great rarity. If we can develop a satisfactory arrangement, these books would be available through normal library research channels.

One provision of the Charter of the Foundation calls for us to provide technical and testing support for R&D efforts aimed at simple navigational instruments and aids. One reader has such a device under development and we will provide assistance under that provision.

Our Canadian members and others will be interested to know that Penny Caldwell has just been appointed Editor of Canadian Yachting.

Finally we are negotiating with the Superintendent of Documents and the Defense Mapping Agency for designation as a sales agency for Bowditch, H.O. 229 249 and the Nautical Almanac. This will allow us to make these available to our members at a discount. We also have an arrangement with Cornell Maritime Press through which we can provide their books to our members at a discount. If you wish a Cornell catalogue let us know and we can then quote you the exact discount.

READERS FORUM

Capt. Norman Cubberly notes that his ship is the Eastward not the Eastwind, and then goes on to say:

"As to sighting eye, I have an interesting problem, the one which led me down the road to higher magnification. That is, my right eye is the weaker, both in nearsightedness and astigmatism, but is my aiming eye. Thus any telescope, with infinite focus, improves my sighting. I cannot leave the left eye open or it adds confusion. When going into light to record the sight I close my right eye so that it remains dark adapted so the eyes get used alternately. In very bright sunlight the reverse becomes true in that the left eye becomes 'shade' adapted. If possible I then restore a somewhat weird binocular vision by checking ships course, the radar and whatnot before taking up serious shiphandling or sight reduction. I am acquainted, by now, enough with these strange short term effects so that I can handle emergency maneuvers and such while still recovering. I checked out their effect on my performance by docking canoes and rowboats while under the influence. When shooting pistol, I leave both eyes open and favor the left eye with good results. Pistol-shooters must concentrate on sight alignment and let the target go fuzzy. With both eyes open and a rather squared stance, I see through a clearly defined pistol outline a fuzzy target, most useful at longer ranges. So with sextant and telescope I deliberately concentrate on my sighting eye; with pistol, on the non-sighting eye!

"Ernest Brown's comments on the radar target caused by overhead wires brings back old memories. I had noticed this error and reported same to Notice to Mariners. Mr. Brown contacted me and suggested I write something on it for the Institute of Navigation. This I did, complete with drawings. Mr. Brown then contacted me as a law firm was interested. I thus became an expert witness in the case of the Japan Erica v. the Canadian National Railway. Said ship, one foggy night, removed a span of one of said RR's Vancouver narrows bridges through steering thru a power line tower on the right, the target caused by the wires on the left as the draw abutments. This probable cause was first noted by an officer in the Canadian Coast Guard and the phenomena has been noted in radar manuals for years. However I was the only person in print on the matter in his own name. When contacted by an old friend who, it turned out, represented the other side, I guess I became the 'World's expert.' Unfortunately the courts frown on doubling one's fee by representing both sides.

"A subject allied to Celestial Navigation, in that it is also an 'art,' is the use of natural ranges in the navigation and handling of ships. Subjects such as this might prove interesting to a broader group of readers, bring them into the fore and encourage them at Celestial. Great Lakes skippers, for example, have long held that an absolute genius placed the aids to navigation on those waters, because only an absolute genius could have put them all in the wrong place. Since I operated a Buoy Tender on Lake Huron at the time, I was understandably impressed. Turning on the lights of Willow Street did work better than the Government ranges and the impossible three succeeding ranges at Harsen's Island were completely ignored after being shown that steering for one oak tree would do just as well! I long mystified crews by seeming to vaguely stare off into the distance when making landings. I was merely seeing which trees in the park were not moving laterally, and thus the precise direction in which I was sliding. Though we set our buoys on formal horizontal sextant angles, we usually 'positioned' them with natural ranges and thereafter checked them the same way.

"The 'art' of navigation should not be construed too narrowly."

Robert McAuliffe of 7000 Six Forks Road, Suite 106, Raleigh, NC 27609 writes:

"After reading the latest issue of THE NAVIGATOR'S NEWS letter you sent me, I thought I would write to you to see if you could solve a problem for me. I need a copy of Volume III of H.O. 214. I have been collecting my set one by one, but cannot find Volume III (for obvious reasons, one of which is that it strides the Latitudes in the Caribean Basin) and I would really like to buy one from somebody to complete my set.

"H.O. 214 is the best system as far as I am concerned although I can use 208, 211, 229, 249 or 214."

Dr. Harry H. Dresser, Jr. writes:

"As your list of navigational schools grows, it might interest you to know that secondary school aged youngsters who have an interest in navigation will find a full year course at Gould Academy in Bethel, Maine. I teach this course which focuses early in the year on pilotage and gradually moves along into the theory and finally the practice of celestial navigation. My students first solve the navigational triangle graphically on the plane of the celestial meridian, then they solve it mathematically using the sine-cosine laws (and, often calculators), and, only after mastering all that do they move to H.O. 229 for tabular resolution."

Prospective member Thurman Smithey writes:

"Re: One eye open or both eyes open during sightings. I have a Plath sextant with Ful-View horizon glass which I use in what I consider the normal manner, i.e., sighting with my right eye, with my left eye closed. I also have a Baby Tamaya (half size) metal sextant which has a horizon mirror that is half the normal width and all silvered. I found it next to impossible to get useful sights with this sextant (due to my inability to see both the celestial body and the horizon simultaneously) until I discovered a trick which I have used successfully ever since.

"I read of this 'trick' in a book by Bernard Moitessier called 'The First Voyage of the Joshua.' It consists of removing the telescope from the sextant and sighting through the ring only, but with both eyes open. I find this works fine with this otherwise unusable sextant, and permits me to get sights when the seas are entirely too rough for me to use the heavier Plath. Of course, when conditions are more benign I do prefer to use the Plath with its fine optics and magnification."

NAVIGATION NOTES

One of our readers wrote in some time ago asking where he could find a table of "Lunar Intercepts." This method of finding accurate time from the moon was invented in the 18th century and tables for its use were available in the 19th century in the U.S. Nautical Almanac (among others). However these tables were dropped from the Almanac early in the 20th century and I don't know of any that are currently published. By chance member Paul Shaad of Santa Barbara, CA, has submitted the following article on a method for getting time from the moon which is quite simple. I believe the method is new.

The Differential Lunar

by Paul E. Shaad

PART I

When I first went to sea in the later part of the 1920's the mate observed the stars before daybreak. He called these observations "time sights." Using log functions he solved these sights for longitude. He called this "reducing" the sights.

At noon he and "the old man" observed the sun for meridian altitude. They reduced these sights to latitude.

I asked them why they never used the moon. "Moves too fast," replied one. "Not always reliable," replied the other. All of this was a great mystery to me.

Now, after a long career away from the sea I have returned to unravel these mysteries and, having found the moon to be entirely reliable, propose the following:

If you will take a time sight of a star and one of the moon in reasonably close succession and reduce these to longitude you will get the same longitude for each and it will be the longitude of the ship. THAT IS, IT WILL BE IF YOU ARE USING CORRECT G.M.T.!

If you do not have the correct G.M.T., if you have been forced to set your chronometer by guess, you will get two different longitudes, neither one of which will be correct. BUT IN THE DIFFERENCE BETWEEN THESE TWO INCORRECT LONGITUDES LIES THE KEY TO A CHRONOMETER CORRECTION THAT WILL YIELD CORRECT G.M.T. AND THEREBY THE CORRECT LONGITUDE.

Perhaps the reader would like to speculate on how this chronometer correction is derived.

PART II

Derivation of the chronometer correction for the "differential lunar" reminds one of an early day school problem. If two ships, one steaming at 10 knots and the other at 15 knots, leave New York for London at the same time later find themselves 100 miles apart, how many hours have they been under way?

In our case the moon is the slow ship, the star the faster ship and the distance apart the difference between the two incorrect longitudes. The 'speeds' are the amount longitude changes in one hour (while no change is made in the star's or the moon's altitude). For the star this is always 15.041 deg. per hour. For the moon the 'speed' must be determined by adding one hour to the (as yet uncorrected) time of the moon observation and seeing how much the longitude changes in this one hour.

The difference between the two incorrect longitudes is divided by the difference between the two 'speeds.' This is the chronometer correction in decimal hours. If the longitude by moon is the larger the chronometer is set ahead.

After applying the chronometer correction the resulting longitudes will be very close together. If they differ by more than one arc minute you may wish to repeat the process deriving a second chronometer correction which, when applied, will put the two longitudes right together.

Do not expect great accuracy from a "lunar." The accuracy, to be comparable to that from a timed sight, would require measuring object altitudes to the arc second instead of the arc minute. This just cannot be done at sea.

Residual Minutes

The term residual minutes is used in description of steps in interpolation for the Davies Tables. When "rounding" the value of an angle, the minutes are used to determine whether to round to the next greater value or the next lower value. Thereafter they are dropped and the "rounded" value used. The minutes that are dropped are residual and are used in the interpolation to get a value out of a table that will be correct for both degrees and minutes.

It should be noted that if we round "up" to the next larger value the residual minutes are actually sixty minus the minutes of the original value and are negative in sign. That is, from that higher value, we want to go down to the correct value.

Likewise when rounding "down" to a smaller degree value, the residual minutes are those of the original value and their sign is positive.

Director Allan Bayless has the following comments:

Sextants

Although I haven't used one extensively, I have used a few plastic sextants and have been impressed by how well they work, even the simple job that Davis used to sell for something like 10 dollars, without a telescope and with poorly surfaced shade "glasses." With a little care, they should be just as practical as their much more expensive bronze brethren, if not as long lived. And not as soul satisfying nor as impressive, but I suspect they'll do the job very nicely all the same.

I have an extremely dominant left eye that has annoyed me for years when using a sextant (as well as a gun! Particularly a rifle!), but I never knew there was such a thing as a left-handed sextant with the handle on the left side. Or do you use an ordinary sextant exclusively upside down? (Bifocals are a pain in the behind, too!)

I'm no expert on the subject, but I clean the bronze arc on my sextant (which has inset engraved divisions painted black) occasionally with "NEVR-DULL" and the worm gear with light oil once in a while.

A Navigation Problem

On Jan. 23, 1984, at Watch time of $16^{h}17^{m}06^{s}$ a navigator calculates his D.R. position as 18-01'.5 North and 63°06'.3 West. At this position he takes a sight on the Sun's lower limb. He is in +04 zone and his watch correction is -40 sec. With a height of eye of 20 ft. he gets a sextant altitude of 21°43'.6 on an instrument with an Index Correction of -1'.

Question: What intercept and azimuth will he use to plot his Line of Position and from what point will it be plotted? What is his Estimated Position from this single Sun line?

Next issue will include the answer to this plus a more complete problem based on the navigator's "Days Work."

History of Navigation

The following quote gives a different view of the origin of the 360 degree circle. It is quoted from "Astronomy" by the eminent cosmologist and astronomer Fred Hoyle (Rathbone Books Ltd., London 1962).

"The division of the circle into 360 parts was first made, perhaps 5000 years ago, in the river-valley civilization of Mesopotamia, though the circle was similarly divided elsewhere at different times--wherever and whenever men had succeeded in defining the length of the year as approximately 360 days. The division into 360 parts was far more convenient for the people of Mesopotamia than it is for us today, since they used 60 as a fixed base in calculation, whereas we use 10; and as a general rule the units in which quantities are measured should always bear a simple and convenient relationship to the number currently used as a fixed base in calculation.

"It seems it is easier to achieve space flight than to change our archaic system of angular measure. The Mesopotamians imposed the number 60 on us, and we seem powerless to escape from it. The same kind of absurdity shows itself in the divisions of the clock into 24 hours, 60 minutes and 60 seconds. It also shows itself in the British monetary system, and in British and American units of linear measurement. Man's inability to rid himself of inconvenient conventions is a trait that could lead to his undoing."

MARINE INFORMATION NOTES

Vagaries in the List of Lights

Navigators who depend on the light lists published by Defense Mapping Agency Hydrographic/Topographic Center to determine the visual ranges of lights should use the tabulated ranges with caution.

The unwary user may assume that the value given in the range column is the nominal range, as in the U.S. Coast Guard Light Lists. Although most of the ranges are nominal ranges, other ranges are not. This condition is due to uncertainty in the basis of light ranges as reported by foreign sources.

The explanation of column 6: Range in the introduction indicates that the ranges are nominal. The significance of the accompanying note that the listings in the column are taken from foreign sources is "buried" in another part of the introduction. Also the luminous range diagram used to convert nominal to luminous ranges according to meteorological conditions has been omitted from current lists.

The Light Lists have a caution for data on foreign lights as being based on foreign sources and this is the source of the uncertainty - since the exact basis of the visibility figure is not known.

Also the luminosity versus distance diagram has been omitted from current lists. Thus the navigator who calculates when a foreign light should be visible should recognize that the result may be subject to substantial uncertainty. He should not be misled by an earlier or later sighting.

Recently the United States Coast Guard proposed changes to their Licensing Regulations. These changes included the possibility of removing or limiting the celestial navigation section of the current deck examinations. Among the responding letters, the Marine Safety Council received an interesting dissent from the Navigator of the SS San Pedro, John Theodore Ellis, which is excerpted below:

"My navigation log for the last twenty years will include such comments as these:

* approaching a strange coast line, whose identifying configurations were maddeningly similar, during daylight hours, WITH RADAR, on an emergency mission, and having to use a SINGLE SUN LINE, with radar data, to absolutely identify the correct landfall.

* threading reefs in the south Pacific using a single abeam sun line.

* using a single <u>ahead</u> or <u>astern</u> sun or star to determine SPEED when such knowledge was imperative to the problem at hand.

* several DAYS ago, approaching Puerto Rico from the north, setting to the west in a strong current greatly influenced by the prevailing Easterly trades, and given conflicting data by the SATELLITE NAVIGATOR and the LORAN C: a single, nearly abeam SUN line (at a corrected SEXTANT altitude of 16°36.4') taken by this so called OBSOLESCENT vertical-angle measuring device confirmed the accuracy of the SATNAV and the failure of the Loran.

* although the NAVSAT manual, and its inventors, insist that GMT time signals will be accurate to within 200 microseconds: on the morning of Sunday 18 December 1983, steaming toward New York, after three SATNAV FIXES, at morning STAR TIME, the SATNAV began showing time signals 40 SECONDS in error. Short wave radio and a check with our ANCIENT CHRONOMETERS showed the electronic error. Dream machine manually reset.

* Loran C is often inaccurate or simply out of range.

* SATNAV is often sloppy about automatically following the ship's course and has to be re-set manually.

* both Loran C and SatNav systems are subject to ENGINE ROOM POWER PLANT FAILURES.

* Sat Nav fixes are not ALWAYS there WHEN you need them and SOMETIMES YOU CAN'T STOP AND WAIT FOR THEM...

"This is not to in any way belittle the genius of the Messieurs Guier, Wieffenbach & McClure who are certainly in a NOBEL LEAGUE for their NAVSAT conception & development, nor to reduce in any way our reverence for the skills of our electronic heroes from Thales of Miletus to Marconi and beyond.

"NEVERTHELESS, let me assure you, navigation remains an ART <u>and</u> SCIENCE, and the Navigator practicing NOW will combine ALL his knowledge to safely position his craft at sea. I have used a sextant for 22 years. I never cease to marvel at a single man's miracle using this most beautiful of instruments: the sextant. I compete constantly with Scout-launched 140 pound octagonal cylinders! It is easy, fun, reassuring, and VALUABLE."

BOOK REVIEW

SIGHT REDUCTION TABLES FOR SMALL BOAT NAVIGATION
by Hewitt Schlereth
Seven Seas Press, Inc.
Newport, RI, 1983, $25.00.

Reviewed by Allan E. Bayless

These tables are a one volume abridgement of DMAHTC Pub. No. 229, Sight Reduction Tables for Marine Navigation. The original tables require six volumes and 2160 pages of precomputed solutions for altitude and azimuth to cover the entire sphere for the three entering arguments, hour angle, latitude and declination, each in 1° increments. Schlereth's version, by contrast, requires but 276 pages for the tabulated solutions and a page size of 6 x 9-inches instead of the 8½ x 11-inch page needed for Pub. 229. The actual number of tabular entries has been reduced by nearly 95%. This tremendous reduction in volume has been achieved by limiting all three entering arguments:

1) Latitudes are limited to those between 58°N and 58°S, "since most yachting is done between [these latitudes]," and are for even degrees only.

2) Declinations are limited to those between 30°N and 30°S. This range permits the use of sun, moon, planets and 30 of the 57 navigational stars. As interpolation is required for the actual declination of the body, the 1° increments of Pub. 229 are retained.

3) Hour angles are for even degrees only.

Aside from the obvious limitations of latitude and declination, the principal result of the abridgement is the necessity for longer intercepts, twice as long as in the original tables and reaching a maximum of about 85 nautical miles at the equator (60 sec 45°) with consequent reduction of geometrical accuracy. However, this reviewer is inclined to agree with the author, "...in the context of small boat navigation, the loss of accuracy is slight and not of consequence."

Sight reduction technique is the same as for Pub. 229 except that DSD corrections are ignored (though the asterisks remain) and interpolation of Hc for declination is by means of the table from Pub. 249, simpler and to a lesser precision (1' of arc) than the Pub. 229 table. Probably the values for Hc should be to this same precision but over 165,000 entries would have to be altered to accomplish it. In the examples in the introductory pages, Schlereth rounds the final value for Hc to the nearest minute--and does not interpolate Z. There is an abridged offset table (on page xxiv) but, as the author says, "...if you keep your sights within the comfortable range of 10° to 70°, there is little to be gained from this table for the purposes of practical navigation in small boats."

The format of the table is very similar to Pub. 229 as one would expect. The principal difference is the requirement of six pages for each LHA increment rather than two facing pages. The 20° of latitude on each page are arranged with five columns at the top of the page and five below. Entries for latitude and declination of the same and opposite name appear on facing pages. Unfortunately, though there is room at the bottom of the page, the rules for conversion of Z to Zn are found only on page x.

It might be added that the abridgement is also much more compact than Vol's II and III of Pub. 249, Sight Reduction Tables for Air Navigation, the layout is much superior, and little is lost in accuracy.

This reviewer agrees completely with Schlereth: "I would much rather have a handy little book like this that I can pack easily in a duffle and that covers every contingency I'm likely to meet in practice, than to lug the elephantine alternatives on the off-chance that Miaplacidus will be the only star in sight." Also, "...it can be the backup to a calculator." This reviewer feels compelled to add that in his view sight reduction by calculator is so superior to any table that he'd take along a couple of the inexpensive "scientific calculators" that are now available as a back-up for his more advanced instrument. If aboard a small ocean going sailboat, he'd be sure some solar cells were installed to insure electrical power. Only in the case of absolute utter disaster would he ever resort to tables. (In such an emergency, he'd prefer his own Compact Sight Reduction Table [abridged "HO 211"] even though it is a logarithmic method because it's a lot less expensive and quite a little smaller so it'll live happily in the sextant box till that rare day when it's needed.)

This review would be incomplete were the high quality of the printing, paper and binding of this abridgement unremarked. The pages are bound with a plastic "spiral" which permits opening the book flat, ideal for work such as this; the "spiral" is attached to a maroon hard cover, similar to a notebook cover, with a sextant imprinted in gold on the front; title, author and publisher appear in gold on the spine.

All in all, this is a very clever abridgement and a very attractive little book.

(This review is provided courtesy of the U.S. Power Squadron's publication "THE ENSIGN.")

FUTURE ISSUES

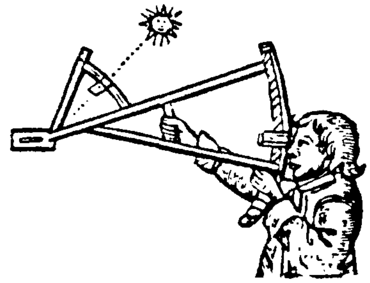
Earlier we announced that we could supply the names of members in your area if asked and we have had one such request. This announcement is to ask anyone who does not want his or her name released to another member to let us know. The Foundation does not intend to release names to anyone other than individual members.

We continue to get new members by the efforts of our current membership. We believe that this is the best way to do it, although we will be getting the word around through additional magazine articles and other publicity. We again urge that you show copies of the Newsletter and provide interested parties with our literature and address. If you prefer send us names of prospects and we will send them literature.

Address all correspondence to:

The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850

THE NAVIGATOR'S NEWSLETTER



FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION ISSUE FIVE, SUMMER 1984

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

Annual Meeting

The Annual Meeting of the Directors was held on Wednesday, March 28, 1984, at the Hilton Hotel, Annapolis, Maryland. Those present were Admiral Davies, Meredith Davies, Terry Carraway, Roger Jones, Ernest Brown, and Henry Shufeldt. All current billings to the Foundation have been paid, and a modest positive balance in the Foundation's bank account was reported. A copy of the Financial Statement is available to any member who requests one. The principal expenditures over the past year have been in connection with the preparation and mailing of the Newsletter and bulk mailings announcing the establishment of the Foundation and soliciting new members.

The membership in the Foundation is still growing. Current members are encourged to provide information about the Foundation and its activities to other interested persons known to them. If names and addresses are furnished to the Foundation, a prompt mailing will be made to those who are thus identified as having a possible interest in the Foundation.

Current members are encouraged to renew their annual donations to the Foundation. We have received word of the results of the IRS review of our Tax-Exempt status. IRS has validated our status as exempt under the code paragraph which makes donations to the Foundation allowable as deductions in individual returns. With this mailing we are including the month and day of your original donation on each label. This should serve as a reminder of the appropriate date for each annual donation.

Rare Navigation Books

The Foundation is now able to accept donations of rare or out-of-print navigation books which the owner feels should be preserved and kept available for researchers. We have an agreement with the library of the U.S. Naval Observatory, which will accept and identify books from the Foundation on indefinite loan. They will preserve and index these books, which will then be available to researchers through the interlibrary computer system. Members interested in this service should drop us a note.

Discount Books and Charts

We are pleased to report that arrangements have been made to offer discount books and charts to Foundation members. Agreements have been reached or are in progress with the following publishers.

° Cornell Maritime Press, Centreville, Maryland, publishers of the Assumed Altitude Tables, the Compact Sight Reduction Table (Modified H.O. 211), A Star to Steer Her By (a new self-teaching guide to off-shore navigation reviewed in Issue Three of this Newsletter), and many other books, has agreed to offer its publications through the Foundation at a discount of 20%. Catalogues will be sent upon request addressed to the Foundation. Book orders should be made to the Foundation.

◦ The U.S. Government Printing Office, publisher of the Nautical Almanac, Bowditch's American Practical Navigator, and many other books and references, has accepted the Foundation as a bookdealer. This will enable us to purchase most Government publications at a significant discount. Foundation members will be able to purchase them at a discount of 20%

◦ An agreement between the Foundation and the Defense Mapping Agency, publisher of H.O. 249 and H.O. 229, is anticipated. This agreement will result in discounts of 25% on charts for orders more than $30.00. For chart orders under that amount a 20% discount will be given. A discount of 20% on all books will be available, plus a handling charge of $1.00 on book orders of less than $10.00.

Awards

In response to contacts made with the Coast Guard Academy and the Merchant Marine Academy, the Foundation has been informed that the existing array of awards for excellence in the study of navigation at both institutions already covers those areas of interest to the Foundation. Contacts will therefore be initiated with several of the State Maritime Academies. Meanwhile, the Foundation's interest in navigation education at the secondary level has led to acceptance by the Gould Academy, Bethel, Maine, of an offer to sponsor an award there. A full year course is given which includes solution of the navigational triangle graphically on the plane of the celestial meridian, solution mathematically using the sine-cosine laws, and then tabular resolution.

READERS FORUM

Kenneth A. Porter, Capt., USN (Ret.), has written that celestial fixing aboard U.S. Navy submarines went out altogether in the early 1970's with the final removal of the Type II periscope from nuclear submarines, and that it was really only used in the submarine fleet in recent times as an accurate azimuth check on the functioning of the inertial navigation systems. With the newer systems in the SSBN 640 class Polaris submarines, comparison of the two inertial systems after a reset assures a greater azimuth accuracy than was available from the periscope celestial practice. In retirement, however, Capt. Porter has returned fondly and respectfully to celestial navigation and reliance on the sextant. He notes that the continuity of consistency of dual inertial navigation systems, both receiving optimum high quality satnav fixes, always led him aboard Navy vessels to assume high confidence in the accuracy of position data, but that good sextant fixes at sea in a small sailboat are the only source that give him equivalent confidence today, and he emphasizes the only source. While his letter does not say so in so many words, it would seem that Capt. Porter's years of experience would give pause for reflection on the part of small boat sailors who are equipped with loran, satnav, and other "black boxes." The point is - they are likely not equipped with dual systems coupled to inertial navigation devices, and in the absence of that degree of systems capability, the sextant remains as the ultimate foundation for gaining confidence in positional data.

Leonard Eyges of Wellesley, Massachusetts, has written letters of interest describing a system of "small angle navigation" devised by him. Given the name Telefix, the system consists of two simple and yet innovative devices that easily fit into any coastal navigator's kit. Eyges, a physicist for both M.I.T. and the Air Force, has redesigned the simple rangefinder, and has developed a companion protractor of an immediately apparent practical utility in working with marine charts. Excerpts from several of the Eyges letters and literature may be of interest to the readers of the Newsletter.

"I redevised (the principle is ancient) a rangefinder which I called Telefix. It measures small horizontal (and vertical) angles, and partly to extend its usefulness, I began to think of how one might exploit such angles. It is this which led to my interest in 'small angle navigation,' which extends the accuracy and convenience of transit lines of position to objects that are almost in transit. These are the ones for which the angle they form with the observer at the vertix is a few degrees or so.

"Practical coastal navigation is not entirely the problem of getting fixes. You may know exactly where you are and still be puzzled by what the chart indicates as compared to what you see. In such cases you can quickly orient yourself by comparing the angles measured by the protractor on the chart with angles measured by Telefix on deck. You will find that a few minutes of this kind of measurement is as informative as many hours of casual sailing into and out of the harbor - which is why I call it 'instant local knowledge.'

"You don't know where you are, and no landmarks or navaids are suitable for the usual methods of fix (such as crossed magnetic bearing lines). Telefix and the protractor enable a novel variety of fixes from small horizontal angles associated with pairs of visible objects or with the width of visible objects (such as islands). Basically, a Telefix measurement on deck of the horizontal angle between two landmarks implies a circle of position on the chart. All you need to know is that the protractor does on the chart what Telefix does on deck.

"There is another use for small angles in navigation besides sorting out landscapes (instant local knowledge) and getting fixes. One can use them as invisible 'railroad tracks' on the water and choose to sail along one that avoids dangers. This is no different in principle from keeping on a 'range' (i.e., a transit line), but it is more useful in that you have a variety of 'railroad tracks' to sail on. You monitor the angle with Telefix, and if it is too large you steer toward the transit line; if it is too small, you steer away from the transit line. I have tried it and it really works."

Roger Jones has experimented with the Eyges methods, and he confirms good results. Among the types of navigational fixes that can be obtained quickly are ones involving the following: (1) two landmarks, height of both known; (2) two landmarks, height of one known; (3) three landmarks, heights unknown; (4) single landmark, height known; (5) distance from vertical dimensions; (6) distance circles of positions; and (7) angle circles of position.

In essence, Telefix is a small, very light device with a lanyard that is worn around the neck. When not in use, it can virtually be forgotten as it hangs at chest level on the observer. It substitutes for the sextant in measuring small vertical and horizontal angles, and it incorporates a multiplier that enables quick conversions of angle data into distance from the observed object or objects. Its accuracy is quite acceptable for its intended uses. This accuracy derives in part from the calibrated, fixed-length chain lanyard which positions the device a precise distance from the observer's eye.

NAVIGATION NOTES

Interpolation Tables: H.O. 249 v. H.O. 229

The HO 229 interpolation tables are, many times, the source of confusion for student navigators and even experienced persons who have not used them in a while. The arrangement of an otherwise simple interpolation table does seem to be "overkill" in the interest of a mathematical accuracy (1/10 of a minute of arc) frequently not justified by the accuracy of the sight to which it is applied. It may be helpful to new and old users of the table to know that the simpler interpolation table of HO 249 may be used as an alternative in finding the correction to tabulated altitude for minutes of declination, with only a small loss of accuracy. This HO 249 table is labeled as Table 5, and the exact same table is included with the Davies Assumed Altitude volume for the Sun, Moon, and planets. It may be used by entering the value of "d" from HO 229 at the top of Table 5 and with the value of the residual minutes of declination at the side. The responding number at the intersection of these two entries is the minutes to be added to the tabulated altitude. In effect, users of HO 229 may continue to use their 229 volumes, but may wish to substitute the simpler HO 249 interpolation table for that found inside the front and back covers of the volumes of

HO 229. Where the doubled second difference interpolation is necessitated by the non-linearity of the values of H_C, the procedures in the 229 instructions must still be followed, although the number of "asterisked" values of "d" is more extensive than necessary for an accuracy of one minute of arc.

The Willis Method

Captain Shufeldt has recently recalled the Willis Method, which is an old technique for getting a position from three sights on the same body, thus getting a rate of change of altitude. It has the advantage of giving a position without any D. R. or other information as to where you are. It also does not require a plot. However, it is extremely sensitive to the precision of the sights - a very small error will throw the position off substantially. With only average competence with the sextant, errors of 20 to 30 miles could result. Expert observers can frequently do well enough to get usable positions, however. The following example, supplied by Capt. Shufeldt, demonstrates an appropriate use.

"A single-hander departs St. George, Bermuda, bound for the Channel in late July '83. Some days out he becomes violently ill from food poisoning; he secures the helm and lets the boat lie-to, and takes to his bunk. After several days he recovers and uses the Willis Method to get an idea of his position.

"On 10 August, 1983, three strings of sights, made between GMT 1254 and 1305 are obtained and plotted against time. From the plots, the following GMT's and Ho's are extracted:

1. GMT 1256, Ho 48°05.8
2. GMT 1300, Ho 48°49.6
3. GMT 1304, Ho 49°33.0

The difference between first and last sights is: 1°27.2 or 87.2 minutes.

The value of sin N is obtained by dividing 87.2 by the difference in time expressed in minutes of arc (8 x 15 = 120), which gives sin N = .7267, and N = 46°.607672 (by calculator).

The Latitude is calculated by the formula:

$$\sin L = \cos N \times \cos [H_O \times \arcsin (\sin D/\cos N)]$$

The value of the declination (D), 15°38'.4, is taken from the Almanac for the time of the second or middle sight. The sign in the formula is minus when L is of the same name and greater than D, as is the case here. This gives the result of L = 38°14'.2.

The next step is to obtain the Sun's meridian angle, t, using:

$$\sin t = (\sin N \times \cos H_O)/(\cos D \times \cos L);\ H_O = \text{altitude of the second sight}$$

This yields t = 39°.233647. When added to the Sun's GHA at the time of the second sight, 10°39.3, this gives longitude of 49°53.3."

The actual location used in this example was L = 38°14.7, and long = 49°53.1, which suggests that the sights were taken with extreme care - and a careful plot used to effect averaging. To illuminate the sensitivity of the method as to accuracy, an error of one minute was added to one sight - producing a change of latitude of 28.2 minutes. With such an error the position would be useful only as a starting point for a later round of stars.

New Nutation — Precision Tables

Cornell Maritime Press has now published new Nutation - Precession Correction Tables for use with the Davies Assumed Altitude Star Sight Reduction Tables. The updated Nutation - Precession tables are operative through 1986, and all new copies of the star sight reduction tables will contain the updated nutation - precession correction tables. Cornell Maritime Press will supply the updated tables upon request for a price of $1.00 to cover mailing and handling. Such requests should be sent directly to Cornell Maritime Press, Centreville, Maryland.

History of Navigation

Readers of the Newsletter may have wondered about the Foundation's logo. It depicts an early 17th Century mariner using the Backstaff. The Cross-Staff was the first instrument which utilized the visible horizon in making celestial observations. It consisted of a long, wooden shaft upon which one of several available cross pieces was mounted perpendicularly. The cross pieces were of various lengths, the one being used depending upon the angle to be measured. The navigator held the shaft with one end beside his eye, and adjusted the cross until its lower end was in line with the horizon and its upper end with the body. The shaft was calibrated to indicate the altitude of the body observed. In using the Cross-Staff, however, the navigator was forced to look at the horizon and the celestial body at the same time.

In 1590 John Davis, author of The Seaman's Secrets, invented the Backstaff. He was one of the few 16th Century seamen to invent a useful navigational device. (Davis Straight is named for him, in honor of his attempt to find the Northwest Passage.)

The Backstaff marked a major advance. The navigator turned his back to the Sun and aligned its shadow (on a flat plate) with the horizon. It had two arcs, and the sum of the values shown on each was the zenith distance of the Sun. Later, this instrument was fitted with a mirror to permit observations of bodies other than the Sun. The Backstaff became an instrument that was particularly popular with American colonial navigators.

A Navigation Problem

With this issue of the Newsletter, the Navigation Problem is being extended at the suggestion of several readers. A cruise of the sailing vessel Backstaff has been planned, and will be carried out in the pages of this and succeeding issues. Armchair navigators are invited aboard to participate in the solution of the problems as they arise, including: sun, moon and planet sights; predicting optimum times for observations of bodies at twilight and at other times; star and planet identification; the time of local apparent noon (LAN) and the problem of the easterly or westerly movement of the vessel; backsights; great circle sailing; the intricacies of time and the international date line; useful techniques; and many other problems and matters of interest. Readers are invited to compare their solutions, however derived by them, with the solutions which will appear in these pages. Readers need not have access to the charts covering the areas of Backstaff's voyage. For those who wish to plot their solutions, the use of a simple universal Mercator plotting sheet is suggested. However, for some problems, access to a current Almanac and some method of sight reduction will be necessary.

Backstaff departs from Annapolis, MD, on May 15, 1984, and the first leg of a much longer voyage is the short run to Bermuda. Her crew will utilize the easy run down the Chesapeake Bay as an opportunity to brush up on basic navigational skills before entering the sea lanes of the Atlantic. The departure is at 0800 Eastern Daylight Time (EDT) from a point just east of a prominent bell buoy at 38°-56.1 N, 76°-25.9 W. The initial course is 180° True; initial speed is 4.30 knots. The sextant instrument error is negligible, but the index error, as checked by the navigator, will be reported in these pages where appropriate. Time aboard will be determined and kept in various ways as stated.

For immediate purposes, the navigator is unconcerned with tidal current. Initially, there are no unusual temperature or barometric pressure conditions. As a check on his sextant and his own rusty observational skills, the navigator wishes to shoot the sun at local apparent noon, and to use the resulting latitude value as a check on his speed as well as his progress on the course down the Bay.

Problem 1. What is the estimated EDT of LAN, assuming the vessel remains on a course of 180° True, and what considerations must be kept in mind when computing the estimated time of LAN?

Problem 2. The navigator's height of eye is 12 feet. Index error is checked and found to be 2 minutes "off the arc." His watch is set to EDT and is 7 seconds fast. At 13-02-19 by his watch he observes the sun (lower limb) "hang at its highest altitude," and Hs on the sextant arc is 70°-14.5. (Assume that in reality the navigator has tracked the sun with a series of sights just before LAN while it was still rising, one or more sights during the "hang time," and one or more sights as it begins to descend. From a quick inspection of the trend of these sights, or perhaps from a graphic plot of them over time, he selects the one that seems to best represent the sun at its highest altitude.) From this data, and without plotting any line of position (LOP), what is the latitude, and what average speed has the vessel made good, assuming the latitude value to be accurate?

Solution to the Navigation Problem Presented in Issue Four

1. The intercept is 2.8 miles Away, Azimuth 239°.5 true.

2. This should be plotted from Lat 18°N, Longitude 63°-09.3 West.

3. Estimated Position is Lat 18°-01 and Longitude 63°-06.7 West.

MARINE INFORMATION NOTES

1984 Edition of Bowditch

Last year, work was ongoing at the Hydrographic - Topographic Center of the Defense Mapping Agency to reprint Volume I of Bowditch as a corrected print. Revisions and corrections were largely limited to line for line substitutions for existing material. During the advanced stage of this production, a decision was made to print the book from magnetic tape rather than from the page negatives derived from the metal type method. The proof-reading work associated with converting to the modern printing method precluded being able to increase the general scope of the revisions of the previously planned corrected print. The conversion to the tape printing method should serve to insure that more of the desirable changes will be included in subsequent printings, however.

The new edition will include an updated fictitious chart of "Port Maury" - a very valuable training tool in that it illustrates the latest cartographic practices. This chart is usually printed in quantities greater than required for the Bowditch printing. In the past, several navigation training activities have found the separately issued copies of "Port Maury" to be useful in their chart instruction programs.

The Long Term Almanac, which is an Appendix in the recent issues of Bowditch, contains two errors that can be simply corrected by readers who might have occasion to use the Almanac. The Sun's declination for March 16 under column 3 of the Sun Table is shown as 7°-04'.5 S. This value should read 2°04'.5 S. Additionally the Sidereal Hour Angle of Rigel Kent is shown incorrectly in the Star table. It should read 140°-34'.3.

BOOK REVIEW

Mariner's Celestial Navigation

by Captain William P. Crawford
Miller Freeman Publications, Inc.
San Francisco, California

Reviewed by Roger H. Jones

Originally published in 1972, Mariner's Celestial Navigation received substantial initial publicity that was well-deserved. However, the rights to this publication were purchased by CBS Consumer Publications from the Miller Freeman publishing house, and for a number of years it was not widely seen on the shelves of the leading sellers of books dealing with nautical and marine subjects although it continued to remain available from the W. W. Norton Company of New York. The Norton Company served as agent for CBS Consumer Publications.

Recently, this book has again appeared on the shelves of some book sellers, and this reviewer heartily welcomes it back. There are four things which come to mind after a careful reading of this book, and after having used it as the text for a course in celestial navigation taught by this reviewer to beginning students of the subject several years ago. The first is that its illustrations are outstanding and they are most complete. Each of the illustrations serves a particular purpose, and each seems to achieve that purpose. If there is truth in the old saying that "a picture is worth a thousand words," that truth is well served in the Crawford treatment of such subjects as nautical astronomy, the imaginary celestial sphere surrounding the Earth, the intricacies of time, and the navigational triangle. The illustrations depicting the Marcq Saint-Hilaire concepts of the circle of equal altitude and the altitude intercept are the best that this reviewer has seen in any text, including such classics as Dutton's and Bowditch.

The second noteworthy feature is thoroughness. This is a book which starts with all of the necessary theoretical concepts and then presents the practical application of each concept. It accomplishes this in a logical sequence of chapters which move the student or seasoned expert from theory, through the finding of latitude and longitude by various methods, to capstone subjects such as star identification and the ways and means of using the sextant, plotting tools and chronometer It is thorough in its treatment of both H.O. 229 and H.O. 249, and its treatment of the Almanac represents a significant leap in clarity over the instructions and explanatory material in the Almanac itself.

A third feature of this book is its easy and relaxed style. Crawford is a Master Mariner and teacher who knows how to communicate. His choice of words is, at times, even delightful. He creates mind images that enhance understanding, and he seems to sprinkle them at just the right intervals throughout his text. One example: "We've done it! This chapter has taken our paunchy, bifocalled navigator with his salt-stained sextant and transformed him into a perfect man holding an ideal instrument. We've magically eliminated the bending influences of the atmosphere. We've lowered him from his elevated vantage point on deck to sea level. And by the last step we've perched him on a slag of hot iron at Earth's exact center. Now he can really accept what Figure 77 tells him . . . 90°-Ho=Zenith Distance." Indeed, the reader can grasp at this point the true significance of the altitude of a body as measured by the sextant, and why that altitude must then be corrected to account for refraction, parallax, semi-diameter of the sun or moon, height of eye of the observer, and index error of the sextant.

Fourth, Crawford presents at the end of each chapter very well conceived practical exercises. These, in conjunction with his work forms and excerpts from the Almanac and from H.O. 229 and 249, enable any student or experienced practitioner to experience first hand all of the problems that might be encountered at sea. The pitfalls and the things to be especially borne in mind are all there, together with Crawford's patient guiding hand in resolving all problems.

Neither compact like Mary Blewitt's little classic, Celestial Navigation for Yachtsmen, nor of the bulk of Bowditch's American Practical Navigator, Crawford's contribution is a balanced volume of some 400 pages of theory, practical application, and profuse illustration. It should stand the test of time well.

FUTURE ISSUES

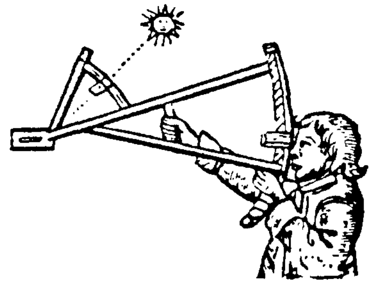
We hope to present more information from our more experienced members and more questions from all our members. We expect to expand our membership significantly by a pending very substantial mailing to a highly focussed list of prospects. Our prize program is progressing and we expect to expand it during the summer.

We continue to get new members by the efforts of our current membership. We believe that this is the best way to do it, although we will be getting the word around through additional magazine articles and other publicity. We again urge that you show copies of the Newsletter and provide interested parties with our literature and address. If you prefer send us names of prospects and we will send them literature.

Address all correspondence to:

The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850

THE NAVIGATOR'S NEWSLETTER



FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION ISSUE SIX, FALL 1984

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

Membership and Renewals

While the membership of the Foundation continues to grow, renewals are lagging. In the last issue we announced that labels would include the date of contribution and thus would serve as a reminder for the next annual contribution, and many members have responded promptly. However, there still are a few who are not responding, in enough numbers that we feel that we should initiate a further reminder to sort out those who may have forgotten from those who do not wish to continue their membership. Therefore, we are including a notification letter for those whose date of contribution has passed by more than a month. This should provide adequate time for renewal, and keep the Newsletter coming.

One of our Directors, Dr. Allan Bayless, has recently written about the Foundation to the Ensign, the magazine of the U.S. Power Squadrons. Publication of this letter has stimulated a number of new members, and more should be forthcoming as a result of a new mailing of solicitation to all of their members who have qualified in navigation. Hopefully, the new members will participate through the Reader's Forum, and meanwhile we continue to have good participation from our present membership, as this issue of the Newsletter demonstrates.

Awards

We have received the first of our Bronze Plaques, to be awarded for excellence in the study of Navigation, from the firm of Award Crafters in Fairfax, VA. The first award has gone to Theodore D. Kennedy of the Gould Academy in Bethel, ME. The Plaque is of bronze, mounted on a wooden base board and inscribed with the name of the winner. The school gets an additional plaque mounted on a larger base, allowing room for a succession of names of future winners. The full year course in celestial navigation offered at the Gould Academy was noted in Issue Five of the Newsletter.

Discount Books

We have received the first order for navigation books (Bowditch, the Almanac, H.O. 229, etc.) from a member who operates a navigation course in Norristown, PA. Members are encouraged to take advantage of our discount opportunities both on navigation books (Cornell Maritime Press, Government Printing Office, and Defense Mapping Agency) and on charts. Either large or small orders will be welcomed. Details with respect to these discounts were reported in Issue Five of the Newsletter, and we will be happy to furnish this information again to any member who writes for it.

Annual Meeting — A Suggestion

A member has recently asked about the possibility of having an annual meeting of members - perhaps one on the East Coast, and one on the West Coast in alternate years. Such a possibility is under consideration and we would be interested in any opinions of members on the subject. Membership growth suggests that such a meeting might generate enough of a turnout to be interesting, possibly by next year. Initial thought is to have an East Coast meeting somewhere on the water (possibly in the vicinity of Annapolis) at a time related to another maritime event such as a boat show or a regatta. Accommodations could be kept reasonable by group rates, and we would expect to have about two days of worthwhile navigation papers presented with ample time for discussion. The same structure would apply to the West Coast. We would like to hear from members with ideas pro or con.

READERS FORUM

Roger Burns of Fairbanks, AK, has written a short note in which he reiterates the observation that navigation will soon be lost as an art. From the tone of his letter we assume he refers to celestial methods of navigation. He notes: "As a flight navigator and part-time instructor of navigation in the local community college aviation technology program, I can point out a perfect example. There is an excellent text on aircraft navigation written by Lyon, which is now in its (at least) 18th edition. The first edition is all meat, the last is all water. Please let me know if there is hope."

Our reply is that indeed there is hope! As noted in the first letters we sent out announcing the formation of the Foundation, our thesis was that with the advent of the wealth of admirable electronic aids that have come on the market, there has tended to be a masking of the critical importance of the basic human skill of the navigator who uses a sextant and the various means of sight reduction. The responses were prompt, and they came from the full cross section of mariners - single-handed sailboat voyagers, merchant marine and Navy ship masters, teachers of navigation, and many others. Our growing membership attests that many share our concern and that of Roger Burns. In this same context we are intrigued with the masthead editorial in the September 1984 issue of Cruising World magazine in which it is noted that dependence on electronic technology is becoming a fact of life, but there are those who are bucking the trend. The Editor of Cruising World then goes on to note that Marvin Creamer of Pittman, NJ, has completed his 30,000 mile circumnavigation without the aid of any navigation instruments whatsoever, and the magazine contains an article by Creamer describing his celestial method of using only his eyes, shoulders, and hands for measuring devices (in the place of the sextant). We, of course, have followed Creamer's progress with great interest. Our members may wish to join us in a "Well Done!" to one, who, without sextant, compass, electronics of any kind or even a wristwatch, has put the known declination of a few stars to such good use in conjunction with charts and his ability to estimate, by eyeball and arm, when a star was in his zenith.

Several people have written in response to the mention in the last Newsletter of the Telefix system devised by member, Leonard Eyges. Inadvertently, we omitted Mr. Eyges' address from the piece in the Reader's Forum about his "small angle navigation." Mr. Eyges may be reached at: Nautigon Marine, Box 218, One Grove Street, Wellesley, MA 02181.

Member Donald J. Pegg, of Fort Pierce, FL, with whom we have become acquainted through several letters, is a collector and preserver of naviation tables, historically significant treatises on navigation, and other hard-to-find references. He has written in response to the piece by Paul Shaad, "The Differential Lunar," which appeared in Newsletter Issue Four. Excerpts from Mr. Pegg's recent letter follow.

"I believe Mr. Paul Shaad stated the (lunar) principle quite accurately. I do not believe the method is new, however, and on checking Mr. Shaad's article, I find no statement to that effect. As a matter of fact, a few articles on the subject have appeared in issues of the Journals of the Royal Institute of Navigation and of our Institute of Navigation over the past several years. In addition, Dr. Frances W. Wright devoted four pages to the subject in the "Particularized Navigation" in 1973, and John S. Letcher, Jr., in 1977, brought out his book, Self Contained Celestial Navigation, which covers the subject quite thoroughly.

"In all the above mentioned methods, one important point is to be noted: No lunar distances are required. Since the altitude of the Moon above the horizon is used in this method of working lunars, it is not necessary to use or to compute the lunar distance. In addition, the final adjustments for the correct GMT are performed by plotting and not by the 'mathematical' method given by Mr. Shaad.

"Although lunar tables were omitted from the N. A. after 1907, and various auxiliary tables in Bowditch were omitted after 1914, the lunar distances can be computed by the method given in the N. A. (Nautical Almanac) for 1925. The Earl of Dunraven, in a very readable work of 3 volumes, Practice and Theory of Navigation, (now out of print) also gives an easily workable method. This method requires a table of versed sines, although haversines can be used by making the appropriate changes in the formula.

"I am enclosing a copy of page 102 of the N. A. for the year 1925 . . . [and] a list of the articles mentioned in the beginning of this letter."

We believe that Mr. Pegg's enclosures may be of interest to some readers, and they follow below.

JOURNAL

THE ROYAL INSTITUTE OF NAVIGATION

Vol. 19 No. 1 January 1966
Longitude without time
. . . . Francis Chichester

Vol. 19 No. 2 April 1966
Modern view of lunar distances
. . . . HMNA Office

Vol. 19 No. 3 July 1966
Longitude without time . . J. J. Evans

Vol. 21 No. 2 April 1968
Longitude without time . . D. H. Sadler

Vol. 218 No. 6 December 1977
The "NAUTICAL MAGAZINE"
Improved plotting solution to Longitude without time . . Bruno Ortlepp M.R.I.N.

JOURNAL

INSTITUTE OF NAVIGATION (USA)

Vol. 17 No. 2 Summer 1970
The method of lunar distances and Technical Advance . . . . . Saul Moskowitz

Vol. 18 No. 3 Fall 1971
Examples of Moon sights to obtain Time and Longitude . . Dr. Frances W. Wright

LUNAR DISTANCES.

THE COMPUTATION OF LUNAR DISTANCES.

Tables of lunar distances are no longer given in the Almanac, in accordance with the decision of the Navy Department that they are now of little practical use to navigators. However, in case it is desired to use this method, the angular distance between the Moon and any heavenly body may be calculated by solving the spherical triangle of which the known parts are the polar distances of the Moon and the other body and the difference of their right ascensions, or, in other words, the angle at the pole between their hour-circles. Then, the Greenwich mean time of the observation being approximately known, and the lunar distances for the star or other body calculated for the *even hour before and after*, the required lunar distance may be interpolated and the longitude derived by the methods given in books on navigation.

EXAMPLE 1.

Find the lunar distance of Aldebaran, Jan. 11, 1925, at 22^h (10 P. M.), Greenwich Civil Time.

Let α and δ = Right Ascension and Declination of the star
" α' and δ' = " " " " " " Moon
" D = Lunar Distance
Also let $\tan M = \tan \delta' \sec (\alpha - \alpha')$
Then $\cos D = \sin \delta' \cos (M - \delta) \operatorname{cosec} M$

α	$4^h\ 31^m\ 37^s$	M	36° 40′.2
α'	$8^h\ 52^m\ 57^s$	δ	+16° 21′.5
$\alpha - \alpha'$	$19^h\ 38^m\ 40^s$	$M - \delta$	20° 18′.7
$\alpha - \alpha'$	294° 40′.0	$\sin \delta'$	9.47237
δ'	17° 15′.7	$\cos (M - \delta)$	9.97212
$\tan \delta'$	9.49239	cosec M	0.22388
$\sec (\alpha - \alpha')$	0.37951	cos D	9.66837
tan M	9.87190	D	62° 13′.6

EXAMPLE 2.

Find the lunar distance of Jupiter, Nov. 19, 1925, at 12^h (noon), Greenwich Civil Time. In this case the distance is smaller and the following method is more accurate:

Let α and δ = Right Ascension and Declination of the planet
" α' and δ' = " " " " " " Moon
" D = Lunar Distance
Also let $\tan N = \tan \frac{1}{2} (\alpha - \alpha') \cos \frac{1}{2} (\delta + \delta') \operatorname{cosec} \frac{1}{2} (\delta - \delta')$
Then $\sin \frac{1}{2} D = \sin \frac{1}{2} (\alpha - \alpha') \cos \frac{1}{2} (\delta + \delta') \operatorname{cosec} N$

Sin N and $\sin \frac{1}{2} (\alpha - \alpha')$ have the same algebraic sign.

α	$19^h\ 26^m\ 24^s$	$\tan \frac{1}{2} (\alpha - \alpha')$	9.01055
α'	$18^h\ 39^m\ 36^s$	$\cos \frac{1}{2} (\delta + \delta')$	9.96732
$\alpha - \alpha'$	$0^h\ 46^m\ 48^s$	$\operatorname{cosec} \frac{1}{2} (\delta - \delta')$	2.15426 *n*
$\alpha - \alpha'$	11° 42′.0	tan N	1.13213 *n*
δ	−22° 21′.2	N	94° 13′.1
δ'	−21° 33′.0	$\sin \frac{1}{2} (\alpha - \alpha')$	9.00828
$\delta + \delta'$	−43° 54′.2	$\cos \frac{1}{2} (\delta + \delta')$	9.96732
$\delta - \delta'$	− 0° 48′.2	cosec N	0.00118
$\frac{1}{2} (\alpha - \alpha')$	5° 51′.0	$\sin \frac{1}{2}$ D	8.97678
$\frac{1}{2} (\delta + \delta')$	−21° 57′.1	$\frac{1}{2}$ D	5° 26′.4
$\frac{1}{2} (\delta - \delta')$	− 0° 24′.1	D	10° 52′.8

NAVIGATION NOTES

Daylight Observations of Venus

Member Leonard Rifkin of Alhambra, CA, has provided an instructive example of daylight observation of Venus. It is a subject which is mentioned in passing in many texts on navigation, but is rarely highlighted. Many practitioners have commented that they tend to shy away from attempting daylight observations of Venus due to supposed difficulty in locating the Planet after the Sun has risen. Actually, the difficulty is not as great as might be supposed. The Rifkin example is reprinted here in its entirety.

"There are many opportunities to observe Venus for a significant LOP during daylight hours. Whenever the meridian passage of Venus differs from the Sun's meridian passage on the order of 2 hours, we have such an opportunity. Venus is observed on the meridian, and then the Sun is observed for its LOP. There are times when Venus, Sun, and Moon are thus available for a 3-body fix. The accompanying sheet shows an illustrative example. The 1977 Bowditch excerpts are used for N. A. (Nautical Almanac) data.

"For Saturday, May 31, 1975, it is noted that the meridian passage for Venus is LMT 1512. Assuming that the ship's clock is keeping Zone Time to within 30 minutes of the central meridian, it is not necessary to determine a DR position with a high degree of accuracy. In our case, we use the ZT 1500 DR. Using DR Lat. we solve for 'h' in the stated expression. Altitude correction is applied in REVERSE to obtain H_p (Precomputed). Set H_p on the sextant, face North or South as the case may be at transit time, and low and behold there is Venus shining brightly. Carefully measure the meridian altitude. Compare 'h_s' with 'H_p' - the intercept difference is then translated into miles north or south from the DR Lat. As soon as 'h_s' is taken and recorded, turn and take an observation of the Sun and solve in the usual way."

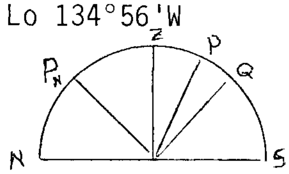
Daylight Observation of Venus
Enroute Yokohama to San Francisco, CA

Course: 098 Speed: 6.0 Zone: +9
HE: 10 Ft. IC: +1.5' Date: 5/31/75

(P. 1134, 1977 Bowditch) Venus Meridian Passage: LMT 1512; d = N23°45.8'

1500 DR: L 41°07'N - Lo 134°56'W

L=d+z=d+90-h



h=d+90-L=23°45'.8+90°-41°07'
h=72°38'.8

Corr -1.8 (REV)	(P 1128)	(+)	V	(-)
H_p=72°40'.6	IC	1.5		
h_s=72°47'.6	D			3.1
a 7.0T	P			0.3
(LAT 41°00'N)	Add'l	0.1		
	Sum	1.6		3.4
	Corr		(-)	1.8

GMT 00-10-00, June 1, 1975 SUN LL
IC +1.5
h_s 45°13.5

Latitude by Polaris

Just as many practitioners shy away from daylight observations of Venus due to the supposed difficulty in locating it after the Sun has risen, so, too, an appreciable number of practitioners tend to shy away from Polaris observations because it is a dim star not easily located during twilight. That is especially true at evening twilight for those who would locate Polaris by the familiar method of finding it on a straight line projected from the stars which form the outer side of the "cup" of the Big Dipper. By the time the Sun has set long enough to see the Big Dipper constellation and Polaris, the horizon is usually too dark to be useful. Hence, the navigation texts urge their readers to locate Polaris by setting the DR Latitude on the sextant, pointing the instrument in a True North direction while the horizon is still sharp, and finding the pin-point of light on or near the horizon in the sextant optics which is Polaris.

Mr. Rifkin has forwarded, in addition to the daylight observation of Venus example, an example of a Latitude by Polaris during morning twilight. In the case of the morning shot, assuming Polaris has been visible most of the night preceding the shot, the problem of locating the star is not as great as it is at evening twilight when the star has not been previously visible to the naked eye. Mr. Rifkin notes:

"During morning twilight there should be no problem in locating Polaris. A precomputation for use at evening twilight will offer a chance to capture Polaris while the horizon is still sharp and clear . . . .

"For Sunday, June 1, 1975, we find that morning civil twilight is LMT 1419. Note ZT 0400 DR. Determine LHA Aries; calculate 'H_O'; apply altitude correction in REVERSE to obtain 'H_p'. Set 'H_p' on the sextant, point North, and Polaris will be sparkling in the mirror system. Carefully measure 'h_s'. Compare 'h_s' with 'H_p'; the difference can be translated into miles north or south of DR. Continue taking rounds of other sights."

Mr. Rifkin's practice of applying sextant corrections in reverse to arrive at a precomputed value for an observation is a familiar technique. It can be used with virtually any observation of any body. As noted by Mr. Rifkin, the technique provides a precomputation which, at the time of the observation, gives a very quickly derived intercept. Some readers may be interested to know that it is this same technique which is used by the authors of texts in devising their examples, and indeed we use it in connection with the Navigation Problems presented in the Newsletter. Only rarely are the examples printed in the texts reflections of actual observations performed at the time and location given in the examples. Foundation members who are interested in honing their sight reduction and LOP plotting skills may wish to make up their own examples, never leaving their armchairs.

History of Navigation

John M. Luykx, Lt. Cmdr., USN, and a member of the Foundation, has written a number of interesting letters. His most recent comments on the note in the last Newsletter on the Foundation's logo, which depicts an early 17th Century mariner using the backstaff. He reports actual 20th Century experience using both the cross-staff and the backstaff. He notes that in his experience, they provide comparable accuracy at altitudes below 65°, but that for celestial bodies with higher altitudes the backstaff is superior. He also notes that the backstaff measures altitude as well as zenith distance, and that most of these early instruments were designed to read for altitude and zenith distance at the same time and on the same scale. Finally, he explains that the cross-staff was also used to take back-sights, and that its accuracy in that mode is superior to that of fore-sights. He sent to us tables showing results obtained by him comparing cross-staff back-sights and backstaff fore-sights. Readers will be interested to know that John Luykx teaches celestial navigation courses at the University of Maryland.

Results Obtained by John Luykx

	Cross-staff (Back-sights)	Backstaff
Body	Sun	Sun
No. of Sights	60 (12 groups of 5)	72 (24 groups of 3)
Mean error	2'.6	3'.3
Std. error	3'.2	4'.3
90% error	5'.3	7'.2
Range of error	9' (-5' to +4')	12' (-5' to -17')
Altitude range	52° - 51°	62° - 70°

A Navigation Problem

Before presenting the continuing voyage of the sailing vessel Backstaff and the continuing problems faced by its navigator, it is appropriate to acknowledge John Luykx, who, in the same recent letter as noted immediately above, provided especially good comments on Problems #1 and #2 which appeared in the last Issue. We would have offered the same comments and solution to the problems, but are pleased that he has benefited the readers of the Newsletter by his timely solutions and comments. He writes:

"Finally, I enclose a solution to navigation Problems #1 and #2. I do this because one of the difficulties with an LAN sight, such as this, is that when a vessel is heading due south the Sun will apparently reach a maximum altitude at some time interval after the actual meridian passage of the Sun at LAN (Local Apparent Noon). The best way to determine latitude at LAN, in such a circumstance, is to determine the time interval and then to solve for latitude by ex-meridian procedure.

"The time interval may be found by the formula:

Step A. $t=\frac{L1+d1}{2a}$

Step B. $t=\frac{4''.3+0''.6}{8''.8}$

$=\frac{4''.9}{8''.8}$

= .56 minutes

= 33 seconds

Where:
- t=time interval in minutes
- L_1=rate of change of latitude per minute
- d_1=rate of change of declination of the Sun per minute
- 2a=2 X altitude factor (a) Bowditch Table 29

Step C. Enter Table 29 of Bowditch with a and 33 seconds. The correction is 0'.0. In this case the correction to observed latitude is so small that no correction is required. However, if the vessel were at a higher latitude and the speed was 20 knots or more, an appreciable correction would be required. In North Latitude during the Fall and Winter an appreciable correction would also be required."

Commander Luykx's solution to the problems presented in the last issue are correct, but our answers are presented here in somewhat fuller form.

Solution to Problems Presented in Issue Five

1. The estimated EDT of LAN is 13:02.

   Considerations to be kept in mind:

   a) The vessel's DR Long. is 1°25.9 west of the standard meridian. Thus the estimate of LAN will be later than the time of meridian passage given in the Almanac.

   b) The time of meridian passage given in the Almanac is only to the nearest minute. Therefore the increment of time for 1°25.9 (5:44 rounded off to six minutes) which is added to the meridian passage time of 11:56 gives only an approximate estimate of LAN - not a precise one.

   c) Using the equation of time, it would be possible to compute a more precise estimate, but this would not be of great utility in view of the fact that the vessel may or may not be exactly at the DR Long of 76°25.9 W, and good practice would have the navigator on deck "tracking" the sun several minutes before the estimated LAN.

   d) One hour must be added to account for EDT, thus the estimate is 13:02.

   e) Rarely will the body seem to "hang" at its highest altitude at a single instant in time. Rather, depending on latitude, altitude, and time of year, it will seem to "hang" for a period of from several seconds to perhaps as much as two minutes.

   f) If there is a large southerly or northerly component of the vessel's motion, the computed time of meridian transit may not coincide with the highest altitude of the body. This is due to the fact the apparent change in altitude of the body due to the vessel's motion may be greater than that due to the nominal apparent motion of the body (due to rotation of the earth). In those circumstances, the highest apparent altitude may occur several minutes before or after meridian transit. In the instant case, however, the speed of Backstaff is not sufficient to produce this effect.

2. Lat. =

	89°60.0	
	-70°28.7	H_o South
	19°31.3	ZD North
	-19°01.5	Dec. North
	38°32.8	North Lat.

H_o is named N or S according to the bearing of the body.

Zenith Distance is given the name opposite to the bearing.

Declination is given its own name, and is added if of the same name as ZD. Otherwise, subtract the smaller from the greater and name Latitude after the greater.

Departure: 38°56.1 N
13:02 Lat. -38°32.8 N
23.3 = 23.3 n.m.

Departure time: 0800 EDT
Time of sight 1302

Time interval 0502

$$\frac{23.3}{5.05} = 4.61 \text{ kts. average speed}$$

Navigation Problems for Issue Six

Backstaff's DR is 38°34.6 N, 76°25.9 W. (We know from Problem 2, Issue Five, that the actual latitude, if the sextant observation for LAN was accurate, is 38°32.8 N.) The navigator's height of eye is 12 feet, and the sextant index error is 2 minutes off the arc. The watch is set to EDT and is 7 seconds fast. At 12:54:20 by the watch the navigator is "tracking" the still-rising sun, and he observes its altitude as 70°09.9. He again observes that same sextant altitude at 13:09:54.
(Problems are numbered consecutively beginning with #1, Issue Five.)

3. At what time did meridian transit of the Sun occur?

4. From the time of meridian transit, compute the longitude of the vessel.

5. Is Backstaff east or west of her DR longitude, and by how much? Assuming the latitude derived in Problem 2 to be accurate, and the longitude in Problem 4 to be accurate, and assuming that the actual position is the result of current combined with the course and speed of the vessel (180° true and 4.66 kts), what was the approximate set and the drift of the current during the 0800 to 1300 run?

(Note. It is not necessary to plot in answering question 5.)

BOOK REVIEW

Chartwork and Marine Navigation For Fishermen and Boat Operators

Second Edition 1984

By Geoff A. Motte
With Thomas M. Stout

Cornell Maritime Press
Centreville, Maryland

Reviewed by Roger H. Jones

Captain Motte, a former British merchant seaman, is currently Vice President for Academic Affairs at the Massachusetts Maritime Academy. His colleague, Captain Stout, is an Assistant Professor in the Department of Fisheries and Marine Technology at the University of Rhode Island. Together, in the 1984 update of this book, which was first published in 1977, they have produced a work which is a marvel of succinctness. In their pursuit of meaning through elimination of excess verbiage, however, they have not sacrificed breadth of coverage or clarity of expression.

The book is presented in two parts. The first deals with a comprehensive array of subjects: from chartwork to running and other types of fixes; from the Earth's magnetism to ships' magnetism and marine compasses; from tides to wind and current factors; from horizontal and vertical sextant angles to the sextant itself; and from various types of bearings to the sailings (plane, parallel, mid-latitude, and Mercator). Part One ends with a chapter on plotting sheet construction which is interesting because it goes beyond the basic steps (establishment of the proportionally correct meridians and parallels using the familiar line having an angle with the central parallel equal to the middle latitude chosen) into instructions as to the precise methods for constructing accurate linear scales of longitude.

The beauty of each of these subject matter chapters is that each is presented in just a few pages of carefully worded and interrelated paragraphs, and each is followed by its own practical problems, which are individually succinct, but comprehensive in collective coverage. These chapters are models of brevity, but they reflect unusual effort on the part of the authors to speak in clear, concise and simple terms. These are chapters for the beginner and the seasoned veteran.

Part Two follows a tough act, but does its own job very well. In this part there is presented full coverage of all the necessary subject matter areas of celestial navigation. Solar system and celestial mechanics, principles of time, the celestial sphere, and instruments and sextant angles are the appetite-whetters. Those chapters are followed by ones dealing with latitude by meridian altitude, asimuths and amplitudes, the Pole Star, the celestial LOP, methods of sight reduction (calculator, short table, and inspection table), and fixing position. Again, each chapter has its own practical problems, and both problems and text reflect the same admirable effort towards clarity, meaningful brevity, and simplicity of terms.

All told, there are 39 chapters presented in only 166 pages. The appendix includes Almanac excerpts, but none from the inspection tables such as H.O. 229 or 249. However, the problems and examples in the celestial chapters contain data from such tables. If this reviewer were to focus on any omission, it would be the fact that the book illustrates sight reduction very well using data from the sight reduction tables and the Almanac, but in its brevity the one thing missing is full instructional material on how to enter and extract data from the Almanac and the inspection tables. In their overall purpose of achieving a concise format, the authors understandably rely on the fact that the Almanac and the sight reduction tables have self-contained and detailed instructions for their use, coupled with their own illustrative examples.

The many illustrations are varied and well done. Each is designed to present an essential concept, and they generally are not cluttered with the confusing lines and symbols that attend multi-purpose illustrations, although the inescapable "spider web" is to be seen in those dealing with the celestial sphere and sextant altitude corrections.

This little book is definitely a traveling companion. It will fit easily into almost any navigation kit, and it is comprehensive to the point of eliminating the need for numerous other books. It is not for the mariner who places primary reliance on electronic aids, but for the coast-wise or blue water sailor who relies on his own skills of piloting and position fixing; it is a shipmate worthy of a berth.

Flight Deck

Reviewed by Henry H. Shufeldt

Flight Deck is a 58-page manual, prepared by M. N. Peterson, P.O. Box 1552, Cupertino, CA 95015, together with 17 program cards designed for use with the Hewlett Packard Series 41-c calculators. Price, $48.00. An HP card reader is required.

These programs are designed for the use of the air navigator and permit rapid reduction of observations of the Sun, Moon, navigational planets, and selected stars. For further information, address Mr. Peterson.

Rare Books

A member has written in asking where he can get a list of the rare books at the Naval Observatory which are available through the library system. No such list is published and the procedure to obtain any reference work through the normal library channels must start with a request for information. This is entered into a library computer system through the librarian and may turn up an old book as the primary source of information. Such books, if they are not classified as "Rare" books may be available on an interlibrary loan. In the case of "Rare books, however, the researcher must come to their location and do his research in accordance with the rules of the archive which contains them. Obviously this rule is necessary to preserve the books, which are usually kept in a room with controlled temperature and humidity.

MARINE INFORMATION NOTES

Transit

In response to a U.S. Navy request, the Department of Defense has agreed to extend its support of the Navy Navigation Satellite System (TRANSIT) to 1994.

Omega

The U.S. Coast Guard has declared the Omega Navigation System operational in the region bounded by approximately 20 N - 35 S latitude and 70 W - 20 E longitude. Through an extensive data collection and validation effort, the Coast Guard determined that the system meets the predictable accuracy requirement of 2-4 nautical miles (95% confidence level) in the region. The validation effort will continue during the next four years.

1984 Edition of Bowditch (Vol. I)

The 1984 edition of Volume I of Pub. No. 9, American Practical Navigator (Bowditch), should be available for sale sometime during the period December 1984-January 1985. (Note that this may be purchased through the Foundation at a discount).

Contents of *Summary of Corrections* Reorganized

The contents of Volumes 3 and 4 of the Summary of Corrections, published by the Defense Mapping Agency Hydrographic/Topographic Center, have been reorganized beginning with new editions dated June and July 1984, respectively.

Volume 3 will include Subregions 16 thru 19, 21, 22, 29, Region 6, and Region 7 (Eastern Pacific, Antarctica, Indian Ocean, and Australasia).

Volume 4 will include Regions 8 and 9 (Western Pacific).

Volumes 1, 2, and 5 will remain unchanged.

U.S. Modified Aids to Navigation System

On April 15, 1982, the United States agreed to modify the U.S. lateral buoyage system to incorporate the International Association of Lighthouse Authorities (IALA) Maritime Buoyage System for Region B. The U.S. lateral system is not materially changed. A majority of the U.S. aids already conform - red buoys and daymarks to starboard, green daymarks to port. The non-conforming aids - chiefly black buoys - will be converted on a gradual basis as they are routinely replaced or serviced.

Until the conversion program is completed, mariners should be familiar with both systems and alert to the fact that changes may not be immediately reflected on published charts. All changes will be published in the U.S. Coast Guard Local Notice to Mariners and where appropriate the Defense Mapping Agency weekly Notice to Mariners.

provided by Ernest Brown

FUTURE ISSUES

Our first Bronze Plaque award has arrived and been presented to the winner at the Dresser Academy. We now have a mold which will make further awards more timely - and, of course, will reduce our costs. We expect to have established additional award arrangements by the next Newsletter.

Director Ernest Brown now receives and reviews Notices to Mariners on a regular basis and our Maritime Information Notes will carry his clarification, explanations or corrections. These should be helpful to members who may find the Notices not always as understandable as they might be. Of course other maritime publications will also be reviewed, and we will continue to provide corrections and clarifications to them.

We should also be able to report on the results of a very substantial membership solicitation by direct mail, currently underway. Meanwhile we continue to receive new members and prospects as a result of our own members' efforts. We want to thank those members for their work.

Address all correspondence to:

The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850

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280 Ny.Rn. 22

S S Amerika via S S Titanic and Cape Race N.E. April,14,1912

Hydrographic Office,Washington DC

Amerika passed two large icebergs in 41 27 N 50 .8 W on the 14th of April

Knutp,10;51p

62496 filed with 2995	HYDRO. OFFICE Rec'd APR 15	1912
	Enclosures	

Telegraphed H.O. New York April 15, 1912.

P.C.

WWM

THE NAVIGATOR'S NEWSLETTER

FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION ISSUE SEVEN, WINTER 1984

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

Membership

Membership in the Foundation continues to grow. Our large solicitation mailing mentioned in the last issue has been productive of substantial increases. The influx of new members occurred at the very moment we were transferring the Foundation list between two non-compatible computers, a TRS 80 and an Epson QX-10. This transfer has now been completed, and some members may note a slight change in format of their labels - but not any errors, we hope.

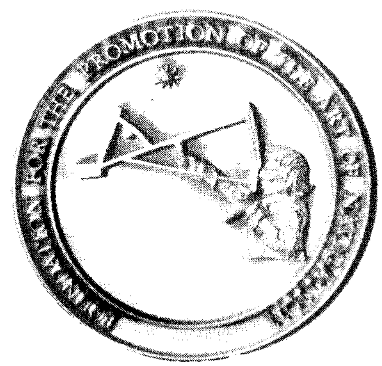
Members who had failed to renew by several months were notified by slips inserted in their last Newsletter. These have produced some results, but the renewals still lag. We will shortly mail each member in arrears a notification which will include a franked return envelope. We hope that this will be effective.

The Foundation now has under preparation a free descriptive brochure which can be distributed to interested parties. Members who can usefully distribute them should write in.

Medallions

We mentioned in the last letter that our Navigation awards program had been instituted at an Academy in Maine - but had the name wrong the last time we mentioned it. The name should have been the same as the initial mention, the GOULD academy of Bethel, Maine.

Incidentally, the bronze medallion which is mounted to form the plaque was so well done that we are including a picture of it herewith.......We have received several suggestions as to other places where such an award may be appropriate, and we welcome such suggestions.



Back Copies of the Newsletter

There have been numerous requests for back copies of The Navigator's Newsletter, some of which we have been able to fill and some not. As a result we are undertaking to reprint and fill all requests in the near future. To cover the costs of reprinting and mailing, we will need a handling charge of $2.00 per copy. If those readers who are interested will re-submit their requests, we will be able to fill them in the near future.

Annual Meeting

Several members have indicated an interest in an Annual Meeting. We will hold off on any decision on this until we receive further indications pro or con. Members who are involved in teaching Navigation appear to be particularly interested in such a get-together to discuss mutual interests. We would like to hear from others with this interest.

READERS FORUM

From member Paul E. Shaad, we have the following notes:

"In issue number six Mr. Pegg has given us an excellent list of articles about 'lunars.' To this list may be added: Second Method of Recovering Longitude, p. 160, 'The Calculator Afloat,' by Shufeldt and Newcomer, Naval Institute Press, 1980.

"Members may be interested in a recently introduced quartz timepiece available at Radio Shack stores. It is inexpensive, has a very large and very readable digital read-out, has clock, calendar and chronograph modes and can be set precisely to GMT with great ease. It can be held in the palm of the left hand while adjusting the sextant. It sells for about $30."

Member Edward I. Matthews, writes:

"As a staunch advocate for the use of programmable calculators in celestial navigation solutions, I have developed 'user friendly' programs for both the TI-59 and HP-41CV calculators. Errors are minimized by the use of calculator prompts for the required NA hourly data and other inputs. Correction table look-ups and calculations by the user are entirely eliminated. Output information eliminates the need for plotting, generally.

"The TI-59 has the advantage of unlimited storage by utilizing magnetic cards for additional input, with some inconvenience. Period cards prepared from the Almanac for Computer Tables eliminate the need for <u>any</u> user lookup. The major disadvantage <u>is</u> the requirement for frequent battery recharging.

"The limited storage capacity of the HP-41CV precludes use of the A/C and requires the NA. On the plus side, this device has long battery life, alpha prompt displays and program selection convenience.

"Issue six of the Newsletter described Commander Luykx's ex-meridian solution to the LAN latitude sight requiring a reference to Bowditch Table 29. My stong aversion to lookups prompted the derivation of a trigonometric solution for calculator use:

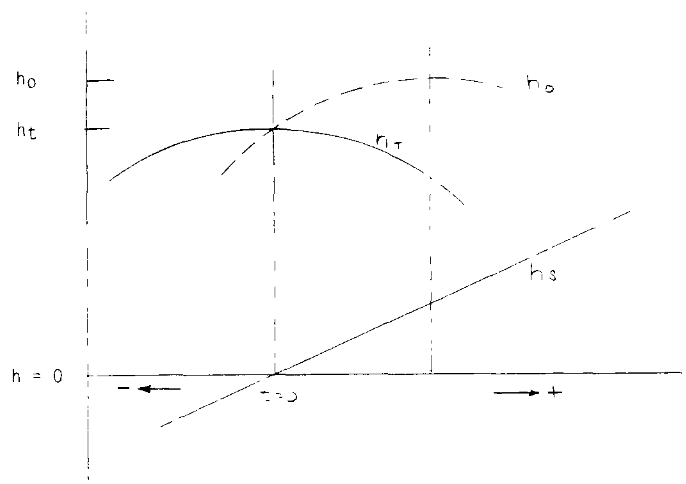
$$\sin t = \frac{-S \times \cos C \times \cos h}{900 \times \cos d \times \sin (h \pm d)} \quad \begin{matrix} (+)d > L \\ (-)d < L \end{matrix}$$

$$T = 4 \times t$$

where S is speed in knots, C is true course, d is declination (assumed constant), h is apparent meridian transit altitude and t is the meridian angle difference from true meridian passage. T is the time difference in minutes.

"As a small yacht sailor with limited on board storage for tomes such as Bowditch (1966 edition), HO-299, etc., and required to perform on-the-lap plotting techniques, I rely on my calculators stored in plastic bags and use HO-211 for backup."

The Matthews' Derivation follows:



h true: $h_t = \sin^{-1}(\cos d \times \cos L \times \cos t + \sin d \times \sin L)$

h speed: $h_s = \dfrac{-S \times \cos C \times t}{15 \times 60}$

h observed: $h_o = h_t + h_s$

Differentiating:

$$\frac{dh_o}{dt} = \frac{-\cos d \times \cos L \times \sin t}{\sqrt{1 - \sin^2 h}} - \frac{S \times \cos C}{900}$$

$$= \frac{-\cos d \times \cos L \times \sin t}{\cos h} - \frac{S \times \cos C}{900}$$

Since $t \cong 0$ $\quad \cos L \cong \sin(h \pm d)$ $\quad + \; d > L$, $\; - \; d < L$

For max h_o $\quad \dfrac{dh_o}{dt} = 0$

$$\sin t = \frac{-S \times \cos C \times \cos h}{900 \times \cos d \times \sin(h \pm d)} \text{ degrees}$$

$$T = 4 \times t \text{ minutes}$$

Norman Cubberly notes the following:

"Involved up to ↑ here in rigging and prepping the Bark GODSPEED (68') for recreation of Jamestown voyage (1607) from England. There are plans to use cross-staff etc. - plus more modern methods. (Back-staff not yet invented.) Will send a writeup when I have details."

In a short note Bob Peters writes:

"I would like to see a celestial navigation problem in your newsletter and also instruction on celestial techniques such as how to tell time with the moon."

We have several letters about the discount books, which we hope the information in this Issue will answer. Apologies for the delay.

Suspension apparatus of a western astrolabe, from J. Koebel: *Astrolabii Declaratio* 1532.

NAVIGATION NOTES

Salvaging Sights in Ageton's "Forbidden Zone"

Since Ageton first published his "Dead Reckoning and Azimuth Table" (H.O. 211) in 1931, it has been recognized that sight reductions in the area where K approaches 90° is a risky business due to the large errors in H_c which may appear. Herrick[1] suggested interpolating the figures, particularly B(R) from A(R); Smiley[2] suggested interchanging D and L in the usual reduction format. However, the best solution of all was proposed by Donald H. Sadler,[3] former Superintendent of H. M. Nautical Almanac. This involves the re-ordering of the reduction and is applicable only in the "forbidden zone," defined in Bowditch as the area where K lies between 82° and 98°.[4] Sadler's technique:

Conventional Ageton	Salvage (K between 82° and 98°)
A(R)=A(t)+B(d)	A(h')+A(L)+A(d)
A(K)=A(d)+B(R)	A(h")+B(L)+B(d)+B(t)-B[(H'+h")/2]
A(Hc)=B(R)+B(K~L)	Hc=h'+h"
A(Z)=A(R)-B(Hc)	A(Z)=B(d)+A(t)-B(Hc)

The technique is best shown by example: t 89°06'W, d 53°16'S, L33°19'S, Ho 27°00'. In this instance, K is 90°.

```
          t 89°06' W -------------> +B 180390   +A     5.4
          d 53°16' S    +A  9614    +B  22323   +B 22323
          L 33°19' S    +A 26022    +B   7798      sum
         h' 26°07' <---  A 35636        sum         :
         Ho 27°00'                                  :
      h'+Ho 53°07'                   + 210511       :
  (h'+Ho)/2 26°34'  ------------->  -B   4846       V
         h"  0°30'  <-------------   A 205665    + 22328
(h'+h")=Hc 26°37'  ---------------------------> -B  4865
         Ho 27°00'               Z S 41°59' W <-  A 17463
          a    23 mi Toward      Zn 222.0°
```

It will be noticed that an approximate altitude is used in finding the calculated altitude; usually H_o suffices for the purpose. It is noteworthy the method is not sensitive to fairly large errors in approximating H_o. It will also be noted that the calculation of azimuth is exactly the same as in the "standard" Ageton reduction technique.

The accuracy of the method is best appreciated by comparing it to direct calculation of H_C by the basic Law of Cosines formula and with the value obtained by the usual Ageton technique:

Sadler's "Salvage" Technique	H_C 26°37'
Direct Calculation	H_C 26°37.1'
Standard Ageton Method	H_C 26°07'

It should be recognized that the error in the usual technique fluctuates in a saw-toothed fashion from + to - so that at various points it is zero, even in the forbidden zone. However, the magnitude of the swing increases geometrically as K approaches 90°. In the "Compact Sight Reduction Table,"[5] an abridged version of Ageton's table, the maximum error in the body of the table is about 1'; using Sadler's technique, one can expect the same or better accuracy in the forbidden zone. As might be expected, Polaris sights can be accurately reduced using Sadler's technique.

Thus, it would appear that Ageton's method has finally achieved universality, at the cost of the necessity for a different schema for sight reduction in the formerly "forbidden zone."

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1 "The Accuracy of Ageton's Method in Celestial Navigation," Samuel Herrick, Pub. of the Astron. Soc. of the Pacific, 56:149-155, August 1944.

2 "Increased Accuracy with Ageton's Method," Charles H. Smiley, Popular Astronomy, 52:379-383, October 1944.

3 Personal communication, February 1982.

4 American Practical Navigator (Bowditch), DMAHTC Pub. 9, Vol. II, 1981, page 15 describing Table 35, The Ageton Method.

5 "Compact Sight Reduction Table," Allan Bayless, Cornell Maritime Press, Inc., 1980. (See Bowditch, reference 4, page 518; sample page on page 517.)

History of Navigation

During a recent visit to the Royal Naval Observatory at Greenwich (now a museum), I was able to examine a number of interesting and ancient Astrolabes. The details and uses of these beautiful instruments are not always appreciated by today's observer - who sometimes is "turned off" by the excessive detail. A few points that should be of interest.

There are two versions of the Astrolabe - the Mariner's and a "land based" version. The land based version has two sides. One is a version of the Rude Star-finder. More properly I should say that the Rude is a version of the Astrolabe. These devices, whose origin is undated, go back to the tenth century at least. Rather than the plastic overlays of the coordinate system that go with the Rude, they have a set of metal "underlays" or plates - each with the coordinate system for a given Latitude. By using the correct underlay and "setting" the time and date, the face would show the location of the stars and the Sun, in terms of altitude and azimuth.

The reverse side incorporated an "Alidade" (an Arabic word still in use) for measuring angles - usually in the vertical plane. Being used ashore it could be hung by a ring and so kept vertical. Under these conditions the accuracy was quite good for determining Latitude or locating stars - and of course in reverse one could get the altitude and azimuth of a Planet, and then determine in which Zodiacal "House" it was at the given time. Astrological uses were important in those times.

A peculiar use was related to the existence of "equal" and "unequal" hours. This time-keeping system divided the time between Sunrise and Sunset into 12 equal parts, regardless of the actual length of the day, and the Astrolabe provided a dial for converting from one system to the other - based on the month, day and Latitude.

The Mariner's Astrolabe, on the other hand, omitted all of the "Rude Star Finder" aspects. The accuracy was necessarily severely reduced by ship's motion, and this was reflected in the greatly reduced length of the Alidade. To allow the use with stars, the Alidade was equipped with two holes to be aligned, in addition to the "Blades" used with the Sun. This is the version mentioned in the last issue by John Luykx, in this section.

At some point in the history of the Astrolabe, the users found the numerous "underlay" plates too cumbersome, and some innovator developed the Universal Astrolabe, which did not require the plates - but was more complicated to use. Interestingly, this device was the predecessor of the Brown-Nassau computer, another modern day navigational device. The Universal Astrolabe can be traced back as far as the Tenth Century - and there were two versions in use.

A mariner's astrolabe in use for determining the meridian altitude of the Sun From Pedro de Medina *Regimiento de Navegacion*, Seville, 1563.

A Navigation Problem

Solution to the Problems Presented in Issue Six:

3. Using a watch error of 7 seconds "fast" and a Zone Description of +4, the GMT of the two observations of the Sun was, respectively, 16-54-13 and 17-09-47. The interval between these two times is 15 minutes, 34 seconds. Half of the interval is 7 minutes, 47 seconds. Adding 7-47 to the first GMT of 16-54-13 results in a GMT of meridian transit of 17-02-00, 15 May 1984.

4. The time of meridian transit, 17-02-00, converted into arc, yields a longitude of 76° 25.4' West.
Note: This method may not yield results as precise as those obtained from a careful observation of a body East or West of the observer, but the results are quite often acceptable.

5. Backstaff was pushed by the current 1.8 nautical miles South (beyond) of her DR, and she is .5 minutes of arc East of her DR. In essence, it took the current five hours to push the vessel 1.8 miles beyond the point she would have been without any current. It appears that the approximate average speed of the current during this time was .36 knots, and it flowed from a direction of very slightly west of North.

Navigation Problems for Issue Seven

6. After the observations taken around the time of Local Apparent Noon, the navigator wishes to plan ahead for an evening round of star sights. He sits down to his lunch, and upon finishing he gets out the Almanac. He also consults the tide tables and notes that during most of the afternoon the current will be against the southerly heading of the vessel. Ignoring a current that he feels will not move the vessel towards any known hazard, he decides to continue to use a vessel speed of advance of 4.30 knots for planning purposes. He consults his chart, and notes that after continuing on his present course for another 7.4 miles, he will be required to alter course to 150° True, and he can remain on that course for at least 22 miles. After that his course will shift

back to a heading of 180° True. A quick inspection of the chart reveals that in the early evening his longitude will be in the near vicinity of 76° 13.0 West and his latitude will be near 38° North. For time planning purposes, he decides to use 38° N 76° 13' W as a rough but adequate estimate of his position at the time of twilight.

At what approximate EDT should he plan to be ready to begin his round of star sights? (Note the date is still 15 May 1984, and the Almanac must be consulted.)

7. Still using the Almanac, will any of the navigational planets be visible during twilight, and, if so, which ones? (Note it is always wise to plan ahead to distinguish planets from stars.)

8. For those readers with access to Volume I, H.O. 249 (Epoch 1980 or 1985), what three stars would the navigator plan as his primary targets, assuming a position of 38° N, 76° 13' W, and EDT of 2041 at the beginning of the round of sights?

9. At the time of the evening round of star shots, the vessel will be in the Chesapeake Bay within sight of land to the East and West. If the navigator observes a star to the East or West, what can he do to ascertain that he is using a true water/sky horizon rather than an apparent land/water line of demarcation?

BOOK REVIEW

Concise Tables for Sight Reduction
First Edition, 1984

By Thomas D. Davies, Rear Admiral, USN (Ret.)

Cornell Maritime Press
Centreville, Maryland 21617

Reviewed by Roger H. Jones

While recent issues of The Navigator's Newsletter have contained reviews of other new releases by the Cornell Maritime Press, and while there is a natural inclination to "broaden the field" to include new offerings of other publishers, the opportunity presented by the subject of this review was just too good to be deferred to a subsequent issue. Concise Tables for Sight Reduction is not only just off the press and is thus yet to be reviewed in any other publication, it is so new that it has not even been widely announced by its publisher. It was this reviewer's good fortune to obtain one of the very first copies on which the ink was barely dry.

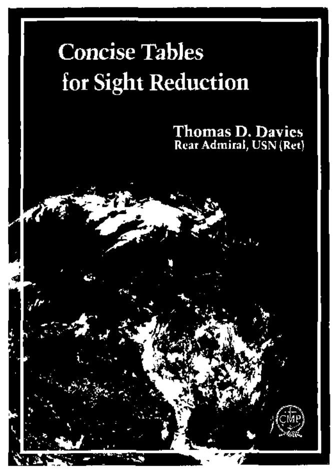
In just 32 actual pages of tabular data there is presented a complete set of tables for reduction of a sight of any celestial body as taken by an observer situated anywhere in the world. In addition, there is a list of 46 stars covering the full useful range of both North and South declinations, together with their sidereal hour angles, a long-term almanac for the Sun and for Aries, and even a similar almanac presentation for 38 of the 46 stars listed for identification. Other supplemental tables include those for correction of the observed altitude of Polaris and the azimuth of Polaris, and the familiar table for correction of Sun and star altitudes between 10° and 90°. Together with the instructions and illustrative examples, the main and supplemental tables comprise a thin volume of only 64 pages and just three-sixteenths of an inch thick. These tables are indeed concise. They may easily slip into any navigator's sextant case or travelling kit. The Naval Observatory is reported to be considering the possibility of including these tables as an appendix to The Nautical Almanac.

In concept, these new tables are as novel as the assumed altitude tables devised by Admiral Davies and first published in 1980. Readers familiar with the latter may recall that for the first time in the history of navigation, the observer was presented in 1980 with a practical and easy method that enabled him to shoot a "target of opportunity" star without knowing its identity and without doing any precomputation of altitude or azimuth. They may also recall that they were instructed to enter the inspection tables with an assumed altitude of the body rather than an assumed position of the observer, and that this method presented advantages then and now over the justly applauded Volume I of H.O. 249. (The first assumed altitude volume is for stars. A companion volume is also available for the Sun, Moon and planets.)

It is clear that Admiral Davies has again given his brethren of the sextant art some significant new advantages - advantages this time over the other available compact tables which exist, such as H.O. 211 and its modern derivatives. The new Concise Tables use entering arguments of assumed latitude and local hour angle and responding quantities that are expressed in degrees, minutes and tenths of arc. Logarithms are not used. The new tables are thus similar to such inspection tables as H.O. 229 and 249. All data necessary to begin a solution, for all sights from any given latitude, are available at a single opening of the book. Multiple page openings are avoided, as are the errors which can creep in when one has to look up log values in several different places throughout a volume. Moreover, the actual number of steps to a solution is appreciably less than that required by H.O. 211, and all adding or subtracting is of two-digit numbers (the arc-minute values). A simple Schedule of Signs clearly indicates when to add and when to subtract.

H.O. 211 and even H.O. 229 and many other tables which provide complete global coverage have otherwise usable areas in which accuracy is degraded. For example, H.O. 211 forbids using values of K between 82° and 98°, and H.O. 229 has areas where complicated additional interpolation methods are recommended. These new Concise Tables are highly accurate throughout all usable portions of the globe for sight reduction purposes, and they are fully suited to related problems, such as star identification, calculation of amplitudes, and layout of great-circle tracks. While neither the author nor publisher of these tables reveals the "computer facts" in the introductory textual material, readers of this Newsletter may be interested to know that altitudes were computed for more than 7 million possible combinations of entering arguments. No error greater than one minute of arc was found for altitudes of 77° or less, and for greater altitudes computer testing revealed errors of no more than two minutes in arc in only .03% of the cases. Adm. Davies acknowledges the major contributions of Dr. Paul Janiczek to the development of the tables.

The single small volume of H.O. 211, the three volumes of H.O. 249, the six volumes of 229, and the two volumes of the Davies assumed altitude tables are all on this reviewer's book shelf. The new single, thin volume of Concise Tables has found a permanent home with his travel-ready sextant. As this was being typed, he was working on a chance to use the new tables in the Caribbean.



MARINE INFORMATION NOTES

Buoy Position Checks

The U.S. Coast Guard normally checks buoy positions only during periodic maintenance visits which often occur more than a year apart. It is imperative that members of the navigation community include as part of good navigation practice the reporting of defects in floating and other aids to navigation. It is also imperative that they take the time occasionally to use reliable means (sextant angles) to verify the positions of these aids.

Ocean Claims

Notice to Mariners 39/84 contains a summary of the various national ocean claims (June 1984). The material is published solely for information relative to the navigational safety of shipping and in no way constitutes legal recognition by the United States. For each country the distance in nautical miles is given for territorial sea, fisheries or economic zone, contiguous zone, and continental shelf.

provided by Ernest Brown

FUTURE ISSUES

We are continuing efforts to establish other awards, now that we have covered the "front end" costs of the mold for our medallion. Eventually we hope to put this to multiple uses.

In spite of the favorable returns from our most recent mailing, we believe that there are many more interested and interesting potential members out there - and we urge our members to tell their friends about the Foundation, and to encourage their participation. Incidentally, for the benefit of new members, our short name (which can be used on checks) is "The Navigation Foundation."

Finally, we again ask that you examine the date on your label to determine when a renewal contribution is due. A timely forwarding of this will obviate a separate mailing. The Navigation Foundation is a non-profit, tax-exempt corporation. A donation of $25.00 is requested of new members and annually thereafter. Address all correspondence to:

The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850

Suggestion: Membership in The Navigation Foundation makes a year-long holiday gift.

Discount Books and Charts

The interest in this service is growing rapidly, and it is clear that the method of ordering needs to be clarified and improved. In this issue we are including a price list of selected U.S. Government books and Cornell books. These prices are those currently listed (the Government warns that they are subject to change without notice). The rules for discounting are also restated below, and we are providing a coupon for ordering.

Discount Book Price List

American Practical Navigator (Bowditch) Vol. I	$18.00
American Practical Navigator (Bowditch) Vol. II	13.00
Nautical Almanac 1985	10.00
Air Almanac, Jan.-June 1985	11.00
Sight Reduction Tables, HO 229, 6 Volumes (each)	9.00
Sight Reduction Tables, HO 249, 3 Volumes (each)	9.00
Sailing Directions (area must be specified)	13.00
The Amateur Pilot, Milligan	7.50
Celestial Navigation by HO 249, Milligan	12.00
Celestial Navigation Planning, Gray	12.95
Chartwork and Marine Navigation, Motte	11.50
Coastwise Navigation, Wright	7.50
Compact Sight Reduction Table, Bayless	4.50
How to Navigate Today, Hart	4.00
Navigator's Pocket Calculator Handbook, Noer	16.00
Sun Sight Navigation, Birney	12.50
Yachting Signal Book, Collier	17.50
Celestial Navigation, Wright	12.00
A Star to Steer Her By, Bergin	16.50
Star Sight Reduction Tables, Davies	28.50
Sight Red. Tab. Sun Moon & Planets, Davies	27.50
Package of both of the Davies' Tables	50.00
Concise Tables for Sight Red., Davies	8.50

Other navigational books are available, as listed in their catalogue, which will be sent upon request directly to Cornell. We will also augment this list in later issues.

Prices for charts and publications sold by DMA (in effect until 30 September 1985) are shown on the list below.

Charts and publications of the same price are grouped into 14 price categories. Each price category has been assigned a letter code. For example, letter code B represents a price of $12.00.

Discount Chart Price List

General Nautical - World International Series - Coastal - Harbor and approach Charts - LORAN and OMEGA Plotting Charts - LORAN and OMEGA Coverage Diagrams - Display Plotting Charts - North Atlantic Training Chart - Plotting Chart for Pacific Yacht Races - Gnomonic Plotting Chart, North Atlantic	A	$11.50
General Nautical - Coastal - Harbor Approach (Foreign Reproductions)	B	12.00
Great Circle Sailing and Polar Charts - Great Circle Tracking Charts - LORAN Reliability Diagrams - Display Plotting Chart Border Strips - Reference Charts (Symbols, Abbreviations, Ensigns, Flags) - North Polar Basin - Geophysical Data Charts - Plotting Charts - Southeast Coast of North America - Whale Chart - Sunrise, Sunset, Twilight Diagrams - Compass Roses - Special Bathymetric of Mediterranean - Great Circle Distance and Azimuth Charts - Ice Surveillance Charts - Antarctica Plotting Charts ...	C	5.50
Pilot Charts - Radar Plotting Sheets and Maneuvering Boards	D	4.00
Position Plotting Sheets - Chart Correction Template - Universal Plotting Sheets	E	3.50

Rules for Discounting

1) All Cornell books: make your check for 20% less than listed, and send order to the Foundation.

2) Government publications: same as for Cornell.

3) Charts: a 25% discount for orders over $30, 20% discount for chart orders less than $30.

NOTE: These prices and discounts include postage or shipping costs, with the exception of Government book orders less than $10. On these small orders we require an additional handling charge of $1.00.

Order Form

To The Navigation Foundation:

Please send me the following

______________________ @ ________

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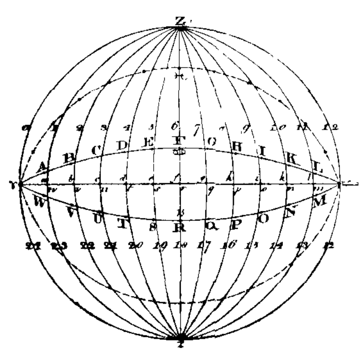
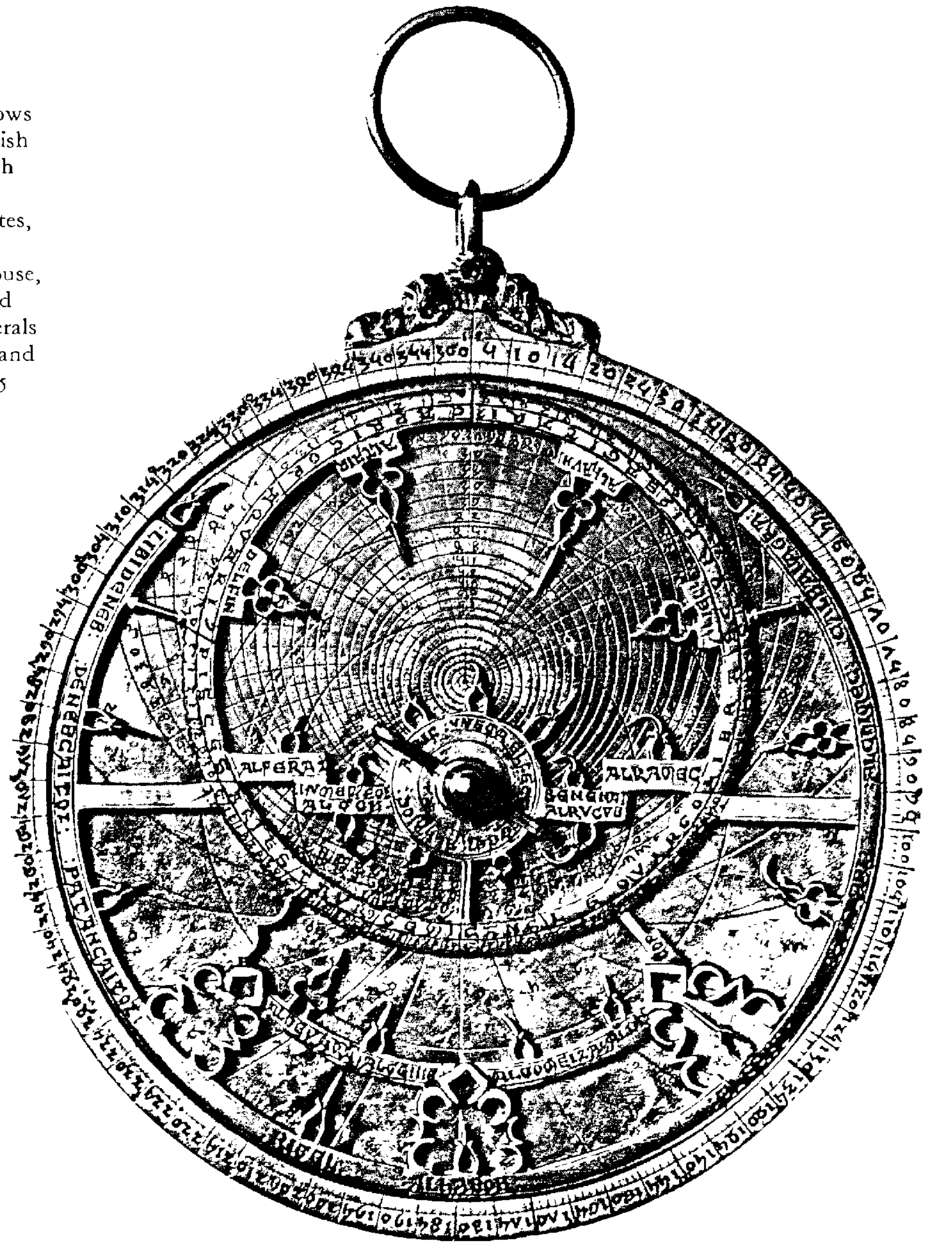
Total ________

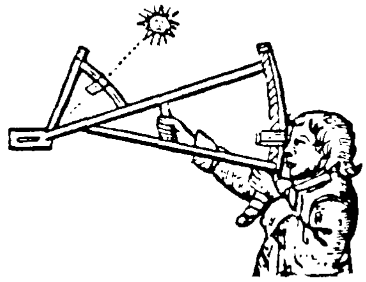
I have applied discounts as specified in the Newsletter, and my check is made out to The Navigation Foundation. I understand that these prices include postage.





Moorish/Gothic, c.1300. This astrolabe shows evidence of Moorish influence, although probably made in France. Seven plates, including ones marked for Toulouse, Paris, Chartres and Sens. In the numerals used here ꝶ , ᛘ and ʌ are used for 4, 5 and 7.
A39/ NA38-1661C

THE NAVIGATOR'S NEWSLETTER



FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION ISSUE EIGHT, SPRING 1985

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

Membership

Our membership has reached a level which ensures continuity of our effort; if members spread the word and pass their Newsletters around, we can expect growth to continue. We have a brochure under preparation which will be available shortly for distribution by members who come in contact with prospects (navigation students, for example).

At the moment our biggest problem is renewals. These are coming in slowly but well behind where they should be. Consequently we have sent out Renewal Forms to members who are overdue, with a return envelope post paid. If members do not return these with their contribution, we will be unable to continue their Newsletter.

Our discount books and charts listing is producing numerous orders which are being filled as promptly as possible. In some cases, particularly the 1985 Nautical Almanac, the government suppliers have been slow in their response. At the moment we have had to make a hand pick-up of these Almanacs, so that we can supply our members promptly. Additionally, members are now ordering back copies of the Newsletter and we have these readily available.

We are currently negotiating a discount arrangement with the Naval Institute, which publishes a number of important navigational books, including Dutton's. Dodd, Meade & Co. has been suggested as another possibility, and we will be talking to them shortly. It appears that we will eventually have to publish a catalogue to cover both books and charts.

Corrections

The authorship of "Salvaging Sights in Ageton's Forbidden Zone" was inadvertently omitted. It was written by Allan Bayless. We have also omitted other authors occasionally, a mistake we will try to avoid in the future.

An alert reader has also pointed out an error in the solution of the navigational problem posed in the fourth issue, Spring of 1984. The correct solution was an intercept of 1.2 miles, Toward. This gives an EP of Lat. 17-59.6N, and Long. 63-10.4W.

READERS FORUM

Member Neal Walker, of Bellflower, CA, writes:

"Would you put a note in a future issue asking if any members who are navigation instructors would be interested in forming a group for the interchange of information from the education point of view -- perhaps as a sort of sub-group of FPAN."

This prompts us to again add that we will periodically publish a list of locations of courses of navigation instruction if instructors will send us the data. Such a list should be useful to members who wish to take courses, or have been asked to recommend one to friends.

Member Joseph Federico, Jr., of Norwood, MA, writes:

"I have rearranged the formula for the solution of the altitude to a somewhat more interesting form. The formula is usually given as:

$$\text{Sin } h = \text{Sin } L \text{ Sin } d + \text{Cos } L \text{ Cos } d \text{ Cos } LHA$$

Where h = altitude
L = latitude
d = declination
LHA = Local Hour Angle

"I propose the following:

$$\text{Cos(co-alt)} = \tfrac{1}{2}[\text{Cos}(L-d)-\text{Cos}(L+d)] + \tfrac{1}{2}[\text{Cos}(A-LHA) + \text{Cos}(A+LHA)]$$

Where A = Auxiliary Angle
and $A = \text{Arc Cos } \tfrac{1}{2}[\text{Cos}(L-d)+\text{Cos}(L+d)]$
and Alt = 90 - co-alt.

"Although this formula is somewhat long, only a table of cosines is required, and simple division by 2. Enclosed herewith are solutions for the four cases given in Volume II of Bowditch, Publication No. 9, 1981, starting on page 500.

"My apologies if this formula has previously been published."

We have omitted the examples for lack of space, but they do give the correct answers by the use of only a table of Cosines. Are any of our readers familiar with the method?

Member Anthony L. Kelley of Hicksville, NY, writes about a specific item in the book "Atlantic High," by William F. Buckley (Random House). In Chapter 10, Kelley says that Buckley makes the case for inverting the sextant, for ease of bringing the star and the horizon into coincidence. Kelley then quotes Buckley as advocating doing the "fine tuning" as well as the initial sighting, while still in the inverted position, as follows (Buckley's words):

"And here is an important dividend. Since you are pointing now at Arcturus, having brought the horizon to it, you have substantially eliminated what one might call the pendulum factor. When you bring a star down to the sea, you cannot know that it sits truly on top of the sea unless you simulate with your sextant the movement of a pendulum, to establish that you are holding it perfectly perpendicular. If your hands are slanted, you will find, when you arc the sextant, that you are sinking the star into the ocean or floating it up into the sky.

"But when you lift the horizon, you all but eliminate the pendulum. If the horizon is now tangential to the heavenly body, it makes little difference if the sextant is at an angle, the distance measured doesn't change. You can swing your sextant fifteen degrees clockwise or fifteen degrees counterclockwise, and if Arcturus was touching the horizon in the first instance, it will be touching the horizon in the second."

Now, Kelley says, "WFB pushes the point beyond our normal usage. I would like to hear via this publication any responses to this 'WFB Method.' Don't forget by silence you are consenting that this way is better."

Our answer is that WFB's method is wrong, but let's hear other responses. Perhaps member WFB has further words on the subject.

NAVIGATION NOTES

Rating the Quartz Timepiece

Paul E. Shaad

The question is asked "Can the rate of an ordinary quartz timepiece be adjusted?" The answer is, "Yes, usually."

With the timepiece open, as for changing the battery, one will usually find a small slotted head screw centered on a slightly larger round disc. This is the padding capacitor across the quartz crystal. Changing it will slightly change the speed of oscillation of the crystal thus altering the rate.

The screw will turn easily and the adjustment is made with a small screw driver. Some optical assistance will be helpful if not necessary in the final adjustment.

The first trial adjustment should be not more than the width of the screw slot, say 5 degrees of rotation. From the amount and direction of this change vs. the amount and direction of change in rate the second adjustment is calculated. A third adjustment should bring the rate to within one second per week. With great patience and care the rate can be brought to less than one second per month but the final movement of the screw head will be so small as to be observable only under a 4x magnifier.

The timepiece should be in active use during the rating process because the rate of most inexpensive quartz timepieces will be affected by their average ambient temperature. Typically an inexpensive quartz adjusted to a near zero rate will drop off one second if removed from the wrist and placed in the refrigerator for 24 hours.

A fresh battery is advised before starting the adjustment. The timepiece cover should be in place while rating. The rating and adjustment process may, of necessity, drag out over weeks but the results will be rewarding.

Selecting Stars for Precomputation

T. D. Davies

Precomputation of star altitude and azimuth as a way of ensuring rapid identification has been popularized by the table arrangement of HO 249 and earlier tables where star names were one of the entries. Although "Star Sight Reduction Tables for 42 Stars" gives a simultaneous method of post sight identification and reduction, there are methods of identification by "working the sight backwards" in other current tables for sight reduction, and the Rude Starfinder may also be used. I believe it is useful to give some simple rules for picking stars for precomputation when HO 249 or "Star Sight Reduction Tables" are not at hand.

Issue One of the Newsletter discussed times to be used for planning your sights, but in any event Local Sidereal Time - LHA of Aries must be worked out for the time of the sights. Once that is done the following simple steps will ensure the selection of several well-placed stars:

a) A star with SHA = 360 - LHA Aries and declination = Latitude will be directly overhead. Find a star listed with values close to these, picking a higher declination where available, for a star which will approximately define your zenith.

b) Pick two SHA's, 45 degrees greater and 45 degrees smaller than the above. Stars with these SHA's with declinations close to the Latitude will provide two more stars well displaced from each other.

c) Using the SHA from a) above, pick a star of declination about ½ of your co-latitude, but of opposite name.

These steps will give you a set of stars which will generally define the useable portion of your sky. Obviously other close-by stars shown on the Star Charts in the Nautical Almanac may be used to enhance brightness or Azimuth distribution. As this technique is used variations will emerge to suit the individual navigator.

For example, selection of evening stars on January 23, 1984, at 45 North Latitude, 60 West Longitude, we would use an LHA Aries of 25 degrees. Subtracting from 360 gives 315 degrees. Using the Almanac's "Index to Selected Stars," the right hand column, we select as follows:

a) Mirfak (SHA 309,50N) as star nearest overhead.

b) Elnath (SHA 279,29N) as star of 45 degrees less.

c) Alpheratz (SHA 358,29N) as star of 45 degrees more.

d) Rigel (SHA 282,8S) as star of opposite name.

These stars give the following precomputed values: Mirfak, H=71°-52', Z=065°; Elnath, H=43°-17',Z=090°; Alpheratz, H=65°-49',Z=237°; Rigel, H=18°-04',Z=123°.

A Navigation Problem

Solution to the Problems Presented in Issue Seven

6. Referring to the daily page for May 15-17, 1984, in the column for Civil Twilight next to the Sunset column, the navigator notes the times indicated for latitudes 35° and 40°N, respectively. They are 19-26 and 19-40, the difference between those two times being 14 minutes. Using Table 1 on page xxxii, he enters on the left with the 3° difference between the tabulated latitude of 35°N and the true latitude of 38°N (which appears on the second line of the third block of figures down from the top). Moving to the right to the column for 15^m, he notes that the correction is 9^m (15^m being the nearest value to the actual time difference of 14^m). By inspection of the trend in times on the daily pages, he knows that this 9^m correction is to be added. This correction is for latitude only. The correction for longitude is taken from page i for the 1°13' that the vessel will be West of the standard 75° meridian, a correction of 4^m52^s. The estimated time of Civil Twilight for 38°N 76°13'W is thus: 19^h-26^m + 9^m + 5^m (4^m52^s rounded off to 5^m) = 1940 LMT, which is 2040 local daylight time. The navigator remembers that the interpolation for times falling between the tabulated times on the daily pages is not linear, although as a practical matter he could merely inspect the times tabulated on the daily pages and go on deck at the time indicated for 35°N as corrected for longitude, and then wait for the stars to begin to appear as sunset deepened into civil twilight.

Note: The times for twilight given in the Almanac are strictly for the middle date at the Greenwich meridian. Interpolation for the first or third day on any page is usually ignored.

7. LMT 1940 (2040 Local Daylight Time) on 15 May 1984 = 0040 GMT 16 May 1984. Inspection of the daily page for 16 May shows that Venus will be considerably more than 90° to the West of 76°13W and thus will be below the western horizon. (At 0000 it will be at GHA 189° 06.7' and at 0100 it will be at 204° 06.1'.) Using similar quick inspection, it appears that Jupiter will be below the horizon to the East. This may be confirmed by reference to the discussion of the visibility of the planets on page 8. Mars and Saturn may be visible low in the East, but their magnitude is such that the brighter navigational stars may be better choices.

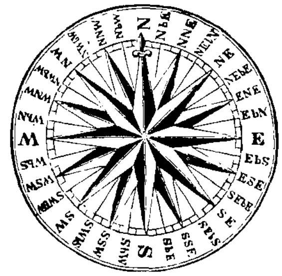
8. Vol. 1, H.O. 249 (Epoch 1980) was used. The problem specified an EDT of 2041, a minute later than the time estimated for the beginning of Civil Twilight. This was essentially an arbitrary later time which was selected to illustrate the point that stars often will not yet be visible at the beginning of Civil Twilight, especially those in the West in the evening. Often they may not begin to appear until it is dark enough that the horizon is no longer sharp. In the tropics, where the span of twilight is very brief, star observations must be done quickly. For EDT 2041 (LMT 1941) the LHA Aries is calculated to be 167°-57.0 (using GMT 0041 16 May). Using LHA Aries 168°, the

navigator quickly determines that Kochab, Spica, and Pollux may be his best bets for star sights.

9. The problem of the true water horizon should not be ignored. One way of minimizing it would be to determine the distance to the land appearing on the true bearing of the star to be observed, and then to use the Bowditch tables to select a height of eye that would place the true water horizon at or very near the distance of the water-land line of demarcation. That height of eye might or might not be possible to achieve aboard the particular vessel.

10. It is now March 30, 1985. Backstaff has long since left the Chesapeake. She visited Bermuda, and then proceeded south to the Virgin Islands where she spent the winter months. She is now in latitude 15°-05N, longitude 65°37W (south of Puerto Rico) on a true heading of 250° bound for the Panama Canal. Her speed is 6.2 knots. The time is 0850 LMT. Her navigator wishes to arrive at an estimate as precise as possible of the LAN time, assuming that the vessel's course and speed will remain unchanged. He is mindful that with a significant westerly component to his direction of travel the problem is more complicated because he has to deal with the fact that the Sun is moving westward towards his position at the rate of 15° per hour, and his vessel is also moving westward. In terms of longitude, he is not "standing still" waiting for the Sun to catch up to his position. (Readers may recall in Problem 1, Issue Five, the problem of estimating the time of LAN was relatively easy because the vessel was on a heading of 180° with no easterly or westerly component to its direction of travel, and hence it was, in terms of longitude, "standing still" as the Sun advanced at the rate of 15° per hour to cross its meridian.)

In practical terms, at low latitudes and low rates of vessel speed, the problem is not as significant as it would be for a vessel in high latitudes at fairly high rates of easterly or westerly speed. Nevertheless, because our navigator likes to be precise, he undertakes to work the problem. There are several ways of approaching it. At least one will be presented in Issue Nine.



BOOK REVIEW

The Yachting Book of Celestial Navigation

First Edition, 1984

by Stafford Campbell

Dodd, Mead & Company, Inc.
79 Madison Avenue, New York, NY 10016

142 pages - $9.50 suggested retail price

Reviewed by Roger H. Jones

The title of Stafford Campbell's little book catches the eye and the ear. Visually, it is arresting because the word "Yachting" appears in the familiar and distinctive lettering that once each month sets Yachting Magazine apart from its competitors on the newsstand, and to the ear the spoken words say: "Here, indeed, is something especially for the Yachtsman." Those familiar with Campbell's frequent and continuing contributions to Yachting Magazine will greet this little book with the pleasure of instant recognition. Those not, as yet, familiar with his writing, may sample some of the best in his new little book.

Actually, Campbell has written a complete yachtsman's text, under the title of The Yachting Book of Practical Navigation. It will be available in the late spring in hard cover. Meanwhile, Dodd, Mead has separated the coastwise and celestial portions, and has published each in paperback form. It is the paperback portion dealing with the celestial art that is the subject of this review.

Campbell, a former U.S. Navy officer, saw duty during World War II in the destroyer fleet, and for more than forty years he has been a practicing navigator on commercial vessels, ocean racers, and pleasure boats. From the vantage point of all of those diverse command bridges, he writes for the yachtsman, and the latter is a person whose needs and temperament he seems to know well.

In his Introduction, Campbell echoes the sentiment of the Foundation: in this day of electronic marvels, the celestial art must be preserved, because it will get you home when all else fails. With commendable brevity and clarity of purpose, he then launches immediately into his subject. There are thirteen chapters, most of only a dozen pages or less, including illustrations and excerpts from the Nautical Almanac and H.O. 249. At the outset he announces why and how his chapters are organized as they are, and he is faithful to his purpose. His purpose is to guide his readers through the steps and procedures of taking and resolving celestial sights before they are cast into the sometimes murky waters of celestial theory. His message to the yachtsman is simple: you don't have to know all the workings of the internal combustion engine to learn to drive a car, and neither do you need to master celestial theory before you learn to navigate with a sextant. He seems to say: "Come, let me show you how easy it is to do this thing with a sextant, and then, pleased with your own progress, you will not later be intimidated by the theory."

It is not surprising that Campbell therefore starts where some authors end. He introduces his readers to the sextant. They have it in hand when next they are led to the sun sight. Chapter Two deals with timing the sight that has just been taken of the Sun, and then, in logical sequence four chapters deal with extracting data from the Almanac, calculating the computed altitude, determining the intercept and azimuth, and plotting the line of position. Throughout, he bases his examples on H.O. 249, and he recommends the 249 tables as the easiest for the yachtsman to use.

Having guided his readers through the sun sight procedures, Campbell next instructs them that "what you have just done with the Sun is equally easy and fun to do with the Moon, four planets, and the stars." Chapters 7-9 deal with each of those three types of celestial bodies, and then the capstone chapter on procedure presents the "special cases" involving meridian transit of the Sun and the shot of Polaris as the age-old shortcuts to finding latitude.

It is only at this point that Campbell leads his readers into celestial theory. Chapter Eleven, only seven pages long, is one of the most concise discussions of celestial theory that appears in any of the many works familiar to this reviewer. From Sumner through St.-Hilaire to the navigational triangle and final result, it is all there. The uninitiated will find his appetite whetted. The old salt will appreciate Campbell's ability to boil the subject down to its bare essentials.

Campbell's last two chapters deal with navigation by calculator and the many practical "wrinkles" - the tips and advice distilled from many years of experience. Sprinkled through all of the chapters, however, are useful little observations that bespeak the many years and sea miles in Campbell's wake. One that comes to mind is his passing note in the chapter on star sights respecting the age-old practice of inverting the sextant initially in order to find and view the elusive star directly through the telescope. He notes that this is easy with a straight scope, but not so easy with a modern monocular. While struck by that little observation, this reviewer was even more struck by Campbell's unusual tabular comparison of the procedures for sights of the Sun, Moon, planets, and stars - succinct and useful recapitulation on two facing pages of all that precedes it in the book.

For traditionalists who believe that theory must be fully grasped before procedures can be meaningful, this book may be an eye opener. For purists who delight in the endless intricacies of the subject of "time," this book may be too brief. For visual gymnasts who savor mind-whirling diagrams of all aspects of the celestial sphere, this book may not be challenging. For yachtsmen, this little book may be just the right thing - an emphasis on procedure flavored with theory, a blueprint for practice that nudges open the door to the deeper understanding that will spring from experience.

¶ Tabula Cōuersionis Horarū ⁊ suarū fractionū in Gradus ⁊ suas fractiones. ¶ Tabula Cōuersionis minutorū dierum in Gradus ⁊ suas frac.

Hor.	g	Horarum m	g	m	Horarum m	g	m	Dierū m	g	Dierū m	g
1	15	1	0	15	31	7	45	1	6	31	186
2	30	2	0	30	32	8	0	2	12	32	192
3	45	3	0	45	33	8	15	3	18	33	198
4	60	4	1	0	34	8	30	4	24	34	204
5	75	5	1	15	35	8	45	5	30	35	210
6	90	6	1	30	36	9	0	6	36	36	216
7	105	7	1	45	37	9	15	7	42	37	222
8	120	8	2	0	38	9	30	8	48	38	228
9	135	9	2	15	39	9	45	9	54	39	234
10	150	10	2	30	40	10	0	10	60	40	240
11	165	11	2	45	41	10	15	11	66	41	246
12	180	12	3	0	42	10	30	12	72	42	252
13	195	13	3	15	43	10	45	13	78	43	258
14	210	14	3	30	44	11	0	14	84	44	264
15	225	15	3	45	45	11	15	15	90	45	270
16	240	16	4	0	46	11	30	16	96	46	276
17	255	17	4	15	47	11	45	17	102	47	182
18	270	18	4	30	48	12	0	18	108	48	288
19	285	19	4	45	49	12	15	19	114	49	294
20	300	20	5	0	50	12	30	20	120	50	300
21	315	21	5	15	51	12	45	21	126	51	306
22	330	22	5	30	52	13	0	22	132	52	312
23	345	23	5	45	53	13	15	23	138	53	118
24	360	24	6	0	54	13	30	24	144	54	324
		25	6	15	55	13	45	25	150	55	330
		26	6	30	56	14	0	26	156	56	336
		27	6	45	57	14	15	27	162	57	342
		28	7	0	58	14	30	28	168	58	348
		29	7	15	59	14	45	29	174	59	354
		30	7	30	60	15	0	30	180	60	360
		2	m	2	2	m	2	2	m	2	m
		3	2	3	3	2	3	3	2	3	2
		4	3	4	4	3	4	4	3	4	3

History of Navigation

T. D. Davies

Allan Bayless responds to our article on the Astrolabe, noting the fact that there is an Astrolabe Kit, with a 24-page booklet, by Roderick S. Webster (1974), available through Paul McAlister and Associates, Box 157, Lake Bluff, IL 60044. The kit allows you to make your own.

Last November, at the Franklin Institute in Philadelphia, I delivered a lecture on some events relating to the discovery of the New World, which involved a relatively new science called Archeo Astronomy. The Moon's motion, as every navigator knows, has always been difficult to pin down, but recent data resulting from the NASA space program has been synthesized by the Jet Propulsion Lab into a high precision program which has the Moon's motion so accurately described that it can be projected to earlier times with great precision. Such a program is available at the U.S. Naval Observatory.

There are reliable contemporary documents which indicate that Amerigo Vespucci, on 23 August (Julian Calendar) 1499, observed a conjunction of the Moon and Mars while at some location on the coast of South America. The Longitude that he calculated from this using a 1474 Almanac (extrapolated to 1500), gave him a position on the wrong side of Panama. As a result many historians have asserted that Vespucci did not make the voyage at all or, at the minimum, was an incompetent navigator. In fact Ralph Waldo Emerson pronounced him "a thief," and many have considered that he "stole" the glory from Columbus, of having the continents named after him.

With the help of Dr. LeRoy Doggett, of the USN Observatory, I was able to show that Vespucci had to be very close to the point that his letter described, and that the Almanac had an error of about 40 degrees, which accounted for the erroneous location Vespucci calculated. Interestingly enough I was able to locate an extant copy of the Almanac (done by a German who assumed the name Monte Reggio) at the Royal Astronomical Society in London, and verify that Vespucci read it correctly.

The complexity of the situation generated by the Almanac error and the lack of any knowledge of that part of the world, is such as to preclude any chance of fakery on the part of Vespucci, or even his associates and I believe that this application of Archeo Astronomy can be said to validate his expertise, heretofore challenged. The method he was using was, of course, the Method of Lunar Distances, discussed at some length in earlier issues.

Although it had been outlined in principle by several early cosmographers (viz. Hipparchus, Ptolemy), Vespucci was the first to make a practical application of the principle to navigation. Vespucci's navigational expertise, demonstrated in this and other ways, so impressed the Catholic Monarchs (Ferdinand and Isabella) that he was made the Chief Pilot of Spain, and directed to train and license all other pilots, and to keep a central map of the results of their explorations.

FIGVRA MVNDVM NOVVM CONTINENS.

MARINE INFORMATION NOTES

Provided by Ernest Brown

The newly issued edition of American Practical Navigator, "Bowditch," contains a number of updates and some omissions. Appendix Z, Extracts from Chart No. 1, which gives Chart Symbols and Abbreviations has been eliminated from this new edition because it was not provided in time. A new edition of Chart No. 1 is in work but will not be in Bowditch. The total changes in the new edition of Bowditch are listed below, from which members can evaluate whether they want to order one.

PUBLICATION--DMAHTC
NEW EDITION OF AMERICAN
PRACTICAL NAVIGATOR, VOL I

The new 1984 edition of Pub. No. 9, American Practical Navigator (Bowditch), Volume I, has afforded the opportunity to incorporate changes to clarify certain parts of the text. In addition, minor corrections and modifications have been made, including a change to the name of the Agency responsible for the publication to Defense Mapping Agency Hydrographic/Topographic Center (DMAHTC).

In Chapter IV new illustrations showing the current light phase characteristics have been provided. The old abbreviations for light phase characteristics are also shown and, as indicated in the text, are being superseded on charts as new editions are produced. A description of the new Modified U.S. Aids to Navigation System for United States waters, which incorporates certain elements of the International Association of Lighthouse Authorities (IALA) Maritime Buoyage System for Region B, is explained.

In Chapter V, the fictitious nautical chart insert, called Port Maury, has been updated to illustrate current chart usage. In addition, the metric side of the Port Maury chart displays the IALA Buoyage System for Region B.

A new method of revising a turn bearing called the slide bar technique has been added to Chapter 10, Piloting.

The two illustrations showing the Standard Time Zone Chart of the World and the Standard Time Zones of the United States in Chapter XVIII have been brought up to date.

In Chapter XXIX the Automated Mutual Assistance Vessel Rescue System (AMVER) has been updated and includes a new Search and Rescue (SAR) Information Questionnaire.

A description of LORAN-C skywave corrections as depicted on charts has been added to Chapter XLIII, Radionavigation Systems.

An overview of the NAVSTAR Global Positioning System (GPS), an all-weather space-orientated navigation system under development, has been detailed in Chapter XLIV, Satellite Navigation.

Appendix R, which described the old LORAN-A system has been replaced by a long term navigation table which enables users to calculate the Greenwich Hour Angle (GHA) and declination of the sun for the years 1981 to 2016.

Appendix S, Charts and Publications of other Agencies has been brought up to date.

Appendix Y, Buoyage Systems, has been expanded to include the Modified U.S. Aids to Navigation System and the International Association of Lighthouse Authorities (IALA) Maritime Buoyage System Region A and Region B. Illustrations of these systems are shown.

Appendix Z, Extracts from Chart No. 1, U.S. Nautical Chart Symbols and Abbreviations, has been deleted from this edition.

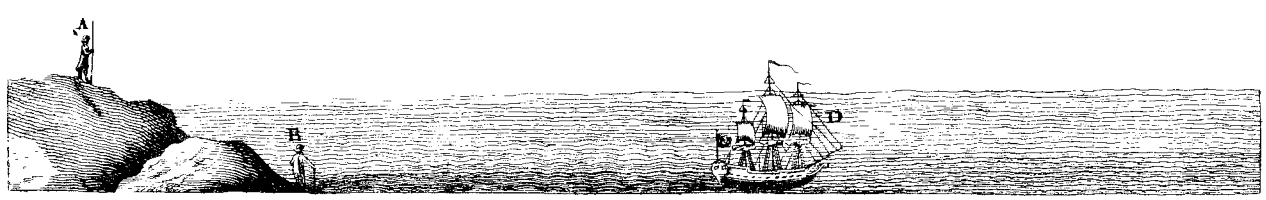
References to the tables in Volume I refer to tables 1 through 41 in Volume II. The latest printing of Volume II is the 1981 edition.

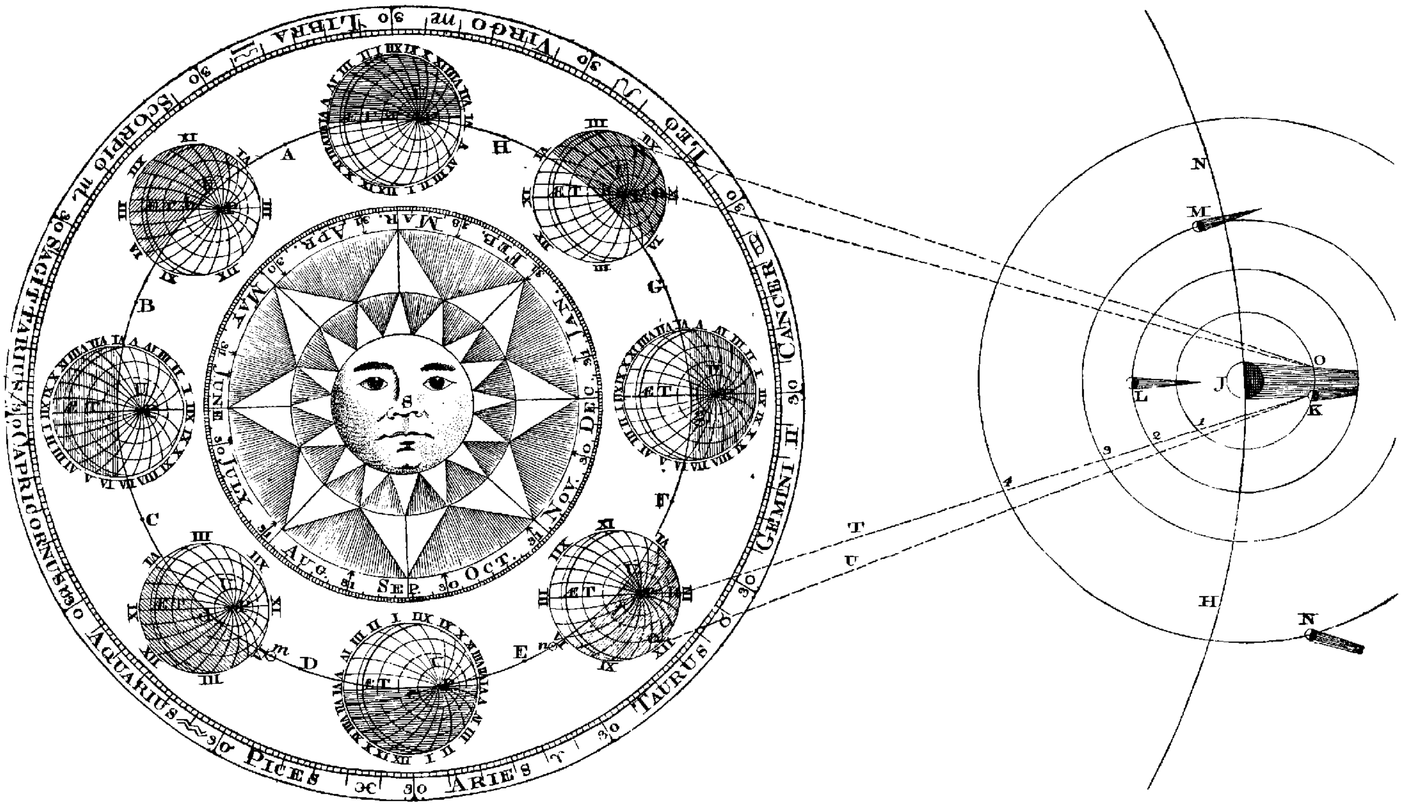
FUTURE ISSUES

We continue efforts to provide information and assistance to our members through the medium of the Newsletter and the supply of discounted books and charts, and to others through the establishment of awards. We have a negotiation underway on the latter and will welcome suggestions for other efforts from our members.

We ask that members continue to try to interest others in joining where it seems appropriate to their pursuits. The Navigation Foundation is a non-profit tax-exempt corporation of Maryland. A donation of $25 is requested annually of members. This donation is fully tax-deductible. Address all correspondence to:

The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850

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THE NAVIGATOR'S NEWSLETTER

FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION Issue Nine, Summer 1985

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

Objectives Reviewed

With this issue we start our third year of publication of the Newsletter. It seems appropriate to review our objectives and how well we have been doing at meeting them.

On 31 July 1981 the foundation received its charter from the State of Maryland, as a not-for-profit corporation. Our objectives were stated to be the encouragement and promotion of the Art of Navigation. I had long felt that the modern development of navigational aids - to the point where they gave a spurious sense of total reliability, had caused the Art, the personal capability, of the seaman to atrophy. The Sea is a demanding master, and when one is off shore on his own, his survival depends, in the end, on his own abilities. While automatic equipment may do his navigating for him successfully for a hundred voyages, there inevitably comes a time that his survival depends on his own ability. When such a time arises there is no time to learn or train to acquire the skills that are essential in navigation.

So those who intend to go to sea should master the arts of seamanship, of which navigation is the lynchpin. Several seamen who shared this point of view joined with me in organizing the Foundation. Captain Terry Carraway and Roger Jones were the two earliest, and we were soon joined by others. Our initial efforts to establish the foundation as a non-profit under section 503(c)3 of the Internal Revenue Code were successful, but timeconsuming. This finding, which has been made final by the IRS after a two-year review, ensures that any donations to the Foundation are fully tax deductible to the donor.

We then set out to establish a membership which would allow us to publish a quarterly Newsletter that would really serve those interested in navigation. We also proceeded to stimulate interest by establishing awards at various institutions, for demonstrated excellence in the field of navigation. The Award is a plaque-mounted medallion incorporating our logo. Further, we offer help in the development of simple aids or devices which address the personal skills or tasks of the navigator. We also sponsor and assist courses and seminars on navigation and make navigational books available to our members at discounted prices.

As the publication of the Eighth Issue indicates, it was early in 1983 that our real efforts at membership started. Since that time our membership has grown slowly but steadily until it is now just short of 500. As our members discuss the Foundation with friends, we expect to continue to welcome new members aboard. The donations of our members are now about adequate for continuing the publication of the Newsletter at its present size. However there are always "dropouts" from loss of interest or other causes, so we have to keep up efforts to gain new additions if we are to keep up publication.

At present we have no regularly paid staff, articles and other writings are done by various members of the Board as their contribution to promoting interest in navigation. Of course our members write in as well, and are a major source of interesting items. Since we have introduced our discount books and charts, the time required of Board members has grown by leaps and bounds. If we can increase membership to the point where we can take on a part time staff, we will be able to improve service in this and other areas.

I believe the Newsletter has taken on a permanent form that meets approval, although there will undoubtedly be changes from time to time. I do not propose to seek advertising or permit it to creep into the Newsletter. Similarly, we have avoided having any commercial members of the Foundation. It seems to me that there is a place for a means of communication between "people," without the somewhat heavy hand of industry participating. In continuing this policy we believe that by expanding our membership we can achieve adequate financial support without commercialization.

Books

We now have an agreement with Dodd Meade & Company of New York, which enables us to give a 20 percent discount on their books. We will shortly publish a new catalogue of the growing list of books and charts that we can provide our members at a discount. The catalogue will include prices and discounts, and will be mailed out separately from the Newsletter.

We have been experiencing some delays with book deliveries, particularly those from the Superintendent of Documents (GPO). Expedited service is available if needed to meet some deadline, but will require additional cost. UPS shipment will be made for DMA books, and if possible the amount UPS will charge added to the bill. If the amount cannot be determined a bill will be submitted by the Foundation, later.

For group orders from the GPO, such as for classes, where a deadline is specified, we will make a hand pickup from the counter facility at Laurel, MD, and ship by UPS. This trip, however, will require a charge of $10 extra, and the UPS fee will be added to that.

Awards

On 28 April the Foundation presented a Plaque award to Professor Marvin Craemer, at Newport, RI, in recognition of his outstanding achievement of seamanship, in circumnavigating the globe. The Award plate was engraved with the words "For Global Circumnavigation by Seaman's Eye." It was presented by member Lee Houchins, representing the Foundation.

ION Meeting

Several members of our Board of Directors will be members of a Panel addressing "The Future of Celestial Navigation," at the ION meeting at Annapolis in June. Any of our members who might be attending the ION meeting should find this session (27 June, afternoon) stimulating. We would be very pleased if Foundation members who might be attending would make themselves known.

The Board will have its annual meeting the following day, at the Annapolis Hilton Inn.

READERS FORUM

John D. Kobrock of Warwick, RI, writes:

"Have you reviewed all of the calculators and their suitability for navigational processes in one of your issues? There appears to be many with more arriving."

K. L. Gebhart writes:

"Enclosed is a copy of our current catalog which we think would be appreciated by your members. As you can see from it, we specialize in celestial navigation equipment almost exclusively. We think it is probably the largest catalog of its kind available anywhere.

Interested members may write direct to Mr. Gebhart at 416 South Pershing, Wichita, Kansas 67218.

Paul E. Shaad of Santa Barbara, CA, writes:

"To accurately measure the altitude of a star the plane of the sextant must lie exactly in the plane of the vertical circle passing through the star. This means the sextant must be exactly vertical and it must be 'pointed in the right direction' (toward the star). Unless these two requirements are met the sextant is not properly aligned and too great an altitude will be measured.

"The line of sight to the star is the axis around which the plane of the sextant is turned to bring it into the vertical plane of the star. Almost without thought the experienced navigator aligns his sextant by rotating it around this axis until the star, centered in the scope, dips to its lowest point. He then takes the measurement. This is sometimes called 'dipping.' But remember, the process of alignment also includes keeping the star centered in the telescope, that is keeping it within the vertical central field of the telescope.

"Let us consider the matter of alignment further. When the star is low on the horizon the axis points the sextant in the right direction. It remains to slightly rock the sextant around the axis to dip the star thus establishing the vertical.

"But when the star is high toward the zenith this axis established the vertical and it remains to sweep the horizon to establish the proper direction.

"In between these two extremes a combination of rocking and sweeping is required and if in the process the object is kept centered in the scope the result is perfect rotation around the axis.

"The amount of error which results from misalignment (which is also the observed dip) is a complex function of the angle of misalignment and of the altitude. It is zero when the star is on the horizon and zero again when at the zenith. It reaches a maximum at 45 degrees at which altitude a misalignment of 5 degrees creates an error of 6 arc minutes whereas an error in misalignment of one degree creates an error of only 0.2 of an arc minute. If the observer is properly rotating his sextant around the axis for alignment he sees this error as the dipping movement of the star and this allows him to achieve a very accurate alignment indeed. But if he is not properly rotating his sextant he may have trouble.

"The same rules for alignment and the same error of misalignment apply to the inverted sextant. The only difference is that the axis around which alignment is made is always straight down the barrel of the telescope unaffected by the mirror system of the instrument.

"I suspect that WJB was observing Arcturus at a high altitude where the dip was slight, that he may have been using somewhat the wrong motion for alignment and that it was a combination of these that made him think alignment was easiest in the inverted mode.

"Perhaps he will tell us."

Member Harry C. White of Linwood, NJ writes:

"During and after World War II the AAF, USAF and Navy produced a number of very good training films on celestial navigation. I wonder if the Foundation could acquire those films and have them reproduced on VRC tapes. These tapes could then be sold or rented to members of the Foundation.

"I myself would be very interested in airborne navigation films. I presently have 6 bubble sextants which I use from the deck of my home."

We will investigate this possibility.

William F. Presch writes as follows:

"In response to numerous and continuing inquiries as to the availability of problems for practice in the art and science of navigation, be advised that I will be self-publishing such material.

"Similar to what was contained in the 'Where in the World Was He?' feature of SEA and RUDDER magazines but not confined solely to small boat cruising, the problems will be directed toward the use of calculators and the basic formulas as well as via the more conventional tabular solutions. Initially, the almanac data will be included with the problems but a copy of the current Nautical or Reed's Almanac will be required as the series continues. The subscriber should have available the volume(s) of his or her favorite sight reduction tables, through, at least, latitude 45 degrees. Charts of the areas of the problems will not be required but a world atlas or globe would enhance understanding and solution. Plotting on universal or self-drafted small area plotting sheets will be necessary. A synopsis of the solutions of each problem will be included in the following issue. A minimum of ten issues per year is planned."

Interested members may write member Presch at P.O. Box 6337, San Diego, CA 92106.

From the Gould Academy, Bethel, Maine, Headmaster Dresser writes, "The 1984-1985 recipient of the Foundation for the Promotion of the Art of Navigation Award is James W. Feeney.

"I remain excited about this award. The students in my class have been aware of the award and there has been some active competition for it. My thanks to the Foundation. I am hoping to attend part of the ION meeting in late June, perhaps I will get to meet you then."

NAVIGATION NOTES

Correcting for Nutation, Precession and Abberation

T. D. Davies

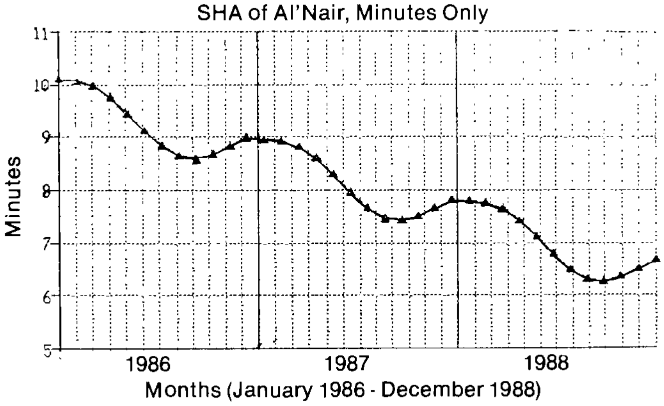
In tables such as HO 249 (and my Star Sight Reduction Tables) the computations used in generating the tables must be made around a given set of star locations. These are listed in the tables, and are generally taken as an "average" location for each star, during an "epoch" that the table is calculated for. Thus a table published in 1980 may use average star locations for 1982, and be considered reasonably accurate through 1984. HO 249 gives a positional movement for each year of its cycle, which is supposed to correct for deviations of star locations from those used in constructing the table.

The actual changes in star locations are largely the result of the precessional motion of the axis of the Earth. This in itself is far from smooth, since the axis "nutates" with a series of small conical cycles, along the larger conical path of the pole for the long-cycle precession. The irregularities induced by these two motions are further complicated by aberration, which results from the changing direction of the orbital velocity vector of the Earth. There are other subtler phenomena at work, but the above are the primary cause of changes of such magnitude that they affect the celestial navigator.

The net result of these phenomena is that the stars may be significantly distant from the average annual locations used in the tables and in the positional correction computation. This can be readily seen by examining the monthly values of a given star, which are listed in the back of the Nautical Almanac. For example, Altair, in 1985, varies in Sidereal Hour Angle from 62-29.8 to 62-28.6, a spread of 1.2 minutes within this one year. Many other stars have similar variations; more extensive over the several years of the table useful life.

A point of some significance is that almost all of the star's variations in declination are considerably less than the variation in Sidereal Hour Angle. Altair, during the same year, has a range of declinations from North 8-49.5 to 8-49.8, a spread of only .3 minutes. This difference extends through a number of years, and suggests that differences in SHA are more important to correct for than are differences of declination.

SHA of Al'Nair, Minutes Only



If we combine the above information with a basic fact of this type of table, i.e., that SHA differences are also easier to correct, we are led to a simpler and more accurate type of correction for the difference in star location with the passage of time. Entry into all of these type of tables is at a whole degree value of LHA, which is achieved by the device of using an assumed longitude. The plot of the line of position is done from the assumed longitude and the assumed latitude. If the SHA of the star at the time of the sight differs from that used in the table, the difference may be corrected for by simply adding (or subtracting) it to the assumed longitude.

This is most simply done by displacing the plotting position from that of the assumed longitude (along the assumed latitude line), at the time of plotting each sight. This displacement in longitude should, of course, be in the amount of the difference between the two SHA values. The rule for doing so is simple. If the current SHA from the Almanac is greater than that used in the table, move the plotting point to the Eastward (in either E or W longitude). If the SHA listed in the Almanac for the current month is smaller, move the plotting point to the Westward. By this method a difference in SHA may be precisely corrected. A check on the variation in declination should show only a very small (less than 1 minute) difference, which may be ignored without substantial loss of accuracy.

The use of this method for correction for Nutation and Precession was used in the "Star Sight Reduction Tables" with a small variation to adapt it to the method. However it can also be used in lieu of the positional correction in HO 249. It has the advantage of providing correction for the actual current value of the SHA, rather than the annual average that must be used in the table of annual corrections. Of course it requires an additional step (determination of the difference in SHA) for each sight, whereas the annual correction method has only one replot for the several sights which make up the Fix. However a check of the variation in SHA over several years, for a sampling of stars, will quickly show the accuracy of this method over the use of an annual averaged SHA. The method will work for any of the tables which have star locations built into them.

A Navigation Problem

Solution to the Problem Presented in Issue Eight

10. Answer: Local Apparent Noon (LAN) will occur at LMT 1205. The standard time is 1227.

There are several possible approaches to the solution of this problem. The one used for the above answer is the following.

Step 1. From the daily page of the Almanac for March 30, 1985, note the LMT of the Sun's meridian passage. LMT = 1204.

2. The navigator has already converted his present zone time to LMT. As stated in the problem, the LMT is 0850. That is to say, when the vessel is at 15° 05'N and 65° 37'W the LMT is 0850, the standard time being 0912.

3. Using the difference between the two LMT values, an interval of time of 3 hours and 14 minutes is derived. In 3 hours and 14 minutes (3.233 hours) at a speed of 6.2 knots, the vessel will advance along its course line a total of 20.04 nautical miles. Use a rounded figure of 20 nm. Starting from the 0850 position, plot a new position 20 nm further westward on the course of 250° True.

4. That plot establishes a DR longitude of 65° 56.5'W. The difference

in longitude between the starting position and the new DR is 19.5' of arc. That arc difference is equal to 1 minute and 18 seconds of time. (See the table for Conversion of Arc to Time in the Almanac.) Round the time value off to 1 minute.

5. Since the vessel is on a westerly course, the one minute is added to the time interval derived in Step 3. The interval is thus 3 hours and 15 minutes.

6. To be precise, the navigator would then compute the vessel's travel in the small time difference derived in Step 4, and he would re-plot the DR. In this case, the DR would be moved further westward by only a tenth of a nautical mile, a negligible amount in the instant circumstances.

7. Using a Noon Interval of 3 hours and 15 minutes, the predicted LMT of LAN becomes 1205 (not 1204 as noted in the Almanac). The standard time for Zone + 4 would thus be 0912 + 3 hours 15 minutes or 1227.

If the plotting work is accurate and if no current has adversely affected the vessel's progress, the prudent navigator would be on deck tracking the Sun five minutes or so before his estimated time of LAN.

Problem No. 11.

Backstaff has proceeded on its course of 250° True and is still logging 6.2 knots. It is now the early evening of 30 March 1985. The sky is largely obscured, but the navigator momentarily notices what looks to be a star located astern of him to the East. Without knowing what celestial body it is, he nevertheless makes a sextant observation, noting the time and the azimuth of the star. His watch is set to standard time, zone + 4, and he notes the time as 18-35-07. The watch is ten seconds slow. Applying the local variation, he determines that the true azimuth of the body was approximately 085°. He notes that his height of eye was 12 feet, and the index error was 3' off the arc. However, he is really not too concerned immediately with sextant altitude corrections. Rather, he wants to know what body he observed. He figures that his DR longitude at the time of the observation was 66° 33.5'W, and his DR latitude is 14° 47'N. What body did he observe? He glances at his sextant and notes that the altitude of the body was approximately 40°.

History of Navigation

T. D. Davies

Although many have been brought up to believe that the Chinese invented the magnetic compass, there is actually great doubt that this is the case. The early history of the device is shrouded in ambiguity and conflicting stories and it seems likely that the Arabs and the Italians had magnetic compasses in a useable form at least as early as the Chinese.

The earliest unquestionable description of the magnetic compass occurs in a work of 1269 by Petrus de Maricourt, entitled "Epistola de Magnete." It appears that Italian traders from the port of Amalfi had used the floating magnet as a means of navigating offshore even before this. There is also evidence that the Norwegians were using some form of the magnetic compass at about the same time. Thus, like many inventions of a historic nature, it seems to have appeared in many places at about the same time.

Vespucci mentions the floating magnetic compass in a fragmentary letter of 1503. He literally cites the magnetic variation (or magnetic declination) for a point on the coast of South America in 1501. But his words give some insight into the construction of his compass. He uses the Italian word "calamita" which meant "reed," indicating that the magnet was in the form of a needle inserted into a reed, which served as a float. The whole was housed in a box, called in Italian "bussola," which we call "binnacle."

In northern latitudes, where Polaris is visible, measurement of magnetic variation was relatively simple. In fact in Columbus' writings we find a description of how the variation changed as they crossed the Atlantic "Ocean Sea" in 1492. When the variation reached zero there was consternation among many of the sailors, who felt that this might portend some catastrophy. Vespucci, however, was in south latitude where finding geographic North or South was a more difficult matter. A direction halfway between the azimuth of the Sun at sunrise and sunset was one method. Another was finding the azimuth at Local Apparent Noon. Both posed problems at sea and even on land, with the instruments of the time.

The establishment of directions relates to the compass, but actually has origins long before the compass. The Greek, Andronicus Cyrrhestes, built a "Tower of the Winds" in Athens, from which the directions were named as "Winds." These directions were logically related to the directions of various locales from Athens, and eventually appeared on the Italian "Portolan" charts used by Mediterranean navigators.

The derivation of the names of the directions provide some interesting insight into their origins. North was called "Tramontana," which can be read as "over" or "toward the mountains." These mountains were to the North of Athens, but also of most of the Mediterranean countries. South was "mediodia," which simply means noon, when the Sun was in the South. East and West were "levante" and "poniente" for the rising and setting Sun. Northeast was "Greco" and Southeast was "Scirocco," and Northwest "Maestral," and Southwest "Libeccio," or sometimes "Africo." The north point was indicated with a spearhead, combined with a "T" for Tramontana. These eventually combined to become the now universal Fleur de Lis.

The Portolan charts of the 14th and 15th centuries were charts for the use of mariners, and therefore had only coastal cities, "ports." As a way of indicating directions to travel from one port to another, they included radial lines centered on "Wind Roses," which were true directions, as best as could be determined by the map makers of the day. The likeness to a rose gave them a name which has been retained to this day, not only in the "compass rose," but in the "wind rose," as well.

MARINE INFORMATION NOTES

Provided by Ernest Brown

Corrections to Navigation Rules

Notice to Mariners 11/85, 16 March 1985, gives corrections to Inland Rules 14, 15, and 24 of the Navigation Rules, International-Inland, which are currently in effect.

Summary of Ocean Claims, February 1985

Notice to Mariners 13/85, 30 March 1985, provides a summary of ocean claims compiled from the best available sources. The publication of this material is solely for information relative to the navigational safety of shipping, and in no way constitutes legal recognition by the United States.

When using the summary, particular attention should be given to the footnotes. For example, the claim for a territorial sea may be a distance from a claimed baseline rather than from the actual coastline.

BOOK REVIEW

Almanac for Computers

Reviewed by Henry Shufeldt

93 pages, soft bound, $4.25

Almanac for Computers is published annually by the U.S. Nautical Almanac Office. It is intended for use with computers and advanced calculators, and permits a very precise determination of the coordinates of celestial bodies for a given instant of time. Essentially everything covered in the Nautical Almanac is included in this small volume although the presentation is entirely different. Instead of the traditional tabulation by fixed interval, concise mathematical expressions are used to represent the coordinates for specified intervals of time, with sufficient accuracy for all normal navigation. The volume is divided into six sections, titled A through E.

Section A includes explanations of the use of the other sections. Section B covers julian date, sextant altitude corrections, the equation of time, the times of Sun and Moon rise and set, Polaris data, etc. Section C is titled "Navigation Tables," and includes data necessary to compute the GHA of Aries, as well as that for the Sun, Moon, and navigational planets, together with semi-diameter and horizontal parallax for the latter.

Section D gives Chebyshev approximations of sidereal time and solar, lunar, and planetary coordinates.

Section E lists the mean places of 176 navigational stars.

For use with computers, the data in Section D and E are available on magnetic tape.

For computing altitude, the classic sin-cosine formula

$$\sin H = \sin L \sin d + \cos L \cos d \cos LHA$$

is used, and for computing azimuth the formula given is

$$\tan Z = \sin LHA/(\cos LHA \sin L - \tan d \cos L).$$

This edition includes two new improved formulae. The first, for computing the equation of time developed by James Brimhall, West Virginia State College, is

$$Eq\ T = -\ 7.66\ \text{min} \sin (0.^{\circ}9856\ t - 3.^{\circ}51) - 9.78\ \text{min} \sin (1.^{\circ}9712\ t + 18.^{\circ}37)$$

where t is the number of days since 0 January, 0^h, UT. This formula yields an accuracy of ± 0.8 minutes. A considerably longer formula by Dr. Brimhall yields an accuracy of ± 2 seconds.

The second new formula, given below, by G. G. Bennett of the University of New South Wales, is short, but permits the determination of the refraction correction to be applied to sextant altitudes in the range 0°-90° with an accuracy within ± $0.^{\circ}015$ of that computed by the much longer Garfinkel algorithm, the basis of the refraction table in the Nautical Almanac.

$$R_M = R'_M - 0.06 \sin (14.7\ R'_M + 13)$$

where

$$R'_M = \cot \left(H + \frac{7.31}{H + 4.4}\right)$$

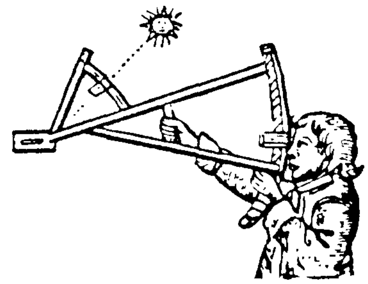
To sum up, the Almanac for Computers is a most satisfactory source for the confirmed do-it-yourself navigator, supplying him with very accurate data.

Address all correspondence to:

The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850

THE NAVIGATOR'S NEWSLETTER

FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION — Issue Ten, Fall 1985



This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

Meetings

The major activity in the field of navigation in the past quarter was the annual meeting of the Institute of Navigation, held at Annapolis in June. The sessions included a panel on "The Future of Celestial Navigation," which I chaired, ably assisted by our board members Allan Bayless and Ernest Brown. A technical paper on the place of the Hand-Held Computer in future celestial navigation was presented by member Melvin N. Peterson, and each member of the panel spoke on his view of the subject for about 5 minutes. This generated a good discussion for the remainder of the period. The ION meeting otherwise was focussed on electronics and business aspects of the field. An excerpt from the remarks of Dr. Ken Seidelmann is included in the Readers Forum.

The following day (June 28) a meeting of the FPAN board of directors was held at the home of Captain Henry Shufeldt. The only absentee was Director Roger Jones who was just moving to Los Angeles at that moment. Progress was reviewed and projects for the future discussed. Information on these ideas will be provided as they develop.

New Telephone Number

The Foundation now has a telephone listing in the Suburban Maryland telephone directory for the Washington, DC area. The number is:

Area Code (301) 622-6448

This phone will usually be manned by Captain Carraway, but will at all times have a tape answering machine which will enable a Foundation Director to return a call promptly. The phone may be used to check on book or chart orders, request help with a navigation matter, or any of the things within our charter. We hope that members will find this a useful service.

Membership Cards

In the near future all members should receive a new membership card which we are producing. The card will serve to identify a member, and will be updated with each renewal.

Book and Chart Catalogue

Our Book and Chart Catalogue will be ready shortly and will be mailed to all members. It will include books available through the Government Printing Office, Defense Mapping Agency, Cornell Maritime Press, Dodd, Meade & Company, and the Naval Institute. Charts currently available are from the Defense Mapping Agency, although we are attempting to make arrangements for charts from National Oceanographic Service. So far this latter agency seems to have requirements that we cannot meet (over the counter service), but we believe that we will eventually get a satisfactory arrangement.

Foundation Brochure

We now have a brochure on the Foundation which we will mail to any member who has a recruiting opportunity. So far they are being distributed to students by navigation instructors, but there may well be other uses to which they can be put which will result in additional members. The brochures are pocket-sized and can be mailed to individuals. We would like to hear from members with suggestions for use. If members can supply a list of prospects the Foundation can mail them directly.

Annual Meeting

We again solicit comments on an annual or bi-annual meeting of members. We have had a scattered response to our last suggestion in this area, with a few members indicating that they would like to meet with other members, particularly those who teach courses in navigation. Additionally, a Chicago member has pointed out the virtues of having such a central point with excellent facilities as a location for a meeting. If we get an increase in interest we will propose such a meeting for next year, make tentative facility arrangements, and invite members to register. This should bring the matter to focus, and give us the basis for a decision.

READERS FORUM

Excerpt from remarks of Dr. Ken Seidelmann of the U.S. Naval Observatory:

"I see three roles for celestial navigation in the future. The first role will be that as a primary means of navigation, for those who are satisfied with the accuracy provided by celestial navigation and cannot justify the increased cost of other equipment and for the yachtsman who enjoys the practice of celestial navigation. Second is a check, or verification, role in navigation. This would provide a means of ensuring that the automated, or black box, navigation system is really providing the correct answer. A prudent navigator will want some means of checking that the electronic systems are working correctly, or that the systematic errors are within tolerable limits. Third is the fall back role in navigation; celestial navigation, if weather permits, will always be available when other equipment on board has failed. I expect that for these three roles the current equipment, publications, and methods will continue to be used, but I also anticipate that some improvements should and will be introduced. Some as options that may or may not be used and some as improvements for all purposes.

"With this in mind, about nine years ago the Almanac for Computers was introduced so the navigator might use hand calculators instead of almanacs and sight reduction tables. We are currently working on the development of what we are calling a "floppy almanac," which will provide the necessary data and software packages to be used in a personal computer. It will also be possible to take the software packages and use them in other computers. We are also currently considering introducing small compact sight reduction tables and equivalent sight reduction algorithms for calculators in the Nautical Almanac. The former would provide for the person who does not have, or cannot count on a hand calculator or personal computer, while the latter would provide the necessary information for sight reductions for the person with a calculator. Thus, for the fall back role of navigation, a sextant and a Nautical Almanac, plus the correct time, would suffice.

"We have for some time been investigating the possibility of improving the age-old sextant. Specifically, the idea has been to add digital readout capability to the sextant. Then the data could be directly transferred into a hand calculator, a computer, or a more extensive navigational system. This would also provide the means whereby a calculator, mounted on the sextant or a separate computer, could directly determine most probable positions or combine a number of observations to determine the positions directly."

Member Thurman E. Smithey of Chula Vista, CA writes:

"Relative to Mr. Buckley's suggestion about the star sights with the upside down sextant, you might be interested in the following:

"I had occasion to write to Mr. Buckley on another subject and included, in a P.S. on the subject of the upside down sextant, the following:

'My own observations concerning your suggested method indicate that only the axis of rotation is changed, the requirement for rotation, or swinging the arc, remains. The angle to be measured is still the vertical angle from the body to the horizon and this cannot be measured accurately by the sextant unless the sextant itself is held vertical for the measurement.'

"In his reply, Mr. Buckley has agreed that my statement is 'quite accurate.'"

Member Joseph M. Chamberlain, President and Director of the Adler Planetarium in Chicago, writes:

"With respect to an annual meeting, another thought. Do not overlook the midwest and specifically Chicago as a location for such a meeting. This is an active navigation area with access to one of the largest fresh water seas in the world. Further, in our Planetarium navigation program we have traditionally taught more than 500 navigation students per year in our several courses.

"The Adler Planetarium also maintains a navigation exhibit in which two chartrooms are featured. The earlier, dated 1780, is a replica of the sailing master's cabin on an Atlantic coastwise schooner. The more recent, dated 1980, is a replica of the chartroom on the Tartan 46 racing sloop 'Six Belles' complete with functioning electronic equipment, etc. And in other exhibit areas and in our collection's reserves we have numerous artifacts from the history of navigation, including probably the largest and most complete U.S. collection of astrolabes.

"So in view of the above, don't count us out. I would be happy to work with you to arrange an annual meeting here in Chicago at some mutually convenient time."

Member Donald J. Pegg of Ft. Pierce, FL writes:

"In reference to the formula by Mr. Federico given in the spring (8th) issue of the Newsletter, I feel that the odds are astronomically high that this formula has not been published previously and the odds are equally high that it will not be used extensively by navigators in the near future. This is not intended as a criticism of Joe or his formula and if I 'read' him correctly, I believe he will go along with this attempt to inject a slight bit of humor.

"Out of a collection of 60 or more formulas for 'h' and 't' that I have gathered over the years, I have seen nothing quite like it. Some 3 or 4 bear some resemblance to the form of the numerator and the members of the denominator in his formula. The formula itself is of a 'type' used during the last century. The use of an 'auxiliary angle' (A) I find once in my notes and it is part of rather lengthy formula for tan t/2.

"Single function formulas are scarce and I find only 4; one is an all sine formula, one is an all haversine or/all versine formula, one the all secant formula and the all cosine form of the fundamental formula.

"When it is considered that any of the 6 basic trig functions can be expressed in terms of the other 5 functions (not counting versines, coversines, haversines, suversines, doversines, external secants and coexternal secants) it is a wonder that a larger number of formulas for 'h' and 't' have not come to light.

"However mathematicians will have their day and as E. G. R. Taylor mentioned in her 'Haven Finding Art,' 'The diagram and explanation of the loxodromic curve by Pedro Nunez was a delight to the mathematicians but the dispair of navigators.'

"P.S. The odd ball Trigonometric functions mentioned above are all legitimate functions and have been used in formulas. I will send anyone interested (?) copies who may want to be convinced."

Member Neal T. Walker of Apple Valley, CA writes:

"In Issue 8 you asked for info on navigation classes. Here is the data.

Orange Coast College
2701 Fairview
Costa Mesa, CA 92626

FALL SEMESTER

Celestial Nav. I (Beginning)

Mon. 4-7 p.m. Walt Gleckler
Wed. 7-10 p.m. Neal T. Walker

Celestial Nav. II (Advanced)

Thurs. 7-10 p.m. Neal T. Walker

SPRING SEMESTER

Celestial Nav. I

Mon. 4-7 p.m. Walt Gleckler
Thurs. 7-10 p.m. Neal T. Walker

Celestial Nav. II

Wed. 7-10 p.m. Neal T. Walker

Fall Semester starts week of August 19-23, 1985 and ends before Christmas.

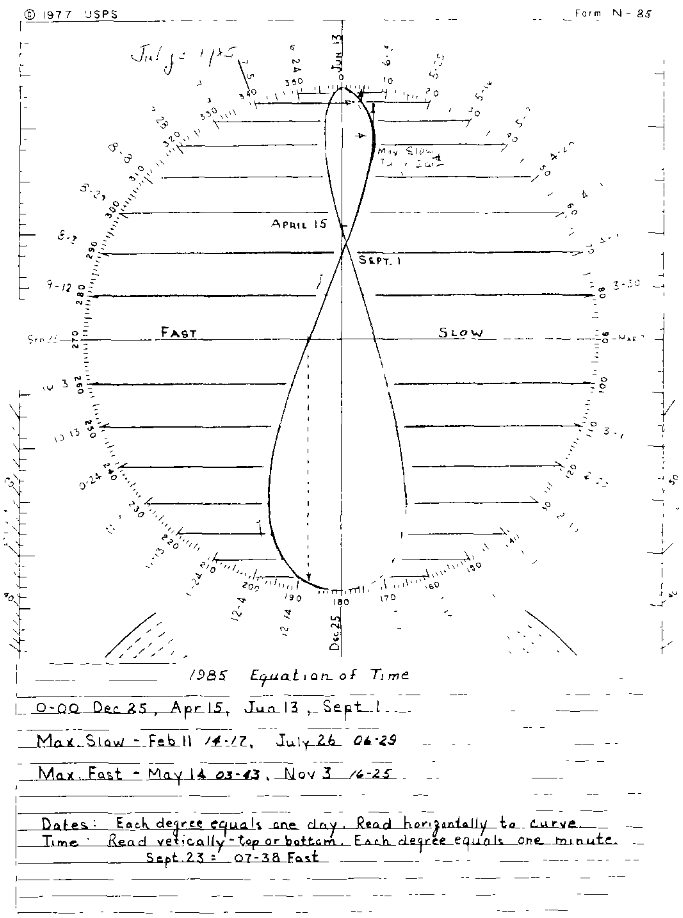
Spring Semester starts week of January 13-17, 1986 and ends at the end of May."

Member Joseph M. Nemoga of Middle Village, NY writes:

"There seems to be 'something omitted' from the Equation of Time formulae - published in Issue Nine, Summer 1985.

"During the period of a year, the Sun is 'Fast' and 'Slow,' twice. This 'cycle' does not seem to appear in that formula.

"To graphically show this to my Naviation studends, I constructed the enclosed diagram.



"It shows the Sun to be about 4½ minutes slow on July 5th. (Roughly, 4½ minutes equals 1°08' slow.) 360° - 1°08' = 358°52', the 1200 GHA of the Sun. [Actual: Nautical Almanac - GMT 1200 GHA 358°52.2'
Equation of Time slow 04m 31s.]

"This 'figure 8' used to appear on the World Globes. It no longer does. It has a name and I forgot it.

"Please, among your staff - someone should know. The only reply requested is the name of that figure."

Editor's Note. The formula quoted in Captain Shufeldt's review does have two periods each of "fast" and "slow." These are not too visible, but the second term has the "t" in it multiplied by 1.9..or nearly 2. That term therefore will have two slow times and two fast times, and dominates the result. The name of the figure is "Analemma."

Member Melvin N. Peterson of Cupertino, CA writes:

"Thank you very much for your courtesies extended on my behalf, during the 41st Annual Meeting of the Institute of Navigation, at the U.S. Naval Academy.

"It was a great pleasure for me to present the subject of: Hand-held Computers' Role in the Future of Celestial Navigation. Your response after the presentation, and that of the audience, combined to make it a most memorable occasion for me indeed.

"Since that time I have had the pleasure of interviewing a number of active flight crew members. Perhaps you would enjoy sharing their candid remarks.

1. C-5A navigators have been phased out, EXCEPT: when flying the corridor into West Berlin!

2. C-141 navigators have been phased out, EXCEPT: when flying parachute drop missions!

3. C-130 airplanes flown by the USAF in the Antartic ALWAYS carry a celestial navigator!

4. EC-135 Electronic Surveillance airplanes ALWAYS carry a celestial navigator.

5. P-3 Orion airplanes ALWAYS carry 2 celestial navigators on their ASW missions!

"The above examples clearly indicate to me, at least, that some upper echelon officers in the military see the wisdom of the safety factor, and redundancy qualified flight navigators provide, when operating under 'simulated wartime' conditions."

Member A. Carey S. Stead of Dorval, Quebec, Canada writes:

"Reference is made to issue Nine of the Newsletter and to the letter of Harry C. White reproduced on its third page.

"I teach students in the Navigation and Junior Navigation courses of the Canadian Power Squadron Program. It has been suggested to the Executive Committee of the Power Squadron to which I belong that it purchase a video cassette recorder. The cost of such a recorder would absorb a considerable part of the squadron's annual budget.

"It has been suggested that the expenditure could be justified by the use which might be made of the recorder as an aid in teaching courses in celestial navigation, piloting, weather, marine electronics and seamanship. I write to ask if the Foundation has any information on the material on these subjects which is available in the form of tapes suitable for screening on a VCR machine. If the Foundation does not now have such material available to it, could you provide me with guidance as to where enquiries could usefully be made for locating such material.

"Individual power squadrons, in Canada at least, have limited funds available for the purchase or lease of training aids, such as VCR tapes. Therefore, the cost of any teaching material available in the form of VCR tapes will be an important factor in deciding whether such material which is otherwise available will be of much use. Any information you might have on the cost of the tapes available will be appreciated."

Editor's Note. The Foundation is investigating celestial navigation instruction tapes. We will have more on this later and will answer member Stead shortly.

Member Clinton Fogwell of West Chester, PA writes:

"As you can see from the enclosed brochure I now use celestial navigation in a strict practical sense. However, in time past I have done my share of the theory.

"I retired from the practice of law about five years ago and have been delivering boats to and from miscellaneous places since then.

"Until recently I had a 'regular' first mate, Don Walker - a college classmate, but he has been 'ordered ashore' for medical reasons.

"With regularity I am in need of good crewmen (male, female or couple).

"Perhaps you could 'spread the word.' Needless to say a bundle of practical celestial would be secured!! We sailed 'Elizabeth' to Italy and back with only my good sextant (purchased from Dale Dunlap).

"My small ad in Yachting has been very successful. I have had many more deliveries offered than I could handle.

"P.S. I understand Dale has sold his shop and 'again' retired! Is this correct? If you see him tell him I said 'hello'!!"

NAVIGATION NOTES

Rating Chronometers

John M. Luykx

I was very interested to read Mr. P. E. Shaad's article in the last Newsletter on the rating of the quartz timepiece. It interested me so much that I went into my chronometer record books to check on the performance of three (3) clocks - chronometers - that I have in my own collection. I finally ended up doing a rather comprehensive analysis of these three timepieces. The results of which, roughly written down, are enclosed.

The three timepieces were maintained under controlled (at home) temperature conditions, where the ambient temperature did not vary more than from about 70° to 75°F.

The results of the analysis of my records appear to show that:

1. The quartz clock or chronometer maintains a remarkably steady rate over long periods of time.

2. Re quartz clock or chronometer, when accurately rated, can accurately predict error for extended periods of time.

EXTRACTS: Chronometer Record Book

Date from Record Book 1985	Week No.	A Weems and Plath Quartz Clock (Seconds) Error	Rate*	B Staiger Quartz Clock (Seconds) Error	Rate*	C Time Bowl Quartz-Z Clock (Seconds) Error	Rate*
Feb. 4	-	+0.6	-	+7.2	-	-10.2	-
11	1	+0.6	0.0	+7.8	+0.6	-11.0	-0.8
18	2	+0.4	-0.2	+8.5	+0.7	-11.5	-0.5
25	3	+0.3	-0.1	+9.2	+0.7	-12.4	-0.9
Mar. 4	4	+0.3	0.0	+9.7	+0.5	-13.0	-0.6
11	5	+0.1	-0.2	+10.5	+0.8	-13.5	-0.5
18	6	0.0	-0.1	+11.3	+0.8	-14.2	-0.7
25	7	-0.2	-0.2	+12.0	+0.7	-14.8	-0.6
Apr. 1	8	-0.4	-0.2	+12.5	+0.5	-15.5	-0.7
8	9	-0.6	-0.2	+13.3	+0.8	-16.0	-0.5
15	10	-0.8	-0.2	+13.8	+0.5	-16.7	-0.7
22	11	-1.2	-0.4	+14.5	+0.7	-17.5	-0.8
29	12	-1.4	-0.2	+14.9	+0.4	-17.9	-0.4

*Weekly Rate.

Line No.		A	B	C
1	Mean Weekly Rate (MWR) 2/4-3/4	-.08	+.63	+.70
2	Mean Variation of Weekly Rate (MVWR) 2/4-3/4	.08	.08	.15
3	Standard Variation of Weekly Rate 2/4-3/4	.11	.11	.21
4	95% Probability of Max. Weekly Variation 2/4-3/4	.21	.21	.40
5	Predicted Clock/Chron. Error on 4/29	-.34	+14.7	-18.6
6	Actual Clock/Chron. Error on 4/29	-1.40	+14.9	-17.9
7	Clock/Chron. Prediction Error on 4/29	1.06	0.2	0.7
8	95% Probability of Max. Prediction Error on 4/29	±1.68	±1.68	±3.2
9	Prediction Validity for Allowable 5 Second Error	23.8 Weeks	23.8 Weeks	12.5 Weeks

For example, the tables show that both the Weems and Plath clock and the Staiger clock appear capable of predicting error to within five (5) seconds for a period of time of up to 24 weeks; a feature of great significance to the navigator of a vessel or yacht which may have lost its radio or which is unable to receive time signals over long periods of time.

Sad to say, however, none of my quartz clocks is capable of adjustment as Mr. Shaad so interestingly describes!!

Explanation

Line #1: = mean value of weekly rate from 2/4-3/4.

Line #2: mean value of the difference between mean weekly rate and actual weekly rate from 2/4 to 3/4.

Line #3: the standard deviation of the variation of weekly rate in line 2.

Line #4: 1.92 x the value in line 3. This figure indicates that if 19 of 20 weeks are considered the max. variation of weekly rate should be no more than the figure shown.

Line #5: line #1 x 8 (8 weeks) added to clock/chron. error on 3/4.

Line #6: actual clock/chron. error on 4/29.

Line #7: difference between lines #5 and #6.

Line #8: line #4 x 8 (8 weeks) = prediction error over 8 weeks.

Line #9: = 5 seconds ÷ line 4. This figure indicates that there is 95% probability that each clock/chronometer listed (A, B and C) will be able to predict time within 5 seconds for the period of time indicated. Thereafter the error of prediction for that clock/chronometer is greater than 5 seconds.

A Navigation Problem

Solution to the problem presented in Issue Nine:

11. Answer. The star is Regulus. There are several "quick" solutions. One is to use a "Star Finder" such as the one devised by Rude, H.O. 2102-D, or any similar device.

Use of Star Finder

Step 1. The corrected watch time is 18-35-17. The zone is +4. The GMT is thus 22-35-17.

Step 2.

GHA Aries, 3/30/85,	2200 GMT =	158° 13.7'
Increment	35'17"	8° 50.7'
GHA Aries, 3/30/85,	22-35-17	166° 64.4'

Step 3. DR Longitude		- 66° 33.5'
LHA Aries, 3/30/85,	22-35-17	100° 30.9'

Step 4. DR Latitude is 14° 47' North. Use the 15° N template. Place it on the N side of the disc, with the arrow pointing to 100° 30.9'.

Step 5. At the intersection of the 085 azimuth line and the 40° altitude line, the star Regulus appears.

Use of Assumed Altitude Tables (Star Sight Reduction Tables for 42 Stars: Assumed Altitude Method of Celestial Navigation, by Thomas D. Davies, Rear Adm., USN Ret., Cornell Maritime Press, Centreville, MD).

Steps 1-3. Proceed as above to find LHA Aries, 100° 30.9'.

Step 4. The DR latitude is 14° 47' N. The approximate altitude of the body is 40°, and the approximate azimuth is 085. Enter the Assumed Altitude Tables on the page marked "15 North" (so marked at the top of page 78) and go to the column headed by "40" (representing an assumed altitude of 40°). Proceed down that column by inspection to the LHA Aries value nearest to 100° 30.9'. You will find this nearest value to be 100° 23' with an associated azimuth of 088. The identifier "T" also appears. You will readily see that there will be no confusion as to which set of values to select from the appropriate column in the Davies Tables.

Step 5. At the back of the volume, page 327, the identifier "T" is listed and is shown to stand for the star Regulus.

Use of Vol. I of H.O. 249

Steps 1-3. Proceed as above to find LHA Aries, 100° 30.9'.

Step 4. Enter Vol. I on the page for 15 N and LHA Aries 100°. (You could just as readily enter on the line for LHA Aries 101°.)

Step 5. Proceed across the line to the column with an azimuth value near to 085. There is one such value, and it appears in the vertical column for Regulus. Note also the tabulated altitude is very close to the approximate altitude of 40° noted by the navigator when he glanced at his sextant.

Comment: The use of Vol. I of H.O. 249 will only yield an identification of the "target of opportunity" star if that star happens to be one of the seven listed for the latitude and LHA Aries values appropriate to the navigator's circumstances at any given time and location. It does not offer the same practical certainty of a positive identification as is offered by the star finder or the Assumed Altitude Tables. Of course, the H.O. 229 tables are not limited in this respect, but a much more complicated procedure must be used with interchange of tabulated values to arrive at an identification of an unknown star. For all practical purposes, the star finder and the Davies Tables cover all stars of sufficient magnitude to be visible and useable as "targets of opportunity," and each yields very fast and uncomplicated solutions. Of course, the Davies Assumed Altitude Tables take the navigator beyond identification of an unknown star to the next logical quest: star sight reduction.

Problem No. 12

It is still March 30, 1985. The navigator has satisfied his curiosity as to the identity of the unknown star he observed at 18-35-17 standard time for zone +4. His DR, as noted in Issue Nine, is Lat. 14°47'N Long. 66° 33.5'W. Height of eye was 12 feet. Index error was 2' off the arc. The sextant altitude is 40° 4.6'. The approximate azimuth was 085 True. Regulus appeared momentarily in the otherwise obscured sky astern of the vessel, and a position line derived from the observation will yield information as to his progress along his course line of 250° True. The navigator decides to try out the Davies Tables. For readers with access to those tables, what is the solution to the star sight reduction problem, and what would the plot look like?

History of Navigation

T. D. Davies

I recently came across an interesting device used in the 16th century and later. It was called a "Nocturnal," and was used to tell time at night. You will find it mentioned in Bowditch, but only one use is discussed, that of determination of latitude by sighting on the Pole Star. The more common use seems to have been for the determination of time at night, which was accomplished by a set of dials and arms on the reverse of the side shown in Bowditch.

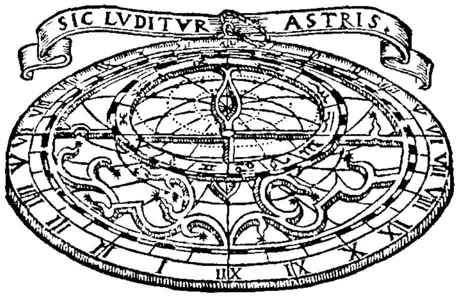
As manufactured, it was only usable in the northern hemisphere, but it was probably used by Vespucci in timing the Moonrise which he describes in his letter of 18 July 1499. There are other examples where 16th century observers express events at night in mean time, known as "equal hours" in those days. Modern writers usually credit them with using hour glasses or water clocks as the bases of the statements, with a consequent low opinion of their precision. The Nocturnal could have been used with a much better accuracy than has been credited.

With the Nocturnal time is found by measuring the angle that the "pointer stars" of the Great Bear (Big Dipper) constellation make with the vertical (determined by a pendulum). Alternatively stars of the Little Bear constellation may be used by means of a second measuring arm.

The instrument consists of a main plate with a handle, which is kept vertical by the observer. One circular scale is divided into the twelve months of the year and then into days. A second circular scale is divided into twenty-four hours with further divisions every 15 minutes. There are additional scales relating to the Moon's age (days) used in determining time of high tide.

To determine the time the selected arm for either constellation is set to the current date. Then, with the handle held vertical and sloped so that the disc is perpendicular to a line of sight to Polaris, and so that star is visible through the center hole, the long arm is swung to intersect the constellation star previously mentioned (either Great Bear or Small Bear). The long arm will then indicate the time on the inner scale (divided into hours as mentioned above).

The construction of the instrument gives a picture of the state of astronomical knowledge at the time. They clearly understood both sidereal and solar time and the relationship between them. They also understood the variation in the motion of the Sun, since the device gives Local Mean Time.



MARINE INFORMATION NOTES

Provided by Ernest Brown

Testing the Franklin Piloting Technique

The Maneuvering Board or similar polar plotting diagram is recommended for use in examining the Franklin Technique as described in article 1009 of volume I of Bowditch and testing its simplicity and accuracy in realistic situations.

With the true position of the observer at the center of the polar diagram and the positions of the objects to be observed plotted accordingly, parallel rulers can then be used to construct the cross-bearing plot with the selected fixed error in each bearing line. The plotting process is simple and rapid. Other situations can be set up and tested rapidly.

It is to be hoped that this suggested means of examining and testing the technique will lead to its wider application in actual piloting situations.

Articulated Light

The articulated light is a floating light designed to have a smaller watch circle than a conventionally moored lighted buoy. This new type of floating light consists of three elements: a sinker; attached directly to this by a variety of devices incorporating the principles of the universal joint, an elongated pipelike structure of sufficient length and diameter; and at a submerged, predetermined distance along the pipe, a buoyancy chamber. Its principle of operation is such that the buoyancy chamber seeks to maintain the structure in a vertical position directly over the sinker. Should the structure heel over under the effects of wind, waves, or current, the righting tendency of the chamber, becoming greater with deeper submergence, forces the structure back to its normal stance.

Although the position integrity of the articulated light is necessarily less than that of the fixed beacon, the use of the articulated light to mark certain waters has been found to be advantageous. Initial cost, comparatively easy deployment, and ability to survive collision recommend the structure as an economical yet efficient aid to navigation, particularly in sheltered waters and along narrow ship channels.

Disposal of Notice to Mariners

DMAHTC publishes a five volume Summary of Corrections compiling information from the Notice to Mariners, Volumes 1 through 4 contain corrections for charts and are regional in coverage. Volume 5 contains corrections for World and Ocean Basin Charts, US Coast Pilots, Sailing Directions, Fleet Guides, and miscellaneous publications. Corrections for the Hydrographic Catalogs, Light Lists, List of Lights, and Radio Navigational Aids are not included in the summaries because new editions of these publications are procured annually or biennially. The latest edition dates of the Summary of Corrections volumes are:

Volume 1 April 1985
Volume 2 May 1985
Volume 3 June 1985
Volume 4 January 1985
Volume 5 March 1985

All effective chart and publication corrections contained in Notice to Mariners numbers 75-27 of 5 July 1975 through 84-40 of 6 October 1984 have either been incorporated in the above summary volumes or new editions of charts and publications to which they apply have been issued. Accordingly, Notice to Mariners number 75-27 through 84-40 may be disposed of.

BOOK REVIEW

Dutton's Navigation and Piloting
Fourteenth Edition, 1985

and

Problems and Answers
In Navigation and Piloting
Second Edition, 1985

by Elbert S. Maloney

Naval Institute Press
Annapolis, Maryland

Dutton's - 588 pages - $32.95
Problems and Answers - 83 pages - $3.95

Reviewed by Roger H. Jones

Now a classic text, Dutton's Navigation and Nautical Astronomy (as it was originally entitled) was first published in 1926. Benjamin Dutton (1883-1937) was the first in a long succession of authors whose names have appeared on his compendium of the knowledge of navigation, and he both followed the example of Bowditch and set an example of his own. From the outset Dutton's, like Bowditch, has been truly comprehensive in subject matter, and it has borne what many have felt was its own distinctive stamp of clarity of word and logic of organizational arrangement. To that testament there must now be added today the simple statement that there is now a Fourteenth Edition which continues the tradition started fifty-nine years ago. It has stood the test of time.

A member of the Institute of Navigation, Elbert S. Maloney is also the current author of another great classic, Chapman's Piloting, Seamanship and Small Boat Handling. He is a contributing editor of Motor Boating and Sailing, and he has been for many years a member of the national education staff of the United States Power Squadrons. He now serves as head of the Coast Guard Auxiliary education department.

Colonel Maloney (formerly of the USMC) has rewritten and updated Dutton's to include information on the most recent developments in electronic and satellite navigation, including Loran-C, Omega and the Global Positioning System (GPS) soon to be deployed. GPS, or NAVSTAR, is scheduled to replace NAVSAT, and when fully operational, it will assure the continuous accessibility of navigation satellite signals worldwide. The eighteen GPS satellites will be higher in orbit than those of NAVSAT, and they will transmit both position and time messages.

The Fourteenth Edition also contains the 1984 revised, full color, edition of Chart No. 1, symbols and abbreviations used on U.S. nautical charts, with a glossary of terms used on charts of various other nations also included. This is the latest and Eighth Edition of Chart No. 1, and it is a fifty-two page bonus with which every mariner should be equipped.

Other new material in the Fourteenth Edition is a description of the new Concise Tables for Sight Reduction developed by Rear Admiral Thomas D. Davies, which were the subject of a recent review in this Newsletter. Those tables, first published only months ago, are being considered for possible publication as an appendix to the Nautical Almanac.

The separate little volume of problems and answers is also updated. It contains extracts from many publications such as the light lists, tide tables, the Almanac, and sight reduction tables. It has lifeboat navigation tables and useful equations and rules. The several hundred problems and answers provide the student with a complete guide to practical application of all that is presented in the larger main volume of 588 pages.

Dutton's is organized into 41 chapters dealing with all of the navigation subjects from piloting and dead reckoning through celestial and radionavigation. A continuing emphasis on the celestial topics is seen in the twelve chapters which deal with the celestial art. Their clarity, illustrations, and organization continue to reflect the standard for which Dutton's has earned an international reputation. There is in the celestial material one omission, however, which may be worthy of note in its own right, and which is further brought to mind by the fact that there is discussion of the Davies Concise Tables. No mention is made of the Davies Assumed Altitude Tables, which first appeared in 1980, and which offer significant new advantages in simplicity, especially for star observation.

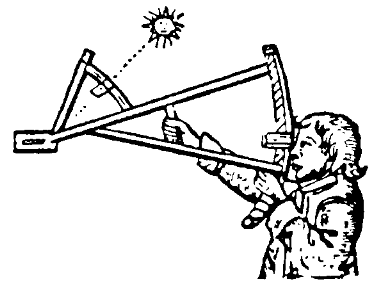
The new Dutton's closes with chapters on inertial, bathymetric and Doppler navigation, and on lifeboat and polar navigation. The last chapter is one on ship weather routing, which closes the circle that was opened in Chapter One where navigation was defined as "the process of directing the movement of a vehicle from one point to another safely and efficiently."

Dutton's is a truly complete reference work for experienced navigators. For students it is an in-depth text. It is not inexpensive, but its worth should be measured not so much in dollars as in the wealth of subject matter content.

Address all correspondence to:

The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850

THE NAVIGATOR'S NEWSLETTER



FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION ISSUE ELEVEN, WINTER 1985

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

Books

During the past quarter we mailed out our Catalogue of navigational books. By now we are receiving orders at a substantial rate, for books listed therein. The catalogue lists two books at incorrect prices. The price for the Nautical Almanac should be $11, rather than $10, and the price for the Air Almanac should be $14 rather than $11.

The telephone listing for the foundation has been receiving enough use to justify its continuation. Expediting the delivery of books seems to be one of the uses to which it is put. Our Book and Chart Catalogue seems to have proven its usefulness by an increase in the number of book orders. We continue to have difficulty with delivery of publications from the Government Printing Office, while those from the Defense mapping Agency seem to give no problem. Please bear with us as we regularizing or relations with the Naval Institute and Dodd Meade.

Awards

We have approached the U. S. Naval Academy with regard to setting up an award in the Navigation Department to be named after Captain Benjamin Dutton, author of "Dutton's Navigation and Piloting", the 14th edition of which was reviewed in the last Newsletter. Such an award has to be approved by a reviewing board at the Academy, but we should receive an answer in the next two months. Captain Dutton was not only a competent professional navigator and author, but an outstanding Officer and leader. His unexpected and sudden death while in command of the U. S. Portland, was a great loss to the nation.

Renewal Notices

The Foundation is changing permit numbers on all business reply envelopes, while it will not have any effect on members, those that receive renewal notices will find a regular envelope with a stamp rather than the normal pre-printed envelopes until the changeover is complete.

Membership Cards

Membership cards are still under preparation. We have had to have them printed on continuous form paper to allow names to befilled in by computer. They should be issued together with the next Newsletter. They will be effective for one year, and subsequently will be re-issued at renewal.

CAPT. HENRY H. SHUFELDT
1898 - 1985

It is with sorrow that we announce the passing of Henry H. Shufeldt, USN (Ret.) on November 1, 1985.

Errata

Recently Cornell Maritime Press has issued an "Errata" to the "Concise Tables For Sight Reduction". Unfortunately prior purchasers of the Tables will not receive this, since there is no record of who these prior purchasers were. Therefore the errata is repeated here.

Page 48. Under "Correction for Assumed Positions" at end of last line of first paragraph, change period to comma, and add:

to allow plotting from the fix or the DR, instead of the AP.

Page 49. The signs in the second schedule of signs are reversed. Where the schedule shows a plus, it should be minus, and similarly minus should be plus.

Page 53. When F is negative (co-H is greater than 90), the sign of H1 (altitude correction for F' and Pc) is reversed.

Page 54. In figure 5 the first and second altitude corrections are interchanged and H1 has the wrong sign. This results in an erroneous value for great circle distance. The sign for Z1 is omitted and the sign for Z2 is reversed. The relevant portion of the figure is correctly shown below:

Ht	33-54
line 3	+29
line 4	- 1
Hc	34-22
co-H	55-38
D	3338 miles
Z1	-56.0
Z2	- 4.8
	360
Z	-60.8
Cn	299.2

Page 55. Lo, the latitude of origin, should read L1.

Editorial

by T.D. Davies

As all our members know it is a basic tenet of the Foundation that personal navigational skill and understanding is an essential ingredient in mobility, both at sea and in the air. This includes an appreciation of the uncertainties and hazards of navigation, and the real need for the navigator to maintain the thread of his position-keeping. An old friend of mine used to say that navigation was like climbing a rope, you didn't let go with one hand until you were sure of your hold with the other.

Modern electronic navigational aids have tended to suppress this view of the art of navigation, giving the false impression that they now yield an error-free position without effort on the part of the navigator. We have previously made the point that learning the personal skills of navigation is not something that can be done at the time of a breakdown of automatic equipment. The question has been raised as to why the electronics can't be made failure-proof. Some recent events give the answer, i.e. that it isn't only the electronics that can fail, but the people!

A few weeks ago in Tokyo, I saw a far-east reporter who has recently done what is generally believed to be the definitive analysis of the cause of the Korean Airlines navigational deviation (resulting in the shoot-down). While there may be some disagreement about his analysis, he makes a convincing case that the automatic navigation equipment was disconnected from the automatic flight controls in order to fly on "vectors" from ground control around nearby mountain hazards. It was never reconnected, so the craft simply flew on a continuous heading and was taken off course (about 300 miles) by the wind.

Subsquently a Japan Airlines aircraft did essentially the same thing, i.e. the automatic navigation equipment was set up but never cut in. This last case received considerable coverage in the press because Soviet fighters were again scrambled but did not shoot the plane down. The pilot came in for severe criticism and was "demoted". Again the electronics were good, but the human element defeated them.

The human element rendered the electronics helpless for the lack of any appreciation of the uncertainties and hazards of navigation, on the part of the persons with the responsibility for the safety of the flight. It seems clear that a pilot (who, since there is no navigator on board, must be considered in charge of the navigation of the craft) must not only set up correctly his automatic navigation gear, but must continually be aware of his position and use whatever equipment he has (such as the mapping radar) as well as personal observation, to check that all agree. It should be ingrained in the navigator that he keeps a constant check on his position, and that he understands that even the best of equipment can be wrong, for a variety of reasons.

All of this applies equally to the navigator of a surface craft. The environment gives many signs that hint as to your position, in addition to the precise information supplied by celestial observations. The navigator should be alert to these and be assessing continuously how they correllate with his estimate of position. The book reviewed in this issue discusses some of these phenomena, albeit from a different point of view.

READERS FORUM

Member L. Nordin, of Ottertail, MN., writes:

"As there are lines of equal magnetic deviation, east and west, on navigational charts, so should there be lines of equal gravitational deviation on those charts; in the vicinity of underwater sea mounts systems; and other gravitational anomalies. Science Horizon yearbook - 1984, in its Seafloor Panorama article notes, 'The intense gravity low surrounding the distinctive Hawaiian Emperor Seamount Chain in the mid-Pacific clearly indicates how a tectonic plate can bend like a rubber mat under the massive weight of a Seamount'.

As a first cut at the problem, perhaps lines of equal gravitational deviation more than 4 minutes of arc need charting on ocean navigation charts, as lines of equal gravitational deviation.'

Ed Note: This idea would have merit if the deviation of the astronautical vertical from the geodetic vertical was of a magnitude to be significant in navigation. However the maximum of such deviation in the U.S., for example, is less than .5 minutes. Clearly mountain ranges under water, while of some effect, will have less effect on the gravity vector than similar mountains above the surface. It seems, then, that the deviation world-wide will be only a fraction of a minute, and of no significance to the navigator, even though they may seem "intense" to the geologist.

Vol. II of Bowditch has an excellent discussion of this under "Geodesy for the Navigator".

Member Edward I. Matthews of Boxburo, MA writes:

The measurement of apparent distance between star pairs presents an excellent opportunity to practice the use of the sextant in your backyard and provides and accurate means of measuring instrument error.

A hand held calculator can be used to calculate the apparent interstellar distance (SD) including refraction effects by solving the basic spherical triangle equations. The altitude of each star (hc) is determined from:

$$\sin(hc) = \cos(L)\cos(d)\cos(LHA)+\sin(L)\text{-}\sin(d)$$

The azimuth (Zn) is then calculated.

$$\cos(Z) = \frac{\sin(d)-\sin(L)\sin(hc)}{\cos(L)\cos(Hc)}$$

Zn = Z unless Lha is positive. Then

Zn = 360 - Z

The apparent altitude of each star (ha) is then obtained by ADDING the Nautical Almanac correction to (hc). If (hc) is less than 20 deg, then the correction for the next higher increment is used.

The sextant should read the apparent distance (SD) determined as follows:

cos(SD) = sin(90-50)

= cos(ha1)cos(ha2)cos(Zn1-Zn2)+ sin(ha1)sin(ha2)

The difference between the measured angle and (SD) is then the observation error.

Once calculated, observations are simplified since star pair SDs remain substantaially constant over a long time period. The sextant can be preset to the nominal (SD) and then precisely adjusted for current location and conditions.

Rather than using the NA altitude corrections, I prefer a modification of Shufeldt and Newcomer's equation for refraction correction of (he) to (ha).

$$Rm = -0.97'[\tan\left(hc-\tan^{-1}10(he + 3\ deg)\right)]$$

Ed Note: Many members wrote to inform us that the "Figure 8" is an ANALEMMA. Thank you.

Member J. F. Zietlow, Jr. forwarded a copy of his letter to;

The Captain
S.S. Nantucket
Steamship Authority
Woods Hole, Ma.

in which he says:

Dear Sir,

This is in pleasant recall of a conversation with you, I believe sometime within the last year on the freight deck of your ship late in the day or early evening. We talked about celestial navigation and the use of the sextant. I was delighted with your interest and continuing familiarity with the art, all of which of course made an effective and lasting impression.

I mentioned a new navigation organization from which I receive its publication. The organization seems to have developed to such substance that its latest letter inspires initiative to send you a copy of it for such interest as you may have in being current with respect to navigation and the sheer fun of reading about the discipline.

Membership, thus access to the publication, is accessible by request and I believe I pay $25.00 a year. Original comment was that the organization was started in order that understanding in depth and familiarity with celestial navigation and its appreciation not die out.

I hope you find this issue as interesting as I. With very best wishes, and in warm recall of your congenial and affectionate usage "the old hame bone".

Member Macey Casebeer of Davis, CA writes:

John Luykx's navigation note titled "Rating Chronometers" makes a fine pitch for confidence in quartz controlled Weems and Plath, and Staiger navigation time pieces. May I suggest two additional comments?

First, in order to preclude the the quartz chronometer from stopping when an AA or other battery is removed for replacement, simply install and additional battery mounting bracket (battery holder) wired in parallel with the regular battery mounting bracket. Label one battery bracket as follows:

A. January: Place fresh battery into this empty battery holder, then remove and discard the spent battery from holder "B".

Label the other battery holder as follows:

B. July: Place fresh battery into this empty battery holder, then remove and discard the spent battery from holder "A".

This low cost fix precludes the loss of continuity in the time rating record, and reduces the probability that a stopped watch may exhibit a different rate upon restarting.

Second, it is not essential to purchase costly quartz timepieces in order to have highly reliable and stable navigation timepiece rates aboard. More than two years ago, I purchased a round kitchen wall quartz controlled clock with a wooden circular frame (walnut) and a sweep second hand for $17.50.

I installed and wired (in parallel) an additional AA battery holder for Radio Shack, placing it adjacent to the existing holder and SUNBEAM clock movement assembly on the back of the clock.

In order to lend a more nautical and professional appearance to the clock face, I drew with black ink a GMT-like twelve-hour face on plain white paper, and placed the new face over the "kitchen' face using rubber cement.

Then I set about to rate the clock weekly using WWV time obtained from a low cost DX-160 Radio Shack twelve volt multiband communications receiver. During the ensuing twenty-six months, the results were astounding. Here is a narrative summary of the results:

Average monthly errror rate:+0.42 sec.

Average six month rate: +2.5 sec.

Yearly gain: . . . . +5 sec.

Present error (after 26 mo.)+11 sec.

With this low and stable rate available from a "dime store" clock, any attempt to reduce the error rate would seem rather foolhardy- -at least foolhardy when compared with the rates I observed in mechanical chronometers afloat for thirty or so years.

Here are the reasons behind this low cost approach to accurate offshore navigation timepieces:

The Navigator can easily afford two or three such time pieces aboard, including cheap wrist watches. If one fails, simply throw it over the side and buy a replacement at leisure.

Many of my university students cannot afford to pay for labels and brand names.

Accuracy and stability are accuracy and stability, regardless of the cost.

The choices of size, design, shape and brand name of low cost quartz clocks and watches suitable for navigation are mind boggling when compared with the choices of brand named navigation chronometers and watches.

Nevertheless, as an experienced mariner, I must always ultimately suggest "buy the best you can afford, but don't let the high prices of navigation timepieces keep you from going offshore!"

P.S. Why not make a list of those who instruct in navigation--publish it annually as a supplement to the Navigator's Newsletter?

Ed Note: An excellent idea. Many members have already noted, on various pieces of correspondence, that they are navigation instructors, however, since each of these are filed under so many different subjects and a list was not kept, we need to gather that information from all of our members. If all navigation instructors will send us a note on a post card or letter we will publish a list.

Member William F. Presch of San Diego, CA., writes:

Sorry to be late in responding to Issue 10 call for Navigation Class Notice:

CELESTIAL NAVIGATION

A 52.5 Hour course, meeting twice a week for 10 weeks, with two Saturday Field Trips for sextant practice, will start November 12th in San Diego. Both morning and evening classes are available, with attendance optional once registered. Fee $66.00

Tues.- Thur. 9:00 AM - 11:30 AM.
or
Tues. - Thur. 7:00 PM - 9:30 PM.

Contact Midway Continuing Education Center, 3289 Fordham Street, San Diego, CA 92110 or call (619) 230-2375.

Ed Note: Although too late for this course, contact Member Presch for future schedules.

Member, Norman G. Cubberly of Grafton, VA., writes:

I am about to take over as Master of the T-AGOS 3, VINDICATOR, now under civilian contract to MSC. I thought that I might hone off some of the rusty corners of my celestial and also check out the "Assumed Altitude Method". Since my departure for approximately 45 days deployment with SURTASS will commence early in Dec., it appears that I will run out of "Mini-Almanac, Table III" and Alternative Correction for Precession and Nutation very shortly.

I can see that extrapolation and use of the Nautical Almanac and the primary correction method for P and N will help but am open to suggestion as to how to best extend the useful life of these tables. In a book review several years ago I pointed out that this was one of the unfortunate failings of privately printed astronomical tables; what do you do when time runs out? Most practical navigators, such as myself, are not going to take the time to do much extrapolative or mathematical work. They will simply use a more long lasting method.

Allied to the above is a suggestion that the Foundation might take up- - - what are the minimum requirements of celestial navigation as a backup system? Emergency radios are hardly giants of communications, why should backup tables be over precise? Columbus was satisfied with four monumental D. R. solutions, we might be satisfied, in emergencies with 0.1 degree, center altitudes of the sun and the like, if only to compact tables and reduce corrections. I hazard that many an ocean race could be safely run with far less accuracy than we now take for granted?

Unrelated to the above is the question of the safety of shade glasses. I have always assumed that they successfully filter out the harmful UV. After 30 years of sun sights I still seem to be able to see, but how good are they? Can one view an eclipse through a sextant? Manuals seem to be silent.

Ed Note: See Navigation Notes for comments on Assumed Altitude Tables.

Member Walter H. Johnson, of Annapolis, MD., writes:

Solution of Navigation Problem in Issue #8.

I believe that a typographical error was made when stating that the time was LMT 0850. I am assuming that it should have been ZT 0850.

Problem: To determine the ZT of LAN. Date 3-30-1985, Pos at ZT 0850 was 15-05N, 65-37W. Vessel moving on course 250 at 6.2K.

Fact: At LAN the sun is on the meridian of the observer.

At 15 deg N Lat, 1 deg of long = 58.074 Naut. miles. 1 Mile = 1.03316 min of long.

The westerly component of the movement of the vessel is 5.826K; the southerly component is 2.12K.

The rate of change of longitude by movement of the vessel = 6.01919 deg per hour.

The rate of change of GHA = 15 deg per hr.

At 0850 ZT, GMT = 1250. GHA = 11-22.7 or 11.3783 deg.

Let T = hrs required for sun to overtake the vessel, then:

11.3783 + 15 times T = 65.6167 times T

This gives T = 3.64021 hours or 3 hrs 38 min 25 sec.

The time of LAN is therefore 16-28-25 GMT or 12-28-25 ZT. The longitude at that time is 65-58.9 W. The latitude is 15-05 - 07.7 or 14-57.3 N.

I do not have the 1985 Almanac but am using instead my long-term computerized version which may introduce an error of plus/minus 0.1 minute. This almanac covers the period from 1980 to 1995 and is one of a series of navigational programs which I have developed.

Member William O. Land, of Norristown, PA., writes:

Thanks you for saving my neck with my new class starting 18 September. I'll possibly have 30 to 35 in it!!

Member Robert W. Greaves, of Endwell, NY., writes:

I am deeply appreciative of the service you are performing in procuring government publications. My attempts to deal with both the DMA and the Government Printing Office, as an individual, have met with increasing frustration in recent years. Price increases, back orders, wrong material shipped, incredible delays and totally incompetent or incomprehensible handling of adjustments have become the rule. Earlier this year my congressman intervened on my behalf. A ridiculous snafu of 9 months standing was resolved quickly, but no explanations, apologies or reassurances about the future were obtained. I have been ordering charts, books and almanacs for over 20 years. Until 1980. courteous, reliable and timely service was obtained. Since that time, I have not had a single order handled without needless complication or unacceptable delay. My letters to NOAA requesting Gulf Stream broadcasts and publications information have been unanswered for 6 months. It is sad having to accept the dismal deterioration of these services. So, it is very comforting to know that you and your associates are willing to assist the completely dependent, but apparently helpless, private navigators. Many thanks.

Member Harry H Dresser, Jr., Associate Headmaster, Gould Academy, Bethel, MA., writes:

A course in celestial Navigation will be available for secondary school-aged students at Gould Academy in Bethel, Maine, this coming summer.

During the four week campus preparation, students will focus their attention on safety at sea, pilotage skills, electronic navigation techniques and the theory and practice of celestial navigation. The navigational triangle will be resolved diagrammatically, mathematically with a handheld calculator, and using H. O. 229 and 249.

Two weeks of the six week program will be spent aboard a large sailing vessel in the Gulf of Maine applying the pilotage and navigational techniques learned on the Academy campus.

Interested students can obtain more information from Dr. Harry H. Dresser, Jr., Gould Academy, Box 860F, Bethel, Maine 04217.

NAVIGATION NOTES

The Dot Reckoner

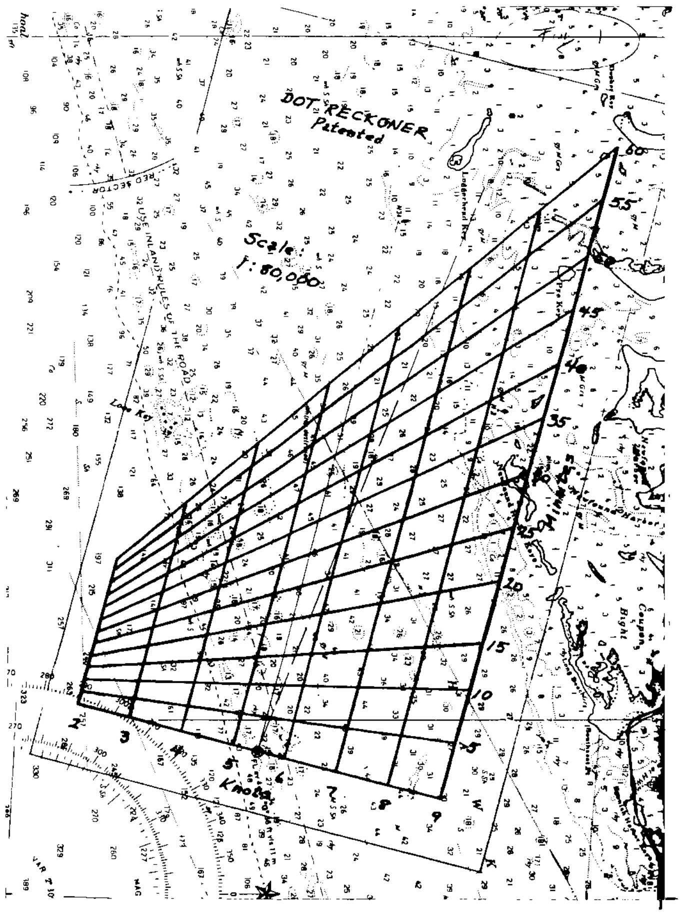
by Leonard Gray

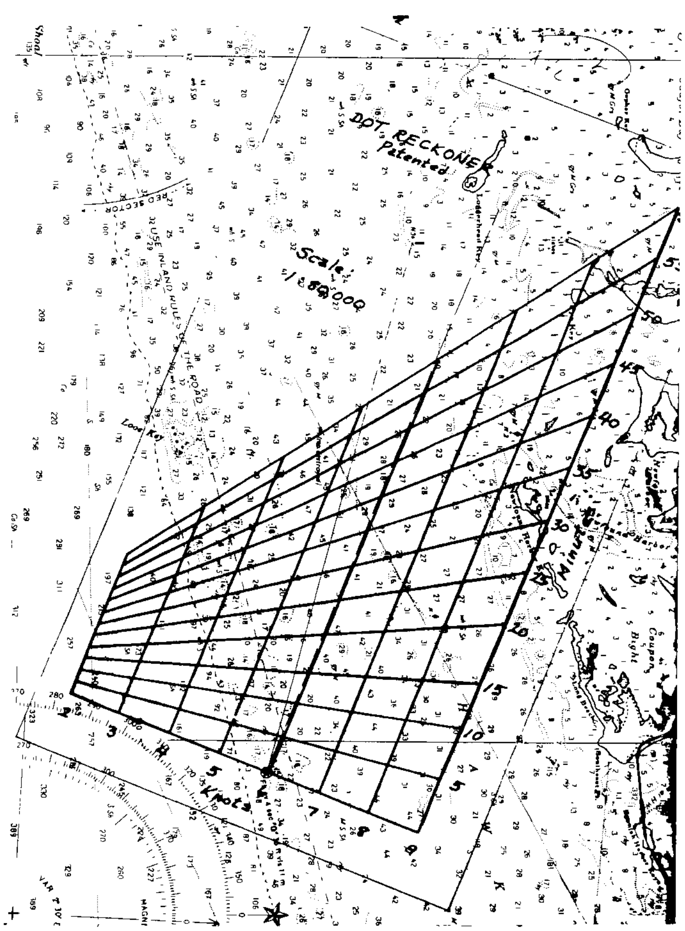
Vernon I. Weihe, a navigation systems consultant of Arlington, Virginia has invented a simple navigational device can be very useful for coastal piloting. He has not found a manufacturer, but is offering the idea free to navigators who would like to make their own. A grid can be drawn on plain paper and then reproduced on a transparency by a copying machine. A different grid is required for each chart scale to be used. Mr. Weihe's design has a series of dots with short dashes between, to avoid clutter, but the illustrations shown here are drawn with solid lines for both speed and time, for clarity.

In Fig. 1, the Dot Reckoner is being used on Chart 11442 to navigate from the flasher to N"34" on course 284 true, predicted speed 5.5 knots. The navigator notes the water depth to expect at each five-minute interval, then compares the actual depths found with the expected depths. In the example:

Minutes	Depths (feet) Expected	Found
15	20	21
20	26	43
25	40	34
30	46	41
35	44	26
40	41	29

The expected and actual times of arriving at visually determined position





lines (such as the limit of the red sector of the light just off the chart to the WSW, in the example) can be added to the table.

After a significant part of the course has been run, the Dot Reckoner is moved around on the chart until the grid intersections match the actual depth found at each time point, as shown in Fig. 2. Then the actual track and speed made good are read off (291 true, 6.0 knots, in the example).

The Dot Reckoner can be used in a cockpit in bad weather (on a chart in a clear plastic case), when it would be difficult to use dividers and a pocket calculator or slide rule.

The Dot Reckoner can be made in a few minutes. First, a table of miles is made up for the maximum expected speed - say, 9 knots:

Min.	Miles	Min.	Miles	Min.	Miles
5	.75	25	3.75	45	6.75
10	1.50	30	4.50	50	7.50
15	2.25	35	5.25	55	8.25
20	3.00	40	6.00	60	9.00

The grid is laid out on plain paper by drawing vertical lines, equally spaced, to represent speeds from 0 to 9 knots. On the right, at the 9 knot mark, the distance traveled (at 9 knots) for each time point is laid off, using the latitude scale at the center of the chart having the scale for which the Dot Reckoner is made (1:80,000 in the example). The slanting lines are then drawn from each point on the 9-knot line to the 0-knot point at the left of the bottom line. Dots can be used (as in Mr. Weihe's design), instead of the grid, and the section below 2 or 3 knots can be erased, if desired.

The complete design includes some additional parts, a track line, a position marker, and a means of holding the parts in place. But the basic overlay can be used, as indicated here, without these refinements. The method could also be used for cross-country VFR flights in small aircraft.

A Navigation Problem

Solution to the problem presented in Issue Ten:

12. Answer. Calculations are shown below.

Corrected Watch Time		18-35-17
Zone		+ 4
GMT		22-35-17

GHA Aries	22-00-00	158-13.7
increment	35-17	8-50.7
GHA Aries	22-35-17	166-64.4
DR Longitude		-66-33.5
LHA Aries(Observed)		100-30.9

Hs	40-04.6
Index error	2.0
	40-06.6
HE 12 feet	-03.4
Ha	40-03.2
Correction	-01.2
Ho	40-02.0
H (assumed)	40-00.0
Intercept	2 mi, T

LHA Aries (Tab)	100-23.0	Az=087
LHA Aries (Obs)	100-30.9	Az=085
Longitude offset		7.9 West

Identifier "T", Regulus.

Note: Correction to plotting point for precession and nutation, 1985, move point 4 miles in Azimuth of 100 (from correction table issued by publisher of Assumed Altitude Tables , epoch 1980).

Readers of the Newsletter will see at a glance that the above procedure for reducing a star sight is both simple and very brief. Computation of the LHA of Aries is straightforward, as is the correction of Hs to arrive at Ho. Traditional logic governs the labeling of the intercept as "Away" or as "To". Perhaps the only unfamiliar aspect of the procedure is the comparison of LHA Aries from the Tables with LHA Aries as observed, with the resulting difference in longitude values. That difference is used as an East or West offset of the plotting point from the DR longitude. From the plotting point the tabulated azimuth is plotted in the conventional manner, and then the intercept (the difference between the observed altitude and the assumed altitude) is likewise conventionally laid out. One of the nice features of the Assumed Altitude Tables is that "targets of opportunity" can be shot without any precomputation and without even knowing their identities. Indeed, LOP's for any number of stars can be produced without even knowing the identities of the stars, although the tables do provide identifiers for each star. The plot of the LOP in the instant case is reproduced here to further illustrate the assumed altitude method.

Problem No. 13

It is now nearing the time of morning twilight, March 31, 1985. Backstaff has maintained her course of 250 true. The sky has been clearing in the north and the navigator is anxious to check the vessel's latitude. At evening twilight the previous day he was only able to get a quick shot of Regulus, which rendered useful longitude information, but he has had no check on latitude since the noon shot of the sun on March 30. The wind has been light during the night and Backstaff has been holding a log speed of 4.5 knots. At 0538 the DR position is 14-30 N, 76-22.5 W. Having preset the sextant to 14-30, at 05-38-29 the navigator finds and observes Polaris low in the northern sky. The watch is still 10 seconds slow. Height of eye is still 12 feet, and index error remains 2 min. off the arc. Hs is 14-13.4.

(a) Assuming the DR longitude is correct, is Backstaff still in standard time zone +4 ?

(b) Using the Almanac method , what is the latitude of the vessel ?

(c) What is the Azimuth of Polaris?

(Note: the navigator may wish to compare the true azimuth with an azimuth on board in order to find the compass error).

(d) Based on the latitude obtained, what new considerations should the navigator bear in mind ?

History of Navigation

T. D. Davies

In a previous article we discussed the use of the Moon to tell time as a method of determining longitude, and the efforts of Amerigo Vespucci in this regard. The Greek astronomer Hipparchus had suggested that simultaneous observation of a celestial event at two different places would enable the determination of the difference in longitude of the two locations. It was this principle that Vespucci was attempting to utilize when he took his 1499 sight on the coast of South America (then "Terra Incognita"). The method eventually developed into "The Method of Lunar Intercepts", which was used from the latter part of the 16th century until the early part of the 20th century.

The potential of using a clock which was portable was first mentioned by a Flemish astronomer, Gemma Frisius, in 1530. Mechanical difficulties seemed insurmountable at that time, and for some time thereafter. Stationary clocks had reached a surprisingly advanced development by the mid 16th century, but portability was out of the question. Incidentally, while in Venice last August, I observed a tower clock in St. Marks square which had been built about that time, and which actually had a digital readout!

An attempt to build a portable clock was made by the Dutch scientist, Christian Huygens, in 1662. His clocks were actually were tested at sea, and found to be unreliable. Later experimenters fared no better. However in 1714 the British government offered a reward of 20,000 pounds sterling, for any means of determining a ship's longitude within 30 nautical miles after a 6 weeks voyage. It is noteworthy that the fulfillment of this condition required that a portable clock keep time to within 3 seconds per day, better than any of the shore-based pendulum clocks of the time could do. Nonetheless the reward stimulated several efforts to meet the requirement.

The actual winner of the prize was a self-taught Yorkshire carpenter named John Harrison, who built 4 practical marine chronometers between 1729 and 1760. Harrison's clocks, although meeting the conditions, were delicate, complicated and costly. The reward was only partially paid , and Harrison spent the better part of his life trying to collect the money. Meanwhile other watchmakers moved in with successful devices and received their rewards, not from the British Board of Longitude, but from the sales of their successful instruments. In 1765 Pierre Le Roy, of Paris, produced a marine timepiece which anticipated almost all of the features of the chronometer, until the arrival of the electronic quartz crystal controlled device of modern times.

Harrison's 4th clock is preserved, in working order, at the Greenwich Observatory, and that of Le Roy is in the Conservatoire des Arts et Metiers in Paris. These devices represent well the beginning of the long effort to determine longitude, which played a crucial role in the history of the development of the New World and indeed in world history for several centuries.

MARINE INFORMATION NOTES

Chart and Radarscope Correlation

Provided by Ernest Brown

Difference in the scales of the radarscope and the chart in use, may make correlation difficult even when the nature of the charted features should make the interpretation of the scope easy. A simple technique can be used to make the correlation more obvious when the position plan indicator (PPI) displays concentric circles.

The technique requires the use of range-circle chart overlays which can be quickly constructed from transparent plastic material with a matte surface, such as Mylar. Range circles corresponding to those on the PPI should be constructed on the plastic, at the scale of the chart to be used. Make one overlay for each chart scale which you intend to use.

As is the case with most special techniques, maximum benefit is derived from their use with navigational planning. In the planning phase, investigation of the feasibility of use is accomplished. Center the overlay circles at various points along the intended track to see if good radar targets are so situated with respect to the range rings, that visual correlation of the chart and the PPI display is facilitated.

The navigator may find that an isolated target lies on a range circle at a point on the the intended track where a critical turn is to be made. Other good targets may also lie in good positions with respect to the range rings. Or the investigation may reveal that neither of these is the case, but that an acceptable alteration in the intended track will result in an ideal radar situation.

With radar targets lying in good positions with respect to the range rings as the vessel makes its transit, placement of the overlay on the chart to match the PPI display can be used to fix the vessel's position with good accuracy. Such use may interfere with normal radar plotting techniques, but is usually justified by the results obtained.

BOOK REVIEW

EMERGENCY NAVIGATION

by David Burch

(Foreward by David Lewis)

INTERNATIONAL MARINE PUBLISHING COMPANY
CAMDEN, MAINE, 1986

Reviewed by Roger H. Jones

David Burch is the Director of the Starpath School of Navigation in Seattle, Washington, and is a member of the Institute of Navigation. His articles on navigation appear regularly in 48 deg. N., Sea kayaker, and Waterlines. Dr. Burch's PH.D in physics is from the University of Texas, and he is a member of the Graduate Faculty of the University of Washington. With more than 30,000 blue-water miles in his wake, he practices what he preaches. His experience has left its hallmark on Emergency Navigation, for it is doubtful that so many intriguing insights could have been so well presented by one who has not "been there".

David Lewis, an expert in no-instument navigation in his own right, would seem to agree. In his Forward, Lewis states: ".... this work, despite its title, is far more than an essay on the principles and practice of emergency procedures. It is a particularly well-written account of the principles of navigation in general, and as such, cannot fail to bring fresh insights to all of us."

The subject undertaken by David Burch was first explored in Harold Gatty's 1943 classic, The Raft Book - Lore of the Sea and Sky, and in the following four decades was further explored by David Lewis and others. More recently, Marvin Creamer's circumnavigation without instuments was an example over a seventeen-month period of many of the procedures described by Burch. Those who have read the accounts of Creamer's "Incredible Journey" (as it was described in Cruising World) and who were left wondering about many of the specifics need wonder no more. Burch opens the way to pleasurable understanding in a definitive work of instant appeal to the seamen of all levels of experience who will open its pages.

There is so much in Burch's book that it is difficult to do it justice in a brief review. He leads his readers through a succession of chapters on how to navigate with acceptable precision in varying circumstances which all have a common denominator: You, the navigator, are without one or more of all of your instruments - the sextant, Almanac, sight reduction tables, chronometer, compass, and star finder. For every situation Burch has one or more answers. Thus it is that he deals with steering by the stars and the sun and by other things in the sky, finding latitude and longitude without one or more of the normally crucial instruments (including the sextant and chronometer), and finding time by the height of the Moon (without the necessity for lunar distance tables). Burch says that the latter "bit of magic" was first described by John Letcher in 1964 and later independently discovered by Sir Francis Chichester, but Burch certainly wraps it all up in a nice and clear package for his readers.

The concluding summary in Emergency Navigation is particularly useful. From "Routine Navigation with Everything" Burch the proceedes up the ladder to "Everything but GMT", "Everything but a Sextant", "Everything but Sight Reduction Tables", "Everything but a Compass", "Everything but an Almanac", and "Nothing but GMT".

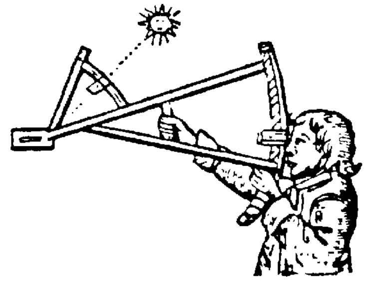
For those who go to sea with all possible instruments and backups for each of them, the book is full of insights into nautical astronomy that this reviewer has rarely seen in other standard works on navigation. These insights are useful whether there is an emergency or not. For example, there is a trick for quickly finding the exact time of day when the summer sun will bear due east or west from any northern latitude of 30 deg. or greater. You may have every conceivable instrument aboard, but all you need is a watch set to local time, a rough idea of your latitude and a set of sunrise-sunset tables. Would you know what to do? Read Burch for the answer to this and many other practical nautical astronomy questions.

Emergency Navigation reflects a great deal of wisdom. It is full of sound seamanship for coastal dead reckoners and open water mariners alike. It will provide fine company afloat and ashore. Like a favorite book of verse, its readers may be drawn back again and again to their favorite specific chapters.

Address all correspondence to:

The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850

THE NAVIGATOR'S NEWSLETTER



FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

ISSUE TWELVE, SPRING 1986

This newsletter is published quarterly, on the 15th of March, June, September and December to keep members up to date on the activities of the Foundation, to provide useful notes on navigation techniques, to review books on the subject and to maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

Books and Charts

Our discount book program was slow in getting started, but I believe it has now stabilized. As several of our readers may have noticed, the latest difficulty involved books from the U. S. Naval Institute. Just before Christmas, we sent in a number of orders, but received no immediate response. The difficulty has now been resolved and all past orders should have been filled.

The Government Printing Office is still slow, but we believe we have learned to cope with their bureaucratic system, at least for the Nautical Almanac, which is main item ordered from the GPO.

As an interesting aside, I learned recently that the government sells about 40,000 copies annually of the Almanac. This statistic would seem to indicate that there are many people, who take Celestial Navigation seriously enough to invest in the cost of the book.

If that deduction is correct, then we must have a vast market for our Newsletter that is as yet untouched. Obviously not everyone who buys the Almanac would find it useful, but we ought to be able to interest more than about one percent of the market. We need more "talking it around" by our members! Remember, we now offer our Brochure, copies available for the asking, for members to show to others who might be interested.

Membership

Membership Cards are now at the printer and will be sent out shortly to renewing members. The cards will accompany the acknowledgement of your contribution. After we catch up with the renewals we will try to go back and supply cards to those who have renewed in past months.

New Series

With this issue we will start a new series of columns, "Navigation Personalities". In this section we propose to give you a brief resume of the career of a present or past personality associated with the art of navigation. Until his death on 1 November 1985 Henry Shufeldt was one our most distinguished Directors, and a man with whom I am proud to have been associated. We are pleased to start the series with a description of his career.

At-Sea Training Course

One of the possibilities that we are currently exploring is that of setting up an at-sea navigation training course, with the focus on developing expertise with the

Sextant under actual conditions. Costs and other details of the course are not yet available, but I would like to have expressions of interest from members. The idea is to have a boat available for about 6 to 8 students for periods of one week, probably in the Caribbean in the winter and the New England area in the summer. The course would emphasize the use of the sextant, and provide for daytime, evening and morning sights daily, under conditions of ship motion and the limited visibility of the real world.

Instructors will be highly qualified volunteers. We are investigating the possibility of periodic donations of charter boat time as the source of the boat. Since the tax deductability of such donations is assured by the IRS ruling on the status of the Foundation, themutual advantages of such a donation during an otherwise slack period are considerable. As a result, we expect to be able to provide such training at substantially lower cost than may be currently available.

We would like to hear from members who would be interested in such training or who may know of charter boats that might be available on the proposed basis.

Back To Basics

There have been indications in some of our recent correspondence that the Newsletter could be better oriented towards less experienced members. One letter implies that we do not have anything for the student or someone whose interest is recent.

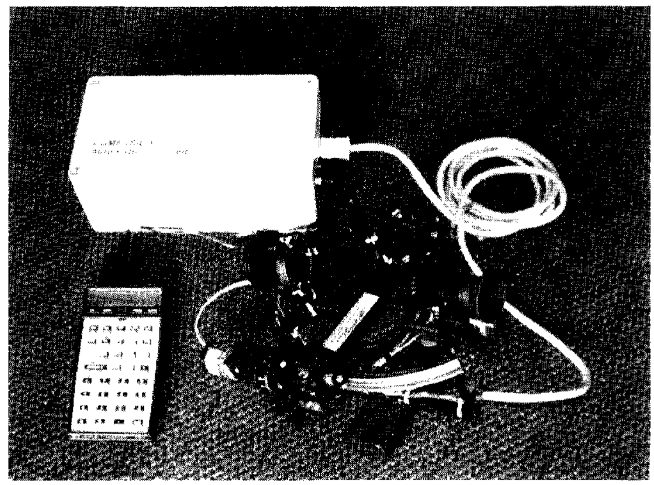
To address this issue I propose to start a new department in the next issue, which we will call "Navigational Basics Review." Each edition will take one concept or idea basic to navigation and deal with it in a way that will be helpful to the student of navigation. I hope that our readers will find this beneficial. Contributions for this area from members will be welcomed.

Awards

We are in contact with the Navigation Department of the US Naval Academy, who have welcomed our offer to set up a navigation award there, to be called "The Benjamin Dutton Award in Navigation." We expect to finalize the arrangements in time for an award at the end of this academic year.

READERS FORUM

Dr. John Decker, Jr., of Maui, Hawaii, writes of his progress on his new "Compusight." This is a sextant equipped with digital readouts which can be fed directly into a computer. He has forwarded a picture of the device, complete with computer, which is reproduced below. Comments from our readers would be helpful.



Walter Johnson of Annapolis, Md., writes that he has a computer program which derives a Fix without use of a plot. His paper on the subject follows.

"Use of Fix without Plot

During evening twilight on June 3, 1986, the corrected altitudes of four stars were obseved. The chronometer was on Greenwich time. The observer knew only that he was in North latitude and west longitude. He extracted the data for GHA and Declination from the Almanac.

Body	Vega	Spica	Regulus	Pollux
Brng	NE	NE	SW	NW
GMT	001920	002010	002050	002140
Ho	16-46.6	40-39.3	53-34.3	33-26.5
GHA	256-59.2	257-11.7	257-21.8	257-34.3
SHA*	80-52.5	158-52.8	208-05.5	243-53.1
GHA*	337-51.7	56-04.5	105-27.4	141-27.4
Dec	N38-46.0	S11-05.5	N12-02.2	N28-03.8

One body must be westerly, the other easterly. Positive results are obtained when both bodies bear northerly or both southerly. When one is northerly and the other southerly, then two positions are given, one of which is correct. Usually the incorrect position is quite out of the ball park. The results obtained form the above data are listed below. The input data are GHA, Dec, and Ho.

	Lat	Long	Lat	Long
Vega,Pol	N35-07.9	W74-19.0		
Reg,Spic	N35-07.9	W74-18.9		
Reg,Vega	N35-07.3	W74-18.4	N39-23.7	W78-15.5
Spic,Pol	N35-07.9	W74-19.0	N17-24.4	W106-42.

The program works equally well in N or S latitude and in E or W longitude. The fix is more accurate than can be obtained by normal plotting methods.

Member Edward I Matthews of Boxborough, MA writes:

"May I call your attention to two typographical errors in my letter appearing in issue 11 of the Newsletter?

The first appears in the equation for Sin(he) where the hyphen at the end of the line may be mistaken for a minus sign. The end of the equation should read:

+ Sin (L) Sin (d)

The first equation on the following page should read:

Cos (SD) - Sin (90-SD) rather than (90 - 50)

I would like to comment on quartz crystal watch error rates which I have experienced over the long term (years). I have found that these devices run faster as the battery ages. I wonder if other members have experienced this.

Since I have quoted your organization, I am enclosing a copy of my letter to the ION for your information."

Member J. Herbert Watson of Ponte Vedra Beach, FL writes:

"Re issue eleven - A Navigation Problem - Problem #13.

Is the stated DR position - 76-22.5 W. correct? Or should it be 67-22.5 W.?

Would like to see the Newsletter on a monthly issue basis - its great".

Ed Note: The correct stated DR position is 67-22.5.

Member Walter H. Johnson of Annapolis, MD writes:

"There is an error in the listing on page 6 of issue 11. The rate of change of longitude by movement of the vessel was listed as 6.01919 deg/hr -- a very fast vessel indeed! It should have read min/hr instead.

If the time was actually 0850 LMT then ZT would have been 09-12-28 and CMT would have been 13-12-28 yielding 16-59.8 min for GHA of the sun. The resulting value for T would then become 3-15-47. The ZT of LAN would be 12-04-29 or 1204. The position at 1228 should be 65-57 W, 14-58.4 N.

Perhaps my assumption was incorrect but I could see no reason for using LMT for the time of an observation.

In Problem 13 I find a very significant error in the DR for morning twilight on March 31 which gives the longitude as 76-22.5 W. By my calculations this would require a speed of about 30 knots -- the DR longitude probably should have been 66-22.5 W. If we take the position: lat = 14-58.4 N, 65-56.6 W for ZT 12-28-15 on March 30, assume a constant speed of 4.5K then the westerly component becomes 1.54K. His DR at 0538 on March 31 therefore should be 14-32 N, 67-11.6 W. If Ho Polaris is 14-12 at 05-38-29 then the latitude becomes 14-41.3 N, the vessel is still in zone +4 and the azimuth of Polaris is 000.7. My estimate of his position at 0538 March 31 is: 14-41.3 N, 67-11.6 W.

It is not convenient to plot by computer -- it is much easier for me to find mathematical solutions which are usually much more precise than the situations warrant.

I am, at present, teaching celestial navigation to a small class which is being held at the local Coast Guard Station. We are using HO249."

"I expect that you have seen the article by Stafford Campbell in the January issue of "Yachting" magazine. He did give me some much needed publicity for which I have written to thank him.
I should also like to thank you for making it all possible. Since that time I have received a number or queries from coast to coast.

Member David F. Burch of Seattle, WA writes:

"In response to the request from Issue 11, Winter 1985. A member navigation instructor: David Burch Director, Starpath School of Navigation 2101 North 34th Street, Seattle, WA 98103-9101, (206) 632-1293,

Starpath offers evening classroom courses continuously throughout the year on Celestial Navigation, Inland and Coastal Navigation, Marine Weather, Loran, and Sailboat Racing Tactics. We have had over 5,000 students since 1977; course completion qualifies students for American Sailing Association certification in Celestial and Coastwise navigation. Self-study courses are available by mail for Celestial Navigation and Coastwise Navigation. Brochure and schedule available."

NAVIGATION NOTES

History of Navigation

by T. D. Davies

One of the interesting questions in the history of navigation relates to the ability of Columbus to determine latitude by Polaris. There are three occasions in the Diary of Columbus when he appears to report a latitude of 42 degrees North. At these times he was apparently between 19 and 22 degrees, in Cuban waters. Samuel Eliot Morrison concluded that Columbus did not understand how to use Polaris!

To appreciate how such an idea could come about, one needs to understand how the 15th century Quadrant was constructed and what the source of the Diario really was. These are both elaborated in a book called Terrae Incognitae.

The original of Columbus' Diario has been lost, largely through the greed of his grandson, Luis, who seems to have sold it. However the contemporary historian Bishop Bartolemeo de las Casas at one time was able to copy it, and his version has survived. So we are reading his interpretation of Columbus' recording of his latitudes.

The actual Diario was kept by Columbus during his lifetime, and passed upon his death in 1506 to his eldest son Diego. Diego, second Admiral of the Indies, died in 1526, and Luis received the inheritance. Apparently Luis was totally lacking in the character of his grandfather--He seems to have been imprisoned at one time for having three wives at the same time! In any event, his finances demanded that he sell everything that he received as the inheritance.

The early Quadrants indicated in degrees but also had scales of tangents and cotangents. A number of Quadrants with such markings have survived or been salvaged from sunken ships. Robert Fuson, Professor at the University of South Florida, has speculated that the Diario entries were actually tangent readings rather than degrees. since the Bishop de las Casas was not skilled in the art of navigation, he may have failed to appreciate that fact, recording the tangent readings as degrees.

If one converts these tangents to degrees, Columbus' position appears to be correct. For example, arc tan of .42 equals 22.3 degrees, which agrees with his position as calculated from the descriptive data in the text. The validity of this hypothesis is convincing to a trained navigator.

There are other illogical items in the Las Casas copy of the Diario, but on the whole it presents a remarkable picture of the Admiral of the Ocean Sea, and we owe the first Bishop of the New World our gratitude for his labors.

Navigation Notes

by T. D. Davies

I recently received a letter from Navigator Jim Brown, written while sailing across the Indian Ocean. Jim sailed first from California to the Marquessa Islands some time ago, using the "Star Sight

Reduction Tables for 42 Stars." Jim is still an enthusiastic practioner and wanted to know when a new edition of the tables would be out, in view of the changing positions of the stars incorporated in the tables.

In fact, the tables had a method of correcting for Nutation and Precession as the 1980 epoch stars' apparent positions change as a result of these phenomena, but the method is only approximate and has reached the end of its utility. Consequently a new edition is in order and a date of publication will be available shortly.

Some of the revisions to the new edition may be of interest. In an article in Issue Nine, the substantial variation of SHA during a year's time was pointed out, noting the inadequacy of a single annual correction. The new volume will provide a quarterly Precession correction throughout the next seven years.

Other changes to improve the format of the tables have been incorporated, including a new compact size. In spite of the availability of other tables and calculators, the problem of star identification under partial cloud conditions remains a real and continuing one for the blue-water navigator. The book that is reviewed in this issue highlights that problem.

In the course of developing the configuration improvements for the tables (new name, "Sight Reduction Tables for 42 Stars") I prepared a simplified version of the Long Term Almanac from Bowditch. It is reproduced here as being of utility and interest to navigators. It eliminates the use of 1972 as the base year, and reduces the number of corrections to be combined to get the GHA Aries.

Compact Almanac for GHA♈

	1986	1987	1988	1989	1990	1991	1992
Jan	99-22.2	99- 7.9	98-53.6	99-38.4	99-24.1	99- 9.8	99-55.4
Feb	129-55.6	129-41.2	129-26.9	130-11.8	129-57.5	129-43.1	129-28.7
Mar	157-31.4	157-17.1	158-01.9	157-47.7	157-33.3	157-19.0	158-03.7
Apr	188-04.7	187-50.4	188-35.2	188-20.9	188-06.6	187-52.3	188-37.0
May	217-38.9	217-24.5	218- 9.4	217-55.1	217-40.8	217-26.4	218-11.2
Jun	248-12.2	247-57.8	248-42.7	248-28.4	248-14.1	247-59.7	248-44.5
Jul	277-46.4	277-32.0	278-16.9	278-02.6	277-48.3	277-33.9	278-18.7
Aug	308-19.7	308-05.3	308-50.2	308-35.9	308-21.6	308-07.2	308-52.0
Sep	338-53.0	338-38.6	339-23.5	339- 9.2	338-54.9	338-40.5	339-25.3
Oct	8-27.1	8-12.8	8-57.7	8-43.4	8-29.0	8-14.7	8-59.5
Nov	39-00.4	38-46.1	39-31.0	39-16.6	39-02.3	38-48.0	39-32.8
Dec	68-34.6	68-20.2	69-05.1	68-50.8	68-36.5	68-22.1	69-06.9

Day/Time Correction Table

No.	Day	Hours	Min.	Sec.	No.	Min.	Sec.
1	0-59.1	15-02.5	0-15.0	0.2	30	7-31.2	7.5
2	1-58.3	30-04.9	0-30.1	0.5	31	7-46.3	7.8
3	2-57.4	45-07.4	0-45.1	0.8	32	8-01.3	8.0
4	3-56.6	60-09.9	1-00.2	1.0	33	8-16.4	8.2
5	4-55.7	75-12.3	1-15.2	1.2	34	8-31.4	8.5
6	5-54.8	90-14.8	1-30.2	1.5	35	8-46.4	8.8
7	6-54.0	105-17.2	1-45.3	1.8	36	9-01.5	9.0
8	7-53.1	120-19.7	2-00.3	2.0	37	9-16.5	9.2
9	8-52.3	135-22.2	2-15.4	2.2	38	9-31.6	9.5
10	9-51.4	150-24.6	2-30.4	2.5	39	9-46.6	9.8
11	10-50.5	165-27.1	2-45.5	2.8	40	10-01.6	10.0
12	11-49.7	180-29.6	3-00.5	3.0	41	10-16.7	10.2
13	12-48.8	195-32.0	3-15.5	3.2	42	10-31.7	10.5
14	13-48.0	210-34.5	3-30.6	3.5	43	10-46.8	10.8
15	14-47.1	225-37.0	3-45.6	3.8	44	11-01.8	11.0
16	15-46.2	240-39.4	4-00.7	4.0	45	11-16.8	11.2
17	16-45.4	255-41.9	4-15.7	4.2	46	11-31.9	11.5
18	17-44.5	270-44.4	4-30.7	4.5	47	11-46.9	11.8
19	18-43.7	285-46.8	4-45.8	4.8	48	12-02.0	12.0
20	19-42.8	300-49.3	5-00.8	5.0	49	12-17.0	12.2
21	20-41.9	315-51.7	5-15.9	5.2	50	12-32.1	12.5
22	21-41.1	330-54.2	5-30.9	5.5	51	12-47.1	12.8
23	22-40.2	345-56.7	5-45.9	5.8	52	13-02.1	13.0
24	23-39.4	360-59.1	6-01.0	6.0	53	13-17.2	13.2
25	24-38.5		6-16.0	6.2	54	13-32.2	13.5
26	25-37.6		6-31.1	6.5	55	13-47.3	13.8
27	26-36.8		6-46.1	6.8	56	14-02.3	14.0
28	27-35.9		7-01.1	7.0	57	14-17.3	14.2
29	28-35.1		7-16.2	7.2	58	14-32.4	14.5
30	29-34.2		7-31.2	7.5	59	14-47.4	14.8
31	30-33.3		7-46.3	7.8	60	15-02.5	15.0

To obtain the GHA♈ from a GMT, enter the upper table with the year and month of the GMT, and read an initial value for the GHA♈. To this value add increments for the day, hour, minutes and seconds. These increments are taken from the lower table by entering the left column (headed "No.") with the number of each day, hour, etc., and reading the *corresponding increment in the appropriate column. Note that* the 6th column is also headed "No.", but applies only to minutes and seconds from 30 to 60.

Example: For 23 August, 1989, at 14^h-44^m-10^s GMT, the GHA♈ will be 308°-35'.9 plus 22°-40'.2 plus 210°-34'.5 plus 11°-01'.8 plus 0°-02'.5. The sum is 192°-54'.9, which is the desired GHA .

To obtain the GHA Aries, for a given GMT, enter the upper table with the year and month of the GMT, and read an initial value for the GHA. To this value add increments for the day of the month, the hour,and the minutes and seconds. These increments are taken from the lower table by entering the left column (headed "No.") with the number of each day, hour, etc., and reading the corresponding increment in the appropriate column. Note that the 6th column is also headed "No.", but applies only to minutes and seconds from 30 to 60.

For example: for 23 August, 1989, at 14-44-10 GMT, the GHA Aries will be 308-35.9 plus 22-40.2 plus 210-34.5 plus 11-01.8 plus 0-02.5. This sum is 192-54.9, which is the desired GHA Aries.

Navigation Personalities

Henry H. Shufeldt was born in 1898. A native of Chicago, he was educated in this country and abroad. During World War I, he served as a sergeant in an Army intelligence unit.

Between the wars he took up the career of a Yacht Broker, and was involved in the founding of two well known yacht building companies, Pearson Yacht Corp., and Bristol Yacht Corp. He was on the Board of Directors of the latter company for many years.

He was commissioned in the U.S. Navy in 1942 and served until 1954. During the war he served as navigator of a carrier, and commanded two logistics ships, an ammunition ship and a repair ship. His last command was the converted yacht "Saluda", which served as a patrol vessel in the Atlantic Fleet.

Retired from the navy as a Captain, Shufeldt became an associate with the Weems System of Navigation, where he worked extensively in the field of celestial navigation. One of his most notable contributions was a field study of the acquisition of skill in the use of the sextant at sea.

A long series of tests (conducted under contract to the Office of Naval Research) demonstrated that practitioners continued to improve their skill with the sextant, even after as many as a thousand sights.

Captain Shufeldt is probably best known as the author of the 12th edition of "Dutton's Navigation and Piloting." More recently, he developed programs for pocket calculators to be used in all aspects of navigation. He was the co-author of a successful book on the subject.

He was a member of the New York Yacht Club, The Cruising Club of America and the Storm Trysail Club. Captain Shufeldt had been a Director of the Navigation Foundation since 1983, and has been a substantial contributor to this Newsletter.

A Navigation Problem

Solution to the problem presented in Issue Eleven:

Correction: The correct 0538 DR position is 14-30 N, 67-22.5 W. vice 14-30 N, 76-22.5 W.

13. Answer.

(a) The vessel is still in time zone +4. It will enter time zone +5 when it crosses the 67-30 W meridian.

(b)

Watch	05 38 29	
slow 10	+10	
	05 38 39	
	+ 4	
GMT	09 38 39	
GHA Aries	09 00 00	323deg 40.9
Increment	38 39	9deg 41.3
GHA Aries	09 38 39	332deg 82.1
Long W.		-67deg 22.5
LHA Aries		265deg 59.6

Hs	14deg 13.4	HO	14deg 8.2
IE	+ 2.0	+ao	1deg 28.6
	14deg 15.4	+a1	0.4
HE	- 3.4	+a2	0.3
HA	14deg 12.0		15deg 37.5
Corr.	- 3.8		- 1deg
HO	14deg 8.2		14deg 37.5 N Lat.

(c) Azimuth is 0deg 0.6

Problem No. 14

Backstaff, in the time intervening since that of Problem 13, has passed through the Panama Canal, and in the course of a leisurely year has visited the Galapagos and French Polynesia. The navigation chronometer aboard is set to Greenwich Mean Time, and the Greenwich date is March 2, 1986. The vessel is on a course of 270deg True nearing the Undu Point Light on the Fiji Isalnd of Vanua Levu, which lies at Latitude 16deg - 08 S, Longitude 179deg - 56 W.

In this part of the World, the Date Line jogs eastward 7 1/2 deg. to include all fo the Fiji Islands in the East (-12) Done. Before it gets to the Samoan Islands, it turns due South and then veers westward again to coincide with the true 180deg meridian southeast of New Zealand. Thus Backstaff has already crossed the Date Line, and at the time of crossing the navigator noted the change in the local date.

Notwithstanding the local date, it is 1400 hours GMT on March 2, 1986 and with reference to the true 180deg meridian Backstaff is in Zone +12. the navigator expects to cross the 180deg meridian at 1600 GMT.

(a) At the moment after crossing the 180deg meridian what will be the Greenwich date?

(b) At the moment after crossing the meridaian what will be the local date aboard Backstaff?

MARINE INFORMATION NOTES

provided by Ernest Brown

The Swinger and the Cross-Bearing Plot

When using horizontal sextant angles for fixing, navigators usually give proper attention to the need for avoiding swingers (revolvers) in their selection of charted objects. But, perhaps, not enough attention is given to the fact that the geometry of the swinger can give misleading results with cross bearings.

In checking an anchored vessel's position by cross bearings affected by an undetected and constant compass error developed after anchoring, a point fix removed from the original position can be obtained if the swinger geometry has not been avoided. This and subsequent point fixes may lead the navigator to the erroneous finding that the vessel has dragged anchor.

Marine Safety Reporting Program

The Marine Safety reporting Program (MSRP) is a test of the transferability of the voluntary safety reporting concept used by the Federal Aviation Administration to the maritime industry. The purpose of this program is to identify hazards related in some way to vessel navigation for which some preventive measures might be taken before an accident occurs. The key to the program is that the reports be voluntary and anonymous.

MSRP is intended to supplement (not overlap) mandatory reporting requirements. Reporting to MSRP does not relieve one of these requirements. Types of incidents or problems which should not be reported to MSRP include: (1) those involving any form of criminal activity; (2) those that deal with actual marine accidents (bear in mind that these include loss of propulsion or steering), any non-negligible damage to vessels, and all groundings however slight, as well as any episode which results in injury or death, and (3) those that involve specified equipment failures that are required to be reported.

Additional information can be obtained for Mr. A. L. Lavery at:

Marine Safety Reporting Program
Transportation Systems Center
Kendall Square
Cambridge, MA 02142

Transfer of RACON/RAMARK Information

Racon/Ramark information is being removed from Publications number 117A and 117B, Radio Navigational Aids, and placed in geographically corresponding volumes of List of Lights and Fog Signals. Users are advised to refer to both the List of Lights and Radio Navigational Aids for full details of Racon/Ramark information. The transfer is expected to be completed in 1987.

Dangerous Submerged Reef Line Off the Coast of Bermuda

Notice to Mariners 38/85 announces the special precautions to be exercised by mariners passing within 30 miles of the island.

BOOK REVIEW

Celestial Navigation With the 2102-D Star Finder - A User's Guide

By David F. Burch

Paradise Cay Publications
1001 Bridgway, No. 405
Sausalito, CA 94965 (1984)

79 pages; $8.95 *Reviewed by Roger H. Jones*

David Burch's new book, Emergency Navigation, was the subject of our review in the last issue of the Newsletter. In the aftermath of reading that book and preparing the review, we became aware of the compact and handy little booklet by the same author that is the subject of this review. From the author's own note to us, it appears that it is not often found on the shelves of the nautical book dealers, but is available for the publisher listed, and the personal name of the publisher is Matt Morehouse. It is also available form Starpath Publications, 2101 North 34th Street, Seattle, WA 98103-9190.

Burch notes in his Preface that after teaching celestial navigation to over 3000 students during the period 1978-1984, he has discerned a number of recurring questions and comments. A frequent question apparently has been: "Where can I find more detailed instructions on the use of the Star-Finder - the ones that come with it are just too brief." Burch's little booklet is intended to remedy that situation.

Anyone who has read or even skimmed some of the standard works on navigation (Bowditch and Dutton'sfor example). or the contributiions, thick and thin, by such authors as William Crawford, Mary Blewitt, Robert Kittredge or Donald McClench, will immediately recognize that Burch's little book departs from the norm. Many of the most enduring works on celestial navigation make only brief references to the use of the Star-Finder, and some do not address the subject at all. Burch, in 79 pages of text and illustrations, probably devotes more page space to the subject than any four or five of the well-known works combined.

He starts with a detailed description of the 2101-D (so named because it was once a government product labeled H.O. 2101-D) and of its constituent parts. He relates this description to the celestial bodies for which it was designed by a background section on celestial body motions, brightness and color, and time-keeping in celestial navigation. He then launches into a detailed, yet readable, discussion of the applications of the Star-Finder.

It is at this point that some experienced navigators, who are familiar with its use in pre-computing data for star shots and in identifying unknown stars, may appreciate more fully that it has other uses as well. In the latter respect there is a particularly good section dealing with the use of the Star-Finder in connection with day-time observations of the Moon and Venus together with the Sun. Throughout, Burch draws useful comparisons between the Star-Finder procedures and those used in connection with H.O. 249 Volume I and other tabular methods of identifying celestial bodies. Finally, the booklet presents such other non-traditional uses of the device as: picking the time between Sun sights for optimum running fixes; pre-computing Moon, planet and star combinations; and uses of the device in emergency steering situations. (Various methods of steering without a compass are presented in Emergency Navigation, but the use of the Star-Finder for this purpose is best described by Burch in the Star-Finder Booklet.)

This booklet is 6 by 8 inches, and only a quarter of an inch thick. It is, in this reviewer's opinion, a worthy addition to the shipboard library of even the smallest vessel. It is a valuable guide for those who would learn the use of the Star-Finder on their own, and it will expand the understanding and insights of many who are already somewhat familiar with the "2102-D".

Address all correspondence to:

The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850

Membership in the Foundation is available by sending a tax-deductible donation of $25 to the Foundation at the above address.

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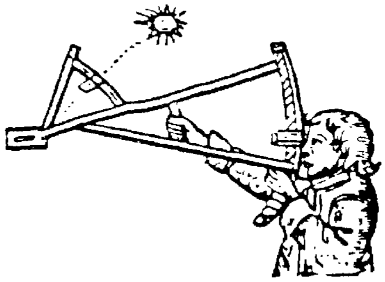
For class convening dates and other information write direct to the above addresses.

THE NAVIGATOR'S NEWSLETTER



FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

ISSUE THIRTEEN, SUMMER 1986

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

Awards Established

The "Benjamin Dutton Award in Navigation" is now established at the U. S. Naval Academy. The first award was made on 15 May, at a ceremony at Annapolis. The winner, selected by the faculty of the Department of Seamanship and Navigation, was Midshipman Keith A. Beals. Present at the ceremony were two members of the Dutton family, a son, Captain (Ret) William T. Dutton and Commander Pierre Charbonnet III, a grandson. Midshipman Beals received an appropriately engraved plaque and an autographed copy of Dutton's Navigation and Piloting. He will also receive a free membership in the Navigation Foundation for one year. The logo of the Foundation is displayed on the permanent plaque at the Naval Academy as well as on the personal plaque.

A second award was made at the Gould Academy in Bethel, Maine. The winner was Thomas N. MacDonald of Phillips, Maine. The Plaque was presented by one of our members, Dr. Harry H. Dresser, the Associate Headmaster. Mr. MacDonald will also receive a membership in the Foundation for one year.

First Membership Cards Sent

A number of the new membership cards have now been sent to recent renewals. In setting up the computer to generate these cards, which also serve as a receipt for donations, we discovered that our list had to be altered to include an expiration date instead of a renewal date. Consequently you may find that the address labels now have a date one year later than previously. Eventually all members will receive a membership card.

The Naval Institute is working up a list of persons who have been purchasers of navigation books. We hope that this will be useful to expand our membership. We have also been promised a full page add in the commercially published nautical almanac. We are always looking for ideas as to how to bring our story to people with an interest in navigation.

Book Orders

Our book deliveries have been less troublesome this quarter. Members should let us know if delays are encountered. Our telephone (number at the end of the Newsletter) is always available for such report as well as any other communication desired.

We soon expect to complete arrangements to handle books and publications from Paradise Cay publications, of Sausalito, CA. These will be available at our standard discount.

New Look For Newsletter

With this issue we will commence a new publication technique for the Newsletter. Using desktop publishing software (Page Maker) in conjunction with a Macintosh Plus and Apple Laser Writer Plus, we can now accomplish text editing, layout, typesetting and paste-up on our computer screen. We hope that this will decrease the number of errors in the copy and that the laser typography will enhance the appearance of the text.

Brush Up On Basics

The new series on navigation basics starts with this issue. We believe that this will prove useful for newcomers to navigation and for many other members as well. Among our members who teach navigation there may be some who would like to try their hand at this. Contributed articles will be welcome.

At Sea Training

Our contacts so far have indicated that we must directly approach boatowners who have their boats in charter, and find themselves with unused weeks.

So far Charter operators seem to have no interest in promoting our plan. Again we request members who are in contact with persons who might be interested in this plan to let us know.

READERS FORUM

Member Stanley Harkins of P.V.E., CA, forwarded an old article on the Analemma, which gives a great deal of detail. Interested members can get copies from the Foundation.

Member Robert D. Bagguley of Oak Ridge, TN writes:

Count me in as an interested member with regards to your inquiry for future participants in a small boat at-sea navigation training course. This sounds like a winner to me!

Referring to Newsletter Issue Ten, Fall 1985, specifically to Member Clinton Fogwell's stated need for crewmen on his boat delivery cruises, my response to his call through the Foundation resulted in a very interesting experience for me! Captain Fogwell was to bring a 44 foot CSY cutter out of charter service from Tortola, BVI, in early January 1986, to be delivered for the owner to Seattle, WA. The Captain, in need of a crew member during the delivery, contacted me through his wife. After checking with my wife, and work, I responded positively to this opportunity - and in very short order. The result was that I spent the next four weeks or so in February aboard the Cutter Argonaut as crew, joining her at Kingston, Jamaica, sailing south across the Caribbean, traversing the Panama Canal aboard her, then up the Pacific Coast of Central America where I departed her at Acapulco, Mexico to return home.

This working cruise broke the ice for me in several ways. Not only did I visit several countries in the region for the first ime, including the trip through the Panama Canal in a small boat, but I had a wonderful learning experience in all aspects of long distance blue water sailing. This certainly includes some piloting and celestial navigation under the guidance of an excellent captain, Clinton Fogwell. He, along with other people I met during this voyage (other crewmen, other traveling boaters and those friendly and helpful natives of the host countries) made a lasting impression on my mind. The whole cruise was just great!

I'm ready to sail again on such a cruise when the opportunity permits, perhaps practicing a bit more navigation this time.

Member Clinton Fogwell of Exton, PA writes:

Currently we are delivering a CSY 44 foot Cutter from Tortola, BVI to Seattle, WA via Panama and Acapulco etc. Member Bob Bagguley of Oak Ridge, TN contacted me and crewed with us from Kingston, Jamaica to Acapulco.

He was a fine person to have aboard. Under some light guidance for me he polished up his practical knowledge of "Celestial".

If you can send us more like Bob we'll be gratful and I am sure the individuals will enjoy a challenging trip, learn some celestial and see some fascinating ports.

Ed Note: Any members who are interested in crewing for Member Fogwell or know of some willing individual please contact:

G. Clinton Fogwell Attorney at Law
527 Merioneth Drive Exton, PA 19341
Tele. 215-524-1244

Director Ernest Brown of Houston, TX writes:

On a cassette I just received from Byron E. Franklin, QMCM(Ret), there is a very interesting account of the evolution of his constant error finding technique. This cassette also has a very interesting account of how he convinced the C.O. of the *Intrepid* that there was a 1.5 deg gyro error. Azimuths of the Sun indicated that there was negligible error. Master Chief Franklin stood by his guns because he knew that the error as obtained by the Franklin Piloting Technique (FPT) was correct. On the FORACS range, the gyro error was determined to 1.65 deg. Master Chief Franklin (always thinking) then figured that the azimuth's indication of negligible error was due to the azimuth circle. He took it to a tender where the instrument people found it to have a 1.5 deg error.

Master Chief Franklin has a long history of being able to get good cross-bearing fixes when other experienced people could not. When he reported aboard the *Intrepid* to relieve another chief, he was able to demonstrate the value of his technique the first time underway. Observing the chief he was to relieve and who was doing the piloting and not getting good fixes, he glanced over the other chief's shoulder and told him he had a 1.5 deg E. gyro error. A number of cross bearings later, the plotter finally took his advice and immediately got good fixes.

Over a good number of years Franklin has shown others how to handle the constant-error problem. In addition to the Intrepid, he has done this aboard naval auxiliaries, YPs at OCS Newport, and submarines.

Member Walter H. Johnson of Annapolis, MD writes:

I have always believed that our celebration of new year should be a 1200 GMT on December 31, when, for an instant, the entire earth has that date. But that would probably not be accepted —no one would consider a party at 0700!

Member John M. Luykx of Forestville, MD writes:

I just received the 12th Issue of The Navigator's Newsletter and found it very interesting. I have a few questions and comments.

A. AT-SEA-TRAINING-COURSE

1. I recommend that prior to at sea training all candidates be thoroughly grounded in sextant basics best accomplished ashore.

a.Nomenclature

b. Adjustment (sextant and telescope)

c. Use and application of shades and filters

d. Computing the sextant I.C.

e. Applying altitude corrections

f."Swinging" the sextant and taking actual upper limb and lower limb observations. Preliminary sextant practice before going to sea can easily be accomplished from a spot ashore and using the bay horizon as a reference

2. The At-Sea-Training phase could provide a fertile testing ground if adequate and sufficient records are maintained to determine statistically if there really is a significant accuracy advantage in using the prism level device compared to the old fashioned method of "swinging" the sextant to establish sextant verticality.

B. USE OF FIX WITHOUT PLOT

1. I would like to know more about this program!!

a. For which computer is the program designed?

b. Can the computer be taken readily to sea in a small vessel?

c. What advantage does the program have over the Tamaya NC88 or the HP 41? *(Ed. note: Member Johnson please answer.)*

C. STARPATH COURSES, BY D. F. BURCH

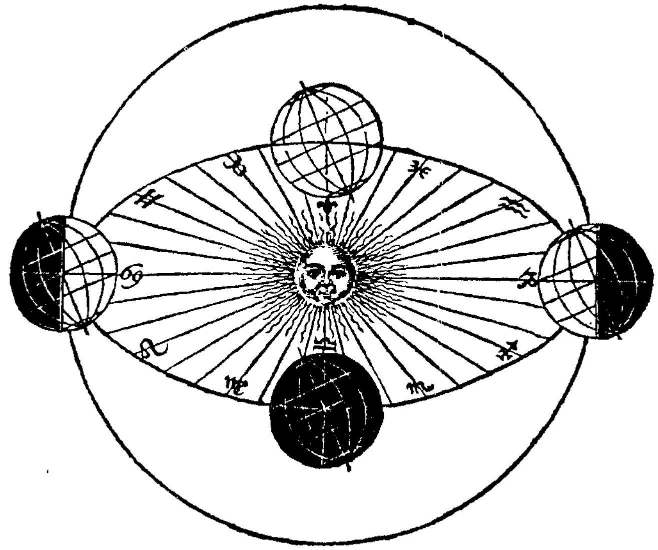
1. What are the requirements for a celistial or piloting course to qualify students for the American Sailing Association Certificate? *(Ed. note: Member Burch please answer.)*

D. HISTORY OF NAVIGATION

1. Under what circumstances would Columbus have recorded the Tangent (or Co-Tangent) of the observed altitude rather than the altitude angle itself? Was the Tangent square (or scale) more accurately engraved or calibrated than the altitude scale graduated along the periphery of the quadrant's arc? *(Ed note: Most probable that TAN/COT scale was only scale on the quadrant.)*

2. How is it possible that an altitude of 42 deg be recorded when the observation is made of Polaris at an altitude of 19 deg to 27 deg (depending on the position of The Guards) unless the wrong star was observed to begin with? *(Ed note: Again, Columbus' log may well have recorded TAN rather than degrees, but was incorrectly labeled by Las Casas in his copy, since he was not familiar with such terms.)*

3. I would like to know more about 15th centruy Seaman's quadrants!! are there actually, 15th century Seaman's quadrants extant? Where are they located? *(Ed Note: Maritime and Observatory Museum, Greenwich, England.)*



4. Who is the author of the book "Terrae Incognitae"? Where and when was it published? *(Ed Note: Published annually by Indiana University Press for the Society for the History of Discoveries.)*

E. THE SWINGER AND CROSS BEARING PLOT

I believe that, anytime, when an undetected and constant compass error develops after anchoring, a point fix removed from the original position can be obtained even if the "swinger" geometry has been avoided!! one would definitely know that there was error in the bearings if the error of the fix was in the direction from which the wind and current were flowing.

F. CELESTIAL NAVIGATION WITH 2102-D STARFINDER: A USERS GUIDE.

1. If a N/S Declination scale is penciled in on both sides of the base plate, relatively accurate Sun, Moon and Planet predicted altitudes and azimuths are possible. Additionally, if interpolations are made between data for the two (2) Latitudes (Templates) bracketing the observer's DR Position, accurate computations of the following are possible:

a. Star, Sun, Planet and Moon amplitudes/azimuths.

b. Great circle sailing initial course and distance.

c. Sun and Planet predicted altitude and azimuth. All of the above to within 1/2 degree (30' arc) or better.

G. Enclosed is a brochure and application form for the courses I teach at the University of Maryland. I would appreciate it if you would include this data in your listing of Navigation Instructors, courses are available in the Spring and Fall.

NAVIGATION BASICS REVIEW

by T. D. Davies

Time

Every citizen is quite familiar with Standard Time and Daylight Time, and the various time zones on land, but the navigator must be able to use other kinds of time to be able to engage in celestial navigation, coastal piloting or navigation planning. Over the centuries they have developed certain specialized and differently measured time systems that the navigator must be comfortable handling if he is to safely and competently cruise the seas.

The primary way of measuring time is by the rotation of the Earth, which stone-age star gazers and scientists thought generated a uniform day of equal hours. As the breadth and depth of knowledge increased it became apparent that there were complexities of the Earth's motion which produced unwanted variations in time measured by the rotation, so that additional measurement systems had to be invented, defined and calculated.

The astronomer's way of measuring the Earth's rotation is against a point "fixed" among the stars. The point in space used is called the First Point of Aries because it was in the constellation of Aries when it was initially selected. Each time the meridian of Greenwich, England on the Earth passes that point is the begining of a "sidereal day." There is one more sidereal day in each year than there are calendar days, the sidereal day being about 4 minutes shorter than the calendar day. This point is also the reference point of the system of celestial coordinates used to specify the position of celestial bodies. On the celestial sphere the equivalent of a terrestial meridian is called an Hour Circle, and moves with the rotation of the First Point Of Aries, i.e. that of the fixed stars.

The Sidereal Time may be found at any time by the use of the Nautical Almanac. For this the tables tabulate the "GHA of Aries" at any Greenwich time. The GHA of Aries is simply the Sidereal Time at Greenwich, expressed in degrees and minutes. The details of the use of the tables in the Nautical Almanac will be covered in a later article of this series. Sidereal Time is used to locate stars for use in position finding, and will usually be calculated from the GHA of Aries.

The apparent motion of the Sun throughout the seasons varies because of several physical laws which govern the Earth's motion in its orbit and on its axis. To provide a uniform solar-based time it was necessary to invent, at least conceptually, an imaginary Sun called the "Mean Sun", which rotates around the Earth at the equator, at a uniform rate. Time measured by this Mean Sun is called Mean Time, and the Mean Time at Greenwich (GMT) is the reference time for the entire Earth. Bands of longitude 15 degrees wide have been established which are called time zones. Zone Time is the Mean Time of the central meridian of each zone. A ship passing through several zones changes time one hour when it crosses from one zone to the next.

The rate of rotation of the Mean Sun is such that at four times during the year Mean Time coincides exactly with the time measured by the true (called the apparent) Sun. The time-difference between the time given by the apparent Sun (Apparent Time) and and the Mean Sun (Mean Time) is called the "Equation of Time", and can be found for any day of the year in the Nautical Almanac. Its maximum value is about 16 minutes. Thus the Apparent Time can be found for any given Mean Time. Note that the rotation of the Mean Sun differs from that of the First Point of Aries by one day per year, or approximately 4 minutes per day. Mean Time is the basis of the Calendar Year.

An important time-related concept for the navigator is the Hour Angle (HA). This is the angle measured at the Pole from a geographic meridian to an Hour Circle, at a given instant. To simplify calculations using the Hour Angle the convention has been established of always measuring the angle from east to west. On many occasions this results in "going the long way around" and the angle exceeds 180 degrees in value. However subtractions are eliminated and you will find that the convention is a great convenience. The Hour Angle is used to describe the location of some celestial body at some given instant, relative to some fixed position on Earth.

At this point I propose to summarize the abbreviated nomenclature which is used in navigational texts and formats. It will be used from now on in these articles. The meanings are stated below:

GMT Greenwich Mean Time
: Mean Time at Greenwich, England, the zero point of the longitude coordinates of the Earth.

LMT Local Mean Time
: Time measured by the Mean Sun, at a given locality. Numerically equal to the GMT combined with the longitude of the locality.

LAT Local Apparent Time
: LMT combined with the Equation of Time to get the position of the apparent Sun, usually for determining when it is at its maximum altitude, called Local Apparent Noon.

ZT Zone Time
: Each zone is numbered by the hours difference between Zone Time and GMT. This number is called "Zone Description"(ZD). Thus to get GMT one simply adds the Zone Description to the Zone Time.

GHA Greenwich Hour Angle
The angle, measured at the pole, westward from Greenwich to the Hour Circle of any celestial body (Sun, Moon, Planets or Stars), at a given time.

LHA Local Hour Angle
The angle, measured at the pole, westward from your meridian (or the meridian of any locality) to the Hour Circle of any celestial body at a given time.

SHA Sidereal Hour Angle
The angle, measured at the pole, westward from the First Point of Aries to the Hour Circle of a Star. Although it may be taken as a constant in calculations, it is subject to very small variations resulting from wobble of the Earth's axis. Its value at any date is available from the Nautical Almanac.

There are many more details of the measurement of time and its multiple uses, however these discussed above are adequate for the novice navigator to begin to master the art of celestial navigation. I have deliberately avoided explanations where they are not essential, although the student may find them very interesting at a later date. In the next article I propose to discuss the uses of time and hour angle to begin the definition of the celestial triangle.

NAVIGATION PERSONALITIES

Benjamin Dutton, Jr.

by T. D. Davies

Benjamin Dutton, Jr., was born in Shippensburg, Pennsylvania in 1883. He was appointed to the U. S. Naval Academy in 1901, and graduated in 1905. After an early assignment to a smaller ship, he was assigned to the battleship *Kentucky* (1907), in which he made the celebrated round-the-world cruise of President Theodore Roosevelt's "Great White Fleet."

In 1911 he reported to the U. S. Naval Academy for his first tour of duty there. After two years he reported to the battleship *Kansas* which, in 1913 and 1914 operated off the coast of Mexico in connection with the events culminating in the U. S. seizure of Vera Cruz.

His first tour of duty as navigator was in 1915, when he reported on board USS *Machias.* This was followed in 1916 by a second tour at the Naval Academy which lasted until 1918. In 1918 he was involved in convoy duty aboard USS *New Mexico* and USS *Pueblo*. After the Armistice these ships returned troops to the United States.

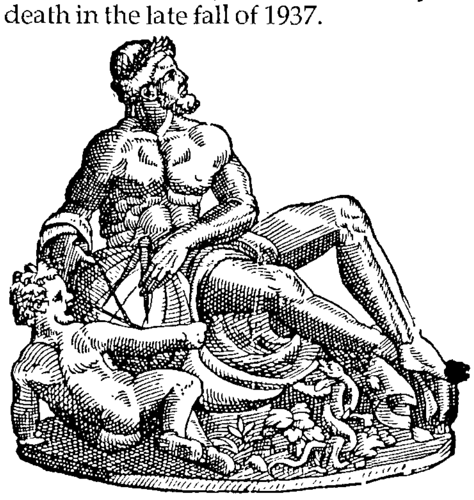
Although the Germans had attempted to scuttle their fleet after the Armistice, the ex-German battleship *Ostfriesland* was recovered and placed in commission in Rosyth, Scotland, in 1920. With then-Commander Dutton as Executive Officer, the *Ostfreisland* sailed to the United States towing the ex-German light cruiser *Frankfurt.*

By 1921 Commander Dutton was aide to Rear Admiral Hilary P. Jones, who was Commander Atlantic Fleet. Admiral Jones fleeted up to the navy's top sea-going job, Commander in Chief, U. S. Fleet, taking his aide with him. In 1923 he was transferred again to the Naval Academy, this time in the Department of Navigation.

It was while in this tour that he produced his world-renown work on navigation. The book, published in 1926, was originally titled *Navigation and Nautical Astronomy,* and was intended primarily as a textbook for the study of navigation at the Naval Academy. The book however fulfilled a need that was much broader than its original inspiration, and continued to be published for the next 60 years through 14 editions. Somewhere along the way the name was changed to *Dutton's Navigation and Piloting.*

He left the Naval Academy for command of a survey of the north coast of Cuba, after which he attended the Naval War College, and continued there on the staff. From 1931 to 1933 he commanded the battleship Wyoming, and served in the Bureau of Navigation until 1935. He was then appointed as the U. S. Naval Attache in our Embassy in Berlin. It was an exciting time to be in Berlin as the Nazi movement was building to its crescendo. Captain Dutton was actually in the very position of the imaginary hero of Herman Wouk's novel, *Winds of War.*

He returned to the United States in 1937 to take command of the USS *Portland,* where I had the experience of serving under him in my first tour at sea as an ensign. All of the officers of that ship can personally testify to the superb competence and leadership exercised by Benjamin Dutton. He was a scholar and a gentleman in all his relationships with his officers, and we were all shocked when this brilliant career was brought to an untimely end by his sudden death in the late fall of 1937.



HISTORY OF NAVIGATION

by T. D. Davies

Mathematical Tables

Mathematical tables appear in our earliest history, an example being one in an Egyptian papyrus, called the Rhind, dating from before 1700 B.C. Babylonian tables for multiplication and tables of reciprocals have been discovered which appear to have been made even before 2000 B.C.

The best known antecedent of the modern mathematical table appeared in the classic work of Claudius Ptolemy called the Almagest. This book appeared in the middle of the second century A.D., but was the basic reference work on astronomy, cosmography and navigation through the 16th century. It was translated into many languages, including arabic, and was the basis of arabic astronomy as well as scientific thought throughout the Mediterranean world. The Ptolemean concept of the "celestial spheres", centered on the Earth, was the standard theory of the solar system until the 16th century works of Copernicus.

Ptolemy's table consists of a table of the values of chords of a circle at intervals of one half degrees, specified to 6 places of accuracy. There are indications that it was based on a table by Hipparchus of about 150 B.C. It is remarkable that the table tabulates first the argument (the entry value), then the value of the chord, and finally a table of differences, much like those of HO 229. The table is written in the sexagesimal system of numbers which had been originated by the Babylonians and used by the Greeks. Of course this was also the origin of the division of the circle into 360 degrees.

The use of the chord predated the invention of the trigonometric functions by name, but could be used in the same way. Thus the sine of 12 degrees is one half the chord of 24 degrees, for which Ptolemy tabulates a value of .207912, which is correct to the last place. The nomenclature of the sine comes from the arabic name for that function, which they got from India. The arabic translation of the Indian word was incorrectly read as "gulf", by the western world, who then applied the latin word for gulf, "sinus." This eventually became "sine", abbreviated as "sin."

Mathematical tables were prepared by both Indian and Arabic scientists, but the it was in the 15th century that the modern development of the art really began. The tables of this period were frequently the life-work of an individual scientist, although usually aided by assistants. In the early 17th century Napier published his great table of logarithms, which gave a fresh start to computation. Thereafter tables of greater accuracy and of different functions grew apace.

Todays electronic computers must compute a trigonometric function each time one is used to carry out a program, and thus are largely dependent upon the methodology developed by these earlier scientists, who searched assiduously for shorter and shorter methods of computing the values in their tables. Whereas the objective of their search was to try to complete a table in a lifetime, today's computer that does each computation in a millionth of a second uses their techniques to calculate its sines and cosines in a tiny fraction of a second, and thus please the user with its "speed."

MARINE INFORMATION NOTES

provided by Ernest Brown

New series of Bound Volumes of Sailing Directions

The Defense Mapping Agency Hydrographic / Topographic Center has begun issuing new editions of Sailing Directions in bound volumes. Since automation has reduced the need for changes to the Sailing Directions by over 90 percent, the requirement for loose-leaf publications and user provided binders is no longer necessary. The conversion to bound volumes is expected to be completed in three years.

New Edition of Summary of Corrections

Volume 5 (1 March 1986 edition) is available for issue. Volume 5 covers world and ocean basin charts, U.S. Coast Pilots, Sailing Direction, Fleet Guides, and other publications.

Special Warnings

Special Warnings are broadcast as needed to announce official U.S. Government proclamations affecting shipping. For example:

Special Warning No. 68

1. Due to the extremely hazardous situation in Lebanon, the danger facing U.S. citizens there, and the limited ability of the U.S. Embassy to be of assistance, U.S. mariners should avoid the coastal waters and ports of that country.

2. Cancel special warning N0. 64.

Fishing Obstructions

Section III of Notice to Mariners list bottom obstructions which have been reported to the National Marine Fisheries Service by commercial fishermen and which will not appear on affected charts until further investigation and verification.

Possible damage to equipment may occur when engaged in fishing operations in the vicinity of the reported obstructions located by approximate geographic position and observed Loran-C readings.

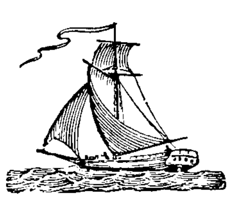
New Geographic Limits of U.S. Coast Light Lists

The U.S. Coast Guard previously published five volumes of Light Lists. Beginning with the 1986 editions of the Light Lists the number of volumes published will be increased to seven. In making this change, Volumes I and II were divided into four volumes. The Light Lists will now be designated as follows:

(1) Volume I, Atlantic Coast, from St. Croix River, Maine to Ocean City Inlet, Maryland. (2) Volume II, Atlantic Coast, from Ocean City Inlet, Maryland to Little River, South Carolina. (3) Volume III, Atlantic Coast and Gulf of Mexico, from Little River, South Carolina to Econfina River, Florida and the Greater Antilles. (4) Volume IV, Gulf of Mexico, from Econfina River, Florida to Rio Grande, Texas. (5) Volume V, Mississippi River System. (6) Volume VI, Pacific Coast and Pacific Islands. (7) Volume VII, Great Lakes.

Notice to Mariners 9/86 of 1 March 1986 264/86(11) Florida-East Coast

1. All mariners are cautioned of inherent dangers in area bounded by following coordinates: 29-00N on the north, 28-24N on the south, 79-30W on the east and shoreline on the west. All vessels transiting this area should maintain an exceptionally careful watch for and are requested to remain clear of, official vessels engaged in space shuttle CHALLENGER debris recovery operations. Midwater and bottom fishing in this area should be avoided because space shuttle debris presents potentially extreme hazards for persons untrained or ill-equipped in special recovery procedures. Particular caution should be exercised in an area having its center at 28-37N and 080-17W and having a radius of three miles. All mariners are strongly encouraged to circumnavigate this area to avoid jeopardizing the high level of difficult underwater recovery operations being conducted. Mariners should not attempt to recover any debris suspected of being from the space shuttle. This debris has proven to be dangerous. Report any debris from the space shuttle to nearest coast guard unit.



NAVIGATION NOTES

The Constant Error Circle - An Alternative Method

by T. D. Davies

The concept of the "Circle of Constant Error" occurs in several aspects of plotting techniques used in Piloting. The concept is particularly important for the small-craft navigator where a gyrocompass is unlikely to be available, and where the magnetic compass is probably not as accurately adjusted as it should be. Elsewhere in this issue you will find a story of a constant error case that occured aboard an aircraft carrier, where the Azimuth Circle had an error in manufacture! Incorrect orientation of the Lubber's Line is also a source of this particular type of error. Whenever a 3-bearing plot gives a triangle instead of a point the navigator should suspect that a situation exists which generates a constant error, and the method outlined below will allow him to correct his plot for this possibility. It is noteworthy that the corrected position will often not be inside the triangle of error.

The method is based upon a basic property of the circle, that bearing lines from two points will always intersect on a circle through the points if the angle between them remains the same. This is exactly the case if both bearings have the same error, since the angle between them does not change. Figure 1 shows this situation.

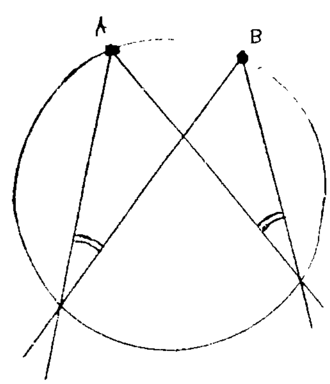


FIG. 1.

This circle of constant error may be readily constructed by the navigator. Plot two additional bearing lines, each 90 degrees from the original bearings. These will intersect at a point which is on the same circle and is diametrically opposite from te two intersections with a line, and the circle center will be the mid-point of that line. With a compass swing an arc from this center point through the intersection of the two bearing lines this will be the "circle of position." Figure 2 shows this situation.

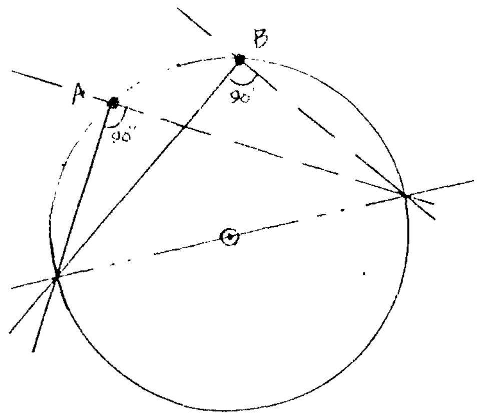


FIG. 2

When only small errors are to be expected from the compass, it may not be necessary to actually swing the arc it may be approximated by a straight line through the intersection and perpendicular to the line joining the two intersections. Thus locating the center and swinging the arc are omitted. Figure 3 shows an enlarged view of the position with this line.

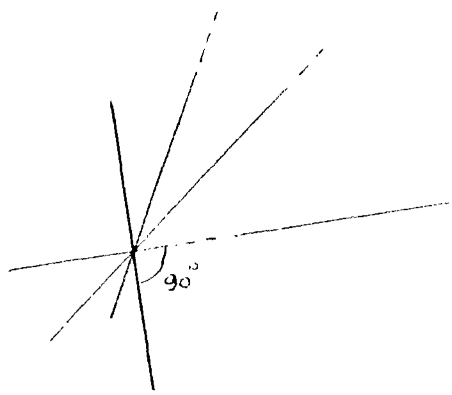


FIG. 3

The circle of position may be used to get a Fix by selecting another target and taking another bearing. In doing so, try to avoid a target anywhere on the circle of constant error, or close to it. Such a target will generate the same circle and therefore not get a good angle of cut for a Fix. A target on the circle is called a "swinger." A circle of constant error may be generated as outlined above, using either of the original targets in combination with the new one. The intersection of the new circle (or line approximation) with the original one will give a Fix, which will often be outside the triangle formed by the three bearing lines themselves. Figure 4 shows this plot.

Finally a third circle of constant error may be generated using the third target and the unused one of

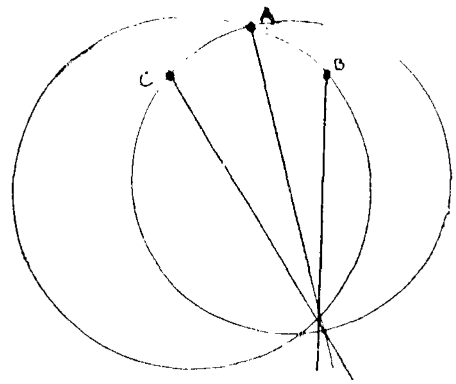


FIG. 4

the original targets. This circle should pass through the intersection of the other two circles if the plotting has been properly done. If it does not there must be additional random error in the bearings, and the most probable position is the center of the triangle created by these three circles. Figure 5 shows such a plot. If time prevents repeating the process for the third circle, a quick check can be made by reading the constant error value from the first two circles intersection and applying it to a third bearing as a check on the Fix.

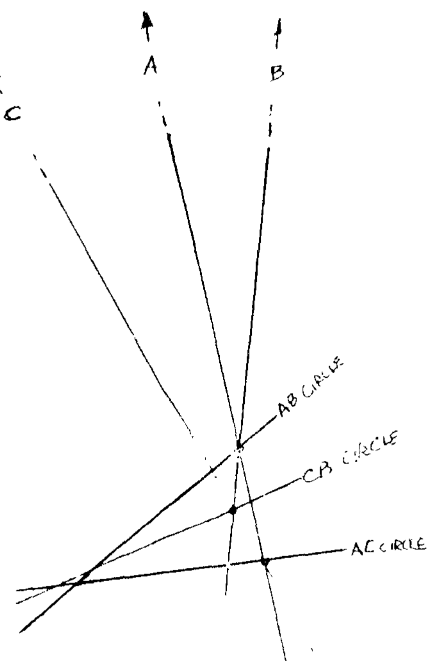


FIG. 5

The method described may be used to plot horizontal sextant angles when the sextant is used for piloting. The direction from the DR position to the first target may be assumed to be 000 (or other convenient angle) and the angle given by the sextant used to plot a bearing line from the second target. Thereafter the method herein described may be used to find the circle of constant error, which will also be a circle of position, useful for avoiding hazards of navigation or giving distance offshore, etc. If a second sextant angle is available it can be used to plot another circle of constant error, which can be intersected with the first to give a position of considerably greater accuracy than that obtained by the average hand bearing compass and even many peloruses.

Obviously these bearings should be close to simultaneous, or their circles of position must be advanced for movement during the interval between them. A little practice with this method should allow the navigator to depend on the extra accuracy offered. The navigator should be able to visualize the location of the circle to expedite plotting of the 90 degree lines. Visualization will also help to avoid chart clutter by only drawing the perpendicular lines near their point of intersection. The center of the circle of constant error may be located by lightly-drawn prependicular bisectors, or by simply dividing the diameter with a scale. In any event it should be marked with a standard symbol to avoid confusion.

Application of the full method (i.e. swinging the arc with a compass) can allow the variation and deviation to both be ignored in plotting. Where simple plotting during entry into a harbor will usually leave a trail of small triangles and a slightly zigzag track, use of this method, particularly in conjunction with the precision of a sextant, will usually give an impressive set of points and a straight track. Finally,the method can be used for post-navigation analysis, and important function not practiced as often as it should be.

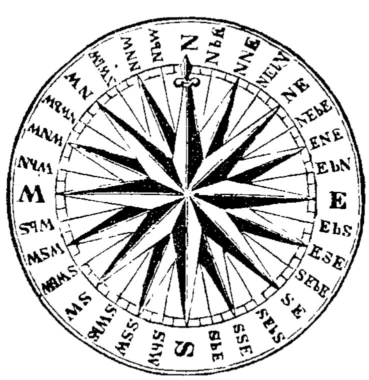
A Navigation Problem

Solution to the problem presented in Issue Twelve:
14. Answer
(a) When vessel crosses the 180 deg meridian the date at Greenwich will still be March 2, 1986. It is only the local data which changes by 24 hours when crossing the 180 deg meridian or such other meridian as may, for political purposes, define the Date Line at any given point.
(b) In terms of the true 180 deg meridian, BACKSTAFF is still in Zone plus 12 prior to crossing that meridian. However, in terms of the Date Line, which has been displaced 7 1/2 degrees to the East for political reasons in this part of the World, the vessel has already crossed over into Zone -12, and the local date is March 3, 1986. When crossing the true 180 deg meridian the local date will remain March 3, 1986.

When on a westerly heading, the local date becomes one day later when crossing from West to East Longitude, and when on an easterly heading, the local date becomes one day earlier when crossing from East to West Longitude. Thus, at any moment the date immediately to the West of the Date Line (in East Longitude) is one day later than the date immediately to the East of the Date Line.

Problem No. 15
It is now June, 1986, and Backstaff has reached Sidney, Australia, where she and her crew will spend a month or two in deference to the southern hemi-sphere winter. Her navigator, having time on his hands, is experimenting with various "tricks of the trade," and he recalls having read of a procedure for navigating along a true course line with only one sight per day. He expects to experience a long northwesterly run in the spring, parallelling the N. E. coast of Australia and the Great Barrier Reef on the way to the Torres Straight. He wishes to experiment now with this procedure. His purpose is not the dangerous one of later relying on only one sight per day, but rather is that of perfecting the procedure so that in the vicinity of the reef he may verify the exact true course he is on and its location in reference to various reef passages. He knows it is an easy thing to sail due East or West along a latitude line (using the same procedure the old sailing ships used before the chronometer made possible the finding of longitude, and using the noon sight to verify latitude only), but he wants the freedom of being able to sail any course other than due East or West. His problem is to time his sight to coincide with the exact time when the bearing of the sun will yield an LOP that verifies whether he is on his plotted true course line or not.

What procedure may he use to accomplish this purpose?



BOOK REVIEW

by Roger H. Jones

Star Sight Reduction Tables for 42 Stars: Assumed Altitude Method of Celestial Navigation. *Second Edition.*

By Rear Admiral Thomas D. Davies, USN (Ret.)
Cornell Maritime Press, Inc. Centreville, Maryland 21617, 424 pages $28.50

The First Edition of the Davies Assumed Altitude Tables appeared in 1980, and it marked the first time in the long history of the many tabular approaches to sight reduction that the data were presented based upon an assumed altitude of the celestial body rather than an assumed position of the observer. These tables represented a major breakthrough, as they enabled the navigator for the first time to "shoot" target stars of opportunity without any precomputation of bearing and altitude for specific stars. They also presented a much easier method of identifying the stars observed, although in the sight reduction and plotting process it was not necessary to know the identity of the stars observed. Finally, these tables, at any page opening, presented many more stars than the few "optimum choices" which appear in the *H. O. 249, Volume I* pages. A full article by this reviewer on these tables appeared in the February, 1982, issue of *Cruising World.*

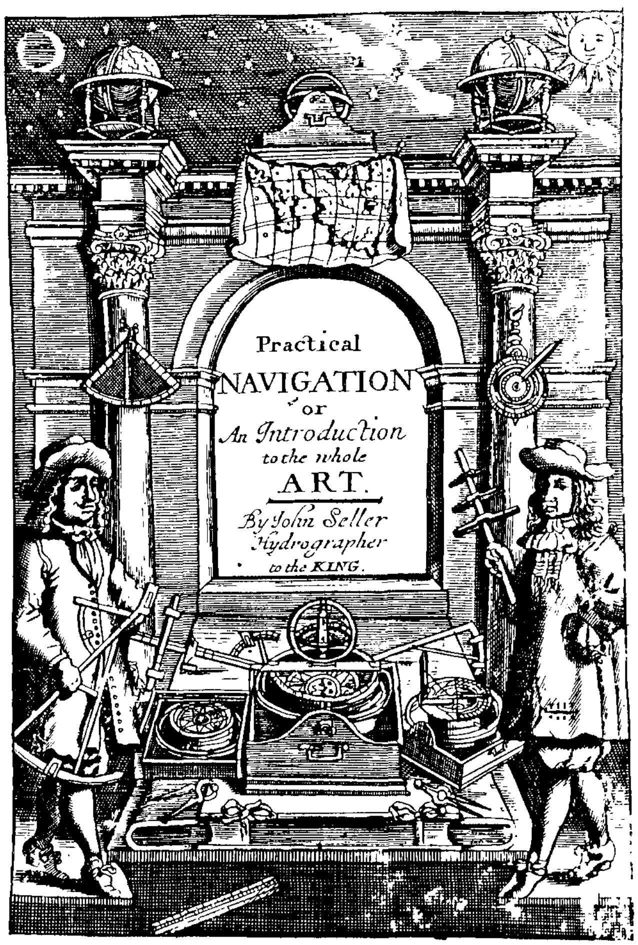
The *Second Edition* is designed for use during the years 1986 through 1992. The data are for stars which may be observed from latitude 60° North through 45° South. The latitude span in the new edition has been reduced from the earlier span of 72° N to 60° S, but this has been done in order to present the tables in a smaller, handier volume. It still covers practically all waters where navigators are ordinarily apt to be, except those in the vicinity of Cape Horn and those north of the southern tip of Greenland. A quick latitude index on the back cover facilitates opening the volume to the correct series of pages.

Within each whole degree of latitude are vertical columns of star altitudes from 15° through 74°, tabulated in descending and ascending order of LHA Aries, together with the azimuths for each star. These *Second Edition* tables, like the *First Edition* tables, appear in one volume, but the overall size is now about the same as that of the Nautical Almanac. This permits easier use in tight quarters and normal bookshelf storage.

The tables are accompanied by auxiliary data and clear instructions. There is a table for SHA correction for nutation and precession through 1992, a table for height of eye corrections, a compact almanac for GHA Aries, a sight reduction procedure format, and a schedule of "rules." The latter are very simple, and the whole process is perhaps less involved than that associated with H. O. 249 because no precomputation is necessary before the sights are taken.

At sea the navigator merely shoots his target of opportunity without even knowing its identity. He notes the rough bearing of the star at the time of the sight, and, after correcting Hs to Ho, he enters the tables with his latitude and an assumed altitude of the star based upon Ho. The plotting procedures involve a "plotting point" unique to these tables, but in all other respects plotting is the same as with any LOP and such tables as H. O. 249 and 229.

Those who have used these tables, including this reviewer, will welcome the *Second Edition.* They greatly facilitate both the star observation and sight reduction processes. Those who are devotees of *H. O. 249, Volume I,* really should try the Davies tables. They may find that they would rather "switch than fight."



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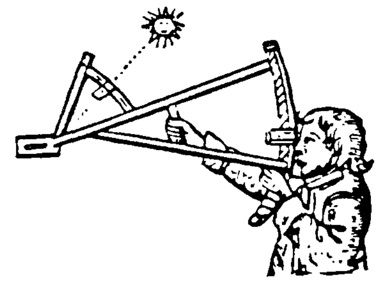
THE NAVIGATOR'S NEWSLETTER

FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

ISSUE FOURTEEN, FALL 1986



This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

John M. Luykx Joins Directors

A new director, John M. Luykx, has been appointed to replace Henry Shufeldt. Director Luykx teaches navigation at the University of Maryland and has a long history of experience in navigation including a sea tour in the U.S. Navy aboard an LST. He has collected an impressive array of antique navigation instruments, which he has actually employed in celestial measurements. The Foundation expects to utilize his talents in many ways, beginning with two articles in this issue.

Membership Cards

By now a good many members have received the new membership cards with their renewal acknowledgement. We also issue the card for initial membership for people joining now. In a few months the entire membership will be so equipped.

New Members Sought

We now have labels for a substantial mailing for new members, based on individuals who have purchased books on navigation. As soon as one final list arrives the mailing will go out. Meanwhile I hope our members will make every effort to interest others in joining. The Foundation has taken a full page add in the Nautical Almanac published by Paradise Cay and we expect to do more advertising on a selective basis. Knowledge of the Foundation appears to be spotty, it extends as far as Australia, but seems to be missing in some places close to home.

Paradise Cay Books Now Available

A new book catalogue is in preparation and will be mailed to all members shortly. We have now added Paradise Cay Publications books to the list; their new Nautical Almanac is now ready (1987). There have also been a few changes in price of other books. Book and chart sales generally have been expanding which suggests that this function is useful to members. We will continue to add more navigational books as they become available.

Solutions Available

One of our members has complained about the inordinate delay in seeing the solution to the navigation problem, i.e. waiting three months for the next issue. This seems to be a legitimate complaint, which we propose to correct by the following change. Readers who send a request and a stamped self-addressed envelope will be supplied with the solution promptly. Director Roger Jones, who prepares the navigation problem, always provides the answer at the same time, so we will have it on hand for interested parties.

Return Mail Costs

Sometimes members desiring to save the Foundation the cost of return mail, put a stamp over the printed indicia on the return envelope. This procedure is not allowed by Post Office regulations, so we are charged 38 cents anyway. If you want to save us the cost, you must use a regular envelope and stamp. We also remind our Canadian members that they should send checks only on banks with U.S. affiliates. Banking regulations require this to avoid a long and expensive collection process. Of course account should be taken of the exchange rate in determining the amount to forward.

At Sea Opportunity Offered

Our At Sea Training idea has borne some fruit. In the Readers' Forum you will find an opportunity offered by one member who operates a charter service. We hope to go farther than this, but at least this is a start. Members who take advantage of this should report on the results.

READERS FORUM

Member Mike Makarounis has been in contact with Roger Jones both by letter and in a long discussion which the two of them held at the recent Newport Beach (California) Sailboat Show. Roger, in turn, has forwarded information about a new product which is off the drawing board and now available from Navigation and Marine Services, 135 Byron Drive, Pleasant Hill, California, 94523, (415) 939-5073. With Mike Makarounis' permission, Roger has written as follows.

Makarounis is a long-time navigator, yacht delivery skipper, and navigation teacher. His new NAV-U-PLOT device is of great interest. It is so new that it is not yet widely advertised, but it is worthy of notice by the Foundation members. Essentially, it is a hand-held computer/calculator with a small printer module that plugs into the left side. Overall, it is about twelve inches long, by four inches wide, by an inch-and-a-half high. It weighs probably about three pounds. The constituent components are: a computer/calculator manufactured by Sharp, a special computer program chip developed and furnished by Makarounis (but manufactured by a leading chip producer), a small battery pack, and the printer. The batteries are rechargeable, and about 40 hours of use can be obtained from freshly charged batteries. It does not have to be kept "hot" (with electrical current) when not in use, and the paper tape print-outs will not fade.

What distinguishes this device from the navigation computer/calculators available from Tamaya, Texas Instruments, Hewlett Packard and other sources is fundamental: NAV-U-PLOT renders an immediate, highly legible (although small in size) plot of the LOP's that result from the computer's performance of the sight reduction problem. In practice, the navigator makes his observations using a regular marine sextant. He then uses the keys on the computer/calculator to insert all relevant data, and it is significant that NAV-U-PLOT "speaks English." It guides the user with step-by-step prompting in the liquid crystal display. The data elements are entered in the same sequence that would normally occur if they were written down on a sight reduction work form. The final key is that which produces the solution and the plot of up to three lines of position. A long term almanac for the Sun, Moon, planets and stars is programmed into the unit.

This device will handle just about any navigational problem that is conceivable. I've worked a number of problems on it, and I was very impressed with its performance. And not only will it produce the LOP's and the associated latitude and longitude reference lines; it will do many other useful things as well. For example, it will print a star list for a given Greenwich date and time and DR position. There is also an ancillary ship's inventory program which divides the vessel into as many as 255 compartments. Up to 255 different kinds of items can be stored in each compartment in quantities of up to 255 for each item. NAV-U-PLOT will keep track of all your stores as well as your navigational numbers.

There are two versions of the same NAV-U-PLOT program. Both do the same routines. The orbital data equations of the first (NAV-U-PLOT 50) have an accuracy of about one minute of arc, valid for any year between 1900 and 2099. The second (NAV-U-PLOT 75) has accuracy of about 0.1 minutes of arc, and it needs updating every five years. The 50 is intended for the small boat sailor, while the 75 is for the large vessel and classroom use.

Finally, Makarounis has devised programs for position determination from compass bearings on known landmarks where the latitude and longitude of the landmark are known, and for tidal current status based on tide table values.

NAV-U-PLOT with the 50 program costs $895. This includes the scientific computer, the two axis printer-plotter, the battery charger, the program cartridge, a case, and instruction manuals.

I have absolutely no interest in the commercial success of NAV-U-PLOT, but I have a great interest in it because of its utility for the navigator. In that sense, I wish it great commercial success, and I recommend that interested readers of the Newsletter write to Navigation & Marine Services for a copy of the brochure and other available data.

Member Edwin H. Perkins of Georgetown, MA writes:

In issue 12 Page 2 there is a discussion of "Use of Fix without Plot". I was interested in it as I worked up a program some time ago for my HP-65 which does it.

Given HO, GHA, and Dec.; Ho2, GHA2 and Dec.2, the program provides the two possible intersections as Lat., Long., and Lat.2, Long.2 so you must know which is your intersection. The program requires GHA1-GHA2 to be plus and less than 180deg., also Dec.2 and GHA2 must not either be exactly 90deg. The program uses one side of the need to transfer degrees, minutes, and then this to decimal degrees. The second side performs the calculations for Lat., Long. and Lat.2, Long.2. Then side one again changes decimal degrees to degrees, minutes and tenths.

The mathematics uses five equations involving sins and cosines.

I do not expect any of this is novel, but I will be glad to submit it to you if you are interested in the old HP-65.

Member Warren P. Davis of Edgewater, MD writes:

I have been actively teaching navigation and related subjects for about 25 years both in classroom and at sea. About a year ago I spent eight months teaching five maritime cadets from the government of Kuwait. With them I covered seamanship, coastal piloting and navigation. Classroom instruction was the necessary basic period for each subject area and after complete understanding in a particular area they were taken aboard a surplus army patrol boat to practice their knowledge underway.

Since these young men were to be the deck officers of two new 140-foot twin screw fire vessels in the Persian Gulf, it was necessary to cover all subjects such as knotting and splicing, navigation rules, ship handling, chart use, piloting and navigation. They were wonderful students, intelligent and interested. The ships engineering officers were being trained in Germany at the same time and now these new vessels are operational in Kuwait's portion of the Persian Gulf.

Our chart work was conducted on both British and U.S. charts of Kuwait and the Gulf since they were somewhat familiar with British Charts, and in turn could readily procure sets of DMA charts for each student.

As you probably know, Saudi Arabia has installed their own Loran C system that provides excellent Gulf coverage. We therefore included electronic navigation in the course of instruction.

Our practical work, both day and night underway training was conducted on NOAA Charts of the Chesapeake Bay and also Martha's Vineyard to Block Island. We used several different vessels, both single screw and twin screw ranging from 20 to 90 gross tons provided by the prime contractor.

I have used calculators both programmable and unprogrammable in navigation for many years. Actually, I prefer tables to calculators except for the NC88. The Tamaya NC88 makes all others seem like toys for use in celestial navigation. I've used mine now for 2 years and would not leave home without it. My bookshelf always includes the Almanac and several different tables for sight reductions but the NC88 is such an elegant and straightforward device that I never cease to enjoy its use.

May I wish you continued success in the Promotion of the Art of Navigation.

Member Jim Brown, Master yacht "Chapulin" in Das es Salaam, Tanzania, E. Africa writes:

I am continually amazed at the number of cruising yachts using Satnavs that simply (the skippers) can't navigate. One - Nace IV, was lost on Alphonse Island last year - she had two Satnavs - Radar and hit anyway while the natives on the island were frantically calling on UHF!!! We'd all love to have a Satnav, Radar and a calculator - they are no substitute for constant practice in celestial observation. Small boats (100 feet and under) have a problem with electronics anyway. Besides what the hell do people do all day if they don't ever try to figure out where they are? They should all read Jon Sanders book - A serious Navigator should take sights a least three times per day, and if they have a lot of electronics - then compare - see how good or bad you are. I have found - using a HP-41C that I can get the L.O.P.S. on top of one another most of the time. I never use the calculator for initial sight reduction. It's just for checking and for those (as in the last passage) times when you need quick sights - when approaching Songe Songe Island below Dar es Salaam Tanzania - I had overcast weather and by rough sun lines was 15 miles off at 4:30 PM, at dusk got a rough Venus - Hadar - Moon, let the calculator do the planet - and we were fine. Made the landfall the next morning - rather afternoon at Dar es Salaam.

As an update - I will spend the next 2 months in Dar es Salaam, Zanzibar and Pemba Islands. I'll head south - down the Mozambique Channel to Durban S. Africa in Oct. and go around the Cape of Good Hope in January, heading for Brazil via St. Helena. My Davis Sextant still performs well even though it is getting hard to "Zero". I have a C Plath Sextant but on a 30 foot boat 4 power magnification is too much (however I've worked out a fix for it)

INFOCENTER of Forestville, MD writes:

"The CN-2000 Celestial Navigation Program designed to run on the Sharp PC-1500A pocket computer was introduced today in the United States by INFOCENTER."

"Unique features of the program save time and make routine sight reduction tasks less laborious for the navigator. User friendly and moderately priced, the program package has particular appeal to the practicing navigator."

Detailed information and brochures are available by writing or phoning INFOCENTER: P.O. Box 47175; Forestville, MD 20747; 301/231-3745 or 301/420-7441.

Member Anthony L. Carrad of Sarasota, FL. writes:

I would like to point out an error on page 4 of the Summer Issue where Mr. Davies states, "to get GMT one simply adds the Zone description to the Zone time." This is, of course, true only in the Western Hemisphere where ZD's are positive. In the Eastern Hemisphere where ZD's are negative , the ZD number must be subtracted from Zone Time to get GMT. Use the old adage, "Follow the sign to Greenwich."

Ed Note: Zone Descriptions are indeed plus and minus and are treated algebraically: i.e. when adding a "minus" ZD, it is subtracted.

Member J. Herbert Watson of Ponte Vedra Beach, FL writes:

The Backstaff Problems are very good, however, waiting for 3 months for the answers one tends to lose interest. Suggestion: A navigation problem each issue with answers in the same issue. Or for a small fee, $2.00, one could write (sending a self addressed envelope) for a thorough explaination of the problem and answers. Suggestions on problems: Course check problems, Problems involving use of the Almanac, LOP problems; L - Ln solutions, 7
4Triangle problems.

Member Douglas V. Guentz of Destin, FL writes:

Our Spring 1986 Navigator's Newsletter was of particular interest to me because of the "At-Sea Training Course" proposal. Please allow me to suggest a joint-venture operation.

I am one of three owner/operators of a charter sailing vessel operating on the northern gulf coast. For some time now, we have considered expanding our operations to the Caribbean area. This service will require U.S. Coast Guard endorsement to our operator's licenses for Region Seven. To this end, we are simply going to run some logged miles under our keel in Region Seven. The Foundations membership, whether power or sail oriented, would be more than ideal to fill out our deck-watch schedules.

We are currently refitting our vessel, a Morgan Out-Island 41 ketch-rigged. She is riding berth at my residence on Joe's Bayou, Destin, Florida.

I have also enclosed a suggested (only) partial itinerary which could commence on/or about 1 March 1987. My plan has been tentatively agreed to by the owners, if, I fill in some more of the blanks and put more of the pieces together. Generally, our company would furnish the vessel, at least one operator/engineer, and related maintenance expenses for the cruise. The participants would furnish their individual transportation to and from scheduled crew change points along the cruise route plus direct variable costs such as fuel and groceries on a pro rata basis. I estimate these latter expenses to fall between $27 and $30 per day per participant. Applicable charts, publications, and plotting instruments will be on board. Except for fuel, freshwater and stores, the vessel is essentially marina free.

Thank you for your attention to this communication. Should you favorably consider these ideas, please write or telephone me. I would also like to express my appreciation for the content and quality of the quarterly Newsletter.

Ed Note: We are following up on this and will advise interested members.

NAVIGATION BASICS REVIEW

The Navigation Triangle

by John M. Luykx

The mathematical solutions required to fix a vessel's position at sea from altitude observations of celestial bodies are based on the Navigation Triangle. The Navigation Triangle is a spherical triangle of special interest to navigators which is formed by three points on the earth's surface. These three points are:

a. The Geographical Position (GP) of the Celestial Body

The GP of a celestial body is that point on the earth's surfacewhere an observer would see the body at his zenith; directly overhead. The GP may also be defined as that point on the earth's surface intersected by an imaginary line drawn from the body to the center of the earth. The GP is established by the body's Greenwich Hour Angle (GHA), the angle measured westward from the Greenwich meridian to the meridian (or hour circle) on which the GP of the body is located and the body's declination (DEC), the angle of the GP north or south of the equator. The declination of the GP is equivalent to the latitude, and must be labelled either north (N) or south (S) depending on whether the GP is on the northern or southern hemisphere. The GHA and DEC of the Sun , Moon and planets are tabulated in the Nautical Almanac for any date and time during the year. The GHA and DEC of a star are calculated in two steps from the data in the Nautical Almanac.

b. The Assumed Position (AP) or Dead Reckoning Position (DR) of the Observer

The Assumed Position (AP) of an observer is the latitude/longitude coordinate of a specified position at or near the observer's actual (but unknown) position for computation purposes. The DR position (DR) is the latitude/longitude coordinate of the best estimate of the observer;s position based on the course and speed of the vessel and the time of observation of the celestial body. Depending on the method of sight reduction employed, either the AP of the observer or the DR may be used for this point of the navigational triangle.

c. The North or South Geographic Pole

The North (N) and South (S) geographic poles are located on the earth's rotational axis and it is at these two points on the earth's surface that the meridians of longitude meet. For an observer in the northern hemisphere, the North Pole is the third of the three points of the Navigation Triangle; for an observer in the southern hemisphere, the South Pole is the third point of the Navigation Triangle.

Of these three points, the pole is fixed, the observer's AP or DR may be stationary or it may move with the course and speed of the vessel and the GP of the body moves from east to west across the earth's surface at the earth's speed of rotation.

When an observation of a celestial body is taken with a sextant and the Greenwich Mean Time (GMT) recorded at the time of observation, the Navigation Triangle becomes "fixed" by 1) the GHA and Dec of the body's GP, 2) the Lat/Long coordinate of the observer's AP or DR position and 3) the position of the Pole. The principle parts of the Navigation Triangle (the three interior angles and the three sides) may then be identified as follows:

1. The Navigation Triangle (see Figure 1)

a. The Interior Angles

1) The Azimuth Angle (Z)

Z is the interior angle at the observer's AP os DR position. Z is the direction of the celestial body from the AP or DR.

2) The Meridian Angle (t)

t is the interior angle at the Pole. It is the angular distance either east or west, up, to 180, from the meridian containing the observer's AP or DR position to the meridian (or hour circle) containing the GP of the celestial body.

3) The Parallactic Angle (X)

X is the interior angle at the GP of the celestial body. It is not generally used in solutions of the Navigational Triangle.

b) The Sides

1) CO-DEC

CO-DEC is the side opposite to the point of the observer's AP of GP position. It is equal to 90 + or - the DEC of the celestial body as tabulated in the Nautical Almanac for the time of observation. If the DEC of the celestial body is in the opposite hemisphere from the latitude of the observer;s AP or DR position, this side = 90 + DEC. If, however, the DEC of the body is in the same hemisphere, CO-DEC = 90 - DEC.

2) CO-LAT

CO-LAT is the side opposite to the point of the celestial body's GP. It is equal to 90 minus the AP or

The Navigation Triangle

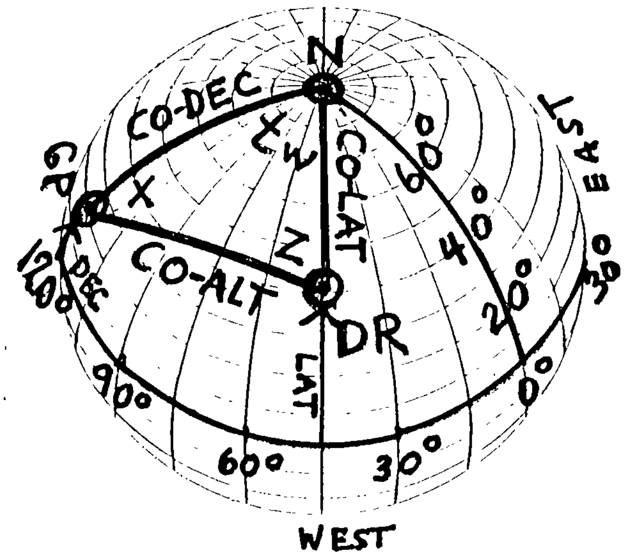


Figure 1.

BODY:	SUN
DR POSITION LAT:	40°N
(OBSERVER) LON:	45°W
GP POSITION GHA:	120°
(SUN) DEC:	20°N
MERIDIAN ANGLE t:	75°W
AZIMUTH ANGLE Z:	N85°W (BY SOLUTION)
CO-DEC:	70°W
CO-LAT:	50°
CO-ALT:	66° (BY SOLUTION)
LHA:	75° (GHA-LON)

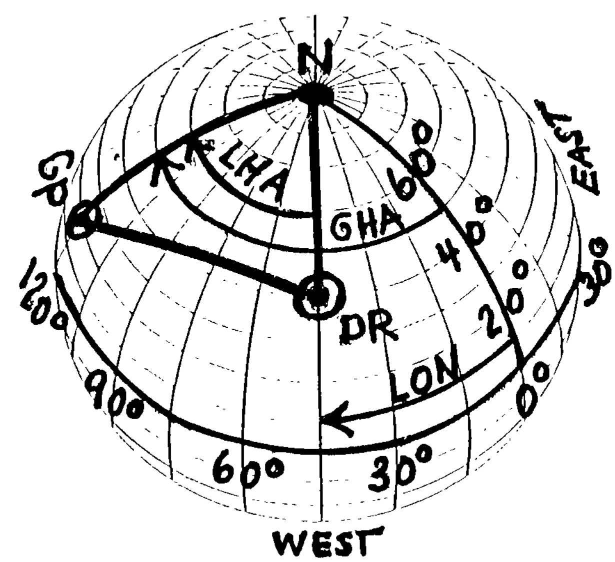


Figure 2.

DR latitude of the observer at the time of observation.

3) CO-ALT

CO-ALT is the side opposite the point of the Pole. It is equal to 90 minus the corrected value of altitude (Ho).

2. Additional Definitions Applicable to the Navigation Triangle

a) Greenwich Hour Angle (GHA)

The angle measured westward up to 360 from the Greenwich meridian to the meridian (or hour circle) containing the GP of the celestial body. Since the earth rotates 360 in one day the GHA of the Sun, for example, would increase at the rate of 15 every hour.

b) The Longitude of the Observer

The angle measured westward or eastward up to 180 from the Greenwich meridian to the meridian containing the AP or DR of the observer. The longitude is always labelled either E or W.

c) The Local Hour Angle (LHA)

The angle measured westward up to 360° from the meridian containing the AP or DR position of the observer to the meridian (or hour circle) containing the GP of the celestial body at the time of observation.

d) The Latitude (LAT)

The angle measured either north or south up to 90° from the equator to the parallel of latitude on which the observer's AP or DR position is located. The Latitude is always labelled either N or S.

e) The Declination (DEC)

The angle measured either north or south up to 90° from the equator to the parallel of latitude on which the GP of the celestial body is located at the time of observation. The Declination of the body is always labelled N or S.

f) The Greenwich Meridian

The meridian passing through the Greenwich observatory in England which since the late 19th Century, has been the international reference for the measurement of Longitude both east and west.

g) The Equator

The parallel of Latitude everywhere equidistant from the North and South geographic poles. It is the reference for the measurement of Latitude North and South.

When reducing (solving) the altitude observation of a celestial body using sight reduction tables or some of the simpler navigation calculators, three fundamental arguments are required to enter the tables or as prompts to the calculator solution. For the time of the observation, these are:

1) The Latitude of the AP (AP LAT) or the DR Latitude (DR LAT) of the observer.

2) The Declination (DEC) of the GP of the celestial body.

3) The Local Hour Angle (LHA) of the GP of the celestial body.

For the time of observation, the observer's Latitude (LAT) is determined from the chart or plotting sheet and the Declination (DEC) of the body found in the Nautical Almanac. The Local Hour Angle (LHA) of the body however must be computed prior to entering the tables.

From the diagram in Figure 2, it can be seen that the value of LHA is dependent upon the values of LONG and GHA. The LHA is computed using the formula:

$$LHA = GHA \begin{smallmatrix} -\text{West} \\ +\text{East} \end{smallmatrix} \text{Longitude}.$$

In a future article the function of the Time Diagram will be discussed, especially in computing the LHA of a celestial body.

NAVIGATION PERSONALITIES

Marcq Saint Hilaire

by T. D. Davies

Almost all navigators are aware that the modern method of using a sight solution to lay down a line of position is called the method of Marcq St. Hilaire. This refers to the determination of the difference between the observed altitude and the computed altitude of a star, and calling this difference the "intercept." The intercept is then laid out along the azimuth line, in the appropriate direction, and an orthogonal line placed at that point, called the line of position.

This technique was once called the "new" navigation, and the previous method was called a "Time Sight," although the latter technique is occasionally still used by an old timer. In any event Marcq St. Hilaire was the first to propose the new method which bears his name.

The name St. Hilaire is more commonly associated with two other Frenchmen, Marco de St. Hilaire and the Marquise de Queux de St. Hilaire. Since they were contemporary with our man, it is easy to imagine the confusion generated. At one time one was described as a blind monk who invented most of the laws of modern navigation! This description was published by a nationally syndicated writer without any disagreement. However from the French Ministry of Marine we can learn the true story of Adolphe-Laurent-Anatole Marcq de Blond de Saint Hilaire.

St. Hilaire was born on July 29, 1832, and entered the French Navy at the age of 15. He was made a Midshipman in 1849. His career included many tours at sea as he was promoted through the ranks from Ensign (1854) to Rear Admiral (1883). In 1875 he was Executive Officer of the school ship Renommee, a frigate. In 1880 he was Flag Captain to Commander-in-Chief Maneuvering Squadron. In 1881 he commanded the first line battleship Colbert, and as a Rear Admiral he was Director of the Cabinet of the Minister of Marine. In 1885 he broke his flag on Duquesne as Commander-in-Chief of the Naval Division of the Pacific. In 1888 he returned to France as Commandant of Navy in Algeria. In 1889 he died at this Post.

St. Hilaire devoted a great deal of his time to researches in navigation, trying to facilitate the methods of calculation to determine the location of the ship at sea. In 1873 he published an article entitled "Determination of a Line of Altitude (Position) with a Single Observation" (recall that the Time Sight requires two observations). Among other articles he published one on the determination of the central point (centrode) of three sights.

While he was serving on the Renommee he published his definitive work on the method which bears his name today. This was covered in an article entitled "Calculation of an Observed Position, Method of Calculated Altitudes." Published in 1875, the article included many modern concepts for the first time. For example he defined the subastral point, which he called the "Terrestial Projection." He then pointed out that the zenith distance of a body measures the distance on the Earth from the point of observation to this "Terrestial Projection." He also defined the circle of equal altitude as a circle of position and pointed out that the intersection of two such circles from two observations would define the observers position on the surface of the Earth.

Recall that the Time Sight and the Sumner Line had been expounded many years before; St Hilaire was developing a different way of generating two intersecting lines of position from two observations. The older methods also required sights of bodies at or near the Meridian. He pointed out that his method applied to sights on bodies at any azimuth. We quote his words below, on the critical point of his article:

"To calculate an observation, make a calculation of the altitude and the azimuth of the body, using the estimated (D.R.) position, and the time of observation, taking the difference between the estimated (calculated) altitude and the observed altitude. Consider this difference (intercept) as a distance, and with the azimuth as a course, correct the estimated (D.R.) position for this distance."

St. Hilaire presented a sample problem, which was worked out by the sine-cosine formula. The cosine-haversine formula was as yet unknown. He covered a number of other navigational problems in the remainder of the article, demonstrating the many situations under which his method was useful. Enough has been covered in the above quotation however, to clarify the role that he played in bringing into being the "new navigation."

As a post-script we should note that Sir William Thompson, Lord Kelvin also published material somewhat along the same line. However his method, although the same in principle, contained complications such that it was never used. Although Lord Kelvin published in 1871, there is no indication the St. Hilaire was aware of Kelvin's proposals, and in any event his method was enough different from Kelvin's that it survived where the other did not.

HISTORY OF NAVIGATION

Finding the Longitude at Sea using the Chronometer

by John M. Luykx

It was not until nearly the end of the 18th century that the marine chronometer, first developed by John Harrison, had reached a satisfactory level of accuracy and dependability so that it could be used, reliably, to determine longitude at sea. Almost all the essential features of the spring-wound, 2-day, marine chronometer, as we know it today, date from this early period; from approximately 1775 to about 1825, when chronometers gradually found their way on board both merchant and warships, especially those of the British East India Company and the Royal Navy. At this time, together with the data available in the Nautical Almanac, originally published in 1767, it first became possible to accurately determine longitude at sea using mechanical as opposed to astronomical means, although astronomical methods such as the Lunar Distance continued to be popular until late in the 19th century.

The contribution of French astronomers and horologists toward the solution of the longitude problem is, as the English one a story in itself; one which will be described separately in these pages at a later date.

To compute the longitude at sea by chronometer from the altitude observation of a celestial body, three fundamental arguments were required in order to solve the navigational triangle. These were:

a. The Time of Observation

Prior to the year 1834, Greenwich Apparent Time (GAT) was used in the Nautical Almanac to facilitate the Lunar Distance computations. However because the chronometer was rated to Greenwich Mean Time (GMT), the observer at sea was required to, not only, correct the chronometer time for accumulated error but also for the Equation of Time (Eq.T.) to obtain the GAT of the observation. It was extremely important during this early period of chronometer use at sea that the daily chronometer error and the daily rate were accurately known, for few opportunities were available to check its "going." Chronometers were usually rated to GMT at the Greenwich Observatory and the error and daily rate recorded. At sea the only method to check the instrument was by Lunar Distance (hardly reliable at best). While in port a time ball might be available in one of the larger, more important harbors, or the error of the chronometer could be computed by celestial observations from a point at sea or ashore of known longitude. The increasing value of the chronometer in computing longitude at sea (compared to the Lunar Distance) was recognized when the Nautical Almanac, in 1834, was extensively reorganized which included, among other changes, the replacement of apparent time by mean time in the ephemeris.

b. The Estimate of the Latitude

The Latitude of the observer at the time of observation was determined by dead reckoning from a previous latitude observation of either Polaris or the Sun.

c. The Position of the Celestial Body

The Right Ascension (RA) and Declination (Dec) of the celestial body, for the time of observation, was found in the Nautical Almanac. In 1952 the abridged Nautical Almanac was first published, in which the Greenwich Hour Angle (GHA) method of tabulation was introduced.

From this data, the three sides of the navigation triangle, 90-L, 90+or-D, 90-Ho were determined and the "Meridian Distance" (Meridian Angle, t) were computed using a formula such as the one given below:

$\cos t = (\sin Ho - \sin L \times \sin D)/(\cos L \times \cos D)$

For a celestial body to the East of the obs.

Longitude = RA - t, (GHA + t)

For a celestial body to the West of the ops.

Longitude = RA + t, (GHA - t)

Because the accuracy of the solution for "Meridian Distance" (t) was, to a large extent, dependent upon the value of the observer's DR latitude, accuracy in computing Meridian Distance was improved when the altitude observation was made with the celestial body (usually the Sun) near or on the Prime Vertical. Under these conditions a small error in the latitude would have little or no effect on the computed Meridian Distance.

This method of finding longitude at sea, known as the "Chronometer Time Sight" was popular with navigators until Captain Sumner ushered in the era of "Position Line Navigation" in the mid 19th century. Some navigators continue to use this method today especially on sailing or other slow-moving vessels because, if desired, no plotting on the chart or plotting sheet is necessary. The "Days Work" consists of alternately computing the latitude and then the longitude; advancing one to the other successively, resulting in a series of running fixes throughout the day.

Editor's note: The author has prepared a sample "Days Work" using the Chronometer Time Sight. Copies of this will be supplied to interested members upon request.

NAVIGATION NOTES

The Local Apparent Moon Sight

by Macey Casebeer

This article is to present an important celestial observation – an observation which has for some hidden reason almost never been discussed in detail in the literature of navigation. It is the use of the local apparent MOON sight (LAM); a single observation which upon occasion may be obtained during either daylight or night hours, when the sky and horizon are clear and the phase of the Moon provides at least a cresent (see Bowditch Vol. II, Arts. 730, 732 and 733).

In fact, a sighting of the Moon at its Meridian passage may sometimes be obtained along with observation of one other celestial body to provide three lines of position, and a respectable fix. Yet I have almost never known another navigator who has sought out and used this interesting and provocative sight. Perhaps the reason is the relatively difficult task of determining the time at which to observe LAM.

Using an hypothetical problem, here is how I have taught the LAM technique to students of Nautical Science at the University of California, Davis (UNEX):

The Problem: The sloop Random Knots is in the vicinity of 10 degrees West, 35 degrees North on 29 May 1986, approaching Gibralter. The navigator wishes to obtain an LAM before continuing into the Mediterranean. Here is what she did.

Part I. From the Yachtsman's Nautical Almanac she determined the additional time required for the Moon to make its apparent transit around the Earth; a time longer than the 24 hours which it takes the mean Sun to make its apparent movement around the Earth every day.

29 May, Greenwich Meridian
passage of Moon is
0515

30 May, Greenwich Meridian
passage of Moon is
0604

0604-0515=excess time,
beyond 24 hours, req'd
for Moon to complete
one rotation =49 min.

Without considering the 49 minute Moon time anomaly (we do that later), the Moon would arrive at 15 W longitude (the nearest standard meridian to the DR longitude of 10 W) about one hour after transiting the Greenwich meridian, as indicated in the sketch below.

The time of passage would be 0615 GMT (0515+one hour Zone Description) It would have taken 20 minutes for the Moon to pass from 10 W to 15 W (5 degrees + 4 min per degree=20 min), therefore the Moon would have appeared over over the observer's meridian 20 minutes earlier, at about 0555 (0615-20=0555 GMT).

Now the 49 minute additional moon transit time will be dealt with. Since the Moon takes 49 additional minutes in its path to circle the Earth, a fraction of the 49 minute anomaly which is attributable to the Moon's transit from Greenwich to the observer's meridian (10 W) must be accounted for. Here is how.

10/360 x 49=1.4 minutes, rounded to 1 minute. Thus it will take 1 minute longer for the apparent Moon to actually appear over the 10 W meridian, arriving at about 0556 (0555+1) GMT.

The navigator took one final step, converted GMT to Zone Time to know the time to be topside for the LAM observation. Zone Time = GMT-1 hour=0456; time of LAM.

Part II. The second phase of the problem was to take the LAM sight and reduce it to latitude and longitude lines of position. Here is how she did it:

The following data was collected:
LL/UL, HE=9ft, IC=0, WE=0
Hs=35-00.0, ZoneTime=04-54-51
Ed. Note: Altitude and Zone Time were obtained from a plot of sights taken 3, 2, and 1 minutes before the time of LAM, and 3 more sights taken after. The sights should fall on a curve rising to a maximum and falling again (for an upper transit). The maximum point gives the Altitude and Zone Time of LAM.

To determine the GMT,
04-54-51+1 hour=05-54-51 GMT

Next, find the longitude, using the Almanac daily page and the increments of corrections page: (GHA Moon at meridian passage equals longitude).

GHA Moon 356-22.5 v=9.8
Time Corr 13-05.3
v corr 8.9
GHA Moon 369-36.7
-360
GHA Moon 009-36.7 = longitude

Gather the following data from the Almanac, while getting GHA Moon.

Dec= S 19-03.0, d=12.2 (-)
d corr -11.1, HP = 58.2
Dec = S 18-51.9

Next the sextant corrections (Moon) must be applied in order to solve for latitude. These are tabulated in a+ and a - column and combined algebraically:

	+	-
IC	0	0
HE		2.9
ALT	56.5	
HP	5.5	
Sums	62.0	2.9
	-2.9	
Comb.	+ 59.1	

Hs 35-00.0
Ho 35-59.1

Before calculating the latitude the zenith distance must be determined. Zenith distance = 90-Ho, =90-35-59.1=54-00.9

Finally the latitude is determined. By examination of the sketch below it is readily evident that (in this case) latitude= zenith distance minus declination.

ZD 54-00.9
Dec 18-51.9
Lat 35-09.0 North

Summary of findings:

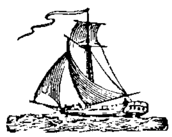
Time of LAM 0456 Zone Time
Latitude 35-09.9 North
Longitude 009-37.2 West

Had a sight of the Sun been concurrently observed, then a 3-LOP fix would have resulted - - even though the Sun line would have been weak because of its extremely low altitude at the time of observation.

There are two major disadvantages in the Moon meridian passage sight discussed above:

a. Inability to find a visible horizon at the time of LAM when it occurs at night.

b. Inability to determine precisely the instant of the Moon's meridian passage – a problem held in common with the local apparent noon sight.



Assumed Longitude by Direct Calculation

by Allan Bayless

When using a sight reduction method which requires an Assumed Position, such as DMAHTC's Pubs. 229 and 249, or Davies' Concise Tables for Sight Reduction, it is necessary to find an assumed value for Lat and Lo. Assumed Latitude (Asm L) is simple enough; it is merely the DR latitude rounded to the nearest whole degree. However finding assumed longitude (Asm Lo) can be confusing, especially where the degrees of Asm Lo differ from the degrees of DR Lo. Most books say something similar to Bowditch:

"The assumed longitude is . . . selected within 30' of the DR or EP so that no minutes of arc will remain after it is applied to GHA . This means that in west longitude the minutes of Asm Lo must be the same as those of GHA; while in east longitude the minutes of Asm Lo must be equal to 60' minus the minutes of GHA."

Direct calculation is more straightforward. Where Asm LHA is LHA rounded to the nearest whole degree, two simple equations suffice:

Asm Lo W = GHA - Asm LHA
Asm Lo E = Asm LHA - GHA

If the subtrahend is greater than the minuend, add 360 degrees to the latter to permit subtraction.

The resulting value for Asm Lo will differ by no more than 30' from the DR Lo.

Examples:

Lo West	Lo East
GHA 142-39.4	GHA 262-58.7
DR Lo - 62-46.3	DR Lo 62-46.3
LHA 79-53.1	LHA 325-45.0
Asm LHA 80	Asm LHA 326
GHA 142-39.4	Asm LHA 326
Asm LHA -80	GHA-262-58.7
Asm Lo 62-29.4W	Asm Lo 63-01.3

A Navigation Problem

Solution to the problem presented in Issue Thirteen:

15. Answer

As Kittredge notes in Self Taught Navigation, if the plotted LOP and true course are "exactly parallel, either they will fall one on top of the other, if we are Dead on Course, or the LOP will fall to one side or the other of the Course Line." The only requirement is to find the Hs (raw sextant setting) and the time for an observation at that setting when the sun's LOP will exactly parallel the course line.

Start with the exact necessary azimuth, and work the sight problem back-wards. Determine the azimuth by adding or subtracting 90x from the value of the course line. For example, if Backstaff is on a northwesterly course in September and in latitude 20x S, then the sun's contrary declination in the morning will place it, relative to the coast of Australia, on an azimuth to the northeast, and the 90x would be added to the course line to get the exact required azimuth. Next, enter tables such as H.O. 249 at the correct latitude page (same or contrary to declination, Northland Press, Flagstaff, Arizona, Fourth Edition, 1977. as the case may be). Taking the full degree value of the declination for the Greenwich date of the sight, run down that declination column until you find the exact azimuth. Hc will appear on the same line as the azimuth. In working backwards from Hc to Hs, the corrections will be applied with reversed signs. Declination poses a minor problem, as you will not yet know the exact time of the sight. You do know it will either be in the morning or the afternoon, and a rough guess as to the hour time of the observation will normally get you close enough for initial practical purposes.

Adjust your sextant to the Hs setting, and before the sun bears abeam your course start to observe it without changing Hs. At the exact moment when it lies on the horizon at that Hs setting note the time. In succeeding days, if you remain on the same true course, the same approximate time (corrected for changes in longitude) will be used to observe the sun at the same Hs setting of the sextant. Then, when you work the problem from Hs to Hc, the bearing will remain 90x to your course line, and the LOP will parallel your course. If you are exactly on course, it will closely coincide with the course line, with any variance being chiefly due to your own observational accuracy and the minor mean errors in any tabular data used.

Problem No. 16

The Greenwich date is September 29, 1986, and the Greenwich time is just after midnight. The DR position of Backstaff is 18o 30.4 South, 147o 35.1 East. The vessel is proceeding in a northwesterly direction along the Australian coast in an area to the North of Townsville. At 00-10-47 GMT the upper limb of the Moon is observed. The height of eye is 12 feet. Index error is 2' "off the arc". HS is 40o 51.0'.

(a) What extra step is necessary in making sextant altitude corrections for observations of the Moon's upper limb.

(b) What is HO and the intercept?

(c) What is the local date and time?

Notice

In March, 1987, J. M. Luykx will inaugurate a computer course in celestial navigation at the University of Maryland. The course will consist of eight two-hour sessions held weekly in the evening. It will be based on the CN 2000 navigation module with the Sharp PC 1500A hand-held computer. For further information contact:

J. M. Luykx
2021 Brooks Drive, Apt. #319
Forestville, MD 20747
(301) 420-7441

BOOK REVIEW

by Roger H. Jones

The Sextant Handbook (Adjustment, Repair, Use and History)

By Cmdr. Bruce A. Bauer, USN (Ret)
Azimuth Press, P.O. Box 4039, Annapolis, Md. 21403, 1986, 189 Pages $19.95

Commander Bauer, a former destroyer captain, presently commands a research vessel operating in Atlantic and Caribbean waters. In addition to his U.S. Navy credentials, he holds master mariner papers for merchant marine service, and he has been a senior instructor in the Master, Mates and Pilots School of Advanced Studies. His articles on the marine sextant have appeared in Cruising World and Sail magazines, and now he has combined in one volume ten modest (in length) chapters that present a virtually complete array of writings about his subject. There is nothing "modest" about the content of these chapters, however. There is a wealth of information in each of them. While book titles all too often turn out to be somewhat misleading, that is not the case with The Sextant Handbook. This is a book which every navigator would do well to keep readily at hand. It is a work which should accompany every well-traveled sextant, both at sea and ashore.

Commander Bauer leads off with a short history of the sextant and its antecedents. Immediately, one grasps that this is a "reader-friendly" work, and this remains true throughout the later, more technical chapters dealing with sextant parts, errors, methods of adjustment, maintenance, and what to look for when considering the purchase of a new or used sextant. Having taken his readers forward from the perspective of history, through the many facets of modern knowledge about the sextant and its use, the author then concludes with a look into the future at the sextants of tomorrow. It is reassuring to note that Commander Bauer shares a basic tenet of this Newsletter that the sextant's importance remains undiminished in the world of the mariner of today and tomorrow.

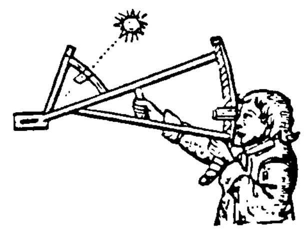
For generations, traditional wisdom has been that he who is at sea would do well to leave his sextant alone and not "worry" it with too many adjustments that are better left to the technicians ashore. Bruce Bauer would be among the first and the last to defend the notion that the sextant is a precision instrument that must be treated with respect, but his theme is that it is also a remarkably durable instrument that will better serve its user if the latter can gain the insight and understanding to make the many adjustments and to perform the maintenance that remains neglected aboard many a vessel.

Elements of the sextant, attachments and accessories, care and repair, and how to make an intelligent purchase of a sextant are all matters in which Bauer provides both insight and confidence. His illustrations seem to be just right—there are not too many and not too few, and each one seems to do the job assigned to it. At this point, roughly halfway through the book, Bauer launches into his treatment of sighting techniques, correcting the sight, timing the sight, and the search for the stars. Again, he provides insight and confidence for his readers. Throughout, he deals with the specifics that do not often appear in the major works on navigation and the sextant. Thus it is that the reader now has at his fingertips information on emergency mirror silvering techniques, discovering whether a sextant has been dropped, and many useful bits and pieces of information on how to really use the sextant in the real world ofthe pitching vessel and the false horizon.

The book has received widespread attention in the few short months since its publication. It has been variously described as "fascinating," "a standard reference," and a "classic." In a more specific vein, we would add our own thought: it is a work which fills a definite void; to our knowledge there is no other modern book about the sextant that presents both the scope and depth of material that has been assembled by Commander Bauer.

Address all correspondence to:
The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850
Telephone: (301) 622-6448

THE NAVIGATOR'S NEWSLETTER



FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

ISSUE FIFTEEN, FALL 1986

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

Foundation Welcomes New Members

As a result of our most recent mailing we welcome aboard a group of new members. In the mailing we included a copy of issue 9 as a sample of the Newsletter. As you can see this issue is number 15. For those who are interested in establishing a file of Newsletters, all earlier issues are available at $2 per copy. Some of the new members have already responded with commments as can be seen in the Reader's Forum. We consider this an important part of the Foundation's effort and encourage comment, criticism and questions.

Books For Members

Shortly all members will have received a copy of our new Book Catalogue. The catalogue includes charts as well as books and offers substantial discounts.

The Library of Congress has issued us a number called an ISSN number, which you will find displayed on the upper right corner of the front page. The purpose of the number is to uniquely identify the title of a serial or periodical publication. The program is international in scope and is administered from a center in Paris. The U.S. program is administered by the Library of Congress. Our number is ISN 0890-5851.

Errata

Our new director John M. Luykx has called attention to an error in the brief biographical note in the last issue: he has not served in an LST. He has however, in 23 years of service in the navy, had extensive experience in navigation including tours aboard two destroyers, two cruisers, an amphibious command ship and a fleet command ship. He has also served as flag and staff navigator.

On the subject of corrections, it appears that the article "Assumed Longitude by Direct Calculation" did not print out as intended. The columns of numbers did not line up as they should have, there were no lines indicating the sums and the algebraic signs were not set off in parentheses. All of the numbers were correct and can, with some difficulty, be deciphered. Apologies to Allan Bayless.

Navigation Puzzlers

One of our functions is to try to answer questions that may have puzzled our readers, and we try to do our best. The latest comes under the heading of "navigational trivia" but is a real puzzler. A member has asked what word is abbreviated by the letter "v" in the Nautical Almanac, at the foot of the GHA columns for the Planets and beside each GHA for the Moon. The number is used in interpolation, as is the "d" in the declination column, however it does not represent quite the same "difference" as the "d" does. The Almanac Office says that they can only guess at the origin of the letter "v" but it probably comes from "variation."

We have had a number of requests for solutions of the navigation problems in advance of waiting for the next issue. In addition we also have had requests for the sample "time sights" offered in the last issue. We are glad to comply with such requests from anyone who will send a stamped self addressed envelope.

We might point out again that the Foundation has a telephone number, shown at the end of each issue. This is to provide assistance more promptly than possible by mail. There will always be either a tape or a live answerer to take your calls.

Classifieds?

It has been suggested that a classified ad section might be of service to our members who are looking for some navigational device or have one for sale. We would be interested to have comments on this idea.

READERS FORUM

Randi Bennett of Bennett Marine Video, 730 Washington Street, Marina del Rey, CA 90292 (213-821-3329) writes:

After reviewing your newsletter, we realized that we have two specific products that would be of interest and value to your readership--a complete course on CELESTIAL NAVIGATION and another on COASTAL PILOTING on videotape. These excellent videos are appropriate for both the boater and the aviator in terms of their navigational information. Both have sold well through ads in Ocean Navigator and Cruising World magazines at our retail price of $49.95 plus $3.00 postage and handling.

Please contact us for further information.

Member Joseph M. Hallissy of Hampton, VA writes:

Two pieces I particularly liked (In the most recent copy of the Newsletter) were the two historical notes: "Marcq Saint Hilaire", by T.D. Davies and "Finding the Longitude at Sea using the Chronometer", by John M. Luykx. In connection with this second piece, I would like to have a copy of the sample "Days Work using the chronometer Time Sight as offered by the author.

A subject I would like to see treated sometime in a future Newsletter is the cosine-haversine formula----what it is, and how it came about. [Although I am a graduate engineer, I have to admit that I don't even know what a haversine is, except that it is a trigonometric function.] My assumption has been that solutions to navigational problems using the haversine function developed either because the form was simpler (and therefore required fewer look-ups in the log tables), or because the accuracy was better in certain ranges of variables. This is the subject area I would like to see explained.

Member Vincent Saltarelli of Millstone, NJ writes:

To introduce myself, I am a dues paying member of the National Maritime Union (NMU), having sailed as able seaman and 'bosun' which classifies me as an "unlicensed seaman". I made my last trip to sea in January 1984 and there is little hope of ever returning to sea. I receive monthly disability benefits from Social Security.

I must join your association because "The History of Navigation", I'm sure is of interest to people in all walks of life.

Please allow me to make a correction, (Vespucci) of which, by now, you are probably aware: The Italian word "bussola", from an Italian dictionary, is an "instrument furnished with a magnetic needle (that would) always point towards north". It is, of course, our "magnetic compass" that is housed in the binnacle. As you wrote in the third paragraph: "The whole was housed in a box, call in Italian "bussola", which we call "binnacle", is a misinterpretation of nautical language. "The whole", instead, "was housed in a box, called, "abitacolo". "Bussola giroscopica" would be our gyro compass, so the confusion is profound, and it is indeed derived for Vespucci's "floating needle", the "calamita". "Chiesola/chiesuola" would be another variant for "binnacle", e.g., (small country church). "Bussola", figuratively speaking, also means, "to lose one's bearings", when speaking in Italian, "perdere la bussola". In other words, it all derives from what Vespucci "mentions the floating magnetic compass in a fragmentary letter of 1503".

(Ed note: Member Saltarelli gives the correct translation in modern Italian; Vespucci's writing was in 1503 and he included Spanish and Portuguese words. In the Portuguese and Italian of that period "bussola" was defined as the "box that held the compass." Depending upon your definition of the compass this could either be the bowl of the compass or the binnacle to which the gimbals are attached. I am indebted to Mr. Saltarelli for his clear explanation and his helpful interest in this subject.)

Member Erving Arundale of South Yarmouth, MA writes:

Coastal navigators, and students of Piloting and Advance Piloting, are well aware of the tedium involved in the calculations (and distance measurements) which are necessary to establish a vessels periodic Dead Reckoning Position. To markedly simplify this important navigational procedure, a "Dead Reckoner" has been developed for use with coastal charts (of scale 1:80,000) and for speeds of 6-19 knots thereby avoiding the need for such DR calculations and distance measurements. This "Dead Reckoner" comprises seven time-graduated strips (two speeds on each strip) with adhesive backing which can be cut out and placed on waterproof 2 inch wide backing strips (of any suitable material) for use afloat or in the classroom. The strip for a desired speed is placed along the vessels DR track with the Zero time mark at the known point of departure. The vessels Dr position can then be easily established and plotted for any time from 5-60 minutes from the time of departure. It can also be used to estimate the anticipated time of arrival at specific way points or the vessels destination and to check the vessels position along the track by periodic depth soundings. Other uses will be apparent to the coastal navigator.

Copies of this "Dead Reckoner" can be obtained by sending a check for $7.00 (to cover the costs of printing, handling, and mailing to:

Erving Arundale
232 Blue Rock Road
South Yarmouth, MA 02664
Additions to Reader's Forum

Member James N. Wilson writes from Pasadena, CA:

In the fall 1986 letter on the local apparent moon sight, reader Casebeer spent a lot of effort calculating the time of meridian passage, when a very simple approach produces this with adequate accuracy for determining when to start taking sights. More significant, she (the navigator in Casebeer's example) neglected a most important correction, that due to the rate of change of declination. This accounts for over three minutes difference between the time of highest altitude (which is what is measured) and the desired time of meridian transit. As a result she is actually 42 miles east of her calculated position, but fortunately still west of Gibraltar. North-south velocity can also have a significant effect on the time of highest altitude, in this case 17 seconds for each knot.

Using the Nautical Almanac yellow pages (column for the moon) part I could be done like this, neglecting the effect of v, since only the approximate time is needed:

May 29, 1986

Longitude 10 W
GHA Moon at 0600 GMT 10-51.3
difference -51.3 = -3m 35s

GMT 05-56-25
ZD +1 (rev)
ZT 04-56-25 Approx. time of meridian transit

From my paper, "Position from Observation of a Single Body", *(Ed Note: an excerpted version of Mr. Wilson's paper appears in NAVIGATION NOTES, this issue).*

Lat 35 N, Dec 19 S, K=16(1.07)=17
d=+12.4 (changing northerly)

Correction = K(Sn-d)
=17(0-12.4)= -211s = -3m31s

So meridian transit occurs 3m31s before time of highest altitude, which would occur at ZT 04-59-56.

In part II, presuming an LL sight, and assuming the vessel has no northerly velocity component, I compute the following:

Time of highest altitude 04-54-51
WE 0
Correction (-) 3-31
ZT 04-51-20
ZD +1
GMT of meridian passage 05-51-20

GHA Moon at 0500 GMT 356-22.5
51m 20s 12-14.9
v = 9.8 51m 8.4
Longitude 8-45.8

Dec at 0500 GMT 19-03.0 S
d=-12.2 51m (-) 10.5
Dec= 18-52.5 S

Hs 35-00.0
IC 0.0
Dip -2.9
Ha 34-57.1
Correction 56.5
additional 5.5
Ho 35-59.1
90 - Ho 54-00.9
Dec = 18-52.5 S

Latitude 35-08.4 N

Summary of correct findings:

Time of Meridian Passage=0451 ZT
Latitude = 35-08.4 N
Longitude = 8-45.8 W

Mr. Casebeer's first concluding observation is correct, but use of the equal altitudes method as described in my paper can allow determination of the time of highest altitude with sufficient accuracy. I enclose a copy.

The use of the moon for determining position near meridian passage is potentially valuable, and my method makes it practical. Instead of "Local Apparent Moon" which has no meaning, I would suggest calling it the Moon Meridian Passage method, so the navigator couldn't be accused of "Taking it on the LAM."

Member Walter H. Johnson of Annapolis writes:

Some time ago I attempted to write a computer program for the determination of LAM but had trouble with cases involving East longitude. The recent article by Macey Casebeer caused me to rewrite the program which now seems to work properly. I know that the foundation is not particularly interested in computer programs, per se, but I believe that the basic procedure should be of interest. I am enclosing a short description of this procedure together with several examples using a print-out program.

In order to keep the description short it applies only to situations in west longitude. Some of the examples included, however, involve positions in east longitude. To check the accuracy I have computed GHA (moon) using the Almanac and the computed time of LAM. In all cases the position of LAM agrees with the computed position within a fraction of a minute of longitude.

I realize that all of this is academic; the small errors in steering and those caused by wind and current will greatly increase the probable error. Theoretically, however it is possible to determine the time and position of LAM very precisely.

(Ed. note: See also article in NAVIGATION NOTES this issue. Readers who would like a copy of the description and examples mentioned should send a stamped self-addressed envelope to Box 1126, Rockville, MD.)

NAVIGATION BASICS REVIEW

Computing the Local Hour Angle and Meridian Angle, Using the Time Diagram

by John M. Luykx

When using modern sight reduction methods, the procedure for determining the Line of Position (LOP) from the altitude observation of a celestial body requires a solution for both computed altitude (Hc) and computed true azimuth (Zn). These values are obtained either by a) trigonometric computation, b) sight reduction table or c) navigation calculator.

To obtain Hc and Zn, three fundamental arguments are required in the solution:

1. The Latitude (Lat) of the observer.
2. The Declination (Dec) of the celestial body.
3. The Local Hour Angle (LHA) and/or meridian angle (t) of the celestial body.

Of these three arguments the first two are easily determined:

1. The latitude is obtained directly from the vessel's DR position on the chart or plotting sheet.
2. The declination is found in the Nautical Almanac for the time of observation.

The LHA and t, however, must be computed from values of the Greenwich Hour Angle (GHA) of the celestial body (found in the Nautical Almanac for the time of observation) and the Longitude (LON) of the observer obtained from the DR position on the chart. The computation of LHA and t is based on the following relationships:

1. LHA = GHA + East Longitude
   LHA = GHA - West Longitude

2. When LHA is less than 180 deg, tw = LHA, and
   When LHA is greater that 180 deg, te = 360-LHA

LHA and t may also be shown graphically by a Time Diagram (figures 1 and 2) in which a projection of the Greenwich, Observer and Celestial Body meridians are depicted on the plane of the celestial equator viewed from above the South Celestial Pole.

The observer's meridian M is oriented toward the top of the diagram. The Greenwich meridian is marked G and the celestial body meridian is marked by the appropriate symbol; i.e. Sun☉, Moon☾, Venus♀, Jupiter♃, and star ✱, etc.

In the Time Diagram, westerly directions are shown counter-clockwise and easterly directions shown clockwise. In Figure 1, for example, the meridian of the observer, M, located at longitude 75 W is shown 75 deg counter-clockwise from the Greenwich meridian, G. The GHA of the Sun is given as 300 deg; therefore the meridian of the Sun is shown at an angle measured 300 deg counter-clockwise from the Greenwich meridian, G.

Figure 2 shows how the values of LHA and t may be computed from the relationships that exist between the observer's meridian, the Greenwich meridian and the celestial body meridian as pictured in Figure 1.

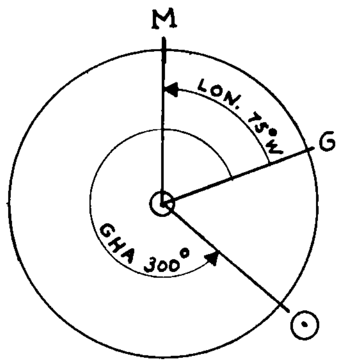
1. LHA = GHA -LON
   = 300 - 75
   LHA = 225

2. te = 360 - LHA
   = 360 - 225
   te = 135

Figures 3 through 6 are typical examples of the use of the Time Diagram in the solution for LHA and t from given values of observers Lon and celestial body GHA. In each of these four figures, two solutions for LHA and t are provided:

1. Solution #1 shows the calculations in cases where the DR position is used as the observer's position and exact values of LHA and t (to the nearest tenth of a minute of arc) are required. The observer's DR position is normally used to compute LHA and t when sight reduction is accomplished by either trigonometric computation, by calculator or by certain specific sight reduction tables such as HO 211.

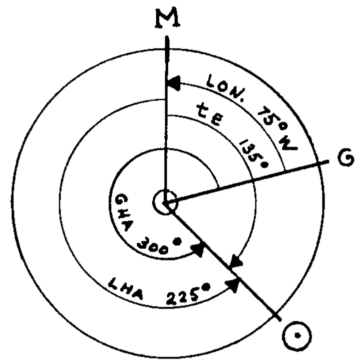
TIME DIAGRAM SUN



GIVEN: LON: 75°W
GHA: 300°W

Figure 1

TIME DIAGRAM SUN



FIND: 1. LHA (LHA = GHA - LON)

GHA: 300°
\- LON: 75°
= LHA: 225°

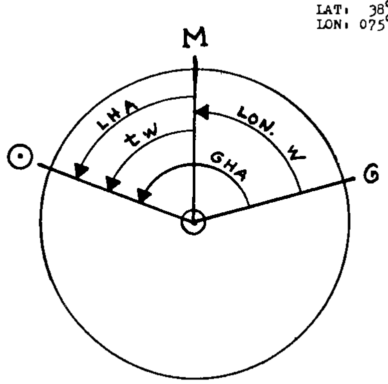
2. t (t_e = 360° - LHA)

Full Circle: 360°
\- LHA: 225°
= t_e: 135°

Figure 2

TIME DIAGRAM SUN

DR POSITION
LAT: 38°47:6N
LON: 075°04:8W



GIVEN: LON: 75°04:8W
GHA 145°29:7

FIND: LHA: ________
t: t: ________

SOLUTION: LHA=GHA-LON
t_W=LHA

SOLUTION #1

LHA/t
GHA: 145°29:7
\- LON: - 075°04:8W
= LHA/t_W = 70°24:9

SOLUTION #2

GHA: 145°29:7
\- aLON: 075°29:7W
= LHA/t_W: 70°

DR POSITION

LAT: 38°47:6N
LON: 075°04:8W

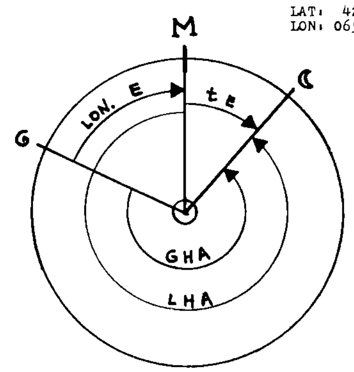
ASSUMED POSITION

aLAT: 39°N
aLON: 075°29:7W

Figure 3

TIME DIAGRAM MOON

DR POSITION
LAT: 42°33:6S
LON: 065°26:7E



GIVEN: LON: 065°26:7E
GHA: 255°14:3

FIND: LHA: ________
t: ________

SOLUTION: LHA = GHA+LON
t_e = 360°-LHA

SOLUTION #1

LHA
GHA: 255°14:3
+LON: 65°26:7E
=LHA: 320°41:0

t
CIRCLE: 360°00:0
\- LHA: 320°41:0
= t_e: 39°19:0

SOLUTION #2

GHA: 255°14:3
+aLON: 065°45:7E
= LHA: 321°

CIRCLE: 360°
\- LHA: 321°
= t_e: 39°

DR POSITION

LAT: 42°33:6S
LON: 065°26:7

ASSUMED POSITION

aLAT: 43°N
aLON: 065°45:7E

Figure 4

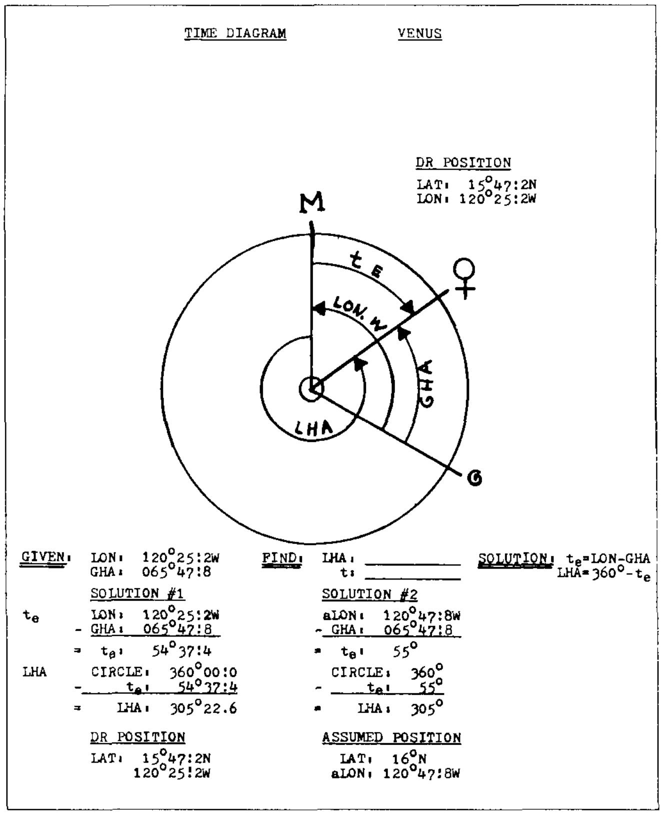


Figure 5

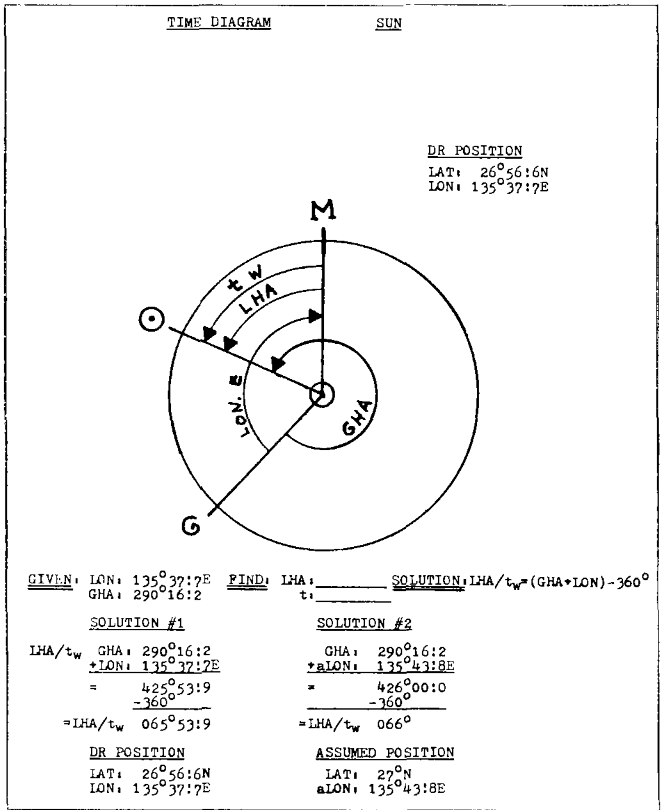


Figure 6

2. Solution #2 shows the calculations of LHA and t from an Assumed Position, the Assumed Latitude (a Lat) and the Assumed Longitude (a LON) in which the values of LHA, t and LAT are computed to the nearest whole degree rather than to their exact values. This is necessary because the values of LHA, t and LAT in the latest sight reduction tables (HO 214, HO 229 and HO 249) are tabulated only to the nearest whole degree. In these computations, aLAT is equal to the whole degree of latitude nearest to the DR latitude, and aLON is that value of the DR LON, which when applied to the GHA results in a whole degree of LHA and t.

In the next issue of the Newsletter we will discuss the altitude intercept method of plotting lines of position first developed and published by Captain Marq St. Hilaire of the French Navy in 1875.

NAVIGATION PERSONALITIES

Thomas Hubbard Sumner

by T. D. Davies

In volume I of *The American Practical Navigator* (Bowditch) there is a section on the history of navigation in which the name of Captain Sumner is to be found under the heading "The line of position." There follows a description of the concept of the line of position, and the details of its "discovery" by the 30-year-old merchant captain. Although Sumner's method at its inception included the solution of two "Time Sights," the name was extended to the generalized line of position as developed later by Marq St. Hilaire. In the last issue of the Newsletter John Luykx described the Time Sight in his article "Finding The Longitude At Sea Using The Chronometer." The discovery of the fact that two sights determined a line which must include the ship's position is described in the Bowditch article and in the book which Sumner published in 1843, *A New And Accurate Method Of Finding A Ship's Position At Sea.*

The details of Sumner's career are not so well known. One of eleven children, Sumner was born in Boston, March 20, 1807. His father was Thomas Waldron Sumner, an architect who was elected to Congress and served from 1805 to 1811 and from 1816 to 1817. Young Sumner was sent to Harvard where he graduated with the class of 1826. Shortly thereafter he shipped for China as an ordinary seaman thus beginning his long career at sea. In 1834 he married Selina Christiana Malcolm and thereafter they raised four children. His epoch-making discovery occurred on a voyage from Charleston, S.C., to Greenock, England in November 1837, apparently while serving as navigator, since he did not achieve the rank of Captain until 1847.

His book was published in 1843 and created immediate interest and comment throughout the maritime community. As early as May 1843 there was a report of a board established by " The Naval Library and Institute" of the U. S. Navy, to investigate Captain Sumner's new method. Their conclusion was that the method would prove a "useful auxiliary" to the present knowledge of Navigators, and recommended it to the attention of all persons interested in the promulgation and improvement of Nautical Science. The report was signed by Lieutenants James Alden, Sam'l R. Knox and Passed Midshipman George H. Preble. Other commendatory articles were published by Lieutenant Raper RN and Lecky. Even Lord Kelvin gave the method high praise in a lecture at Glasgow.

From this pinnacle of success Captain Sumner's subsequent career apparently was not a happy one for very long. His book was published in 1843 and the comments mentioned above were made in the years immediately following. By 1850 he had apparently become incurably insane, confined in the McLean Asylum near Boston. By 1852 his wife petitioned Congress for a gratuity in consideration of her husbands great discovery, and in 1854 Congress approved an act for the purchase of the copyright of his work, apparently in satisfaction of the petition.

Although the Sumner Line has become a foundation stone of almost all modern methods of navigation, the memory of Sumner, with one exception, has been limited to repetition of the name in navigation texts. In the Nautical College that existed in Hamburg , Germany before World War II, there existed a bust of Captain Sumner displayed on the outside wall together with a bust of the great cartographer Gerardus Mercator (real name Gerhard Kremer). How these survived the war is not known. Perhaps a german member could enlighten us. In any event his place in the art of navigation is secure.

HISTORY OF NAVIGATION

More On Finding the Longitude at Sea Using the Chronometer

by John M. Luykx

As in England during the second half of the 18th century, extensive developments in chronometer design were also carried out in France, especially by the two eminent horologists, Ferdinand Berthoud and Pierre Le Roy.

As early as 1763 Berthoud had completed his first "Horologe Marine" and subsequently was commissioned by the Minister of Marine to construct two machines, his #6 and #8, for the King. These were tested at sea in 1768-1769 aboard the frigate "L'Isis." #8 was particularly successful and won for its designer a pension and the appointment of "Horologer de la Marine."

Le Roy also completed his first marine clock an 1763 which was presented to the "Academie des Sciences." In 1766 he completed his masterpiece, the "Montre Marine", on which his fame as an horologist is based. It was submitted for the prize offered by the Academy in 1766. Trials, however, were not conducted with it (and a duplicate) until the following year. Athough this first trial was successful a second trial of the two machines was conducted in 1768 aboard the frigate "L"Enjouee" during a voyage from Le Havre to Newfoundland and back to Brest. As a result of this trial Le Roy was awarded a double prize for the "Montre Marine." Trials were also conducted in 1771 by the Academy and Le Roy again won with his time keepers.

As an example of the use of the chronometer in determining longitude at sea during the late 18th century, the following account is based on the report of the trial of Berthoud's #8 machine conducted in 1768-1769 aboard the frigate "L'Isis." It shows the calculations in somewhat rearranged form, involved in the actual sight reduction of a star observation on the night of 29 March 1769 to obtain the ship's position.

A. Navigation Data

Frigate L"Isis enroute Canary Islands to Cap Blanc (NW coast Mauretania) on course 174 true, speed 4 knots. Noon latitude by observation, 27-30-17. Chronometer (Berthoud #8) daily rate = -8.55 seconds per day

B. Evening Star Observations, Rigel, 29 March.

Time	Altitude
7h 50m 49s	38-43-45
7 53 54	38-11-30
7 57 14	37-30-15
7 59 53	36-58-20
Averages	
7 55 27	37-50-53
Corrections	
+ 29 14	Dip -3-30
+20	Ref -1-14
	Ho 37-46-09

Corrections to time are for daily rate to 27 March, and thereafter to 29 Mar.

Final Paris Mean Time of the observeration was 08h 25m 01s, and the run up latitude for the time of observation was 27-02-29 N.

Sight reduction was by a formula derived by Jean

Charles de Borda (1733-1799):

Sin t / 2 = (sec L x cosec p x cos S x sin(S-h))to the one half power

Where t=meridian angle, L=DR latitude, p=polar distance (the declination of Rigel, expressed as angular distance from the north celestial pole, in this case taken as 98-29-09 since Rigel is in south declination),h=observed altitude and S=(h+L+p)/2. This equation gave t(arc) = 39-31-04, which converts to t(time) = 2h 38m 04s i.e. the meridian angle of Rigel at time of sight.

To convert this to longitude the Right Ascension (RA) of Rigel (from the Almanac) was compared to the RA of the Apparent Sun and the difference added to the meridian angle of Rigel of 2h 38m 04s. This gave an apparent time for the observation of 7h 06m 34s, and a mean time of:

7h 11m 13s
Paris Mean Time 8h 25m 01s

Time difference 1h 13m 48s

Difference in Arc 18-27-00

Of course the time difference expressed in arc is the longitude, in this case measured from Paris. Latitude from the noon observation (run up) was recorded as: 27-02-29 N.

NAVIGATION NOTES

Position From Observation of a Single Body

By James N. Wilson

(Ed. note: Because of its close relationship to the article on the "Local Apparent Moon Sight" in the last issue, this article from "Navigation" is excerpted here. It introduces an important correction that was not included in the previous article.)

Figure 1 is a plot of altitude vs time, illustrating that north-south vessel motion produces a time of highest altitude different from that of a fixed observer. Declination rate of change has a similar effect on time of highest altitude, and may be dominant for the Moon.

Thus the time of highest altitude is different from the time of meridian transit. In using the double altitude method (see Bowditch, Vol.I), this difference is independent of how long before meridian passage the initial altitude is measured, because it is due solely to vessel velocity and rate of declination

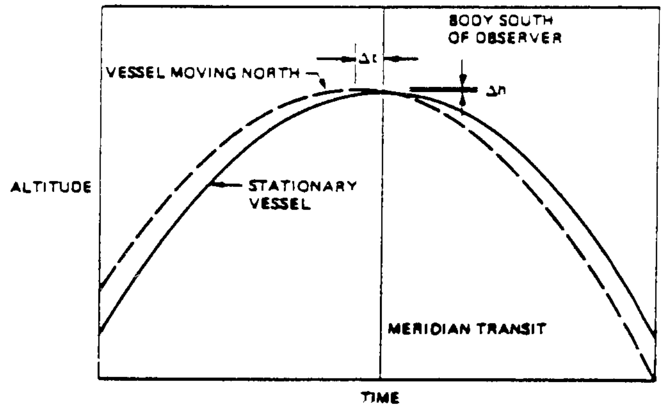


Figure 1
Altitude vs. Time

change. A correction can be applied to the calculated time of meridian transit or to the time average of equal altitudes. Presuming constant speed and course, a quite accurate calculation for the Sun can be made by using the following equations:

LAN = time of highest alt. + delta t

delta t = 48/Pi x (Sn - d)(tan Lat-tan Dec)

Where; delta t = correction in seconds

Sn = north-south vessel motion

d = hourly declination change
(+ if changing northward)

Dec and Lat are both + when north.

The equation for the calculation has been plotted in Figure 2. Entering with Lat and Dec, paying attention to whether they are in the same hemisphere or the opposite one, a value of K can be selected (note: multiply K by 1.07 when using it for a Moon sight). Read K only to the nearest whole unit; interpolation isn't warranted for usual small boat speeds. Multiply K by (Sn-d), keeping track of signs, and delta t results. Add it algebraically to the time of highest altitude to obtain the time of LAN. Note that d may have a different sign from that used for declination computation. For latitudes in the southern hemisphere, reverse the sign of K.

For normal sights an observational error translates directly into a position error, so a 1min error in sextant altitude results in a 1 mile error in the line of position. However in attempting to determine longitude by double altitudes any observer error is significantly (repeat significantly) magnified.

One way to minimize this error is to take the first sights 20 to 30 minutes before meridian transit, but longitude errors are still 2 to 10 times the altitude errors. Another way is to plot Hs vs watch time (WT)

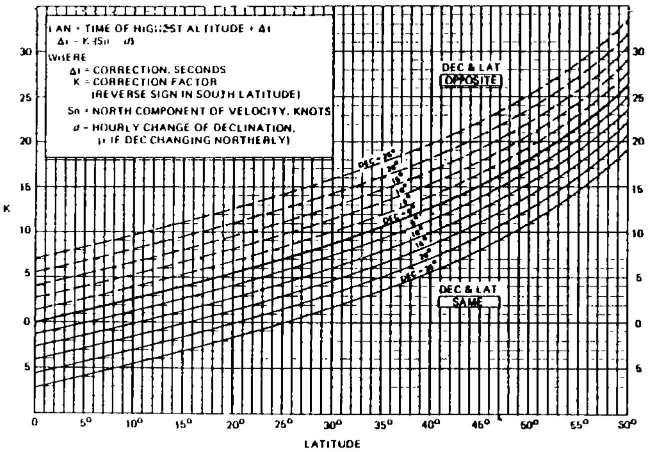


Figure 2
Correction Factor for Time of Sun's Meridian Passage

and fair a straight line thru the plotted points, to select the best Hs.

The following method was derived to obtain a reasonably accurate fix from a series sights near meridian transit, presuming course and speed are constant.

1.About 20 or 30 minutes before meridian passage, record a run of five or more sights. Plot Hs vs WT while waiting for the body to approach maximum altitude; Figure 3 shows such a plot.

2.Record enough sights near meridian transit to be sure that the body has attained and passed maximum altitude, and that meridian transit has occurred. Plot these on a compressed WT scale, so that the body's altitude arc can be faired through the normal Hs scatter. This is used for latitude determination.

3. When Hs has decreased to the highest value of the first run, record another run of at least five sights.

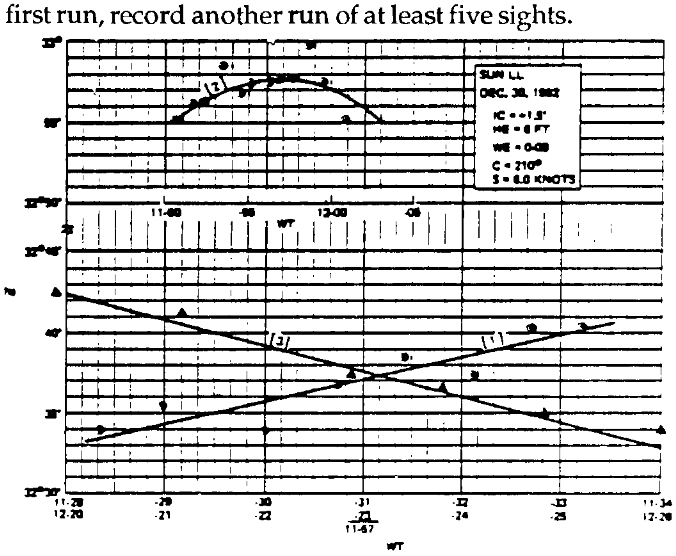


Figure 3
Plot of Illustrative Example

Now a helpful trick. On the same plot, create a second WT scale directly under the first one. To facilitate averaging, start it an even number of minutes later than the first scale. Plot the last run of sights using this scale. Straight lines faired through each of the two sets of points will intersect at a pair of times when altitudes before and after meridian transit are equal. The average of the times from the two scales is the time of highest altitude. Average only the hours and minutes just before the intersection, then read the seconds directly underneath it.

Then determine the delta t corection from the equation or obtain K from Figure 2 and multiply by (Sn-d), paying attention to signs. Apply this correction to the time of highest altitude to obtain the time of meridian transit, after which latitude and longitude can be calculated.

The New "Floppy Almanac"

by Allan Bayless

The "Floppy Almanac" is an innovation for microcomputers introduced by the US Naval Observatory a few months ago. . incorporates data from several publications on a single diskette, among them "The Nautical Almanac" and "The Air Almanac."

The diskette is of particular interest to navigators as it will list the GHA, Dec, Hc and Zn of any body at any time for any location as well as the altitude corrections and their sum to be applied to hs (except, of course, dip and IC). This applies to stars as well as the sun, moon and planets. The GHA of Aries appears as well. Further, it provides the time and azimuth of rising and setting and the time and altitude of meridian transit of any body. If, instead of specifying a single body, one asks for data on "all," it will provide these data for all bodies above the horizon, visible or not. The listings may also be for various intervals of time and for a specified number of times.

The times of nautical and civil twilight would have been of value in sight planning, but, unfortunately, have not been included. Also, it would have been helpful to include the LHA of Aries as well as its GHA.

Accuracy is consistent with that of "The Nautical Almanac (0.1-0.2' of arc)," except in the case of Venus where no adjustment has been made for phase (errors up to 0.5' of arc may result).

There are many additional features that will greatly interest professionals and amateurs in other fields, but which are of relatively little concern to the navigator.

The use of an arithmetic coprocessing chip is advised in the documentation because of the double-precision calculations required for the astronomical data. Waiting periods of about 30 seconds seem average for my 3.6 MHz 8088 processor and would be expected to be more like 6 seconds with the additional chip. The navigational calculations are sufficiently rapid without it, so it isn't vital. However, in ordering the disc, it is necessary to specify whether it is to be used with a coprocessor or not. The disc is presently available for MS-DOS operating systems although other versions are anticipated. Also, at least 256K of memory are required.

The documentation provided with the disc is very complete. Simplicity and ease of use were important considerations in design and this is very evident in the result. There are several ways to enter the required data and several ways to indicate the body desired so that one may likely use "whatever comes naturally." The glossary from the 1987 "Astronomical Almanac" is included as an appendix and will be useful in defining unfamiliar words or phrases.

This innovation is a valuable new tool for those navigators equipped with a microcomputer and may prove an inducement to those who are not to explore the capabilities of these wonderful instruments.

Each Floppy Almanac diskette is $20, and includes one copy of the paper documentation. Additional copies of the documentation may be ordered for $4 each. Payment is by check only and should be enclosed with the order. Checks should be made payable to "U. S. Naval Observatory", and mailed to:

Nautical Almanac Office
Code FA
U. S. Naval Observatory
Washington, DC 20390-5100

MARINE INFORMATION NOTES

provided by Ernest Brown

Disposal of Notice to Mariners

The latest edition dates of the Summary of Correction volumes are:

Volume 1 APR 86
Volume 2 JUN 86
Volume 3 JUL 6
Volume 4 JAN 86
Volume 5 MAR 86

All effective chart and publication corrections contained in Notice to Mariners numbers 75-27 of 5 JUL 75 through 85-16 of 20 APR 85 have either been incorporated in the above summary volumes or new editions of charts and publications to which they apply have been issued since Notice to Mariners number 85-16. Accordingly, Notice to Mariners numbers 75-27 through 86-16 may be disposed of.

Navigator Fined

MOSCOW - Sergei Stepanishchev, chief navigator of the Soviet cruise liner Mikhail Lermontov which sank of New Zealand Feb. 16, has been given a suspended four-year prison sentence and a $29,000 fine for his part in the sinking, the government newspaper Izvestia said Saturday. All 409 passengers and all but one of the 329 Soviet crew were evacuated during a night rescue in poor weather.

BOOK REVIEW

by Roger H. Jones

Celestial for the Crusing Navigator

by Merle B. Turner

Cornell Maritime Press
Centreville, Maryland 21617
First Edition, 1986, 222 pages, $14.95

Merle Turner has been a practitioner of celestial navigation for more that forty years. His voyages have included the sailing, with his wife, of a 35-foot ketch from California through the Marquesas and Tahiti to New Zealand. In his Introduction, he also admits to an academic background. It becomes evident to the reader very early that Turner has combined the scholar's penchant for detail and historical perspective with the practical seaman's ceaseless quest for a nice balance between simplicity and subject matter thoroughness. With obvious relish, he confesses that he remands to his footnotes "historical asides, mathematical embellishments, and details not entirely germane to the ongoing argument . . . a tease for those happy masochists who sense that there is more to a subject than meets the casual eye."

This reviewer read the footnotes as well as the text, and was intrigued to learn, for example, that the best hour glasses for time-keeping aboard the old sailing ships used pulverized eggshell for uniformity of grain. The seamen of yesteryear learned that this "sand" flowed faster if heated, and by warming the glass they could make their watch on deck pass more quickly. Not to be outdone by the historical, the technical plums in the notes are also intriguing, one example of which is Turner's presentation of a method for checking the compass while underway. This involves double or equal altitude observations, one in the morning and one in the afternoon, with noon falling midway in time between the two.

The text proper is addressed to those who are willing to venture ever so slightly into the technical realm. Thus it is that Turner resurrects the basic trigonometric equations and ties them in very nicely with the hand calculator methods that have freed some mariners from total dependence upon sight reduction tables. The tables are not foresaken by Turner, however. He presents a completely adequate treatment of them. He merely reverses the more "traditional" approach by placing the greater emphasis on calculator procedures. In this he shines. His book is a little more than some recent calculator compendium offerings. It does a particularly nice job of telling the novice what keys to push and in what exact sequence.

In organizational approach, Turner is conventional. He starts with a good explanation of terrestrial and celestial coordinates, proceeds with an equally good treatment of time, and then launches into navigational astronomy and the celestial triangle. His remaining substantive chapters are devoted to sight reduction, the sextant, star identification, finding latitude and longitude, and the sailings. Predictably, he concludes with a chapter on navigational practice.

This reviewer was glad to see the plane and parallel, traverse, great circle and Mercator sailings included. They are often omitted form modern works, but every cruising navigator should have some working knowledge of them. Turner's contribution in this area has the technical flavor of the rest of the book, but it is more succinct than many, and is therefore maybe less intimidating. It is also in this area that the calculator approach is thought to emerge as truly superior to one relying on sight reduction and/or log tables.

In each new book on celestial navigation there seems to be one or more little gems of almost forgotten wisdom lurking in obscure places in the text. In Turners's book there are several, not the least of which is his presentation of the method for finding latitude (not longitude) from the timing of sunset.

Gems of history and wisdom are combined with the technical underpinnings of the celestial art. They emerge from Turner's oven as a casserole for the cruising navigator, served up in a seven by ten inch container only three-quarters of an inch thick. Turner set out to achieve the practical directness of a primer, and to build upon something more than a superficial treatment of nautical astronomy. He has succeeded well.

Address all correspondence to:
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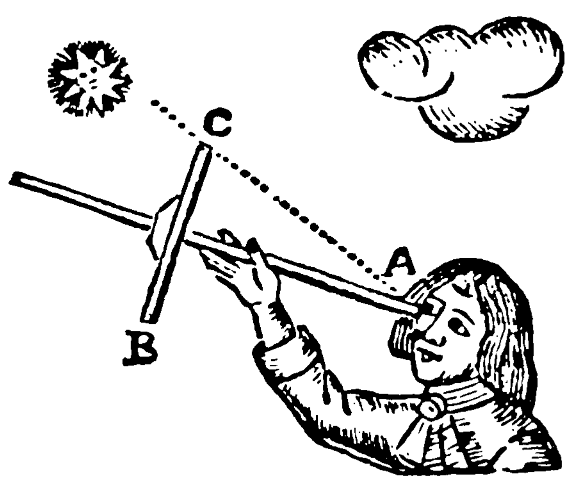

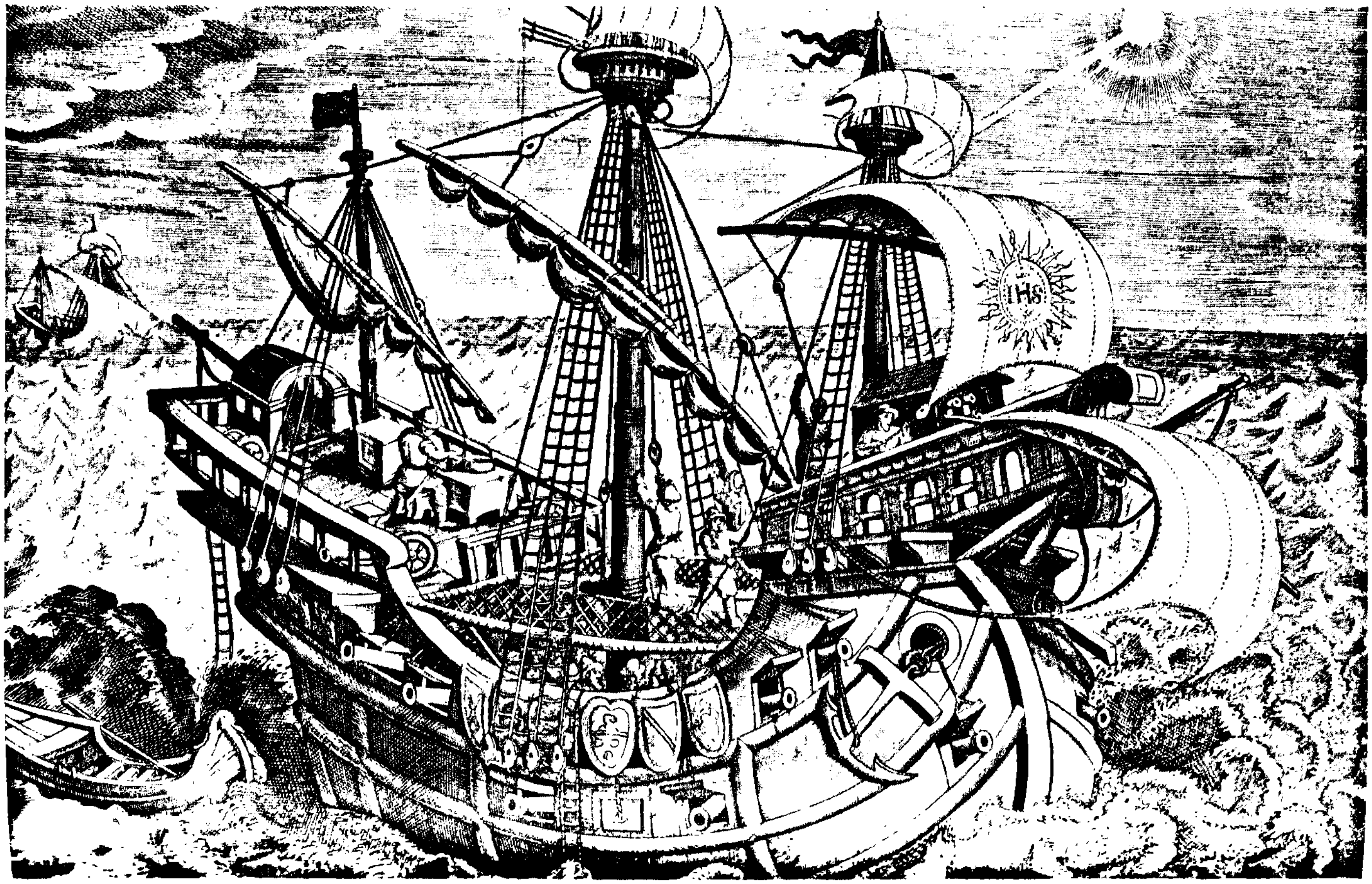
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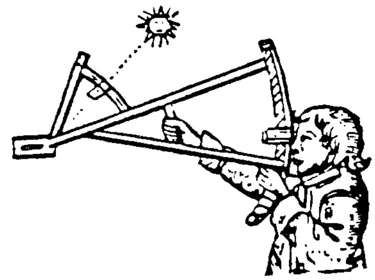
THE NAVIGATOR'S NEWSLETTER



FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

SUPPLEMENT TO ISSUE FIFTEEN, FALL 1986

SUPPLEMENT TO ISSUE FIFTEEN

A Navigation Problem

Solution to the problem presented in Issue 14:

16. Answer.

(a) In the Altitude Correction Tables for the Moon, all corrections are added to apparent altitude. However, when the observation is of the upper limb of the Moon, there is an additional step in which 30 minutes of arc are subtracted from the altitude of the upper limb.

(b) H.O. is 41-15.1, and the intercept is 13.9 nautical miles away. When this is plotted, the navigator knows something is obviously wrong, as the LOP is considerable distance from the DR when a perpendicular is dropped from the LOP to the DR. (A large error or more than 27 miles on the perpendicular was intentionally used in the problem in order to highlight the error). Alert readers will have recognized that the navigator, being human, either has an error in his DR that is uncomfortably large, or there is something wrong with the H.S. figure of 40-51.0. Since this was a daylight shot of the Moon, readers will have concluded, as did the navigator, that it is unlikely the the problem of a false horizon has crept in. However, alert readers will also have seen from the Almanac that it was a waning Moon with an age of 25 days, and hence only a small cresent was visible. It is possible that in shooting the "sliver" of the crescent, an error occurred.

The navigator concludes that he has an unexplained error, that he must be careful with crescent Moon shapes, and that he will get a two or three body fix at the earliest possible time.

(c) The vessel is in time zone -10. The local standard time of the observation was 10-10-47. It was just after ten in the morning on the 29th of September when the observation was made.

Problem No. 17

It is now December 20, 1986. Backstaff, in the weeks since September 29th (the date of Problem 16), has worked her way westward through the Torres Straights and has been visiting various places along the northern coast of Australia. She is now a week out of Darwin bound on what will be a westward crossing of the Indian Ocean. Her DR is Latitude 12-33.5 South, Longitude 118-23.7 East. It is 10-21-37 by the chronometer in time zone-8, and the chronometer is 8 seconds slow. The navigator is trying for a lower limb shot ot the Sun, but the horizon in the Southeast is obscured. He therefore has resorted to the little used technique of the backsight by using the northwestern horizon with the Sun at hs back in the Southeast. Height of eye is 12 feet. Index error is 2 minutes "off the arc". HS of the apparent upper limb is 116-48.1:

(a) What is the procedure when making a backsight?

(b) What is HO and the intercept if the assumed latitude is 13-00.0 South?

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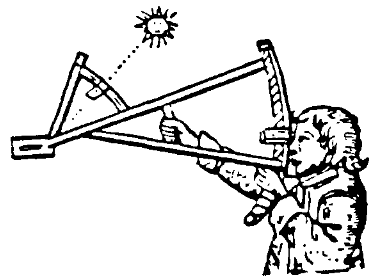
THE NAVIGATOR'S NEWSLETTER



FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

ISSUE SIXTEEN, SPRING 1987

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

Membership

Foundation membership remains stable with a very high percentage of renewals. Nonetheless we feel that there are substantial numbers of individuals who should be interested in our program and the Newsletter, who have not yet been contacted. We hope that members will continue to pass the word to others who share our interests.

Back Issues, Charts, Books

For the benefit of new members we will again point out that back issues of the Newsletter are available upon request, at $2 per copy. Also, members are reminded that NOS Charts are still not available through the Foundation. Negotiations for accessing this source of charts are slow, but we hope that they will eventually be successful. Members will be notified when they are.

We continue to expand the range of books we can supply and expect to add a Coast Guard book mentioned in the Readers' Forum. There have been questions as to the nature of the Nautical Almanac obtained from Paradise Cay Publications. In fact the data in this almanac is identical with that in the "official" almanac published by the Government Printing Office. The difference is that the Paradise Cay publication contains advertising.

In issue 14 Roger Jones reviewed "The Sextant Handbook", published by Azimuth Press of Annapolis, MD. Upon receiving a member complaint about slow delivery of this book, Azimuth was contacted and gave the following explanation. They have received orders far in excess of their expectations and have simply exhausted their supply. The book is back for a second printing and orders will be filled as soon as they are available. Meanwhile the publisher is holding checks that are with orders, but will not cash them until the order can be filled. Meanwhile the address given in issue 14 has been changed. They should now be addressed to: P.O. Box 660, Arnold, MD 21012

Navigation Courses

Member Bill Land (phone 215-539-0790) advises that a new class of instruction in Celestial Navigation will start 11 March, 1987. Director John Lukyx (phone 301-420-7441) will start a new course at the University of Maryland on 19 March 1987, to run to 7 May. This course will be on the CN-2000 system, which is a module used with the Sharp PC-1500A hand held computer, entitled "Astro-navigation, Dead Reckoning and Route Planning".

Classified Ads?

We have received only one response to our proposal to add classified adds to the Newsletter, so for the moment we do not propose to take any further action.

Puzzler

In the last issue we passed on a member's question about little "v". This has sparked at least one reader to come in with an interesting reponse, which we print in the Reader's Forum. In this issue we have a new puzzler:

We are in receipt of a navigational table from a Master Mariner in Yugoslavia, named Mladen Buratovic. The tables are done by hand, involving the hand lettering of about 40,000 digits. Master Mariner Buratovic calls them "Maximum Digression and Meridian Tables."

In trying to evaluate the usefulness of these tables we have been able to understand the Meridian Tables, which are quite straightforward. They address the computation of a latitude from a meridian transit observation. The tables perform the function of combining the altitude and declination in the appropriate way to read out the observed latitude. This is such a simple calculation that most navigators today do it manually. However there may be some who would find the table helpful, and if so we would appreciate comments. Perhaps one of our navigation instructors might have some enlightening remarks.

The real mystery relates to the other half of the Tables, i.e. the "Maximum Digression" table. We have found no one who knows what a "digression" is, and analysis of the sample problems presented yields no clues. Perhaps one of our members will have heard of the term, or know enough Yugoslavian (?) to know if Master Mariner Buratovic has mistranslated something. In any event it is clear the these tables represent a considerable amount of thought and work.

READERS FORUM

William O. Land of Norristown, PA writes:

I have gone into some more books and asked some more questions about an Old Wooden Octant I recently came across. Here is what I found:

The wood is ebony and the octant was probably made by M. Wardell and Son, Shadwell Dock London about 1820. All the metal parts are brass (if we took the time to polish them). It has a small telescope interchangeable with a peep-sight, three brass-framed square index shades and two brass-framed square horizon shades, all of which are missing. The third mirror we wondered about is there so the navigator may use the quadrant as a backstaff if he wishes.

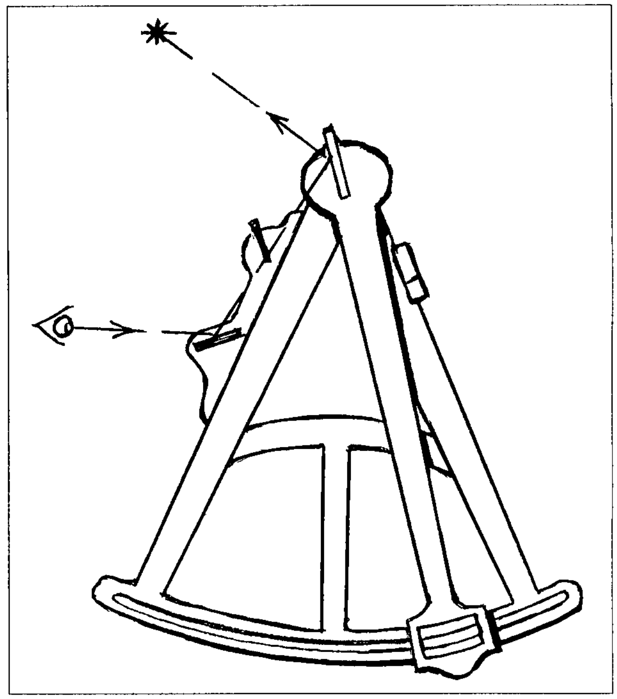
The mystery is solved! The small rectangular relief in the wood on the back side once held an ivory inlay to be used to note the Hs with a pencil. Some octants had an ivory tube attached to hold the pencil. There is no handle, but the octant has three short brass legs to support it while reading the scale and vernier.

The ivory inlay scale, half of the vernier and the ivory inlay name plate are missing. On the back side are brass adjustments for the horizon and backstaff mirrors, while the index mirror adjustment is on the front. The clamp for the index arm is missing. There is no evidence of a screw for fine vernier adjustment unless it was part of the missing clamp.

The only history of the octant is an attached tag which reads "Salvaged from a wrecked ship." Enclosed is a picture of the octant with the overall length of the index arm 16".

It was a pleasure to have lunch with you and again I want to thank you and the other members of the Navigation Foundation for the help you have given me to put my Celestial Navigation course together. I just ran a resume of students and found that since 1982 when I began my first class there have been 780 inquiries, 425 enrollees and 375 graduates. Of these I know of about a dozen who have been navigators in the various Bermuda races, 6 Atlantic crossings and untold numbers who cruised to Bermuda, the Caribbean, Hawaii and other places.

(Editor's note: A diagram of the antique wooden octant is pictured here)



Edward J. Nesbitt of Westport, CT writes:

I had a chance last month to try out my inexpensive Davis plastic sextant on the Sun during a week's cruise in the Gulf of Mexico near Venice and Clearwater, Fla. And I was most amazed: it worked fine (and so did my HP 11 C without any tables, books - only a single page graph of the argument Orbit Time and the declination for the period) which was just what you said would be sufficient for someone who didn't mind some extra calculating.

I also had a homemade refraction angle graph vs. Hs which will be good anytime and I remembered that the Dip in minutes is 3% less than the Ht (in feet), and that the Sun's semi diameter in Oct. is 16.5'.

But the point of this letter is to tell you, in case someone else hasn't come up on it how I obviated the need for the HO 229 tables and used the equation for Hc on which they're based, Hc = Arcsin((Sin L x Sin D) + Cos L x Cos D x Cos H.)

A little algebra on the above generates a value for Cos H, or H, which is

M = Arccos (Sin Hc - Sin L x Sin D)/(Cos L x Cos D)

I solved this for two arbitrary Latitudes, about 10' or 20' apart, each time getting a longitude which is, like the latitudes close to my assumed position. But these two points let me draw immediately my true line of position for that sight. And with the HP 11C I can take the actual angles and longitudes of the Sun computed in degrees (to 4 places) - even the Sun's GHA - which is multiplied by 15 to get GP's longitude, and then added to M to get one of the longitudes for the LOP. Calculator doesn't return to degrees, minutes and seconds till the final longitude for plotting.

I knew system worked when my first LOP was perpendicular to the line to the Sun, and further confirmed it when taking a 3rd Latitude and finding the 3 points were almost in a straight line. Results were all within 2 miles, but I did plot times and angles with each sight (at least 4 pairs) and chose a pair of points on the best mean line through the readings, but that was just anti-plasticizing.

All in all, in was fun and satisfying.

(Ed's note: Member Nesbitt (an aeronautical engineer), for his first experience in celestial navigation, has smoked out a most interesting impact of modern calculators. With these devices the labor of calculation is eliminated, and the a version of the old time-sight may become attractive again since it provides somewhat easier plotting. It was the reduction of the burden of calculation which made the method of Marcq Ste. Hilaire preferred over the time-sight.)

Warren P. Davis of Edgewater, MD writes:

I've just received your catalog of publications and I think it's fine. However, one of the most important publications for the mariner, amateur or professional, is the Coast Guard publication "Navigation Rules, International)Inland." You do not list it and it sells for about seven bucks. It should be freely distributed but it's not.

I have had many students who avidly pursue a difficult course of celestial navigation instruction but who are bored to death about coastal piloting knowledge and who also do not know anything about right of way, lights, sound signals or shapes.

I, of course, blame this ignorance on a wide spectrum of people from budget cutters who now require selling for 7 bucks what used to be freely distributed, to boat dealers who sell an expensive vessel and don't even throw in a copy of the "Rules."

Perhaps those of us who teach celestial navigation should:

a. require our students to bring to class a copy of the "rules" as a textbook

b. inject into our training some coverage of the rules at each session

c. at course end give an "open book" exam of the "Rules"

d. review those aspects of piloting that relate directly to celestial i.e.: bearings, advancing an LOP, longitude and latitude, chart projections, just to name a few.

Reader Anthony Kelley of Hicksville, NY, writes:

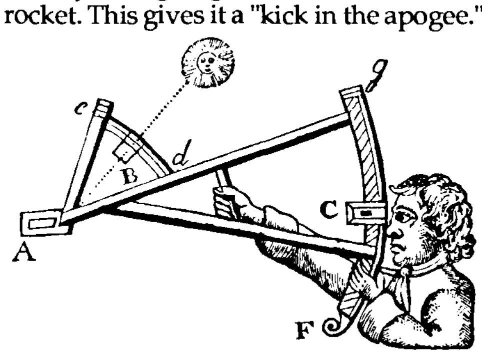
In answer to the question concerning the "v" correction and its meaning from the Fall 1986 issue; there is a very good reason for this use of the letter "v" to abbreviate for a variation in the VELOCITY of a heavenly body.

You remember Kepler's Second Law that heavenly bodies are in Elliptic Orbits about the Sun, and that in equal amounts of time the line from the Sun to the body sweeps out equal areas (Bowditch #1419). When a planet is at its Perigee it is much closer to the Sun and therefore is going much faster to sweep out an area equal to the area swept out when the body going slower at the Apogee and very far from the Sun. So wherever the body is it will have a need for a correction to take care of its variable VELOCITY. This difference in velocity is corrected by knowing the change in GHA of the body, is called "v" and will change for the Navigational Planets and the Moon, but is built into the Sun's GHA entries.

Remember we are looking at the distant planets from the outside of their orbits, whereas for the Moon we are inside at one the Foci, of its elliptical orbit around us. Since the Moon moves so much faster than any other body it is necessary to have the "v" value for each hour. The "v" value for the planets may be constant for several days and only one entry is given for each day.

Remember we are in orbit around the Sun 93 million miles away; we are the ones whose velocity will change! At our Apogee we are farthest from the Sun, going the slowest and enjoying our summer (Northern Hemisphere). Since the Sun is so far away we can build the "v" value into each of the GHA values and have no need for a separate correction.

To remember Apogee and Perigee, I always think of the satellites in orbit around earth. When they wish to get them into a more distant orbit, NASA waits till they are going their slowest, then fires a booster rocket. This gives it a "kick in the apogee."



NAVIGATION BASICS REVIEW

The Line of Position by Altitude-Intercept
The Method of Marcq Ste. Hilaire

by John M. Luykx

The Altitude-Intercept principle of establishing the Line of Position (LOP) is a fundamental concept in the modern method of fixing a vessel's position at sea by celestial observation. It was first described by Captain Marcq St. Hilaire of the French Navy in a paper published in the Revue Maritime in 1875.

The underlying precept of this method is the relationship that exists between the Observed Altitude (Ho) of a celestial body and the angular distance of the observer from the Geographical Position (GP) of the celestial body.

For any value of Ho, the observer's distance from the GP is equal to 90 degrees minus Ho. This angular distance, 90 degrees - Ho, known as the Co-Altitude (CO-ALT) is also the Zenith Distance (z).

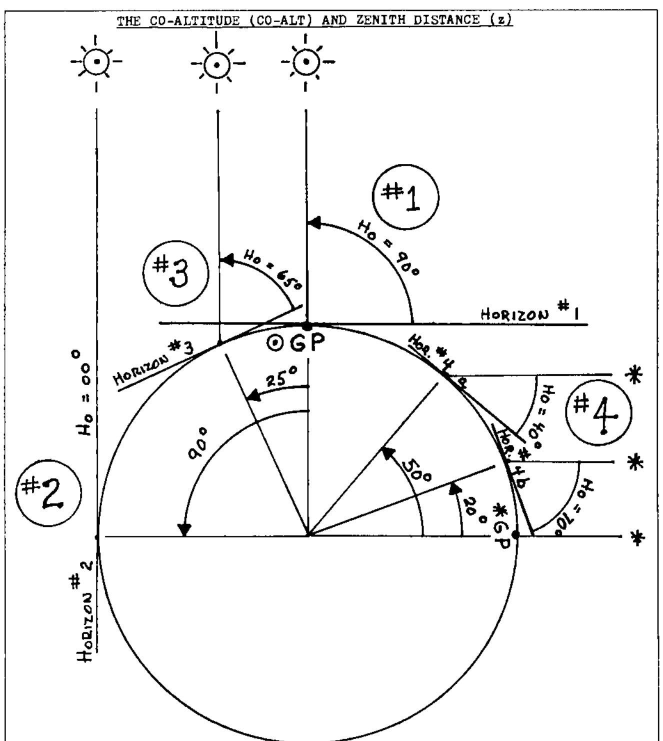
The following discussion illustrates this relationship (See Figure 1):

Imagine the sun directly overhead an observer (#1). The observer, in this case, is located at the sun's GP. The observer has the sun at his zenith and the Ho of the sun would be 90 degrees. The observer's angular distance from the GP = 90 -90 = 00 degrees. If the sun's center were located exactly on the true horizon (#2), the observer would be located 90 degrees away from the GP and the Ho would be 00. The observer's angular distance from the GP = 90 degrees -00 = 90 degrees. Finally, if the observed altitude of the sun is 65 degrees (#3) the angular distance of the observer from the GP would be 25 degrees; 90 degrees -65 degrees = 25 degrees.

If two observers measure the altitude of the sun at the same time (#4), the observer who measures the greater altitude is closer to the sun's GP than the other. He is closer, in nautical miles, by an amount equal to the difference of the two altitudes in minutes of arc.

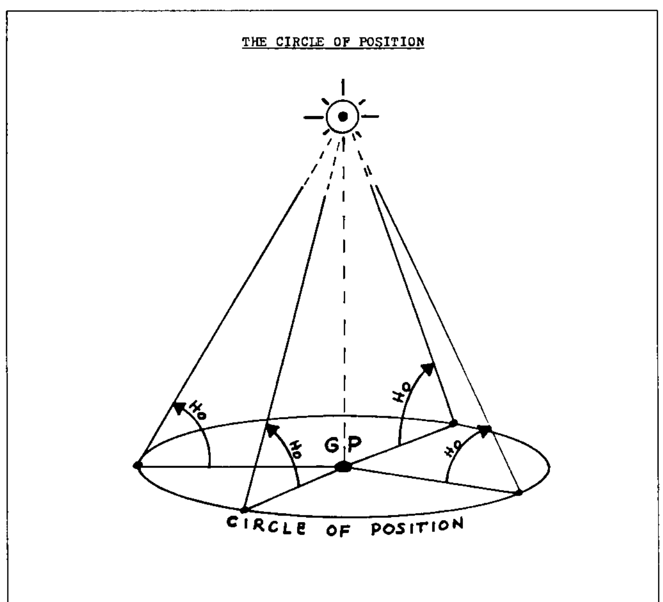
Because the GP of the celestial body is defined, on the earth's surface, by the body's GHA and DEC for the time of observation, an altitude observation by sextant also locates the observer on a circle of equal altitude about the GP. The circle of equal altitude is also a Circle Of Position (COP), the radius of which is 90 degrees -Ho (See Figure 2).

It is now possible to compute the observer's approximate location by a Line of Position (LOP) near the observer's DR or Assumed Position (AP). The LOP is simply a small segment of the large circle of position and is plotted as described below, from the computed Altitude and Azimuth at the DR or Assumed Position. The small segment of the Circle Of Position, the LOP, on which the observer is located is considered a line for all practical navigation purposes (except for high altitude observations)



#1. When Ho = 90°, Sun is at Zenith and observer is at GP.
#2. When Ho = 00°, Sun is on Horizon, observer is 90° from GP.
#3. When Ho = 65°, observer is 25° from GP.
#4. Of two observers, the one who observes the greater altitude is the closer to the GP.

Figure 1



The observed altitude of a celestial body locates the observer on a Circle of Position (COP) about the GP.

Figure 2

although it is actually a small segment of a circle of large radius. The LOP is defined by:

1. The radius of the Circle of Position; i.e. 90 - Ho and
2. The True Azimuth (ZN) of the celestial body. (See Figure 3)

The LOP is always oriented at right angles or perpendicular to the azimuth of the GP as seen from the observer. In other words, as shown in Figure 3, for any point on the circle of position about the GP, the intersection of the azimuth line with the circle of position is always perpendicular.

Since the observation of a single celestial body does not provide a fix but only locates an observer along an LOP, it would require at least two (and preferably more) simultaneous or near simultaneous observations of different bodies to obtain a "fix" of the observer's position. The fix resulting from a series of such observations would then be the point of common intersection of the LOPs. (See Figure 4)

Plotting the Line of Position from a Celestial Observation

To obtain an LOP from the altitude observation of a celestial body, the sextant altitude Hs is first corrected for I.C., Dip, Refraction, Semi-diameter (and parallax for the moon) to obtain Ho. Then with the values of DR LAT/aLAT, DEC and LHA/t, the navigation triangle is solved for Computed Altitude (Hc) and Computed Azimuth Angle (Z) utilizing a sight reduction table or the appropriate trigonometric formulae.

To plot an LOP the value of Z must be converted to True Azimuth using rules stated in the sight reduction table used.

The difference between the value of Ho and the value of Hc is the Altitude-Intercept (a) expressed in nautical miles. It is, therefore, the distance "a", applied to the DR or Assumed Position, along the True Azimuth (ZN) line, which establishes and defines the observer's Line of Position. The Line of Position is plotted as follows (See Figure 5);

1. When Ho is greater than Hc, the observer is closer to the GP than the DR or Assumed Position; i.e., the observer is closer to the GP by the value of "a". In this circumstance, the observer's LOP (drawn perpendicular to the azimuth line) is drawn on the plotting sheet at a point on the azimuth line which is closer to, or toward, the GP by the value of "a", laid out from the DR or Assumed Position, toward the GP.

2. On the other hand, when Ho is less than Hc, the observer is farther away from the GP than the DR or Assumed Position. The observer's LOP is then drawn on the plotting sheet (again, perpendicular to the azimuth line) at a point on the azimuth line farther or away from the GP by a value equal to "a", laid out from the DR or Assumed Position, away from the GP.

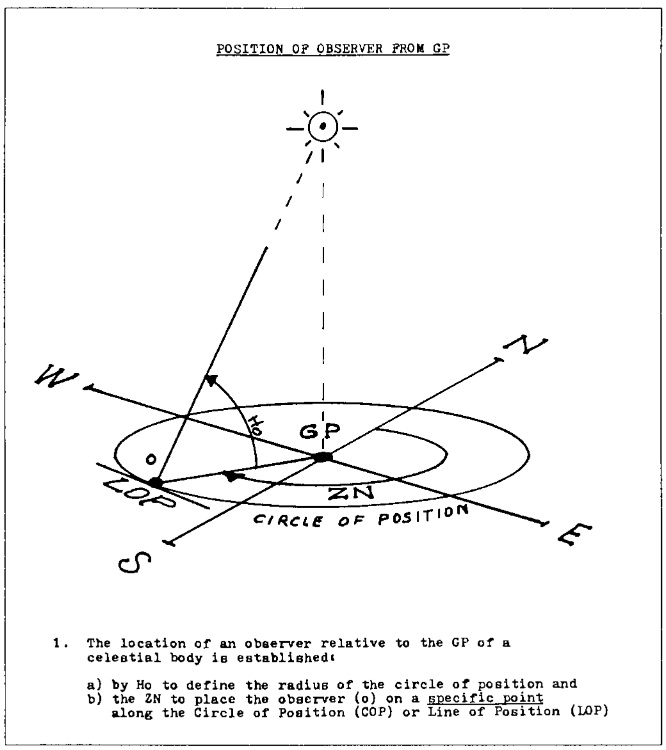


Figure 3

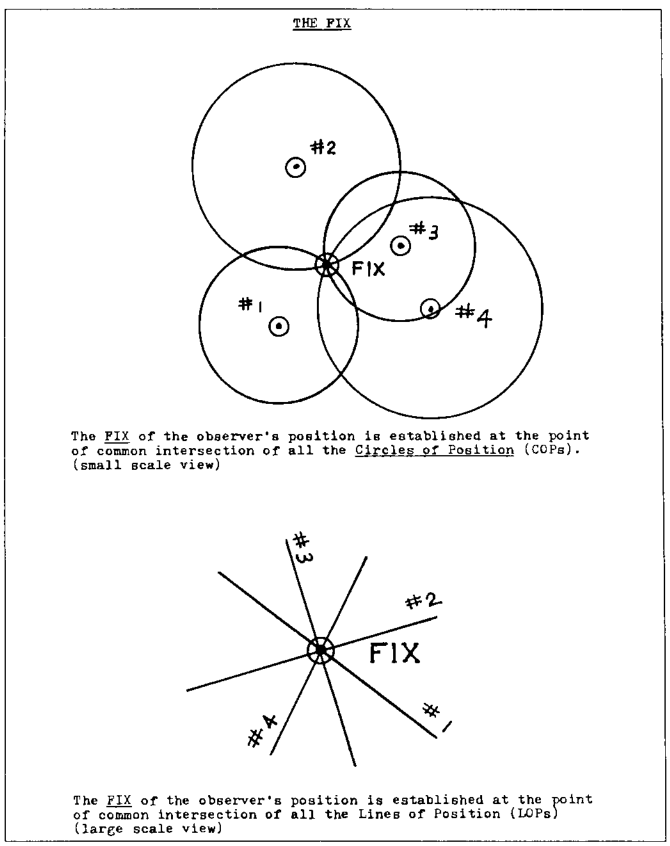


Figure 4

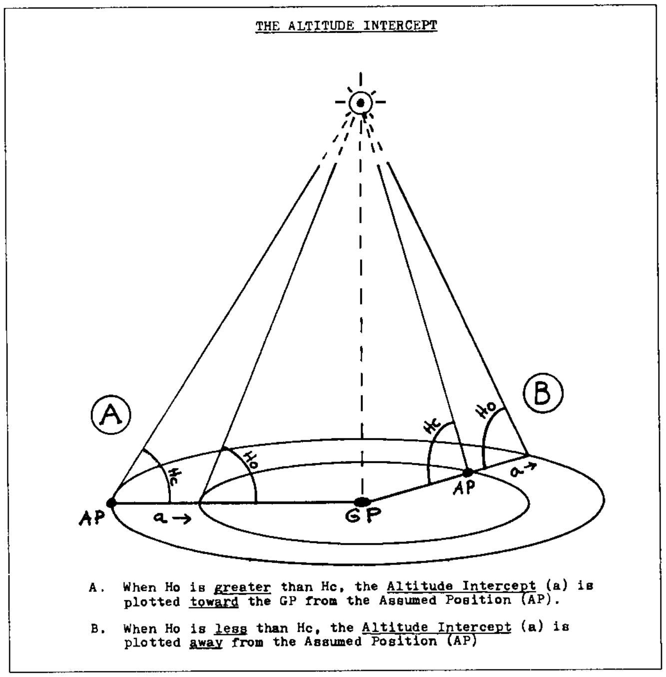


Figure 5

In the next issue we will show how lines of position obtained from near simultaneous observations of several stars are plotted on a plotting sheet to obtain a fix.

NAVIGATION PERSONALITIES

Joseph Y. Dreisenstok

by T. D. Davies

The American Practical Navigator, in the section on "Sight Reduction", has two references to the name Dreisenstok. H.O. Publication 208, known simply as "Dreisenstok", is elaborated at some length giving complete details on the method of sight reduction and use of the tables. In the 1934 edition of Bowditch which I used as a Midshipman sample pages of the tables were shown, such was the importance of the method. The tables were "compact" in the same sense as was Ageton: alas they have not survived as his method has. However navigators of some seniority or of exemplary curiosity will have heard the name, or perhaps have even seen the tables.

Joseph Y. Dreisenstok was a native Washingtonian, born July 4, 1889. He attended George Washington University before entering the U.S. Naval Academy, from which he graduated in 1912. Following graduation he served in the battleship WYOMING and participated in the "Vera Cruz incident", an intervention in Mexico by the United States in 1914. While serving aboard the NEW HAMPSHIRE he also took part in a Central American episode, a landing in Santo Domingo in 1916.

During World War I he was engaged in convoy operations and troop transport. Thereafter he served a tour as an instructor in Marine Engineering at the Naval Academy. In October of 1923, after receiving submarine training, he commissioned and assumed command of the S-23, which was built at the Bethlehem Shipyard at Quincy, Massachusetts. He later commanded the destroyers LARDNER and BERNADOU, before he went to the battleship PENNSYLVANIA where he served as navigator.

In May 1926 Lieutenant Commander Dreisenstok was ordered to Washington as a member of the naval examining board. It was during this tour that he completed his navigation tables which were published by the Hydrographic Office as HO 208. From the PENNSYLVANIA he returned to the Hydrographic Office for his last tour of duty, apparently in recognition of his great expertise in navigation. He received a letter of commendation for his invention of the method of navigation, which he gave to the navy. In 1932 he teamed with Soule to produce a small table for sight reduction by the longitude method, using secants, cosecants and haversines. This table never enjoyed the popularity that HO 208 did.

1933 found the United States in the depths of the great depression. Naval appropriations had suffered along with the rest of the national budget. That year the navy applied draconian measures to reduce personnel costs. Only one half of the Naval Academy class was commissioned and many active duty officers were retired for time in grade. Lieutenant Commander Dreisenstok shared the fate of another navigation expert, Philip van Horn Weems; he was retired on June 1st.

In a few years the navy commisioned the last half of the class 1933 and began to recall many of the valuable officers that had been retired. In January of 1941 Lieutenant Commander Dreisenstok was recalled to active duty and placed in charge of organizing and coordinating the maintenance program for all amphibious craft of the navy. His performance in that capacity led to a Legion of Merit and a citation which recognized the significant contribution he had made to the success of amphibious operations throughout World War II.

On June 28, 1945 he was placed on the retired list as a Captain. He continued to work on the artificial horizon sextant, and a device for parallel plotting on the aircraft chart table. Both of these devices were widely used. Before his death in 1965 he engaged in various businesses including importing, coal sales and stock brokerage. Although modern methods and computers have replaced the results of his efforts I believe that he must be ranked among the great navigation personalities.

HISTORY OF NAVIGATION

Getting Chronometer Error and Daily Rate Before there were Time Signals

by John M. Luykx

Before the invention of time signals such as the rocket, the gun, the time ball and radio time "tick", the 18th and 19th century navigator, in order to check his chronometer at sea, relied mainly on the comparison of longitude obtained by chronometer with the known longitude of the place of observation. The difference between the two, the longitude difference, when converted to time was equal to the Chronometer Error (CE). The daily rate of the chronometer was computed from successive daily observations of chronometer error.

Prior to the mid 19th century, the longitude of a place was normally established by lunar observation and later by transporting chronometers with established error and rate from a place of known longitude such as an observatory, to a place of unknown longitude; usually another observatory or a seaport. The purpose was to determine the longitude difference between the two places. After 1850 the invention of the electric telegraph and the laying of the Atlantic cable greatly simplified the determination of longitude difference between observatories, large cities and seaports and led eventually, at the turn of the century, to a comprehensive compilation of accurate maritime positions throughout the world.

Chronometer Error and Rate

The error of the chronometer may be calculated employing a number of different methods in which, basically, the longitude difference between the longitude computed by chronometer and the actual value of longitude, converted to time, provides the chronometer error. The error is Slow (-) when the computed longitude is East of the actual longitude and Fast (+) when the computed longitude is to the West. The chronometer daily rate is determined from the daily values of chronometer error.

A few examples of the methods used to compute chronometer error and daily rate are:

1. The Lunar Distance. Because the moon's motion relative to the stars is about 33" of arc per minute of time, it provides a method for finding the approximate longitude. Very simply stated, the angular distance between the moon and a star is measured by sextant. The corrected distance when compared with the same distance tabulated in an almanac provided the difference between a reference time (i.e. Greenwich time) and the local time of observation. The time difference converted to arc provided the longitude. Since a 1' of arc error in measuring the lunar distance resulted in an error of 30' of longitude (2 minutes of time) more precise measurements would later be required to accurately determine chronometer error.

2. The Chronometer Time Sight. In this method, the longitude by time sight is computed from observations taken ashore, at a known position, using an artificial horizon. The longitude by observation was compared to the known longitude to obtain longitude difference and chronometer error. Note: The Chronometer Time Sight procedure is described in the Navigator's Newsletter, Issue Fourteen.

3. Equal Altitude Observations. From a known geographical position, altitude observations of a single celestial body are taken ashore, first east and then west of the meridian using an artificial horizon. The two altitudes must be equal and the chronometer time for each observation recorded. The mid-time or chronometer time of meridian passage (LAN) is computed using the following formula:

Chronometer time (LAN) = (Time of 1st obs. + Time of 2nd obs.)/2

The GHA of the body for the chronometer time of meridian passage (from the Nautical Almanac) is equal to the computed longitude which, when compared to the known or actual longitude provides longitude difference and chronometer error. Note: See Navigator's Newsletter, Issue 15, Page 9, Figure 2. for the correction to the time of the sun's meridian passage accounting for the change in the sun's declination during the period of observation.

4. Observation of Stars Both East and West of the Meridian. In this method, near simultaneous altitude observations are made, ashore, of an equal number of stars both East and West of the meridian, using an artificial horizon. The longitude by chronometer time sight is computed for each observation and the mean value of longitude computed. The mean value of computed longitude is compared with the actual longitude to obtain longitude difference and chronometer error.

(Note: The author has provided examples of the calculations for each of the methods described above, which were omitted for reasons of space. Interested members may have copies by sending a stamped self-addressed envelope).

NAVIGATION NOTES

Star Finders

by Anthony L. Kelley

During my studies in Celestial Navigation, I have become enamoured of Star Finders. Right now I've acquired just about all the Star Finders made available during the past years. I prize a 2102B unit my Father purchased before 1940. I have also the 2102D unit that is readily available, and the more expensive Nautech produced Air Force Type CP 300. But I'm missing 2102Cand the "larger" 2102A. This last was mentioned in a 1940's Dutton as being part of the standard equipment on Navy Ships.

A question for the Newsletter Readership to contemplate: In the 2102C and 2102D versions, the sky is reversed. Procyon is to the right of Orion and when you look at the real sky, it is on the left. On the older 2102B, it is on the left as on all the readily available planispheres. Somewhere in its development process (I conjecture), the Astronomers got hold of the device developed by Gilbert Rude (pronounced Roo Day) and took the view of God and looked down on the Celestial Sphere and generated the present version with increasing Right Ascension as the index. This increasing RA agrees with the increasing celestial clock keeping Sidereal Time, while the SHA index is a decreasing scale in the direction of the sky's rotation. To gain this Right Ascension Index, looking down from above, the Astronomers had to reverse the sky. Again this is my thought, am I right? Why didn't they simply add an increasing scale in the direction of the sky's rotation, call it RA, and keep the sky the way the planispheres have it?

Is there a reader out there who was associated with the 2102C or 2102D development who could enlighten us as the reasoning for the 2102D sky being backward. The original patents by Rude and enhancements by Collins both mention either a clockwise or counterclockwise index on the outer edge of the Star Base.

Some Interesting Tables From Sweden

by T. D. Davies

In 1979 and 1980 The Honourable Cross-Staff Society of Stockholm, Sweden, (whose stated purpose is to simplify and popularize practical astronomical navigation!) published a set of altitude and azimuth tables which they call "PET" and "MINI-PET." They were compilied and computed by Peter F. Pfab.

The Society feels that HO 229 and 249 are too bulky for personal ownership and need to use assumed positions. In their opinion no responsible navigator should rely entirely on a pocket calculator. Since other tables use an assumed position which can lead to excessive intercepts, their PET tables were published to use DR position, and to be sufficiently small to be carried handily. These thoughts have a familiar ring.

The method of calculation for the use of the Tables is interesting. The tabulation consists of logarithms of trigonometric functions multiplied by a large number (as in Ageton) to eliminate the difficulties of handling the characteristics, however the unusual function "versine" or "versed sine" is used. This function has been used in earlier navigation methods and is defined as 1 minus the cosine (a definition which is no longer in Bowditch). Unlike Ageton the tables are not based on division of the triangle by dropping a perpendicular.

The tables tabulate 4 values (one has a top and bottom method of entry) as shown below:

Column 1, marked Az* 200 (log cosec Theta)

Column 2, marked L&D 200 (log sec Theta)

Column 3, marked LHA 400 (log cosec Theta/2)

Column 4(top), marked L-D 400 (versine Theta)

Column 4(bot), marked ALT 400 (vers 90-Theta)

The respondents extracted from these columns are organized in a format closely resembling that of Ageton, although the text argues that no special format is required, each user using his own particular way of setting the numbers down. Latitude and longitude entries are indeed made in degrees and minutes from the DR position. This is possible because the arguments of columns 1 through 4 are tabulated in degrees and minutes. Some small interpolation is required but can usually be done by inspection.

The tables are computer generated but are reproduction of rather fuzzy typing done with a ribbon. They can be used for all of the navigational problems such as great circle course computations, amplitudes and reverse solutions for star identification. As in all tables there is an area where uncertainties result from the functions used, in this case uncertainty in the azimuth when the body is very near the Prime Vertical. A comparison of the actual calculated altitude and that calculated (with a simple calculation) for the body on the Prime Vertical gives the answer.

MINI-PET is an abridged version of PET that was published to provide an even smaller table. Incidentally PET has 63 pages of numbers and MINI-PET has 30. In MINI-PET the same values are tabulated but at intervals of every 2 minutes of arc instead of the 1 minute values of PET. The unique manipulation of the mathemetics used in these books is a good example of the apparently endless variety of solutions to the celestial triangle that can be engendered by the human mind. I suspect that this progression will continue.

A Navigation Problem

Solution to the problem presented in Issue Fifteen:
17. Answer
(a) The navigator faces away from the celestial body. What is required is measurement of the supplement of the altitude, or 179-60.0 minus the HS value. The signs for two of the altitude corrections, index error and height of eye, must be reversed. If the body is the Sun or Moon, the normal limb appearance is reversed. What would be the lower limb viewed normally towards the body becomes the upper limb viewed backwards. Of course, the arc of the sextant must be large enough to measure a 90-degree-plus angle. This means the body must be fairly high—always more than 60 degrees above the horizon.

(b)	179-60.0	
-	116-48.1	Upper limb
	63-11.9	Lower limb
-	2.0	Index error, sign reversed ("off the arc" is a plus correction)
+	3.4	Dip, sign reversed (Dip is invariably a minus correction)
	63-13.3	HA
+	15.7	Main Correction, sign is not reversed
	63-29.0	HO
	HC=64-07	(using H. O. Publication 249)
	HC=63-29	
	38	

Intercept = 38 miles away.

Problem No. 18.

The crew of Backstaff have enjoyed their crossing of the Indian Ocean during the southern hemisphere summer. They visited Cocos Island, Mauritius and the islands to the east of Madagascar, but they have made good a fairly straight route to Durban, South Africa, with a view towards restocking and completing the passage around the South African capes before the southern winter sets in. They have decided to forego a visit to Capetown, and having restocked, have departed Durban. It is now March 29, 1987, and Backstaff has rounded the Cape of Good Hope and is at a DR position of 35-30.0 South, 17-00.0 East. The navigator does not have a great circle chart of the South Atlantic aboard, but he wishes to determine his initial great circle course from the DR to the Island of Fernando de Noronha off the coast of Brazil. He also wishes to verify the distance to the island. He has been able to measure the distance on the mercator charts aboard, using a number of charts for successive areas of the ocean, but he wants to verify this using other means. He has a copy of Bowditch aboard, and he has the 249 and 229 tables aboard.

What non-chart method may he use to determine the initial great circle course, the great circle course changes on succeeding days, and the distance to the destination?

****

As of March 29, 1987, Backstaff is well into the second year of her circumnavigation. Readers who have joined us since the start of the cruise on May 15, 1984, from Annapolis, Maryland, may wish to know what previous problems have been presented. The previous problems:

1. Estimation of the time of LAN when there is no westward or eastward movement of the vessel.
2. Determination of latitude from the local apparent noon (LAN) shot of the Sun.
3. Determination of the time of LAN from equal altitude shots of the Sun before and after the meridian cros-sing.
4. Determination of longitude from the time of the Sun's meridian crossing at LAN.
5. Determination of set and drift of the current by comparison of a celestial navigation position with an earlier DR.
6. Planning the time of star shots using the Almanac twilight data.
7. Use of the Almanac to identify planets that may be of use.
8. Use of HO 249, Volume I, to pre-plan star shots.
9. The problem of using a true horizon when a shore line "horizon" is visible beneath the celestial body.
10. Determination of the time of LAN where there is present a component of vessel movement eastward or westward.
11. Various methods of star identification, including: the "Star Finder", the Davies Assumed Altitude Tables, Volume I of HO 249.
12. Use of the Davies Assumed Altitude Tables.
13. Determination of latitude from an observation of Polaris.
14. The problem of the International Date Line crossing.
15. A method for verifying that the vessel is on course, using only one sight per day.
16. A Moon problem involving a mistake by the navigator.
17. The little used technique of the backsight.

MARINE INFORMATION NOTES

Digest of Notices to Mariners, by Ernest Brown

Radiobeacons Added to DMAHTC List of Lights

With the consolidation of Pubs. 117A and 117B in the 1987 edition of Pub. 117, Radio Aids to Navigation , radiobeacons are being transferred to the List of Lights (Pubs. 110 through 116). The first List of Lights to be affected by this change is the 1986 edition of Pub. 114, List of Lights and Fog Signals for the British Isles, English Channel and North Sea .

The change provides a new section in the List of Lights. Corrections to this section will appear weekly in the Notice to Mariners. The weekly corrections are similar to those for lights as an asterisk will indicate that column in which a correction has been made or new information added.

Defense Mapping Agency Hydrographic/Topographic Center New Address:

DMAHTC Representative
World Trade Center
Suite 400, Room E
2 Canal Street
New Orleans, LA 70130
Phone(504) 589-2642

Changes to Lines of Demarcation

Notices to Mariners 52/86 gives changes to Lines of Demarcation in the Navigation Rules, International-Inland.

NAVTEX

NAVTEX is a method of broadcasting Local Notices to Mariners and marine weather forecasts, to mariners having NAVTEX receivers. These are small, low cost ($700 -$1800) printing receivers designed to be installed in the pilot house. NAVTEX receivers screen incoming messages, inhibiting those which have been previously received or are of a category of no interest to the user; they print the rest on adding machine paper.

In areas where it is operational, NAVTEX not only provides marine information previously available only by copying Morse Code messages but allows any mariner who cannot man a radio full time to receive safety information immediately, at any time. All NAVTEX transmissions are made on 518 kHz. Mariners who do not have NAVTEX receivers but have SITOR radio equipment can also receive these broadcasts by operating SITOR in the FEC mode and tuning to 518 kHz.

The U. S. Coast Guard plans to have a national NAVTEX system by the end of 1989, with service 100 nautical miles off the United States East, West and Gulf coasts, and Puerto Rico, Alaska, Hawaii and Guam. International broadcasts are planned. The system is already operational in northern Europe. It is expected that carriage of NAVTEX receivers will be mandatory for all International Maritime Organization regulated vessels after 1990.

BOOK REVIEW

by Roger H. Jones

Form No. 104— Celestial Navigation Workforms for Sight Reduction of all Celestial Bodies using Publication 249 or Publication 229 and the Nautical Almanac

by David F. Burch

Paradise Cay Publications
1001 Bridgeway #405
Sausalito, California 94965 (1985)

The name of David F. Burch will be familiar to many readers of the Newsletter, which has previously reviewed both his book, *Emergency Navigation,* and his excellent little *User's Guide to the 2102-D Star Finder.* Those reviews, like most of the others which have appeared in the fifteen previous issues, focused on very recent publications in which both the subject matter contents and the writing style seemed to have merit.

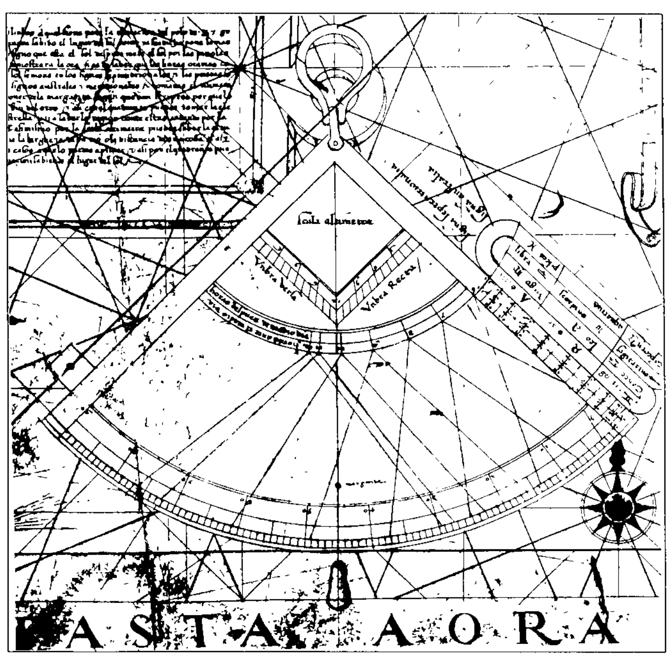
The current review departs a little from previous practice in one respect -- the booklet which is the subject of this review contains very few written words. It is, however, both recent and worthy in its non-verbal content.

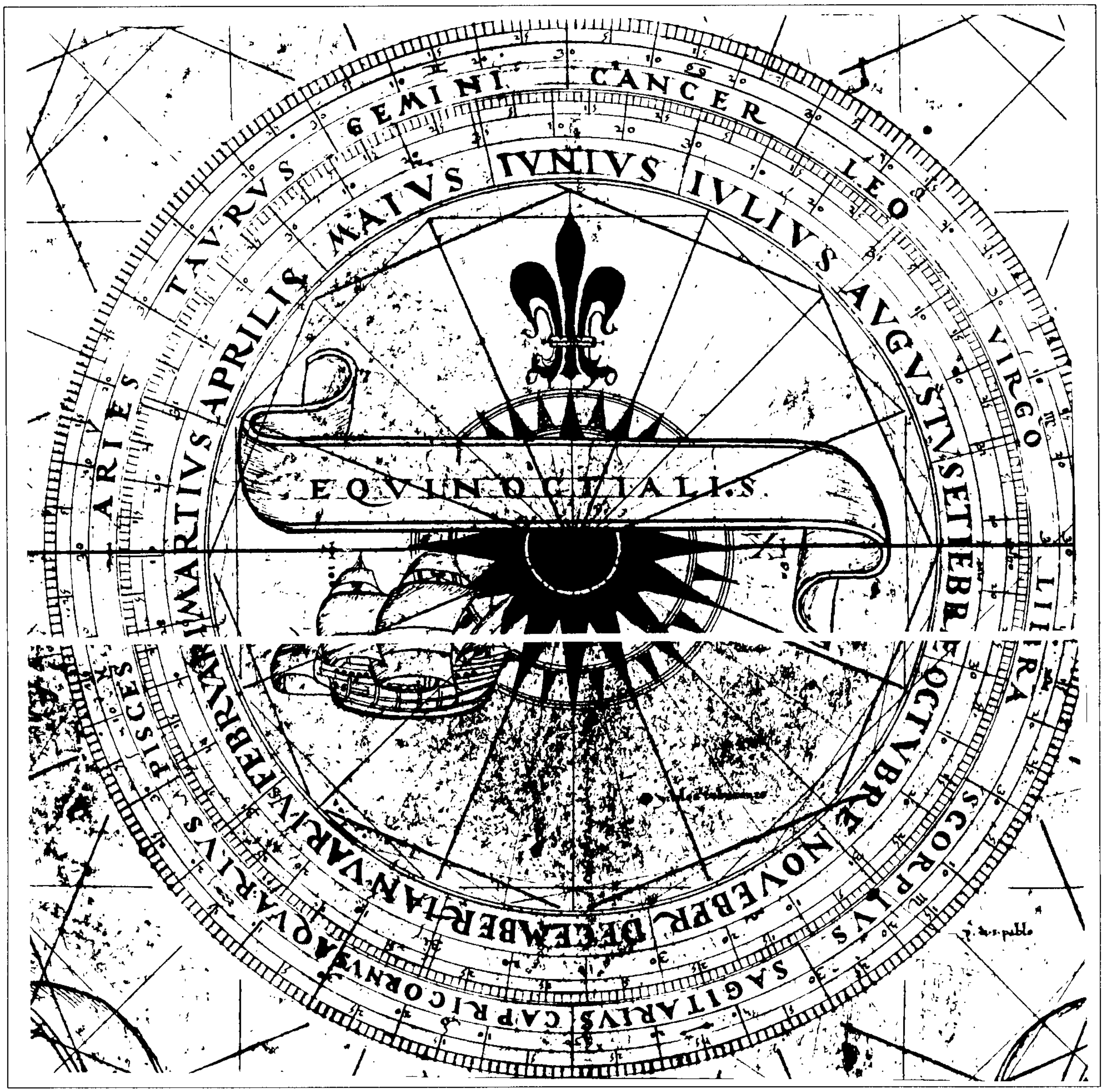
There are perhaps three pages of text in which there is presented a nicely organized set of "box-by-box" instructions for use of the copyrighted workform. These instructions make very clear the differences in approach between HO 249 and HO 229 in the treatment of the d-correction to the tabulated Hc value. They deal specifically with sun, planet, moon, and star lines of position, and they do so in a format that is easy to follow. The workform itself is organized into just six clearly numbered sections, and the one form is used for all celestial bodies. The numbered sections appear in a logical sequence in which data is entered, and this sequence is aided by conveniently placed arrows which lead the user from one step to the next.

Two complete forms are printed on each 8" x 11" page, and there are 102 identical pages in a booklet about a third of an inch thick. Burch obviously had his many students in mind when he designed his form. He avoids the pitfalls of multiple and different forms for different celestial bodies, and in so doing he reinforces the fact (which is not always obvious to new students of the celestial art) that the procedure for all celestial bodies is really just that -- one basic procedure applicable to all.

This reviewer has also designed a universal form, and has grappled with the task of incorporating into one standard form the features of a number of separate forms that were originally designed to be used respectively with the Sun, the Moon, the planets and the stars. Indeed, many a large and small vessel navigator has done precisely that for his or her own benefit. Those readers who have been "draftsmen" in this respect will recognize the utility of Burch's design, and those who have not will find a ready-made answer to the problem of having to deal with multiple forms which may defeat the integrated understanding and the easy recall of procedure that are so necessary to quick and accurate work at sea. Burch is a teacher who has been to sea, and it shows in his quest for the single celestial workform.

Address all correspondence to:
The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850
Telephone: (301) 622-6448




GEMINI
CANCER
LEO
VIRGO
SCORPIVS
SAGITTARIVS
CAPRICORNVS
AQVARIVS
PISCES
ARIES
TAVRVS
IVNIVS
IVLIVS
AVGVSTVS
MAIVS
APRILIS
MARTIVS
EQVINOCTIALIS

THE NAVIGATOR'S NEWSLETTER

FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

ISSUE SEVENTEEN, SUMMER 1987

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

by T. D. Davies

Membership

As we enter our fifth year of publication of the Newsletter, we find that interest and enthusiasm is still holding up. Our membership is growing slowly but if members continue to spread the word by distributing copies of the Newsletter we can accelerate this. Members are asked to notify us of any opportunities that they see, for interested groups or individuals. We will be glad to respond by providing literature or other material.

Awards

On 15 May I had the pleasure of presenting our second "Dutton Award" at the United States Naval Academy, to Midshipman 3/c Norberto Nobrega, of New York. Mr. Nobrega was selected for the award by the faculty of the Department of Seamanship and Navigation. In addition to the Foundation's plaque he will receive the Newsletter for a period of one year.

Additionally we have an award in Maine, at the Gould Academy in Bethel, which goes to navigation student Dresser. He will also receive the Newsletter for a year.

We are continuing in our efforts to establish awards to stimulate interest in navigation, particularly in young people. We also, of course, try to use the award to recognize outstanding acheivement by navigators anywhere. Any members who have suggestions in either category are requested to send them in for consideration.

New Compact Almanac

We currently have under preparation an experimental new compact almanac. This document will be designed to be extremely compact, about 15 pages, and yet provide all necessary ephemeral data on the Sun, Moon and Planets, sunset/rise, etc. In general one or more additional steps of interpolation are required, beyond those of the Nautical Almanac, in exchange for which the user will have a very low-price light-weight pamphlet, which can be easily carried in the sextant box. We are producing the first one year issue as a test, to determine if the document will prove useful to some navigators. If enough interest develops the Foundation will probably undertake the continued publication.

It is our intention to do the publication of this pamphlet under the aegis of the Navigation Foundation, with a view to evaluating the potential of undertaking more extensive publication of specialized items in our field. Comments by the membership are encouraged.

Charters Become Boaters

Chart users among our members will be interested to know that the Rockville (MD) squadron of the USPS have been providing boating experience to the employees of the Nautical Charting Division of the National Oceanographic and Atmospheric Administration (NOAA). These technicians who produce the charts sometimes have no real experience as users, but merely follow the established rules. With some realistic experience they should have a better appreciation of the needs of the user, and the quality of the product should improve.

READERS FORUM

Member H. M. (Don) Wade, Jr., forwards the following:

AMELIA EARHART researcher seeks information and discussion regarding her disappearance in the Pacific. Historical tome currently being written documenting this greatest of all modern-day mysteries. Don Wade, 560 Campbell Hill, Marietta, GA 30060 (404)426-7883.

Member William O. Land of Norristown, PA writes:

I want to thank you for the "plug" you gave our school in the Spring 1987 issue of the "Navigator's

Newsletter" and the diagram for the use of the old octant as a backstaff. I was not sure myself exactly of the application of the third mirror, but the diagram makes it quite clear now.

Enclosed are two articles on sextants from "Sky and Telescope," the amateur astronomy magazine, which I came across while chasing down an article on another subject. (I have all issues of S&T from Vol. 1, #1, 1941 to the present bound and in my library).

The first one is from S&T March 1946 p. 11 on a Miniature Planetarium for Navigation. The second is from S&T June 1946 p. 9 on a Spherical Sextant.

I am curious to know if you have any information on these, have they ever been in practical use, were any made commercially, are there any extant, does anyone know exactly how to use one, etc.?

These articles are 41 years old and I haven't contacted the S&T publisher as yet. Since it refers to navigation rather than stars I thought I would ask you first.

Member Matt Morehouse of Sausalito, CA writes:

Paradise Cay Publications as a small marine-related publisher is looking for manuscripts to publish. It is obvious from reading correspondence to the Navigator's Newsletter that many Foundation members have the talent to convey difficult concepts.

We would welcome manuscripts from Foundation members. If suitable, we will negotiate an agreement and publish. Otherwise, we will return the manuscript.

Send to: Paradise Cay Publications
1001 Bridgeway #405
Sausalito, CA 94965

Member Edward I. Matthews of Boxboro, MA writes:

Continuing the discussion on position by meridian transit (Issue 15), I derived a calculator solution to this problem, which appeared in Issue 7. James N. Wilson later wrote me and correctly observed that the effect of rate of declination change (d) is often significant and should not be ignored as I had done.

The equations were then revised to include "d" and follow:

(1) COS L = sin (Ho + Dec(cos Zn))

(2) Sin t = (cos Ho (d-S cos C))/(60 r cos L cos Dec)

(3) T = 60 t / r

Where:
Ho = Maximum corrected altitude
Zn = Azimuth of body (0° or 180°)
DEC = Declination at time of Ho (- if south)
L = Latitude at time of Ho (- if south)
d = Rate of declination change (- if southerly)
S = Speed in knots
C = True course
r = Rate of change of GHA
t = Meridian angle at time of Ho
T = Time diff from time of Ho to meridian transit (+ after)

The time of maximum Ho is determined from the average times of equal altitudes observed before and after meridian transit. Using parameters from Issue 15:
ZT 4-54-51
ZD + 1

Adopted GHA rate for the Moon		= 14°19.0
	Corr V =	9.8
Rate of change of GHA	r =	14°28.8 (14.48)
Maximum altitude	Ho =	35°59.1 (35.985)
DEC at time of Ho	D =	18°51.9S(-18.865)
Approximate bearing	Zn =	180

(1) COS L = SIN (35.985-(-18.865))
= 0.8176
L = 35.15° (35°09.0N)

(Mr. Wilson uses a value of DEC at a time different from Ho, resulting in a slightly different value of L.)

(2) SIN t = $\frac{(12.2-0)(\cos 35.985)}{60(14.48)(.8176)(\cos(-18.865))}$

= 0.0147
t = 0.8415
T = 60(.8415)/14.48
= 3.4869 minutes
= 3m29s

(Again Mr. Wilson uses a value "d" of -12.4 which is slightly larger than actual.)

ZT	= 4-54-51	GHA-H	356°22.5
ZD	= +1	Min-Sec	12°15.4
GMT	5-54-51	Corr	8.4
	- 3-29	Lo	8°46.3
Meridian	5-51-22		

The use of a calculator avoids the use of complicated rules while providing an accurate one body fix.

Member James N. Bodurtha of Ridgefield, CT writes:

Would you know what became of the Pioneer division of Bendix Aviation? I have its WW II bubble sextant in which the bubble plunger is apparently faulty, and it is hard to get and keep the bubble due to size. Also the lens is clouded. I have dismantled it OK basically for attention, but neither I nor actually the world's largest telescope—space—can get the lens out. So I want to obtain a replacement. I do not receive reply to inquiry now from Historical Technology some 10 years ago at

Marblehead,Mass—Saul Moskowitz. I am working on the part-repair/replacement otherwise, but meanwhile thought you might have an idea.

Editor's Note: Captain John Vest of Cove Point Farm, Centreville, MD 21617, was associated with that organization and may be able to help.

Marvin Sebourn of Enid, OK writes:

I am looking for information on Captain Thomas Sumner, and a copy or reprint of his book, A New and Accurate Method of Finding a Ship's Position at Sea by Projection on Mercator's Chart .

Editor's Note: Sumner's book is available in the Library of Congress and can probably be borrowed through any convenient university library.

Board Member Ernest Brown of Houston, TX writes:

In Navigation Notes of issue sixteen, Mr. Kelley questions the method of displaying the stars on the base of the Star Finder. A former director of the Navigational Science Division at HYDRO, Mr. John H. Blythe, would probably know more about this matter than anyone else.

Mr. Blythe, a resident of Chevy Chase, was 70 when he retired in 1970. I suggest checking the telephone book.

When I was still at the old shop, the file on the Star Finder was extensive. I assume that if this file has not been destroyed, it is buried in the Federal Records Center.

HYDRO found out about the patent on No. 2102-C when the desk of Elmer C. Collins was cleaned out following his retirement. As the story goes, Collins signalled his retirement by not showing up for work.

Member Paul Peak of Denver, CO provides the following information on his navigation courses:

The course provides understanding of use of a sextant to obtain the altitude of a celestial body, and practice with the Nautical Alamanac and H.O. 249 to plot lines of position and obtain a fix.

Captain Paul Peak returned to Denver, his home town, when he retired from the U.S. Coast Guard in 1974. During his thirty-three year Coast Guard career he served in Coast Guard High Endurance Cutters as cadet, deck watch officer, navigator, executive officer, and commanding officer. He has sailed in the Mediterranean, North Atlantic, Gulfs of Mexico and Alaska, and the North Pacific.

A class will meet on eight Tuesday evenings at 7730 East Hampden Circle, Denver. Each session will include time on practical work (sextant, plotting, use of almanac and tables) as well as lecture and discussion. Students will need to furnish dividers and parallel rule (or equivalent). Course fee ($100) includes the text, one volume of H.O. 249, the 1987 Nautical Almanac, and a practice sextant. (If a student already has any of these four items, or if two members of the same family register, the fee will be adjusted.) Note: The current course is already underway and finishes July 14. We assume another will commence at a later date. This may be determined by a phone call to (303) 773)2555.

John Luykx, Board Member of The Foundation and Vice President of the InfoCenter, of Forestville, MD writes:

I found issue sixteen very interesting, especially the Reader's Forum and The Navigation Notes.

a. With regard to Mr. Saud's letter on page 2. I enclose a Xerox copy of parts of Chapter 9 of Cotter's book A History of the Navigator's Sextant which contains details concerning the history, construction and use of Hadley's quadrant (octant).

b. Colonel Davis' letter, on page 3, makes the recommendation that the "Rules" should be taught as part of piloting and celestial navigation courses. Although I completely agree with this, I also believe that the "Rules" are a comprehensive and complicated subject which would take many hours to cover in a formal class setting. In my classes, at the University of Maryland, I introduce the "Rules" as a Team project assignment; to be completed at leisure, "open book style" and turned in to me on the last day of class for checking. I enclose a Xerox copy of The Rules of the Road Questionnaire which I give my students. Perhaps it may be of interest to Col. Davis as well as to other navigation instructors.

c. In Navigation Notes , Mr. Kelley describes tests of various star finders. I enclose a Xerox copy of a star finder developed and published by Dr. Kotlaric of the Yugoslavian Navy in 1977 . Tests I have conducted with this star finder indicate that its accuracy is greater than that of the HO 21022 and the Air Force CDU 300 and is quite comparable to HO 249 when that publication is used as a star finder .

d. On page 10, Mr. Jones reviews the publication of standard sight form for all celestial bodies. I enclose Xerox copies of the sight deduction forms which I use in my classes. This form permits the reduction of 5 sights per page using either HO 214, 229 or 249. Along with some blank sight reduction forms. I also enclose an example of "a day's work" consisting of six stars and four sun observations completed on one sheet !! This type of sight reduction form may be of interest to Foundation members; a form which can be modified to suit individual tastes.

Editor's Note: Members interested in receiving copies of the material mentioned in this letter can obtain them by sending a stamped self-addressed envelope (large) to the Foundation.

NAVIGATION BASICS REVIEW

The Simultaneous Fix

This article, which concludes the series on Navigation Basics Review, describes plotting the lines of position (LOPs) obtained from a series of near simultaneous observations of celestial bodies to obtain a "fix" of the vessel's position. The procedure is best explained and demonstrated by a sample problem.

Sample Problem

In the early morning hours (+5 zone time) of 25 May 1987, a small sailing vessel is enroute to the Chesapeake Bay Entrance on course 270 T at an approximate speed of 5.0 knots. During morning twilight in DR Position:

LAT: 36 43.0N, LON: 074o38'0W, the following celestial observations were taken:

BODY	WATCH TIME	SEXTANT ALTITUDE
Polaris	04-15-27	36 57.1
Jupiter	04-18-06	19 11.4
Nunki	04-19-51	22 58.7

For these observations, the I.C. was -1'5, the height of eye was 6.0 feet and the watch was 20 seconds fast. A few hours later on the same course and at the same approximate speed in DR Position: LAT: 36 51.0N, LON: 075 02.0W, the following celestial observations were taken:

BODY	WATCH TIME	SEXTANT ALTITUDE
SUN (LL)	09-29-57	54 06.3
Moon (LL)	09-31-46	67 25.0

The sextant I.C., H of E and watch error for these two observations remained unchanged from those taken earlier.

The purpose of the observations was to determine the boat's position at 04-15 and 09-30.

Using the Nautical Almanac (1987) and H.O. 229, Vol. 3, the five observations were reduced as follows:

BODY	POLARIS	JUPITER	NUNKI	SUN (LL)	MOON (LL)
GMT	09-15-07	09-17-46	09-19-31	14-29-37	14-31-26
A-LON		074°28'.1W	074°41'.1W	075°11'.5W	075°14'.2W
LHA	306°34'.4	289°	024°	323°	348°
A-LAT		37°N	37°N	37°N	37°N
DEC		N06°33'.3	S26°18'.9	N20°55'.5	N17°25'.1
Ho	36°51'.9	19°04'.7	22°52'.5	54°17'.7	67°57'.3
LAT corr	-1'.6				
LAT	36°50'.3N				
Hc		19°05'.2	22°46'.8	54°09'.8	67°44'.7
Int:		A 0'.5	T 5'.7	T 7'.9	T 12'.6
ZN:		096°.8T	203°.4T	107°.5T	148°.9T

Once the observations were reduced, each line of position (LOP) was plotted using the following procedure:

AM TWILIGHT OBSERVATIONS

MORNING TWILIGHT OBSERVATIONS
THE POLARIS LINE OF POSITION FOR LATITUDE

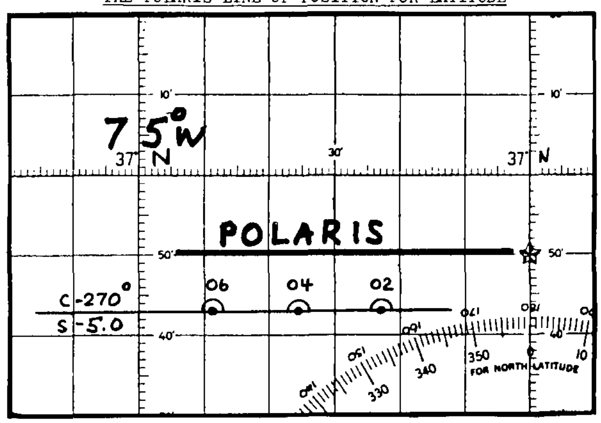


Figure 1

POLARIS (Figure 1)

1. Compute LHA to the nearest 0.1.
2. Compute Ho from Hs.
3. Compute the latitude correction from the Polaris Tables (Page 276) of the Nautical Almanac (1987).
4. Apply the latitude correction to Ho to obtain the latitude.
5. Draw and label the Polaris latitude line on the plotting sheet in the vicinity of the boat's DR Position.

MORNING TWILIGHT OBSERVATIONS
THE JUPITER LINE OF POSITION

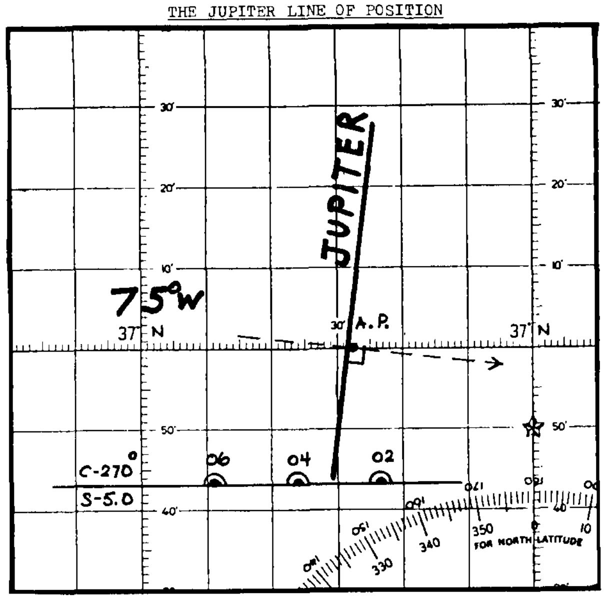


Figure 2

JUPITER (Figure 2)

1. Plot Jupiter's assumed position (A.P.) on the plotting sheet:

A-LAT: 37 00.0N
A-LON: 074 28.1W

2. Retard Jupiter's A.P. 0.2 miles eastward: 2.8 X 5.0/60 = 0.2 miles *

3. Draw Jupiter's azimuth line (ZN = 096o8T) through the A.P.
4. Mark a point on the azimuth (ZN) line, 0.5 miles from the A.P., in a direction away from Jupiter's G.P.
5. At this point draw and label the Jupiter line of position (LOP) perpendicular to the azimuth line. Extend the Jupiter LOP, as necessary, to intersect the Polaris LOP already plotted on the chart.

MORNING TWILIGHT OBSERVATIONS
THE NUNKI LINE OF POSITION

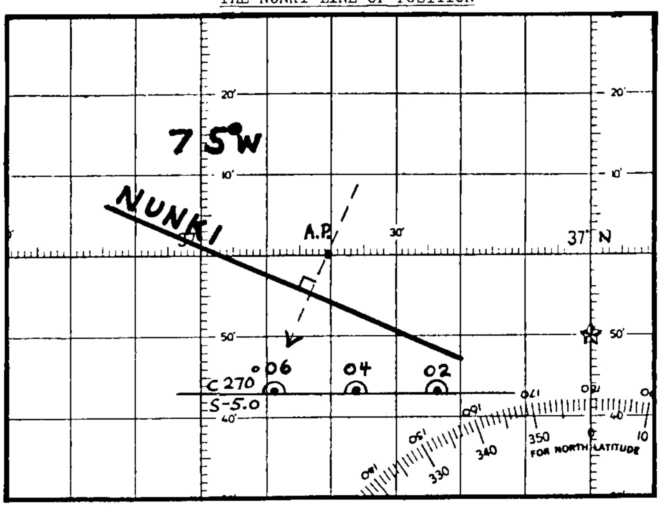


Figure 3

NUNKI (Figure 3)

1. Plot Nunki's assumed position (A.P.) on the plotting sheet:
A-LAT: 37 00.0N
A-LON: 074 41.1W
2. Retard Nunki's A.P. 0.4 miles eastward: 4.5 X 5.0/60 = 0.4 miles.* 3. Draw Nunki's azimuth line (ZN = 156.6T) through the A.P.
4. Mark a point on the azimuth (ZN) line, 5.7 miles from the A.P., in a direction toward Nunki's G.P.
5. At this point draw and label the Nunki line of position (LOP) perpendicular to the azimuth line. Extend the Nunki LOP, as necessary, to intersect the Polaris and Jupiter LOPs already plotted on the plotting sheet.

* NOTE: The Jupiter and Nunki A.P.s were retarded to permit the fix to be plotted for time 04-15.

FIX (Figure 4)

1. If there are no Personal or Systematic errors in the three observations, the boat's 04-15 position is located at

MORNING TWILIGHT OBSERVATIONS
THE 04-15 FIX

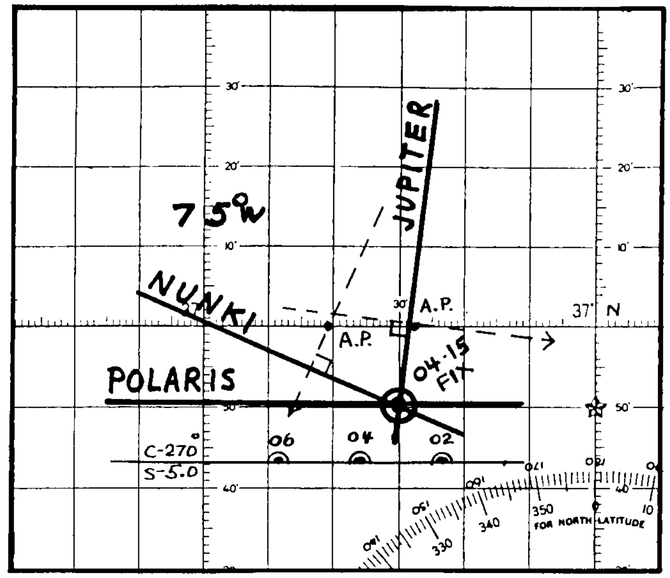


Figure 4

the point of intersection of the three LOPs.
2. 04-15 Fix
LAT: 36 50.0N
LON: 074 30.0W

AM DAYLIGHT OBSERVATIONS

SUN (Figure 5)

1. Plot the sun's assumed position (A.P.) on the plotting sheet:
A-LAT: 37 00.0N
A-LON: 075 11.5W

MORNING DAYLIGHT OBSERVATIONS
THE SUN LINE OF POSITION

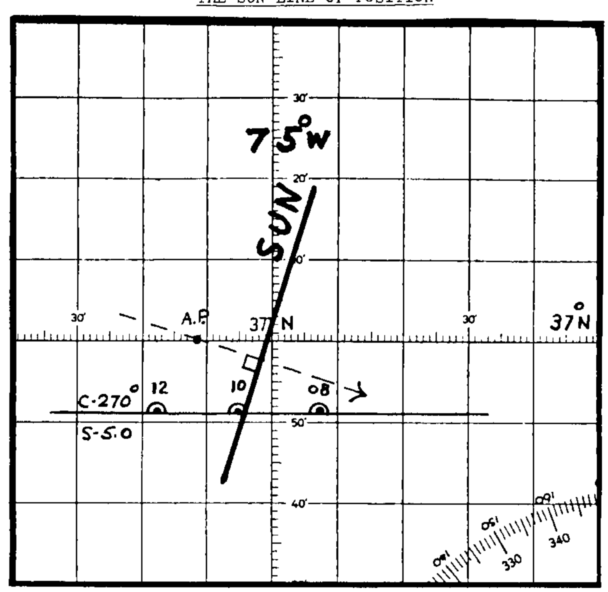


Figure 5

2. Draw the sun's azimuth line (ZN = 107.5T) through the A.P.
3. Mark a point on the azimuth (ZN) line 7.9 miles from the A.P. in a direction toward the Sun's G.P.
4. At this point draw and label the sun's line of position (LOP) perpendicular to the azimuth line. Extend the sun's LOP, as necessary, to the vicinity of the boat's DR position.

MORNING DAYLIGHT OBSERVATIONS
THE MOON LINE OF POSITION

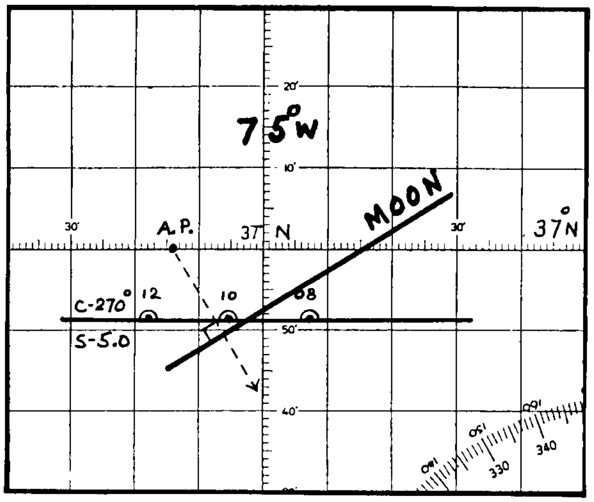


Figure 6

MOON (Figure 6)

1. Plot the moon's assumed position (A.P.) on the plotting sheet:
   A-LAT: 37 00.0N
   A-LON: 075 14.2W
2. Retard the moon's A.P. 0.1 miles eastward: 1.5 X 5.0/ 60 = 0.1 miles.*
3. Draw the moon's azimuth line (ZN = 148.9T) through the A.P.
4. Mark a point on the azimuth (ZN) line 12.6 miles from the A.P. in a direction toward the moon's G.P.
5. At this point draw and label the moon's line of position (LOP) perpendicular to the azimuth line. Extend the moon's LOP, as necessary to intersect the sun's LOP already plotted on the plotting sheet.

* NOTE: The moon's A.P. was retarded to permit the fix to be plotted for time 09-30.

FIX (Figure 7)

1. If there are no Personal or Systematic errors in the two observations, the boat's 09-30 position is located at the point of intersection of the two LOPs.
2. 09-30_Fix
   LAT: 36 50.0N
   LON: 074 05.0W

MORNING DAYLIGHT OBSERVATIONS
THE 09-30 FIX

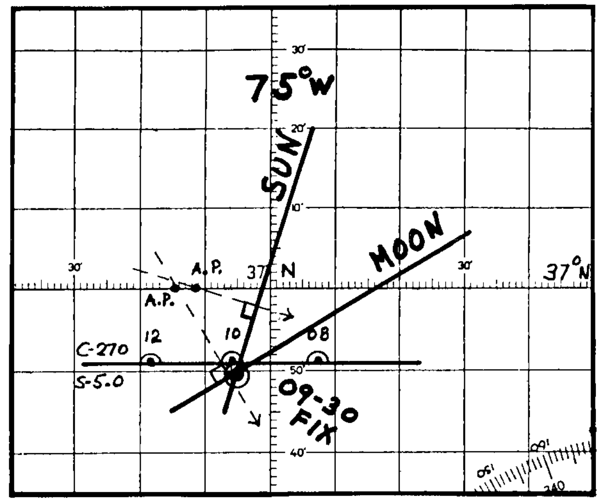


Figure 7

NAVIGATION PERSONALITIES

CAPTAIN PHILIP VAN HORN WEEMS, USN, Ret.

by Dale Dunlap

Capt. Weems was orphanded at an early age and lived in the hills of Tennessee. He received his formal education there through tutors and local schools. At age 17 he entered the old Werntz Prep School in Annapolis to prepare for the Naval Academy entrance exams, a brother entering the U.S. Military Academy about the same time. His rough and tough country upbringing stood him in good stead at the Academy, where he lettered in football, crew and wrestling, with such outstanding performances that he was awarded the sports "Sword for excellence" in athletics. He was a graduate of the class of 1912.

He went on to become a member of the U.S. Olympic wrestling team at Antwerp in the early twenties. It was in the field of Navigation however that he was to attain an international reputation, and receive many of the world's most prestigious navigation and scientific achievement awards. Included among these are the Gold Medal from the Aero Club of France (for his first book on air navigation in 1932), a British award from the Royal Society of Arts (for development of the second setting watch), the prized Magellanic Premium (Gold Medal) from the American Philosophical Society, the LaGorce Medal from the National Geographic Society, the Thurlow Award from the Institute of Navigation, the Gold Medal of the British Institute of Navigation, plus numerous other citations and awards.

Although Navigation was his forte, he excelled in many undertakings, as an author, inventor, and as a Naval Officer. He served as both Chief Engineer and later as Commanding Officer of naval vessels. During this time he sat for the examinations and received both a Masters and Chief Engineers license, oceans unlimited, in the Merchant Marine. At the time he was the only person to hold both tickets. He also served as the first Air Navigation Research Officer at the Hydrographic Office. In the early 30's he retired and conducted his own navigation business and school under the name "Weems System of Navigation." In WWII he was recalled to active duty and served as Convoy Commodore in the Atlantic and also earned his Air Navigators Wings. Quite remarkably, at the age of 72, he again was recalled to active duty to set up a class in space navigation and develop the Navy handbook on the subject.

Unlike previous famous seamen and navigators, Capt. Weems was in his prime at the time of the development of the airplane as a mode of transportation and as a military weapon, and he quickly recognized the necessity of developing faster and more simplified methods of navigation for air.

Modern air navigators still recognize his name as the originator of the "Weems Plotter," the simple little instrument which has survived almost 50 years without any change in concept. Although drift meters, calculators, time keepers, and other devices appear among his inventions, his principal contributions to air navigation involved celestial navigation.

The science has always involved four aspects, observing instruments, timekeeping, almanacs and sight reduction. Capt. Weems was involved in all four areas. In his own eyes, his most significant development was the Weems Star Altitude Curves, adopted by the Army Air Corps in the early days of WWII. It was the only fast method of celestial air navigation available at the time. Capt. Weems and his cohorts had been working on it all during the 30's, a costly and time consuming development which he undertook simply because he thought it was right.

Without modern computers it was necessary to hand compute a set of tables similar to HO 249 and then to plot these into pre-printed curves. The resulting books were both patented and copyrighted. He worked with Lindberg (to whom he taught celestial navigation) on the development of the second setting watch. The Weems model had an outer rotating bezel to which the sweep second hand could be set without stopping the movement of the watch. This "second setting" feature became the basis for the later so-called hack watches. The Lindberg version had the dial calibrated in hour angle rather than time.

He was the first to develop the modern version of the Air Almanac. It was first published by the Naval Observatory in 1933 and then dropped. It was then published by the British during the 30's. In 1941 a change was made at the observatory and since that time we have had the direct tabulation of Greenwich Hour angle and declination to define the positions of celestial bodies. Space prohibits even a listing of all the accomplishments of this remarkable man, from underwater archeological exploration with Ed Link, to making an early flight over the North Pole with the USAF, to writing the first Navy publication on Space Navigation.

I had the privilege of spending a lifetime associated with him, from North Atlantic convoy duty on his staff to association in his business enterprises. Of his many successes, the one which I like the best is that in his WWII days of Convoy Commodore, on coastal convoys, then to North African convoys, then to the North Atlantic run, with thousands of ships having been under his command not one of these vessels was lost to enemy action. A remarkable record for a remarkable man. But then his classmates in the class of 1912 had him sized up correctly, in the Lucky Bag, the comment beside his picture was simply, "And, strange to tell, he practiced what he preached."

HISTORY OF NAVIGATION

The Tordesillas Line

by T. D. Davies

The line established in 1494 by the Treaty of Tordesillas has played a surprising part in the definition of modern geography. The treaty was the result of the discovery of the islands of the West Indies by the Admiral of the Ocean Sea, Christopher Columbus. The Portuguese had followed the strategy of attempting to circumnavigate Africa as a means to get to India and the orient, with the objective of taking over the lucrative spice and silk trade that then arrived in Europe via the middle east, controlled by the Moslems. They legitimized a monoply of these efforts by obtaining a series of Papel Bulls which confirmed their monopoly on this area.

These Bulls described an east-west line, below which all new discoveries were assigned to Portugal. When Columbus was driven into Lisbon upon his return from the first voyage, he was told by the King of Portugal that his "Indies" were in the Portuguese zone. Accordingly when he finally got to Spain an approach was immediately made (by Ferdinand and Isabella) to the newly elected Pope, a Spaniard (Rodrigo Borgia), who promptly issue a new Bull canceling the previous ones and rotating the "line" by 90 degrees, to a north-south direction, set at 100 leagues west of the Cape Verde Islands.

The Portuguese were unhappy about this "end run" and proposed to negotiate a treaty in which they would exchange some benefits for more possible territory. The negotiaters met at Tordesillas and produced two treaties signed on the same date. The better-known set the "linea meridional" farther west to 370 leagues from the Cape Verdes, while the second granted "base rights" to the Spaniards in the Portuguese towns and bases along the north coast of Africa. These were considered of great importance by the Spaniards to support their war against the Turks, who had by then occupied Constantinople and were threatening the entire Mediterranean.

The navigational significance of this treaty lay in the fact that the physical location of the line required the determination of longitude; a feat that was to baffle many navigators for a century or more. The political importance of its location was the source of great pressure on the navigational and scientific experts of the day. This was the basis of efforts by Amerigo Vespucci to utilize the "method of lunar intercepts" in 1499. Its location first determined the limits of what is now Brazil, albeit by a series of guesses and approximations. For a while the Spaniards busied themselves developing the Spanish Main, to the west of the line, until Magellan, a disaffected Portuguese commander, proposed to the Spanish ruler that the Spice Islands (in the Moluccas) were actually in the Spanish sector, if one simply extended the Line around the globe.

Thus the "linea meridional" became global. Some idea of the precision of the longitudes involved can be appreciated if we note that Magellan's navigator, as recorded by the log, was 53 degrees in error on the location of the Philipines. Spanish and Portuguese (who arrived via India) battled in Indonesia for many years. Both the Portuguese and the Spanish empires eventually disintegrated, although there are still some geographic fossiles such as Macau in China and (until recently) Goa in India.

Lesser known is the fact that the line was used as the basis of dividing Australia into two parts (New South Wales and West Australia) in the mid-nineteenth century. Finally, in the late nineteenth century, Portugal used it as the basis of a territorial claim against the easternmost islands of Canada. This claim went to an international court for settlement; the Portuguese lost.

NAVIGATION NOTES

The Haversine

Provided by Donald J. Pegg

In older works on trigonometry the functions are defined in the geometrical manner, by lines rather than by ratios, as in textbooks at the present time. As an example, in a circle of unit radius (Fig. 1) OA OS OB and OC are radii and, equal to 1. Here the cosine is defined geometrically as OM, part of the radius OA and, is defined algebraically as the ratio. Since OS = 1 this

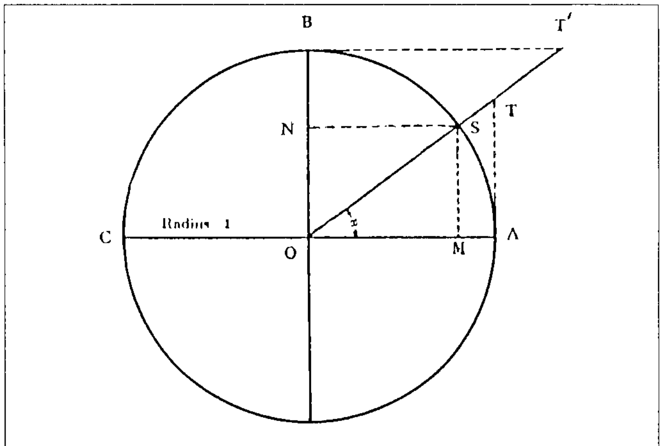


Fig. 1

reverts back to OM as the cosine of the angle x. Again, by definition, the versine is OA-OM (MA) or, (1-cos x). This is usually shortened to "vers x." Half of this or (1-cosx)/2 is the haversine, usually shortened to "hav x."

In like manner the section NB is defined as the coversine but I have found no examples of this function being used in navigational calculations. However a related function, the suversine (1+cosx), has been employed in a formula for P, (t) used by the British Astronomer Nevil Maskelyne and further, a formula using the suhaversine, is described in a little known work on spherical trigonometry published in Scotland. Here the author states, "Despite the advantages obtained by the arrangement of this function in the tables, this function never seems to have been widely used."

Tables of haversines are found in all issues of "Bowditch" since 1912 and, in most other collections of navigation tables.

Should such tables not be available, formulas containing the haversine function can be solved if the expression sin squared of x/2 is substituted, since it is numerically equal, as is shown in the half)angle formula;

sin x/2 = ((1-cos x)/2)<1/2>
and, squaring both sides;
sin<2>x/2=(1-cos x)/2
which is the haversine.

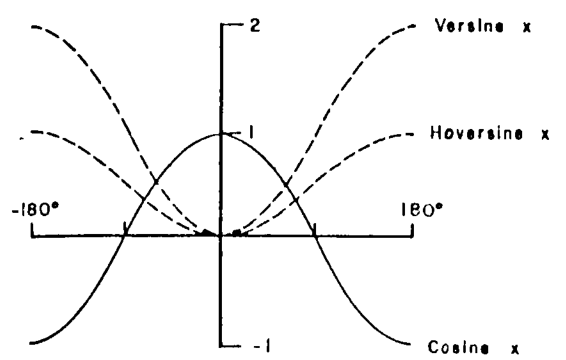
In fact, some of the older formulas used in navigation were of the half-angle type;

sin<2>t/2 = sec L <. cosec p <. cos s <. sin (s-h)
where
s = 1/2 (h+L+p)

When James Andrew published his tables, in 1805, they were described as "Tables of sine squared of half the arc." These tables did not stir too much interest among navigators until the early 1900's, when Percy L. Davis, in England, published for the first time, tables consisting of logarithmic and natural haversines in adjacent columns. These tables proved quite popular and, it has been suggested that this popularity is the main reason that use of the versine declined.

The question of accuracy does not seem to enter into the question of the preference for the haversine over other functions. The reason, frequently stated, is that the function is always positive, 0 to 180 (Fig. 2). In contrast the cosine and sine are negative in the second and third quadrants respectively. In addition if half the angle is near zero, the half angle formulas for the cosine will not give accurate results since cosines of angles near 0 differ little in value. The same holds true of the sine, when half the angle is near 90.

The fact that the cosine and sine functions are negative in some cases, could (and did), cause confusion in the minds of the older, non mathematical minded, seamen of earlier days. This and the appearance of Davis' tables, mentioned above, is as far as I have been able to find, the generally accepted reasons for the preference of haversines, in addition of course, for the reason stated above, that haversines are positive for all values.



A comparison of the versine and haversine functions with the cosine function.

Fig. 2

A Navigation Problem

by Roger Jones

Solution to the problem presented in Issue Sixteen

18. Answer

Where a long distance is involved, great circle sailing will result in a noticeably shorter distance traveled than would be the case if a rhumb line course were followed. Spherical trigonometry is one way of computing the great circle courses and distances. However, the tedium of higher math can be avoided using the sight reduction tables. In the tables, Z, converted to Zn, is the initial great circle course if one treats the destination as if it were the GP of a celestial body. Hc, corrected for declination increment and converted to zenith distance, is the great circle distance to the destination.

From the list of maritime positions in Bowditch (or from a chart), Fernando de Noronha is found to be at 3-51 S, 33-49 W. Using HO 229, the entry arguments would be: Latitude 35; LHA 51; and Declination 3 (same name as Latitude). LHA 51-00 is derived by adding an assumed position (AP) Lo of 17-11 E to the destination Lo of 33-49 W.

The respondents on page 104 of Volume 3 of HO 229 yield the following solutions: Z, converted to ZN, = 292.3; and Hc, corrected for declination increment, = 33-33.8. Zenith distance is 89-60-00 minus 33-33.8 = 56-26.2, and the nautical miles equivalent of that arc distance is 3,386.2. This distance may then be corrected for the latitude and LHA increments by the following procedure. Plot the AP at 35 S, 17-11 E, with course line 292.3 drawn through it. Plot the DR at 35-30 S, 17-00 E, and from the course line drop a perpendicular to the DR. The distance along the course line from the perpendicular to the AP is the correction for the latitude and LHA increments. The correction is +3.7 nm.

The great circle distance is thus 3,389.9 (whereas the rhumb line distance is approximately 3414 nm). The initial great circle course is 292.3, which is close enough without interpolation (whereas the rhumb line course is 303.9).

HO 249 could be used the same way, but the latitude of the destination must be within the 29 degree declination limits of the tabulations. Great circle course changes for each day as the voyage progresses, and the remaining distances, can likewise be determined used the sight reduction tables.

Problem No. 19

After passing Fernando de Noronha, Backstaff and her crew decided to explore the lower reaches of the Amazon River, which they did during late April and early May. The northerly voyage was then resumed with a view towards spending a relaxed summer cruising the islands from Trinidad and Tobago northward to the Virgins. They do not want to venture too far north into the hurricane belt during the May to October time period.

It is now June 21, 1987, and the vessel is on a northeasterly passage from Grenada to Barbados. The DR position is 12-21.0N, 60-30.0W. At 20-03-31 (daylight saving time aboard the vessel) a sextant observation of Vega is made, followed by a shot of Regulus at 20-07-31. The height of eye is 12 feet, and the index error is now 3 minutes "off the arc". Hs of Vega is 12-21.3. Hs of Regulus is 46-57.3.

(a) Using the method of HO 249, Vol. I (Epoch 1985), what is the azimuth and intercept for each observation?

(b) Why did the navigator make the second observation exactly four minutes after the first one?

(c) What correction for Precession and Nutation would be necessary in connection with these star shots?

(d) What position is fixed by the intersecting lines of position as moved for Precession and Nutation?

MARINE INFORMATION NOTES

Digest of Notices to Mariners

by Ernest Brown

ANMS-TWX SERVICE CHANGE

Effective 1 April 1987, Telex II (TWX) access to the Navigation Information Network (NAVINFONET) will be suspended. As of that date domestic users of the Automated Notice to Mariners (ANMS) are advised to use voice grade telephone or standard TELEX to access NAVINFONET. The status of communications links as of 1 April 1987 is as follows:

Type	Number	Baud	Status
Telephone	(301) 227-3351	300	3 lines active
Telephone	(301) 227-4360	1200	1 line active
Telephone	(301) 227-4364	1200	1 line active
Telephone	(301) 227-5295	1200	5 lines active
European CCITT V.21	(301) 227-3457	300	2 lines active
TELEX	908140	110	1 line active
TWX 7108240551		DISCONTINUED	

DEFENSE MAPPING AGENCY HYDROGRAPHIC/ TOPOGRAPHIC CENTER REPRESENTATIVES

New York, NY 10278	26 Federal Plaza, Room 1745 Phone (212) 264-3199
New Orleans, LA 70130	World Trade Center, Suite 400, Room E, 2 Canal St.,, Phone (504) 589-2642
Terminal Island, CA 90731	2518B Custom House, 300 S. Ferry St. Phone (213) 548)2877

NATIONAL OCEAN SERVICE OFFICES: Information concerning National Ocean Service (NOS) Charts and related publications may be obtained by addressing the Director, Charting and Geodetic Services (N/CG22), NOS, NOAA, Rockville, Maryland 20852, or the following NOS offices:

NORFOLK, 439 West York Street., Norfolk, Virginia 23510, Tel. (804)441-6616
SEATTLE, 1801 Fairview Avenue, East, Seattle, Washington 98102, Tel.(206)442-7657
SEATTLE, 760 Sand Point Way N.E., BINC 1570, Seattle, Washington 98115, Tel. (206)526-6622
ANCHORAGE, 701 C Street, Anchorage, Alaska 95513, Tel.(907)271-5136
NOS charts and publications are sold at this office.

CAUTION: CLOSE APPROACH TO MOORED OFFSHORE AIDS TO NAVIGATION.

Courses should invariably be set to pass these aids with sufficient clearance to avoid the possibility of collision from any cause. Errors of observation, current and wind effects, other vessels in the vicinity, and defects in steering gear may be, and have been, the cause of actual collisions, or the jeopardizing of navigation services provided by these important aids to navigation. Experience shows that buoys cannot be safely used as leading marks to be passed close aboard, and should always be left broad off the course, whenever searoom permits.

When approaching an offshore light structure, large navigational buoy, or a station on a submarine site, on radio bearings, the risk of collision will be lessened by insuring that the radio bearing does not remain constant.

It should be borne in mind that most large buoys are anchored to a very long scope of chain and, as a result, the radius of their swinging circle is considerable. The charted position is the approximate location. Furthermore, under certain conditions of wind and current, they are subject to sudden and unexpected sheers which are certain to hazard a vessel attempting to pass close aboard.

Watch (station) buoys are sometimes moored near large buoys to mark the approximate station of the large buoy. Since these buoys are always unlighted and, in some cases, moored as much as a mile from the large buoy, the danger of a closely passing vessel colliding with them is always present, particularly so during darkness or periods of reduced visibility.

BOOK REVIEW

by Roger H. Jones

WE, THE NAVIGATORS
The Ancient Art of Landfinding In the Pacific

by David Lewis

The University Press of Hawaii
2840 Kolowalu St.
Honolulu, Hawaii 96822 (1972)
348 pages - $5.95

The reviews which have appeared in the Newsletter have most often been of very recent books, and some have been of new works not yet released by the publishers. Occasionally, we have reviewed an older book that has stood the test of time well, and we do so again in this issue of the Newsletter.

Members who have been with us for some time may recall that we commented in the Fall (1984) issue about Marvin Creamer's completion of his 30,000 mile circumnavigation without the aid of navigation instruments, and in the Winter (1985) issue we reviewed David Burch's Emergency Navigation, the forward of which was written by David Lewis. It is fair to note that the Foundation is interested in the preservation of the sextant art, but that it also has deep respect for and interest in the navigational arts as practiced by those without instruments, including the ancient Polynesian, Melanesian and Micronesian canoe voyagers. They followed the star paths, and their keen understanding of swell patterns, bird habits, cloud formations and colors, and deep phosphorescence enabled them to make long voyages to precise landfalls without charts or instruments of any kind. They carried remarkable learning in their heads.

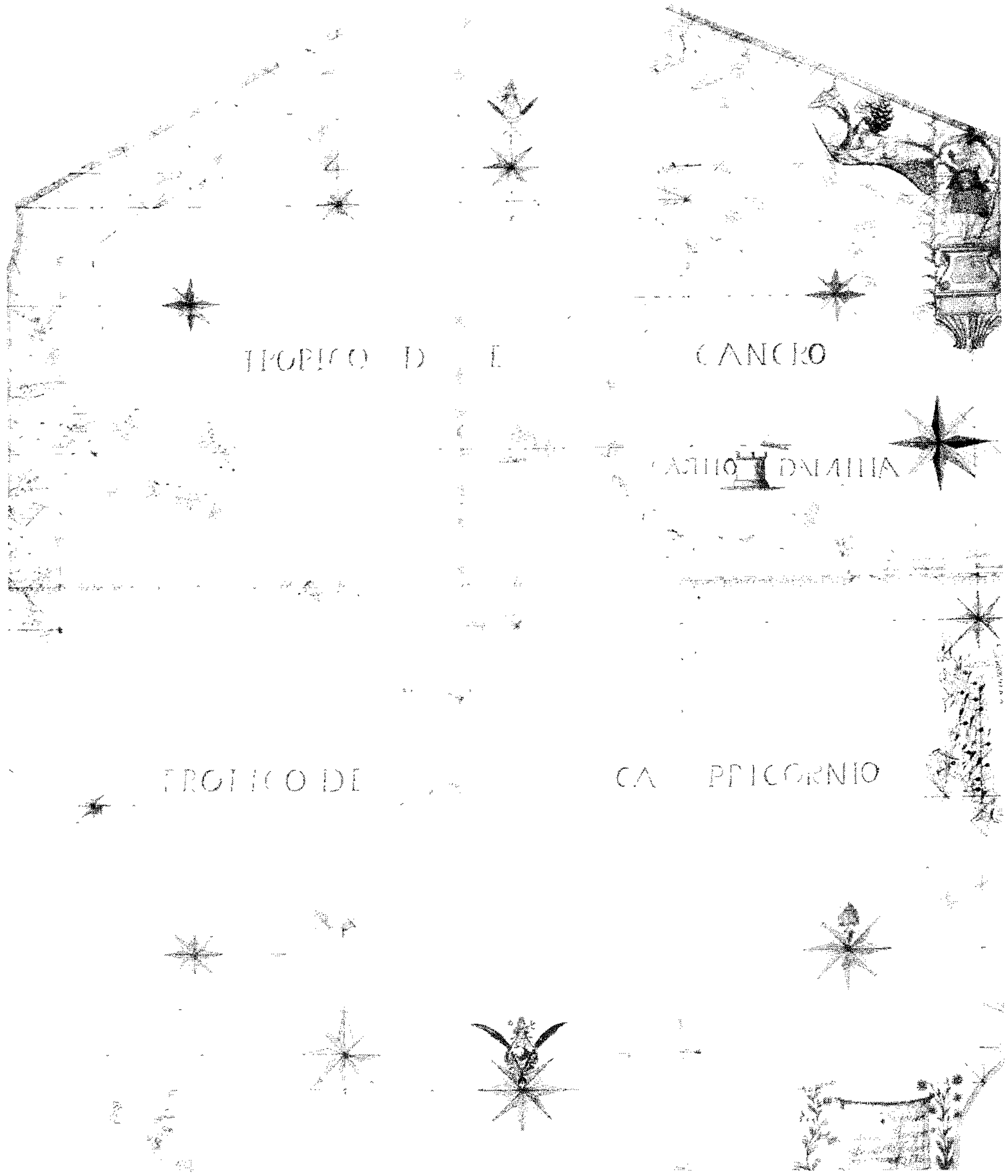
David Lewis' *We, The Navigators* is a firsthand account of his 13,000 miles of sailing in the western South Pacific without resort to modern navigation methods, and under the guidance of island navigators trained in the ancient arts in accordance with the concepts passed from one generation to the next over a millenium of time. For his work, Dr. Lewis was awarded the Gold Medal of the Royal Institute of Navigation, London, and the Superior Achievement Award of the Institute of Navigation, Washington, D.C.

Lewis' book reflects both the deep scholarship and the sense of excitement that was present as the methods were revealed to him. He is not the first to comment upon the marvelous achievements of the navigators of Oceania. Cook and other early European explorers of the Pacific preceded him in written accounts, but Lewis took the inquiry well beyond that of the earlier commentators. He committed the time and the resources to become the student of the very few remaining masters. He traveled with them in their canoes, and he made them the master of his own sailing vessel. What he did was in "the nick of time", for the ancient knowledge has not been well preserved in the 20th Century, and indeed one of his principal tutors, Tevake, the Outlier Polynesian, was lost at sea off Santa Cruz in 1970. It is indeed fitting that We, the Navigators is dedicated to Tevake, a "master navigator" in every true sense of the term.

The comparisons by Lewis of the European and South Pacific methods and concepts are extremely interesting. They reveal how totally different were the approaches used by the master navigators who hailed from worlds apart, and they once again legitimize the respect and even awe that is engendered in one who begins to understand the "high art" that was nearly a science as developed by the islanders of Oceania. Indeed, the understanding and use of the complex wave and swell patterns is but one example of their remarkably intelligent analyses. Another is the "star" or "sidereal compass" as used in the Carolines, and a third is the etak system of reference that enabled the navigators at sea to point out the location of islands invisible over the horizon, and which was not based upon the chart systems of reference developed in Europe.

We, the Navigators is fascinating. Practitioners of the most modern methods of navigation and of the celestial methods alike would do well to absorb the lore of the waves and the swells and even that of the star paths. In the navigational art of the islanders there is celestial wisdom, oceanographic insight, and even zoological learning. We may think of Tevake and his forebears as lacking in formal Western education, but there is much that we may learn from him and the few remaining masters of his art.

Address all correspondence to:
The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850



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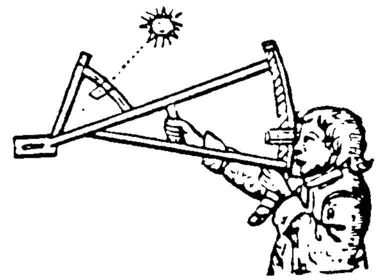
THE NAVIGATOR'S NEWSLETTER



FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION ISSUE EIGHTEEN, FALL 1987

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

by T. D. Davies

Awards

We continue our efforts to expand our Awards Program. Our idea is to use these awards to stimulate interest in navigation, particularly among students, and to utilize them for recognition of outstanding work or performance by anyone in the field. Suggestions from members as to specific individuals or institutions where such an award might prove fruitful will be most welcome. We have currently approached the Sea Cadets of the Navy League, and hope that we can work something out in that area. The key to having some impact lies in the criteria used to determine a winner. We try to arrange it so that the faculty or sponsors propose criteria which we approve, and then the annual application is done by that group.

Compact Almanac

The new compact almanac is on the verge of completion, although its progress has encountered several stumbling blocks. Processing of the data went well until an invisible "bug" was discovered in the raw data (from the Naval Observatory). Of course it was only discovered when the final print-out turned out to be garbage in a few cases. Correction required penetrating into and editing the hexigesimal. After that the tables were finally turned out in a smooth form for processing in our new Macintosh desktop publishing system.

This version, which we have named "The Navigator's Almanac" provides data for 1987. The first copies, which we are sending to board members and a list of people for comment, will be done on the xerox rather than printed. If there is enough interest we could print one or two hundred copies, but by the middle of October we expect to have the 1988 version ready, and will print several hundred copies, probably on coated paper, at a price of about $5.00 each.

The virtue of the 1987 version is that it can be utilized immediately, and should generate some early comments, which we may apply to the 1988 edition. Anyone having an interest in the 1987 edition should communicate with us earliest, our telephone number is on the last page of each issue.

Potential users of the almanac should expect that its compact size carries with it an increase in interpolation, although this is kept as painless as possible by extended interpolation tables only requiring addition of numbers supplied from the tables. Subtraction is not required for any of the main tables. Sun, Aries and planets are simplest; the Moon, as might be expected, presenting more complication and accounting for the greater portion of the size of the book.

Finally, we encourage members to use the Newsletter and also the new compact almanac to generate interest and new members for the Foundation.

READERS FORUM

Bill Land of Norristown, PA, writes that he is starting a new course in Celestial Navigation on 16 September, at the Norriton Middle School in Norristown.

Lloyd M. Smith of Sarasota, Florida, writes:

"I have a sextant I am considering selling. Do you know of anyone who is knowledgeable that could provide me with a 'ball park' figure of what it is worth? Do you know of anyone who specializes in selling used sextants? Thanks for your help."

G. A. Taylor of Glenburnie, Ontario, Canada, writes:

"I am interested in obtaining all the back issues of the voyage of the Backstaff. I have enjoyed the problems in issues 15, 16, and 17.

"Question for Roger Jones: In issue 17 the initial course given was 292.3. Tab Z is 112.3 and you must, I think, include a Z correction of 0.9. Z is therefore 111.4 and Zn is 291.4."

Director J. M. Luykx, writes:

"Would it be possible to obtain Xerox copies of the two articles in Sky and Telescope mentioned by Mr. Land on page 2 of the last issue. I might be able to help identify the instruments.

"I may also be able to help with Mr. Bodurtha's problem concerning a Pioneer bubble sextant. The instrument is most probably a USN MK III or Mark IV octant (USAAF A)5 or A)7 octant), instruments which I have in my collection."

K. L. Gebhart of Celestaire, Inc., writes:

"Reference Readers Forum, Summer issue, James N. Bodurtha request: He wondered what became of the pioneer Division of Bendix, and the bubble sextant they made. Our company, Celestaire, Inc., still handles this sextant. We have complete overhaul facilities, all technical manuals, and offer it for sale in overhauled condition. He can contact us at 416 S. Pershing, Wichita, KS 67218.

"Second subject....Your readers may wish to know ahso that we have just returned from Shanghai, where we completed negotiations to be the sole importer of the Chinese 'Astra III' sextant. This sextant has been all the rage recently, and was thought to be discontinued."

Norman G. Cubberly, Master of the USNS Persistent, writes from At sea, somewhere in northern climes, 20 April, 87:

"After almost three months out here and with another 3 to go am catching up on reading and correspondence. The latest Newsletter is Fall 1986.

"I may have a lead for you concerning the 'v' in the Nautical Almanac as coming from 'velocity.' My first course in celestial navigation was at the now defunct Admiral Bullard Academy in New London, Conn. where I was doing a year of prep. prior to the Coast Guard Academy. My instructor was one Waldo (Brud) Clarke, Jr. who also ran the school ship and who probably still lives in New London. In those days the old (shudder) Almanac was in use, interpolation was the order of the day and the daily page with one minute entries was far in the future. As I remember one had to interpolate between one to 12 hours, depending on the body, each being in a separate section of the Almanac. Precessional errors and the like were taken in a separate table as velocity. This is all far back so some research may have to be done.

"Right now, with a shipload of super sophisticated navigational equipment, my mates and I still run off sights for practice and much to our surprise find 12 pages missing out of the center of a neatly bound HO 229! How's that for black box failure! Would use my Davies Assumed Altitude Tables, latest edition but for a) could not haul them to Rota, Spain where I met the ship and b) a wee, wee too much latitude.

"Also it is interesting to sail with one Plath sextant, 3 Tamaya chronometers, two sat navs and a Loran C to deliver time to say nothing of all the cheap digital watches which make all the above timekeepers more than redundant. (I don't really count the Cesium time standard which keeps the computers all lined up or the two gyro compasses and the stable vertical.)

"Hopefully my wife will send another Newsletter or two along in a care package of reading matter to help wile away the next mission though I doubt if she will drop in the Assumed Altitude Method and I doubt if I will get far enough south to use it."

Walter H. Johnson of Annapolis, Md., writes:

When two planets are in "conjunction" they appear to be close together. But just when does it occur and how near do they approach an eclipse? In order for an eclipse to occur, the GHA of each must be the equal; the declinations must also be equal and of the same name. I decided to make some calculations regarding the time of the closest approach and the great circle distance apart at that time. The distance may be calculated by:

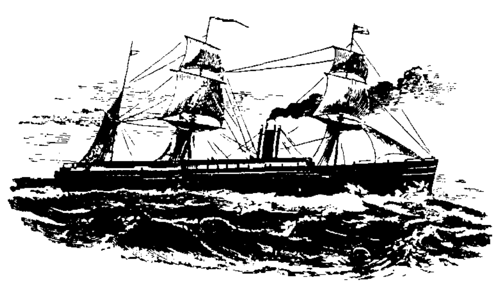
$$\text{Cos}(D) = \text{Sin}(d1) \times \text{Sin}(d2) + \text{Cos}(d1) \times \text{Cos}(d2) \times \text{Cos}(t)$$

Where D is the great circle distance, d1 and d2 are the declinations of the bodies and t is the meridian angle between the bodies.

For 1987 there are four instances where planets are in conjunction. The dates, the planets involved, the times of closest approach, and the distances apart at that time are calculated to be:

Date	Planets	GMT	Distance (Arc) Deg	Min
Jan 25	Venus & Saturn	0230	1	46.4
May 5	Jupiter & Venus	0410	0	34.5
Aug 24	Venus & Mars	0900	0	14.0
Nov 20	Venus & Saturn	1040	2	07.1
Oct 4, '85	Venus & Mars	0030	0	05.8

The 1985 case was the nearest that I have found to an eclipse. Apparently an eclipse is a very rare situation! I would like to know when, if ever, this has occurred.



NAVIGATION BASICS REVIEW

The Navigational Aspects Of Voyage Planning

John M. Luykx

One of the most important phases of the navigator's work is the preparation for and planning of the navigational aspects of a voyage. The following outline is, therefore, offered as a basic guide to those who plan to make an ocean voyage but who may not be familiar with the factors to be considered in the planning process.

I. Preliminary Navigation Planning

A. Establish the point of departure, the intermediate points and the point of arrival for the voyage.

B. Study cruising guides, Sailing Directions, Coast Pilots, Pilot charts and voyage logs to
1 establish:

1. The preferred time of year to make the voyage.
2. The recommended track for the voyage.
3. The predicted wind, weather, climate and current to be encountered during the voyage.
4. The average speed intended for the voyage.
5. The finalized voyage itinerary (ETDs and ETAs for each leg of the voyage, etc.)
6. The finalized voyage Dead Reckoning (DR) Track.
7. The optimum position and time of day for each landfall.
8. The customs, entry and clearance requirements for each port.

C. Establish Equipment Requirements

1. Charts, Pilot Charts, Diagrams, Plotting sheets.
2. Navigation Publications

Sailing Directions (U.S.)
Pilots (British)
Coast Pilots (U.S.)
Tide/Current Tables
Sight Reduction Tables
Nautical Almanac
Light Lists
Lists of Lights
Selected Worldwide Weather Broadcasts
Radio Navigation Aids
Bowditch Tables
Navigation Rules (Collision Rules)
Cruising Guides
Navigation Textbooks
Notices to Mariners
Star Finder

3. Navigation Equipment

a. Electronic (as applicable)

RDF
Echo Sounder
LORAN
SATNAV
OMEGA
Radios
RADAR
Speed/Distance Logs
Calculators/Computers

b. Optical

Steering Compass
Hand-Bearing Compass
Binoculars
Pelorus
Sextant

c. Plotting

Dividers
Plotters
Tables

d. Navigation Timepieces

Chronometers
Watches
Timers

D. Conduct a pre)voyage check of the vessel and equipment for operation and calibration.

1. Sea Trials

Sail vessel handling characteristics
Polar Diagrams
Aux. Engine—RPM/speed trials
Aux. Engine—Fuel Consumption Trials
Vessel Stability and loading

2. Equipment Check-out

Chronometer, watch and timer regulation
Compass adjustment and Deviation Table
Log Calibration
RDF Quadrantal Calibration
LORAN TD Corrections
RADAR Bearing & Range Corrections
Echo Sounder Calibration
SATNAV Calibration
OMEGA Calibration
Navigation Lights
Signaling Lights
Radio
EPIRB
Distress Signals
Calculators/Computers
Sextant Alignment
Binoculars
Pelorus and Bearing instrument alignment

E. Preparation of Vessel Movement Report to include the following:*

1. Vessel visual characteristics
2. Vessel Radio/Visual Call Sign
3. Vessel crew and passenger list
4. Vessel safety and emergency equipment
5. Vessel itinerary

*Note: Copies of the report should be submitted to friends, family as well as others prior to departure.

II. Planning the Enroute Phase

A. Establish daily underway routines for the voy age:

1. Prediction of daily rising/setting twilight data, Sun/Moon/Planets.
2. Prediction of stars for daily morning and evening twilight observations.
3. Routine for the use of electronic equipment for computing lines of position and fix (LORAN, SATNAV, OMEGA, etc.)
4. Daily Routine for Celestial Observations
   AM Stars (Planets/Moon) for fix
   AM Compass Check (Amplitude)
   AM Sun LOPs (Moon/Planets) for Fix, R. Fix
   AM Chronometer Check (Time Signal)
   AM Compass Check (Sun Azimuth)
   Noon Latitude (Moon/Planets) for Fix, R. Fix
   PM Sun LOPs (Moon/Planets) for Fix, R. Fix
   PM Compass Check (Sun Azimuth)
   PM Compass Check (Amplitude)
   PM Stars (Moon/Planets) for Fix
   PM Preparation for AM Stars
5. Log Entry and writing routine
6. Watch standing routine: Duties of watch standers
7. Emergency Routines
   Man overboard
   Breakdown
   Fire
   Rescue
   Collision
   Grounding & Standing
   Illness and Injury
8. Preparation and Assembly of Emergency (Back)up)
   Navigation Equipment.
   Charts
   Nav. Tables (excerpts)
   Watches
   Sextant
   Radio
   Publications

III.Planning the Landfall

A. In preparation for the predicted time and position of each landfall, determine:

1. Predicted wind, weather and visibility
2. The state of the tide and tidal current
3. Predicted set and drift of the ocean current
4. The availability and use of electronic navigation aids; i.e. LORAN, Radio Beacons, RADAR, commercial stations, etc.
5. The availability and use of visual navigation aids; i.e. lights, buoys, beacons, landmarks, high mountains and hills, etc.
6. The availability and use of celestial observations.
7. The bottom contour characteristics for use with the echo sounder to a) avoid danger and b) to fix the vessel's position; i.e.: shoals, pinnacles, steep gradients, underwater obstructions, quality of bottom, etc.

NAVIGATION PERSONALITIES

Arthur A. Ageton

by T. D. Davies

Arthur Ageton is probably best known to navigators the world over for his sight reduction tables, first published in 1930 as HO 211. He was born in Fromberg, Montana, on October 25, 1900. After receiving his early education in the public schools of Pullman, Washington and State College of Washington, he entered the U. S. Naval Academy with the class of 1923.

Following graduation he served at sea for 7 years, starting with duty in the battleship Pennsylvania, and the destroyer Sands. Thereafter he served in the battleship Idaho and as a student at the U.S. Naval Postgraduate School. He was then ordered to the Navy Department in the personnel area, with additional duty as Naval Aid to the President. It was during this tour that he completed his sight reduction tables which were published as "D.R. Altitude and Azimuth Tables." He received a letter of commendation from the Secretary of the Navy for this work.

After more time at sea aboard the Destroyer Pruitt, the Fleet Oiler Salinas and the hospital ship Relief, he returned to the Naval Academy as an instructor in Navigation. It was during this tour that I first met Ageton. He was my instructor in the celestial navigation course during my second class (junior) year. I found him to be an inspiring teacher, replete with practical lessons from his many navigational experiences, and yet fully grounded in the theoretical background of the Art. The development of his famous tables was no accident; he was the man who could do it.

One "sea story" will give some insight into how broad minded he was. Bear in mind that most naval officers were sticklers for detail in those days, particularly when dealing with midshipmen! Following the regulations was the rule.

In the summer of 1936 my class went on a typical midshipman cruise (to Europe) aboard the old battleships Arkansas and Wyoming. Ageton was along as the director of the training operation. Early on he sent for me and handed me a copy of an article on navigation from the Naval Institute Proceedings, which then carried many professional articles of that type. In fact it was an article by Willis, setting forth his method (see Newsletter,issue 5) for getting a fix from a single body.

"Davies," he said, "you will not carry out the required course work this cruise, I am satisfied that you do not need it. Instead I want you to study this article and then carry out a series of sights to test the method. You will write a report to me on the results."

Somewhat shocked at the deviations from the rules, I nonetheless set about studying the method. Although I was a neophyte in navigation I soon found that the method was flawed. After many attempts to pin down a fix, I decided that the method simply required an accuracy that was far in excess of what any careful navigator could produce. In the end I submitted a report to that effect to Ageton.

After spending some time studying my report he handed it back to directing me to put in a proper form and submit it as an article to the Naval Institute Proceedings. To my surprise it was accepted, published and I eventually received a CHECK. In those days it was big money, in the entire event was completely out of line with the highly regulation-bound life at the Naval Academy (things are much different now!).

I saw Ageton many times as we pursued our separate careers in the navy, and always found him a brilliant analyst and an engaging conversationalist. He went on to sea duty aboard a wide variety of naval vessels, including duty on the old China Station. He later returned to the Naval Academy, this to develop a series of traning films on seamanship and navigation.

During World War II he served as Executive Officer of the battleship Washington, participating in the assault on the Gilbert and Marshall Islands and the bombardment of Nauru. He also commanded LST Flotilla 3 in the assault on Leyte, Lingayen, Okinawa, Ie Shima and Iheya Shima. He was awarded a number of combat decorations. At his own request he was retired with the rank of Rear Admiral on December 1, 1947.

After retirement Ageton worked for seven years as a writer, author and lecturer. He received a Master's Degree from John Hopkins University. In July of 1954 he was appointed by President Eisenhower as U. S. Ambassador to the Republic of Paraguay, serving there until 1957. Thereafter he was associated with an export-import house and was also a director of International Products Corporation. He retired from business in 1962.

Admiral Ageton is the author of a long and varied list of books. They include technical professional naval books in addition to his famous tables, but also novels, children's books, a biography (of Admiral Standley) and training manuals. One of his novels has been translated into 7 languages. His contributions have been many and varied, but to navigators, who still use his method, he is the inventor of the best of the small tables.

HISTORY OF NAVIGATION

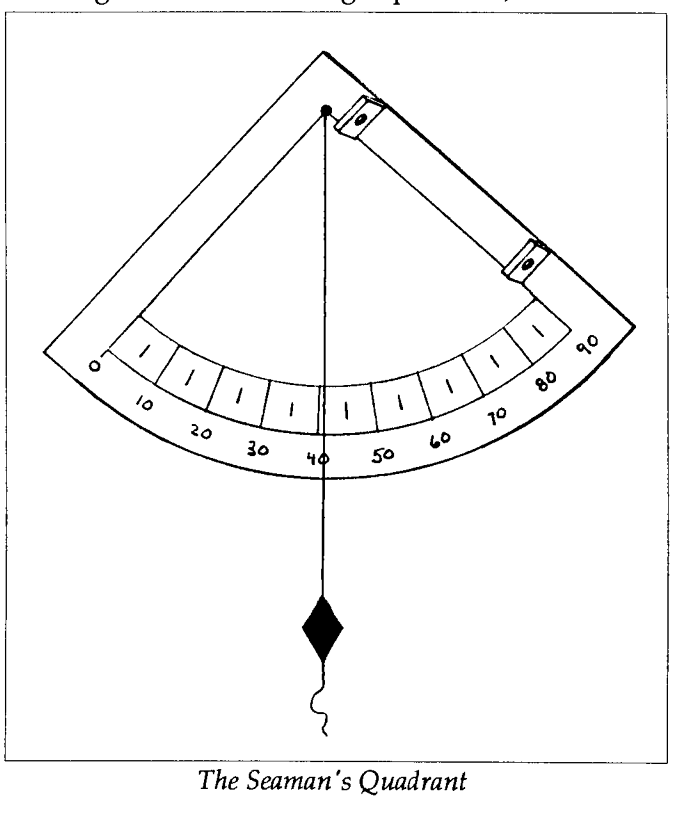
Early Altitude Measuring Instruments: The Seaman's Quadrant

John M. Luykx

The principal altitude measuring instruments used by European navigators prior to the invention of the reflecting quadrant byJohn Hadley in 1731 were the seaman's quadrant, the mariner'sastrolabe, the cross-staff, the sea-ring and the backstaff.

The first of these instruments to be used for measuring altitudeswas the seaman's quadrant, employed by the Portuguese as early as 1460 during the early stages of the exploration of the west coast of Africa.

The quadrant was made of wood or metal in the shape of a quartercircle. On the circular edge an arc was engraved, graduated in individual degrees from 0° to 90°. A set of two pinhole sightvanes were fitted, one near each end of a straight side of the quadrant. A plumb-bob was attached to, and suspended from, the apex of the instrument. Two observer's were normally required to take the observation of a star; one to hold the quadrant and align the star in the sight pin-holes, the other to



The Seaman's Quadrant

record the altitude by noting the point or graduation on the arc intersectedby the plumb-line at the instant of observation. It was also possible for a single observer to take a star observation(usually the star Polaris- by sighting the body in the normal manner, holding the quadrant in the right hand and "clamping" the plumb line to the instrument with the thumb and forefinger of the left hand at the instant of observation. The altitude was read by recording the point or graduation on the arc where the plumbline had been clamped.

In its earliest use by the Portuguese, the quadrant was employed to measure the difference in latitude between Lisbon and the observer's position on the west African coast. The latitude of this position was observed and marked on the arc of the quadrant, permitting the navigator to return to this original position at a later voyage by sailing south from Lisbon, until, while making an observation of Polaris, the plumb line intersected the earlier mark on the arc. At this point, the navigator changed course to the east and sailed along the latitude until the coast was reached. Later quadrants were graduated in degrees of altitude as well as degrees of zenith distance. To obtain latitude south of the equator, observations of the sun at the time of meridian passage were necessary. For these observations the quadrant was oriented toward the sun and the altitude was measured indirectly at the instant when the ray of sunlight passing through the upper or forward pin-hole sight was aligned with the pin-hole in the lower or rear sight. Using this procedure, the observer was not required to look directly at the sun when taking an observation. By 1480 tables of sun declination, day by day, had become available to mariners. The first of these published in Lisbon made it possible for Portuguese navigators to measure the latitude of points along the West African coast, south of the equator.

In the northern hemisphere, a correction to the observed altitude of Polaris, as observed by quadrant, was as necessary in the early days of exploration as it is today when observed by sextant. In the year 1500, for example, the polar distance of Polaris was 3°.05. In the year 1987, it is 0°.08. The correction to be applied was determined in the early 16th Century by noting the position of the star Kochab relative to Polaris at the time of observation. For this position, the navigator followed the instructions contained in the *Regiment of the North Star* (a set of rules for observing the North Star first published around1495- to determine the appropriate correction to apply to the observed altitude of Polaris to obtain latitude.

Because of wind and the effects of the sea on the small ships of the period, it was impossible to obtain accurate altitudes using the quadrant on board ship. At sea, readings were only accurate to within 1/2 to 1 degree unless the vessel were in a dead calm. As a result, the latitude of a place was best determined from observations taken ashore with the quadrant.

To measure the accuracy with which a quadrant is capable of measuring the altitude of the sun indirectly during the day as well as the star Polaris directly at night, the author conducted a series of tests from a position ashore using a reproduction brass quadrant from his collection. The quadrant is made completely of brass with a scale radius of 200 mm. It is graduated in whole degrees from 0° to 90°.

The vertical is defined by a small brass plumb-bob suspended by a thin wire from the apex. The instrument weighs 3 lbs Each sighting vane contains one sighting aperture (pin-hole- 1 mm in diameter. The design of the quadrant is based on the drawing of a sea-quadrant taken from Joseph Moxon's, *A Tutor to Astronomie and Geographie* (1659), reproduced on page 120 of *A History of Marine Navigation* (1973) by Commander W. E. May.

The accuracy test of the quadrant was conducted in the vicinity of Forestville, Maryland on 24 August 1987 and consisted of:

1. 30 observations of the sun in 3 groups of 10 observations each during mid-morning;
2. 10 observations at the time of meridian passage of which 3 were used to determine latitude;
3. 10 observations of Arcturus during the evening;
4. 10 observations of Polaris during the evening.

The observations were taken by a single observer and the time of each observation recorded by an assistant. Altitudes were recorded to the nearest 0°.01. The mean value of time and altitude was computed for each series of 10 observations. The mean altitude was then converted to degrees and minutes of arc. No I.C. was applied to the sun observations. The I.C. computed as a result of the sun observations was applied to the star observations.

The results of the test were as follows:

OBSERVER POSITION
LAT: 38°51.'8N
LON: 76°55.'1W

	1	2	3	4	5	6
BODY	SUN	SUN	SUN	SUN	ARCTURUS	POLARIS
GMT	14-52-42	14-58-24	15-52-30	17-10-00	00-20-50	02-54-00
Hs	48°44.'0	49°42.'0	57°18.'0	62°12.'0	44°47.'0	38°52.'0
LAT			38°55.'6			38°57.'7
Error	-2.'9	-0.'2	-2.'4	-3.'8	-5.'2	+5.'9

The results show that from a position ashore, altitudes of the sun measured indirectly by quadrant during the day are reasonably accurate; i.e., within 5' of arc if a series of observations are taken and the mean altitude is used in computing the latitude. By night, direct observations of the stars appear to yield less accurate results.

The quadrant was eventually superseded as an altitude measuring instrument at sea during the late 16th and early 17th centuries by the cross-staff; an instrument which provided greater accuracy because,with it, the navigator used the more stable visible sea horizon as areference rather than the plumb-bob.

The cross-staff as well as the astrolabe, the sea-ring and the backstaff will be described in future issues of the newsletter.

NAVIGATION NOTES

The Indirect-Horizon Scope

by Thomas D. Davies

Accurate establishment of the vertical angular altitude of a celestial body is essential to the determination of location at sea by celestial means. It is traditionally accomplished by the use of the sea horizon as a zero-point, to which the image of a star or other celestial body is related by the optical system of the sextant, where the vertical angle of elevation of the star is measured. However, the angle so measured must be adjusted by a correction for the "dip" of the visual horizon which is actually below the true horizontal plane tangent to the Earth at the point of observation. This correction is usually taken from a table of values computed for various heights of eye above the Earth's surface.

Among the possible errors that affect celestial sight-taking, the true location of the horizon is the most difficult to compensate for. Conditions at sea vary from day to day and from place to place, making the availability of a "good" horizon anything but certain. The difference in temperature between air and water produces an error of refraction for which there is no readily-available calculated method of correction. A table based on the averaged empirical values by Oguro can be found in some books, but is rarely used. It corrects for "average" conditions, and there are substantial variations in the true corrections with time and place. There are also occasions when the only usable horizon available is 180-degrees from the only desirable star.

The Indirect-Horizon Scope, addresses the three most difficult horizon problems. First, it may be used in combination with a sextant to measure the true angle of "dip" of the horizon resulting from the observer's height of eye, while simultaneously correcting for the actual refraction from the temperature differential between air and water. Second, it may be used to measure the altitude of a star or other celestial body by the use of a more clearly visible horizon 180-degrees in azimuth from the chosen star. Finally, where the horizon is distorted by poor visibility in both directions, it may be used to obtain a "dip" correction that will automatically adjust for the distortion.

The optical components of the telescope consist of reflecting surfaces which are segments of an optical arrangement known as a "corner reflector." The individual optical components are rigidly mounted in a tube or holder to insure that their geometrical relationship is maintained. This tube is carefully mounted on the sextant directly ahead of the Horizon Mirror, so that the rays from the Indirect-Horizon Scope are the only ones entering the Horizon Mirror. The only horizon visible through the Horizon Mirror is the one projected by the Indirect-Horizon. This mounting is removable either by rotating it out of the field or by taking it completely off of the sextant.

An essential feature of the design is that the length of the Indirect Horizon Telescope is great enough to provide clear visibility past the observer's hand to the horizon directly behind the user. This relationship is shown in Figure 1. Here the observer views the horizon directly behind him through the device—instead of the horizon directly in front, which he would normally see.

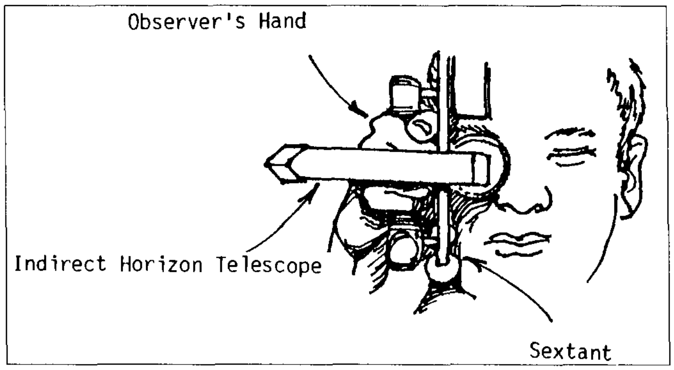


Fig. 1

The Indirect-Horizon Scope has the property of producing an inverted view of the horizon exactly 180-degrees from the direction viewed in all possible planes of rotation. Thus a star sight may be taken by bringing the star's image into coincidence with this rotated horizon with the same precision as if the directly-viewed horizon were used. The horizon 180-degrees from a star, therefore, may be used when it is more visible than the horizon directly below the star.

Another use for the Indirect-Horizon Telescope is the measurement of true "dip." Here the design of the device is identical with the above description, but the sextant index arm is set to zero so that the index mirror provides a view of the direct horizon to the viewer, adjacent to or super-imposed upon the reverse horizon. If there were zero "dip" angle, these two views of the horizons would be in exact coincidence, but since there will always be some "dip" due to the observer's eye height and an element of refraction, they will never coincide exactly. Movement of the index arm of the sextant is used to bring them to coincidence as is done in calibrating the index error of the sextant. The index reading of the sextant will now show a value of several minutes of arc which will be the sum of the "dip" angles of the two horizons. Since these two angles are congruent, this value may be divided by 2 to arrive at the true correction for "dip" for the sight. This geometry is shown in Figure 2.

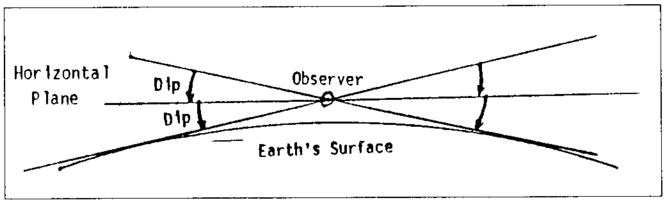


Fig. 2

The value of the above measurement of the true "dip" is determined only by the observer's height of eye and the difference in temperature between water and air, and may be done while the horizons have good visibility in advance of (or after, in the case of morning sights) one or more sights to acquire a correction that may be applied to all of the sights of a set taken within a short time.

On July 17, 1985 a series of experiments was conducted with the Indirect Telescope at St. Maarten in the Netherland Antilles. The revised model of the telescope included adjustment screws for small rotations of the 45 degree prism in two planes - the plane orthogonal to the long axis of the device, and the horizontal plane containing the long axis. Figure 3 shows this arrangement.

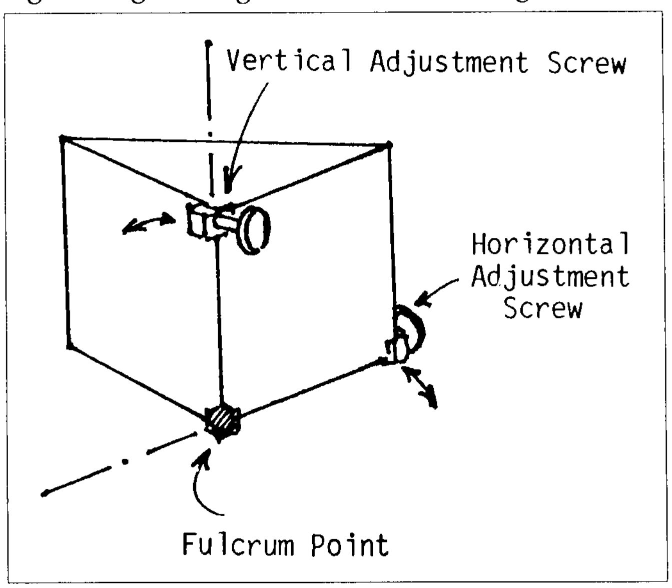


Fig. 3

These adjustment screws were used to remove all error from the scope, which was verified by two actions. First the scope (and Sextant upon which it was mounted) was rocked and adjusted until the rocking produced no separation of the two horizons that were held in coincidence. Second, the scope was inverted and the inverted horizon coincidence reading (actually 2 times the Dip) compared with the same reading in the erect orientation. These values were made equal by use of the second adjustment.

After the alignment of the scope was correct a set of readings of Dip was made. These showed that the measured Dip was > of 16 minutes, or 8 minutes of arc. The Almanac Dip tables showed a calculated dip for the Height of Eye (25 feet) to be 5 minutes.

Next a series of 5 Sun Sights was taken using the indirect or rear horizon. Actually there was no horizon available under the Sun, so the sights had to be made from the reverse horizon. The values of Sextant Altitude from these sights is plotted in Figure 4, attached. A least squares line through these values (done on the HP 11C) shows a correlation coefficient of .999882, or a very close fit. A time value of 07-51-15 was chosen and the coresponding sextant altitude from the least squares line calculted as 40 degrees, 34.8 minutes. With watch time correction this corresponded to GMT of 12-50-00, 17 July 1985. The Almanac gave a Sun GHA of 10-58.5, and a longitude from the map of 63-05.5 West, was used to yield an LHA of 52-07.0.

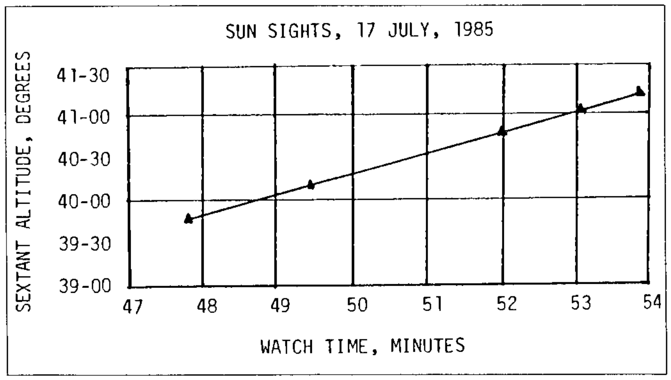


Fig. 4

The computed sextant altitude was modified by an Index Correction of +2, a refraction and semi-diameter correction of +14.9, and the measured Dip correction of +8, added because the indirect or rear horizon was used. This yielded an observed altitude of 40-59.7. The calculator was used to obtain the computed altitude for the exact location from which the sight was taken - known from the chart. This altitude was 41-00.8.

Thus the sight was 1.1 minutes from the calculated altitude. Considering that the sights were taken without any recorder and self recorded, this error can be taken as quite reasonable. It demonstrates two important points about the Indirect Telescope:

1. The use of the rear or indirect horizon is feasible and as accurate as the direct horizon. This device thus offers an alternate horizon for any sight, regardless of altitude (over-the-shoulder sights with the sextant are only available at altitudes over 60 degrees).

2. The geometric Dip was 3 minutes less than that measured by this device. Use of that value would have increased the error of the sight by 3 minutes. This suggests that there is indeed a surface refraction of significant value (probably varying with time and place) and that it can be eliminated as a source of significant error by use of the Indirect Telescope.

A Navigation Problem

by Roger H. Jones

Solution to the problem presented in Issue Seventeen.

19. Answer.

(a) Using an assumed Latitude of 12 North and a LHA Aries of 195 and 196 respectively for Vega and Regulus, the azimuths and intercepts are:

	Vega	Regulus
Azimuth	052	275
Intercept	14.6 Towards	1.0 Towards

(b) The second shot was made four minutes after the first in order to increase the LHA of Aries by exactly one degree, which then facilitates entry into the tables. The navigator would not have to calculate the LHA of Aries for the Regulus shot; it would be one degree greater than the 195 value for the Vega shot. In using the tables, he would simply move down one line from the LHA 195 line to LHA 196 when reading the HC and Zn for Regulus.

(c) In 1987, with LHA Aries of 195/196 and Latitude 12 North, the position line (or assumed position) is moved 2 miles in the true direction of 115 degrees.

(d) Position fix: 12-22.6 N, 60-26.5 W (based upon a plot on a constructed Universal Mercator Plotting Sheet. A chart might yield a slightly different plot.)

Problem No. 20.

Backstaff has spent the summer in a leisurely cruise from Grenada northward through the British and American Virgin Islands. It is now the evening of September 28, 1987, and she is moored in Tortola's Road Town harbor at 18-25 N, 64-37 W. It is still too early, because of possible hurricanes, to resume the northward voyage, and the navigator is brushing up on some seldom used procedures. He decides to use the 2102-D Star Finder to plot the position and determine the altitude and azimuth of the planets Venus and Jupiter. The GMT is 02-10-30, 29 September.

(a) What procedure is used to make the plots, and which of the Star Finder templates is used?

(b) Assuming the mountain terrain of Tortola would not obstruct the view, would either or both of the planets be visible? If so, what would be the altitudes and azimuths?

(Note: In Issue Twelve, we reviewed *Celestial Navigation With the 2102-D Star Finder - A User's Guide,* which is an excellent book on all applications of the Star Finder by David Burch.)

MARINE INFORMATION NOTES

Warning Mined Areas

Mines of various types and ages pose a threat to navigation in many parts of the world. Once mined, an area can never to certified to be completely danger free. Sweeping produces only statistical probability of protection. Mines may still remain, having failed to respond to orthodox sweeping methods. Some swept areas have not been covered by modern surveys and may contain uncharted wrecks, shoals or other dangers to navigation.

Prudent seamanship in former mine fields, swept channels and swept areas includes:

- Transit using only established routes or buoyed channels.
- Avoid shallow water. Sweeping techniques often preclude sweeping in restricted waters. Floating or drifting mines may be remoored in shallows.
- Avoid fishing, trawling or any other form of submarine or seabed activity.
- Mariners are advised to anchor with caution only in established anchorages.
- Consult local authorities and regulations.

Naval Mines: Naval mines of many nationalities still constitute a risk to shipping, fishing, underwater exploration, and other maritime interests. The different types of mines, the conditions under which they are most likely to be sighted, and the recommended action are as follows:

Floating Mines: Consider all floating mines to be live and dangerous. DO NOT TOUCH OR APPROACH. The possibility of drifting mines being camouflaged with seaweed or other innocent appearing floating objects should be borne in mind and avoiding action taken. The following procedures and precautions are recommended:

Ground Mines: On the High Seas . Report the location of the mine by the most rapid means as soon as circumstances permit; this report is to be similar to that required for any hazard to navigation. Mines sighted in anchorage areas or other patrolled water should, if circumstances permit, be kept under observation and reported to the nearest Navy or Coast Guard activity. The recovery or handling of the mine should be done only by qualified explosive ordnance disposal personnel. If a mine is drifting down on a vessel at anchor and it cannot be avoided by other means, it is recommended that a stream of water from a fire hose be played near the mine to force it away from the vessel. WARNING: Mines may explode if a stream of water is played near them. Exposed personnel should remain under cover until danger is past.

Moored Mines: Moored mines may sometimes be seen several feet under the surface if the water is clear, or the mine may be floating on the surface. Often several mines or even a long row of the mines can be seen. Usually the sighting of one or more such mines indicates the presence of a mine field. Approaching the general vicinity of such mines is dangerous and should not ordinarily be undertaken by vessels. When mines are sighted, the location of the mines should be determined as accurately as possible, the area should be buoyed if this is feasible, all ships in the vicinity should be warned, and the appropriate Navy or Coast Guard activity should be notified immediately.

Ground mines are normally laid in water so deep that they will not be seen unless the water is very clear. However, in very clear water with a hard white sand bottom, even a camouflaged mine can often be located because of the long, regular shadow it casts. The sighting of such a mine may indicate a mine field in the neighborhood. Approaching the general vicinity of such a mine is very dangerous. If a mine is sighted, the location should be determined as accurately as possible and buoyed, all ships in the vicinity should be warned, and the appropriate Navy or Coast Guard activity should be notified immediately.

Beach Mines: Any of the above type of mines may be found on the beach, either thrown up by the waves or mislaid by aircraft. Any mine found beached or floating close inshore should be reported at once to the nearest Navy, Coast Guard, Military, or Civil authority, and the mine should be kept under guard until the arrival of responsible authorities. No person except qualified explosive ordnance disposal personnel should be allowed closer than 200 yards.

Reporting of Suspicious Objects Resembling Mines

Ships frequently report objects resembling mines but give insufficient information to properly evaluate the reports. As a result, needless time and expense is incurred only to find that they are not mines but other floating objects. HOWEVER, VESSELS SHOULD NOT ATTEMPT TO RECOVER OBJECTS RESEMBLING MINES OR PASS CLOSE ABOARD FOR POSITIVE IDENTIFICATION, KEEP WELL CLEAR. Since mines are a danger to life and property at sea, masters of ships sighting unidentified or suspicious objects are requested to furnish the following information to the nearest Navy or Coast Guard radio station or activity:

(1) Position of object, and how closely it was approached.
(2) Size, shape, condition of painting, and the presence of marine growth.
(3) Whether or not horns or rings attached.
(4) Whether or not definite identification possible.

Helicopters Conducting Minesweeping Operations

The United States is increasingly employing helicopters to conduct minesweeping operations or exercises. When so engaged, helicopters, like vessels, are considerably hampered in their ability to maneuver. Accordingly, surface craft approaching helicopters engaged in minesweeping operations should take safety precautions similar to those employed with respect to minesweeping vessels.

Helicopters towing minesweeping gear and accompanying surface escorts, if any, will use all available means to warn approaching ships of the operations or exercises being conducted. Also, measures will be taken where practicable to mark or light the gear or objects being towed.

Minesweeping helicopters are equipped with a rotating beacon which has selectable red and amber modes. The amber mode is used during towing operations to notify/warn other vessels that the helicopter is towing. While towing, the helicopter's altitude varies from 15 to 95 meters above the water and speeds vary from 0 to 30 knots.

General descriptions and approximate dimensions for towed minesweeping gear currently being used in conjunction with helicopters are as follows:

(1) Mechanical sweep gear consisting, in part, of large lengths of submerged cables and explosive cutters. The only items normally visible on the surface are three to five international orange floats, depending upon the quantity of gear in use, which generally define the dimensions of the tow. The maximum width is 100 meters and the maximum distance behind the helicopter is 600 meters.

(2) Acoustical sweep device weighing approximately 70 pounds. This device is towed behind the helicopter on a 250-meter orange polypropylene tow cable. When dead in the water, the gear will rise to the surface, supported by a yellow float.

(3) A hydrofoil platform containing equipment used for magnetic influence sweeping. The platform is towed on the end of a 140-meter cable and trails electrodes in the water which extend 185 meters behind the platform. Very often, the aforementioned acoustical sweep device is towed in conjunction with this platform by attaching it to the end of one of the electrodes by a 30-meter polypropylene tow line. In this configuration, the total length of the tow is 215 and 350 meters, respectively, behind the hydrofoil platform and helicopter. Special care must be exercised when crossing astern of the hydrofoil platform as the towed cable is barely visible, and the attached acoustic device is submerged just beneath the surface and is not visible to surface vessels.

As mine countermeasures technology further develops, it is anticipated that the dimensions of helicopter tows will increase.

Helicopters employed in minesweeping operations and their tows may function at night as well as day and in various types of weather conditions. The major danger to any surface vessel is getting the various cables wrapped in its screws.

BOOK REVIEW

by Roger H. Jones

World Cruising Routes
by Jimmy Cornell

International Marine Publishing Co.
21 Elm Street
Camden, Maine 04843 (1987)
432 pages - $12.95

Ocean Passages For the World, first published in 1895 in Great Britain, gained rapid and widespread recognition as a work of unparalleled usefulness to mariners. In its original version and succeeding editions as prepared and published by Her Majesty's Hydrographic Department, it found its way into virtually every serious nautical library ashore and aboard the ships of most of the maritime nations. It, quite simply, filled a void.

World Cruising Routes also comes to the welcome embrace of mariners far and wide via Great Britain. Jimmy Cornell is a London based journalist whose interests are many and varied. He is perhaps best known for his writings about long distance voyaging which have appeared in magazines and other publications, and his new book is the direct outgrowth of the needs of the mariner which he perceived first hand in the course of a six year, 60,000 mile circumnavigation that he undertook with his wife and two children. It is inescapable that *Ocean Passages* will be compared with *Cruising Routes*. It is more than likely that *Cruising Routes* will enjoy a large measure of the early acceptance that propelled Ocean Passages to its rank of prominence.

Mr. Cornell's work is not a comprehensive pilot for the entire world. It is a guide to nearly 300 routes covering virtually all of the world's navigable open waters, and in addition, two extremely useful guides to the Suez and Panama Canals, complete with canal planning diagrams and up-to-date regulations governing transit. The present regulations in the Galapagos Islands, French Polynesia, and British Indian Ocean Territory (Chagos Archipelago), and Indonesia are also presented.

There are 84 maps and diagrams depicting not only the cruising routes, but also prevailing wind systems, world distributions of tropical storms, northern and southern hemisphere storm tactics for the "navigable" and "dangerous" semi-circles surrounding the eye of every major storm system, and all of the world's significant ocean currents. Unlike *Ocean Passages, Cruising Routes* presents all charts within the text proper, and there are many more of them.

Cornell's canal diagrams and summaries of regulations are also unique to his book. Finally, there is a chapter devoted to the specifics of two, three, and four-year circumnavigations with departures from various locations, and this overview is also not available in other works.

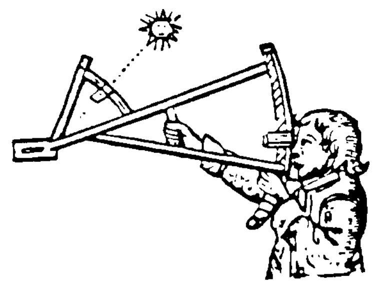
Cruising Routes is a marvel of planning in its own format. Each of nearly 100 areas of the world is presented in terms of its winds and currents, regional weather, and specific routes. The accompanying charts present routes and distances, and there is associated data on the best time of year to make the voyage, storm months, and the specific U.S. and British Admiralty Charts and Pilots that cover the area. Each route is then succinctly described in the kind of non-technical language that every mariner will appreciate. The references to the charts and pilots are not contained in Ocean Passages, and they are a contribution for which many will thank Jimmy Cornell.

Organizationally speaking, *Cruising Routes* requires somewhat less leafing and searching to find a specific route or area of interest than *Ocean Passages*. Its table of contents is far superior. Finally, this reviewer found Cornell's narrative to be somewhat more useful. There is just a quality about it that embodies both economy of words and essence of useful information in a style of writing that is not as clipped and dispassionate as appears in *Ocean Passages*.

When all is said and done, many will probably keep copies of both works aboard. Faced with a choice, I would definitely opt for Cornell's book. It is thoroughly researched and presents up-to-date information. It is somewhat easier to use. It has the unique features mentioned above, and of importance in 1987, it seems to be more directly addressed to the legions of voyagers whose wakes upon the open waters are a true phenomenon of the last third of the Twentieth Century.

Address all correspondence to:
The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850

THE NAVIGATOR'S NEWSLETTER



FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

ISSUE NINETEEN, WINTER 1988

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

by T. D. Davies

An Apology

I must start with an apology for the late mailing of Issue 18. Since inception our newsletter has been prepared for mailing by Mrs. Robin Stammer in Sudlersville. Her competent and reliable work has made that part of the operation run smoothly for 18 issues, however a family move forced us to change to a new person for that function. Finding and breaking in a new person resulted in the above mentioned delay, however our new mailing manager is now in place and we will resume our schedule. This is to express our thanks to Robin and to welcome her replacement, Laura Baxter, aboard.

New Compact Almanac

The new 1988 abridged almanac, called "The Navigator's Almanac" is now available and ready for mailing. We have started filling the orders that are in hand and expect to have more shortly. An order form is enclosed in this newsletter for convenience in ordering. In doing the many calculations necessary for checking the tables I have become convinced that the 20 page book is not only smaller and easier to have with you, but is rapid and easy to use. This comes from the fact that there are so few pages to turn and search through, that the reduced time more than makes up for the extra numbers in the interpolation.

In handling this almanac we have set up a publishing arm of the Foundation, called the Backstaff Press. Orders and comments may simply be addressed to the Foundation at our regular address. The price has been set at $5, and all profits (if any) accrue to the Foundation. After we gain experience with this book, it is our idea that we may find other navigational publishing that would fit our Backstaff Press.

Royal Institute Liason Established

We are in receipt of a letter from Rear Admiral R.M. Burgoyne, Director of the Royal Institute of Navigation in London, from which I quote:

"I would like to take this opportunity to introduce the Royal Institute of Navigation to you. I enclose some literature. It would seem most appropriate that we should establish a Liaison. I would be most interested to have your comments."

I have responded to Admiral Burgoyne, to whom we now send our newsletter, and have subscribed to the Journal of the Royal Institute in the name of the Foundation. Each issue of the Journal will be reviewed for matter which may be of interest to our members,and will be digested for the newsletter, where appropriate.

Testing of Indirect-horizon Scope

The indirect-horizon scope, in a somewhat improved version, is now in the hands of Director John Luykx for testing. Director Luykx not only has an excellent collection of old and new navigational instruments, but has two other intstruments for measuring the actual surface refraction, which were constructed some years ago. After his tests we can expect further discussion onf the device and its utility. The Reader's Forum contains a letter which bears on the subject.

Price Change

Members who order the *Nautical Almanac* from us should note that the price has changed and is now $15.00

READERS FORUM

Director J. M. Luykx of Forestville, MD, writes:

"Just a quick note about the figures in my quadrant article in Issue 18.

A. Page 6, left column:

Corrected version: In the year 1500, for example, the polar distance of Polaris was 3.5 degrees. In the year 1987, it is 0.8 degrees.

B. Page 6, right column: Corrected version: The observation was taken by a single observer and the time of each observation recorded by an assistant. Altitude was recorded to the nearest 0.1 degree.

C. Page 6, right column: Test results: Remove value of Lat from column 3 and place in column 4, i.e.,"

Observation 4

BODY	SUN
GMT	17-10-00
Hs	62-12.0
LAT	38-55.6
ERROR	3.8'

Quartermaster T. Bollin (a new member) writes from the USS A. W. Radford:

"A couple days ago upon arrival at anchor here in Talcahuano I received a copy of Emergency Navigation by David Burch that I had ordered from the Armchair Sailor Bookstore in Newport, RI. It was in the Bibliography of this book that I found your address; indeed, learned of your very existence. Prior to this discovery I was unaware of the existence of any such society as yours within the United States. Needless to say, I am quite pleased to have learned that there is such a society as The Foundation for the Promotion of the Art of Navigation.

I am a Quartermaster First Class serving in the U.S. Navy with an accumulation, so far, of nine years sea time. Initially, I thought that by being a 'navigator' in the U.S. Navy I would learn all about navigation. I have been quite disappointed. Sadly, there is a tendency in today's navy to rely navigationally upon machines. This is unfortunate in that as much navigational knowledge is being overlooked or simply ignored. Quartermasters in our navy are learning to navigate solely with machines and through the use of Sat Nav, Loran A and Omega are becoming very lazy and lax about navigation. I have primarily been taught navigation by electronic means and the greater part of the non-electronic navigational knowledge and experience I possess has mostly been gained on my own.

I am concerned about the state of navigation in today's navy and fear that the Art of Navigation is being lost. Therefore, I am quite willing to support any organization that attempts in any way to preserve the Art of Navigation."

John Armitage of Walden, NY, sends a copy of his letter to "Ocean Navigator" from which we excerpt:

"In this discussion, the error in determining DIP must be mentioned, as it can easily be greater than the errors between sextants we have been talking about. Depending on the mismatch between the air and sea temperature, the 'standard' value of dip can be in error by more than 5', a really substantial error, yet one usually not mentioned in common treatments of sight reduction. I suspect that this factor may be practically one of the most important sources of error in celestial navigation, and one which is relatively difficult to compensate for. I am hoping that soon one of your readers who is really expert in this area might write an article for you on dip errors and dip meters."

The following letter is self-explanatory, name omitted for obvious reasons:

"At the present, I am incarcerated at Bastrop Federal Correctional Institute. I've been a commercial fisherman for well over 20 years, mostly shrimping. Most of my navigation has been with a Loran and Sat-Nav. Since I've been locked up I've been trying to learn celestial navigation. Recently I've acquired a Nautical Almanac and a book of instructions on the art of Celestial Navigation. I've not been able to come onto the Tables: Pub 249, Volume III or Volume II. Sir, I've no funds to purchase one. I hope you could donate one; it would be appreciated very much. I thank you for your time and generosity.

Ed. Note: We will provide table.

John Watkins of Vashon, WA, writes about his new Celesticomp:

"Celesticomp uses Sharp pocket computers with our Celesticomp software to produce dedicated celestial computers. They are small, easy to use, and easy enough on batteries to last through many a long voyage. Our Celesticomp IV model has a perpetual sun)star almanac and guides the navigator through the 'book work' of celestial so easily it can be done without using a form. The program reflects my 26 years' experience as a professional navigator and additional experience teaching navigation."

Interested members my contact him at Celesticomp, Rt. 4, Box 87, Vashon, WA 98070.

Robert C. Wornich, N of Miami writes:

"I refer to your note in Issue Sixteen concerning the non-availability of copies of 'the Sextant Handbook' from Azimuth Press. After ten months and several letters to both old and new addresses, I have heard nothing from them.

"The good news is that this valuable book has now been reprinted by another publisher. Copies may be obtained promptly by sending a check for $19.95 to International Marine Publishing Company, 21 Elm Street, Camden, Maine 04843. It may also be ordered by phone by calling on 1-800-637-9240.

"This is an excellent book, unique in its field and worth every penny of the purchase price. Everyone who owns or uses a sextant should have a copy."

Dr. Robert E. Brummett of 505 N.E. Bridgeton Road, Portland, Oregon 97211 is interested in receiving plans for making a backstaff.

NAVIGATION BASICS REVIEW

The Sailings

by John Luykx

One of the more important considerations in the navigational aspects of voyage planning is establishing the voyage itinerary and laying down the Dead Reckoning (DR) Track for the intended voyage on the chart or plotting sheet. Based on the course and speed required or established, the DR Track will show the projected position of the vessel throughout the planned voyage. The DR position at any point along the DR Track is basically a plot of the course and distance, or a series of courses and distances, from a known position, i.e., the point of departure. The required course(s) and distance(s) between the point of departure and the point of arrival may be determined either by plot or by computation. Solutions to the various problems in Dead Reckoning are provided by methods included in The Sailings .

The various types of Sailings are:

A. PLANE SAILING: In Plane Sailing the earth is considered as a flat surface. Based on the course (c) and distance (D) steered, a solution by plane trigonometry provides the distance made good North or South (Difference of Latitude) l) as well as the distance made good East or West (departure, -p). A course (c) and a distance (D) in other words provides l and p by plane sailing solution. Plane sailing also provides c and D from given values of l of p. (Solutions are also possible using Bowditch Table 3, The Traverse Table.)

B. TRAVERSE SAILING: Traverse Sailing is a method whereby the equivalent or resultant course and distance made good is computed for a series of rhumb lines (i.e., a series of courses and distances sailed by a vessel). In traverse sailing the plane sailing method is employed to compute the resultant distance made good North/South and East/West for a series of courses and distances steered. (See Table 3, Bowditch.) The distance made good N/S and E/W are the components from which the resultant C and D are computed.

C. PARALLEL SAILING: This method is used when sailing due East or due West only. The solution converts distance made good eastward or westward (departure - p) to difference of Longitude (DLO). The conversion is:
a) DLO = p/cos Latitude (L)
b) p = DLO x cos Latitude (L)

D. MID-LATITUDE SAILING: This method provides a solution for (a) LAT/LON coordinates of the point of arrival given, the point of departure the course (c) steered and the distance (D) made good, and/or the course (c) and distance (D) given the LAT/LON coordinates of both the points of arrival and departure. It is basically a solution based on a combination of the Plane sailing and Parallel sailing methods where difference of Latitude (l) and Departure (p) are used in the solution.

E. MERCATOR SAILING: The Mercator Sailing solution is similar, in concept, to solutions by the Mid Latitude Sailing method in that solutions are provided for a) LAT/LON coordinates of the point of arrival, given the LAT/LON coordinates of the point of departure and the course (c) steered and distance (D) made good and/or b) the course and distance, given the LAT/LON coordinates of both the points of departure and arrival. The meridional difference (m) is computed from values of Latitude (M) in Table 5 (Bowditch) rather than difference of latitude (l). DLO is used rather than p in the Mercator Sailing Solution.

F. GREAT CIRCLE SAILING: Great Circle Sailing involves the solution of a series of courses and distances between two points (the points of arrival and departure) established along a great circle track extended over longer distances. Since a great circle is continually changing direction as one proceeds along the track, a number of points are selected along the track and rhumb lines are followed between the points. Solutions to determine or select the points along the Great Circle Track as well as the course and distance between each point are provided by either a) a gnomonic or great circle chart, b) sight reduction table, or c) computation.

G. COMPOSITE SAILING: In cases where the Great Circle Track extends beyond a desired parallel of Latitude a solution by composite sailing is employed. The composite track consists of a) a Great Circle until the Limiting Latitude is reached, b) a course along the limiting parallel of latitude, and c) a great circle from the limited parallel to the point of arrival. Solution is either a) by gnomonic chart, b) sight reduction table, or c) by computation.

In the next issue of The Navigators Newsletter , Plane, Traverse and Parallel sailing will be discussed in greater detail.

NAVIGATION PERSONALITIES

Nathaniel Bowditch

by Thomas D. Davies

Probably the most unusual and certainly the best known of navigation personalities is Nathaniel Bowditch of Salem, Mass. His monumental work, originally called "The New American Practical Navigator", is known and still used throughout the maritime world. He himself considered his greatest work a translation of the great astronomical opus of the French mathematician Pierre Laplace, "Mecanique Celeste." In the field of astronomy his name is still associated with that work. In fact he added many derivations and clarifications that went beyond a literal translation, which was typical of one of his guiding priciples, insistence on such clarity that it could be understood by neophytes in the science. This principle in many ways was responsible for the immediate acceptance and eventual continuation of "The American Practical Navigator." He worked on the theory that everything in the book had to be so clear that he could teach it to any member of his crew. The fact that he made five long voyages as master of his own ship indicates that he understood what such an objective meant, and the importance of fulfilling it.

Nathaniel was the son of Habakkuk Bowditch, who early had followed the sea although he later pursued the profession of cooper. The seagoing predecessors of Bowditch (which go back to a William Bowditch in the 17th century) include one who lost his ship on a "ledge" in Salem Harbor, which was sometimes called "Bowditch's Mistake." After completing his fifth voyage Nathaniel was lured away from the sea by opportunities resulting from his fame as a mathematician.

Bowditch at age 30 became the first American actuary. He accepted a position as president of a Salem insurance company and later headed a Boston firm of the same sort. His mathematical prowess which led to such leadership was the more remarkable because his formal education ceased at age 10. This was the result of the extreme poverty in which the family lived. The genius of the man is clear when you consider his later mathematical and astronomical work, which went far beyond the "American Practical Navigator." He produced papers on the orbits of comets, magnetic variation, tides and Napier's rules.

Harvard College presented him with an honorary Master of Arts, and later he was elected to the prestigious "Board of Overseers." As head of the board he saved the college from financial disaster, although it involved the dismissal of the president of the college. Other honors were heaped upon him. He received an honorary Doctor of Laws from Harvard, was elected to the American Academy of Arts and Sciences, the Royal Society of London, the American Philosophical Society, the Royal Astronomical Society and many others.

A more complete history of Bowditch is readily available in Pub. 9 of the Defense Mapping Agency. However I would like to add a few more facts of a more personal nature, to bring this chronology up to date. Nathaniel had 8 children and was the start of a prolific family. A son, Jonathan, took up the task of keeping the "American Practical Navigator" updated, from the 11th to the 35th edition. Another son, Ernest, named one of his children Nathaniel and in succeeding generations there were always one or more Nathaniels. Indeed there are several of his descendents of that name today.

Some time ago I found myself on a Board which included a Pete Bowditch. The name being as unusual as it is, a later query determined that this was indeed one of the descendents of the original Nathaniel. Eventually I was told that the current "historian" of the family was one Nathaniel Bowditch of Philadelphia. A call to this Nathaniel was most rewarding, and produced many stories of the Bowditches of Salem and their many progeny.

A daughter of Nathaniel was married to Oliver Wendell Holmes. Nathaniel was the first american to establish trade with the Phillipines and is so recognized today by U.S.-Phillipine trading associations. Gilbert Stuart, the colonial painter of many famous americans, did a portrait (unfinished) of Bowditch, now in Philadelphia. The family connections with the navy seem to be limited to in-laws, which include Admirals Sampson, Cluverius and Parsons. There exists a Backstaff used by a Bowditch ancestor, William, in 1750.

The name seems to be limited to the family of Habakkuk, and it is indeed so unusual that his is the only surviving line. It would be interesting to know from members if they know of instances where the name exists but traces to a different Bowditch family. The Bowditch descendents seem to be localized to Boston, New York and Philadelphia, although there are two so named in the Maryland telephone directory.

In any event Nathaniel was not only the founder of an extensive and prolific family but practical mathematician and navigator to whom we all owe a debt of gratitude. His name will certainly live in the annals of navigation, astronomy and mathematics.

HISTORY OF NAVIGATION

Early Altitude Measuring Instruments: The Mariner's Astrolabe

by John Luykx

The mariner's astrolabe was most probably initially used at sea by Portuguese navigators during the first half of the sixteenth century. The design of the instrument was based on the planispheric astrolabe, believed to have been invented by Hipparchus in the second century B.C. and employed by astronomers until the seventeenth century to measure time, to compute latitude and to perform other astronomical calculations.

The purpose of the sea or mariner's astrolabe was principally to measure the altitude and or zenith distance of a celestial body at sea. To provide this capability, the astronomer's astrolabe, believed to be the oldest scientific instrument (many extant examples are also considered works of art) was stripped of its adornments and most of its computational components. Used at sea it consisted solely of a circular disc made of either wood or brass on the periphery of which was engraved a scale showing degrees of altitude or zenith distance and a rotating alidade containing two sighting vanes with pinnules (pin holes) centered on the disc to measure the angle of altitude and/or zenith distance.

During observation, the instrument was suspended from its thumb ring and the plane of the instrument oriented toward the celestial body. The alidade was then pointed at the body and adjusted vertically so that, for example, during the day when observing the Sun, sunlight would pass through the pinnule of the forward sighting vane as a very narrow spot of light. The spot of light when also aligned with the pinnule on the rearward sighting vane would then indicate correct alignment of the alidade on the altitude or zenith distance scale engraved on the circumference of the instrument.

A daylight observation of the sun with the astrolabe was an indirect observation in that the observer did not look directly at the sun when taking the observation.

At night, however, when observing a star or planet (or during the day when observing the moon) direct observations were made whereby the observer sighted directly at the star (as he held the instrument by its thumb ring) so that the star was visible though the pinnules of both sighting vanes thus aligning the alidade with the star.

Because the mariner's astrolabe employed the pendulum principle to define the vertical (and thereby the horizontal) it was much affected by the wind and vessel motion caused by the sea. To reduce the amount of "swing" of the instrument from the vertical during observations at sea, later astrolabes were weighted at the lower sections and portions of the circular plate cut out to reduce wind resistance. In this configuration, the mariner's astrolabe looked like a four spoked wheel with thumbring attached at the top or thin part of the instrument and the weighted (thicker) section located at the bottom.

Brass astrolabes designed for use at sea during the sixteenth and seventeenth centuries typically weighed from three to six pounds (depending on whether they were of English, Spanish or Portuguese origin) with a diameter of five to seven inches. Only a single observer was needed to take an observation for altitude with an instrument of these dimensions. Larger, heavier astrolabes were also used at sea and although more accurate required normally two observers: one to hold the instrument and the other to take and record the observation.

The most accurate observations were those taken ashore. The normal procedure used by navigators during the age of exploration (when close to shore) was to a) maneuver the vessel into an inlet or harbor, b) anchor the vessel, c) take the observation ashore, and then d) proceed again out to sea.

On the high seas, however, observations with the astrolabe were difficult. One had to estimate the "mean" or "average" altitude, as the instrument swung back and forth, by adjusting the alidade to the "estimated mean point" of oscillation.

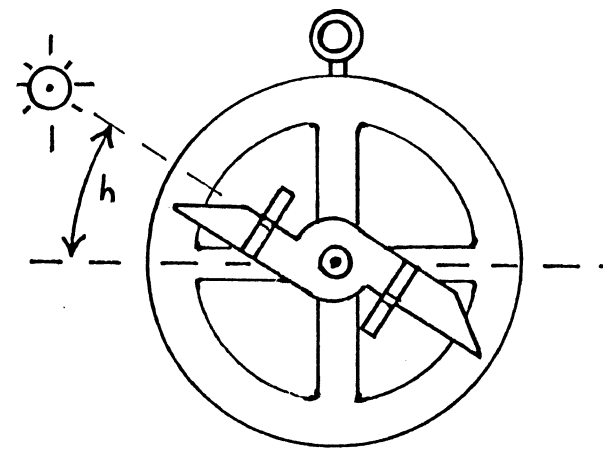
To accomplish the measurement of altitude at sea more successfully, some astrolabes were designed so that the sighting vanes were fixed to the alidade not at the extremities but at a distance of only one-half to one-third the radius from the center. In some cases the sighting vanes were made oversize so that the altitude could be even more easily estimated at sea, especially for indirect observations of the sun.

Nevertheless, with all these innovations, accuracy with the mariner's astrolabe at sea was poor. Normal accuracy was only to one or two degrees; although for high altitude observations (75degrees to 90 degrees), the astrolabe was superior to both the seaman's quadrant and the cross)staff. This was due primarily to its ease of handling, especially for indirect daylight observations of the sun.

To check the accuracy potential of the mariner's astrolabe, the author conducted a series of tests with a reproduction instrument of this type from his personal collection. This replica mariner's astrolabe is made completely of brass, graduated in whole degrees and divided into quadrants to read altitude with 90 degrees at the zenith and nadir. The arc is 160 mm in diameter and the instrument weighs 3 lbs. Each sighting vane on the alidade has two sighting apertures (pinnules): one of 1 mm and the other of 0.5 mm. The design of the replica is based on a Portuguese instrument dated 1555 in the Royal Scottish Museum, Edinburgh.

The results of the accuracy test were as follows:

Date:	16 NOV 1987	16 NOV 1987	22 NOV 1987
Body:	sun (c)	sun (c)	sirius
Observer Lat:	38-51.8N	38-51.8N	38-51.8N
LON:	76-55.1W	76-55.1W	76-55..1W
No. of obs.:	10	10	10
Error:	-3.2'	-6.9'	-2.5'
Method:	Indirect	Indirect	Direct



The results show that from a position ashore, accuracy of observation with the mariner's astrolabe is comparable to that of the seaman's quadrant. (See Issue Eighteen.)

In the next issue we will discuss the history, design and use of the cross-staff.

NAVIGATION NOTES

Chronometer Accuracy

by J. M. Luykx

In previous issues of the *Newsletter* (Nos. 14, 15, and 16) we discussed a few of the significant stages in the historicaldevelopment of the chronometer. We believe that readers may also be interested in some basic data on chronometer and navigation watch accuracy which includes a comparison of the spring wound box chronometers and chronometer watch with the more modern quartz watch used for navigation.

To furnish data for this comparison, records maintained for the watches in the author's collection were used to provide a basis forthe study. To make the comparison, an accuracy test was conducted using daily and weekly error tabulations from the records of four timepieces; two spring wound and two quartz. The period of time selected for the test was from 1 June to 10 August 1987. During the test, the four timepieces were kept in a room indoors with little variation of temperature. The daily error for each was recorded in mid-morning at which time the spring type chronometers were wound. Using this recorded data, the procedure chosen for the comparison was to conduct a simple "predictability" test of ten weeks duration. It consisted of a) computing the Mean Weekly Rate (MWR) of each time piece during an initial period of four weeks and from the computed MWR, b) to predict the error of each time piece for the last day (10 August)of the final six week period and c) to compare the predicted error computed for each timepiece with its actual error recorded on the final day. The most accurate and, therefore, the most "predictable" timepiece would then be that one which "predicted" error at the end ofthe test with the greatest accuracy.

The timepieces selected for the test were:

A. Spring Wound

1. A Hamilton 2-day gimballed box chronometer Model 21.

2. A Hamilton 2-day ungimballed chronometer watch in padded case, Model 22.

B. Quartz

1. A Consort wristwatch, military type with "hack" feature and sweep second hand.

2. A Seachron calculator watch with LCD, 12/24 hour display, manufactured by Sharp Corp.

Table 1.A. gives selected excerpts from the spring wound chronometer and watch records from 1 June to 10 August 1987.

Table 1.B. shows the Mean Weekly Rate (MWR) and Mean Daily Rate (MDR) computations for these timepieces as well as the computation of Predicted Error and Error of Prediction. Table 2.A. gives selected excerpts from the quartz watch records from29 June to 10 August 1987.

Table 2.B. shows the Mean Weekly Rate (MWR) and Mean Daily Rate (MDR) computation for the quartz watches as well as computation of Predicted Error and Error of Prediction.

The results of this comparison test show that in six weeks a) the Hamilton Model 21 generated a prediction error of -5.1 seconds; i.e., less than a second per week, b) the Hamilton Model 22 for the same period accumulated an error of -11.1 seconds; i.e. less than two seconds per week, c) the Consort, for this period an error of -0.6 seconds; i.e. an error of less than 0.1 seconds per week and finally d) the Sharp Seachron which accumulated an error of only 0.1 seconds;i.e. less than 0.02 seconds per week. In any case, these are very good performances although perhaps not typical. The results show the order of accuracy to be expected from typical spring wound and quartz timepieces. It must be remembered, however, that results of this quality cannot always be expected at sea. Significant variations in temperature, changes in climate and continuous vessel motion caused by the sea all have a negative effect on chronometer and watch performance.

Because the accuracy of a chronometer or watch (hence its value as a timepiece) is largely determined by its ability to maintain daily/weekly rate and thereby to predict future error reliably and accurately, it is clearly apparent from the results of this basic test why the modern quartz timepiece has largely replaced the spring wound box chronometer for navigational use at sea. It is simply more accurate, less expensive and it also requires little maintenance.

A basic check of timepiece accuracy and predictability such as that described in this article can also be conducted very easily by the individual small boat owner, skipper or navigator using his own navigation watches. Such a test is, in fact, strongly recommended for yachts and other small vessels, especially when planning ocean voyages in areas where radio time signals may be difficult to obtain for long periods. At such times a timepiece with excellent "predictability" is invaluable to the navigator.

TABLE 1
(Spring Wound Chronometers)

A. Weekly Error

Line (Sec)	Date	Hamilton Mod 21 Error (Sec)	Hamilton Mod 22 Error
1	1 June	-55.3	-0.5
2	8 June	-59.7	-7.5
3	15 June	-63.2	-10.0
4	22 June	-65.2	-11.5
5	29 June	-68.3	-15.2
6	10 Aug.	-83.0	-26.3

B. Weekly/Daily Rates/Predictions

Line	Computation	Sec	Sec
7	MWR 1-29 Jun (lin5-lin4)/4	-3.3	-3.7
8	MDR 1-29 Jun (lin5-lin1)/28	-0.5	-0.5
9	Pred.Error 10/8 lin5+6xlin7	-88.1	-37.4
10	Error of Predict. Diff lin 6 & 9	-5.1	-11.1

TABLE 2
(Quartz Type Watches)

A. Weekly Error

Line	Date	Consort Watch Error(Sec)	Seachron Watch Error(Sec)
1	1 June	-0.2	+1.8
2	8 June	-0.2	+1.8
3	15 June	-0.1	+1.8
4	22 June	+0.2	+2.0
5	29 June	+0.2	+2.0
6	10 Aug.	+1.4	+2.2

B. Weekly/Daily Rates/Predictions

Line	Computation	Sec	Sec
7	MWR 1-29 Jun (lin5-lin4)/4	+0.1	+0.05
8	MDR 1-29 Jun (lin5-lin1)/28	+0.014	+0.007
9	Pred.Error 10/8 lin5+6xlin7	+0.8	+2.3
10	Error of Predict. Diff lin 6 & 9	-0.6	+0.1

A Navigation Problem

by Roger H. Jones

Solution to the problem presented in Issue Eighteen.

20. Answer.

(a) Use the red-line template that is not based upon a latitude value, north or south. Center the template over the Star Finder base, noting that both the template and the base conform to the same hemisphere, which, in this case, is North. (Road Town harbor is at 18-25 North Latitude.) Rotate the template until its arrow (on the outer rim at "0") is over Right Ascension (RA). Plot the planet on the zero meridian, using the radial scale for declination. Where declination of the planet and latitude of the vessel are the same, plot towards the center of the base disc; where they are contrary, plot away from the center.

RA!? This is a term which may leap up at some readers of the Newsletter. Despair not. RA = 360-SHA (sidereal hour angle of the body). RA also equals GHA Aries-GHA of the body. When GHA of the body is zero, GHA Aries is RA.

To determine meridian angle of the planet, rotate the template until the arrow is over GHA Aries. Read the meridian angle from the red lines of the template, east or west through 180 degrees.

(b) Using either formula to arrive at RA, it turns out to be approximately 194-30 for Venus and 25-49 for Jupiter. (The scale on the Star Finder base only reads to the nearest 1/2 degree, so absolute precision is not required in computing RA.) Declination of Venus is South 05-03, and of Jupiter it is North 09-00. (Again, because the declination scale on the template reads only to the nearest two degrees, absolute accuracy is not required.)

Having plotted the positions of Venus and Jupiter, and using a LHA Aries of 335-19 (LHA = GHA Aries minus Longitude West), the red template is superimposed over the blue template for 15 North. The arrows of both templates are set to LHA Aries. It is then readily determined that Jupiter has an altitude of about 40 degrees with an azimuth of 090. (Its meridian angle is 50 east.) Venus has a meridian angle of 140 west and is invisible below the western horizon. In theory Jupiter would be visible. In actuality, the mountain terrain would probably obstruct the view, but if the vessel were moved about 1.5 miles south, Jupiter would be visible rising slightly to the right of the small island of Fallen Jerusalem at an altitude of about 40 degrees.

Problem No. 21.

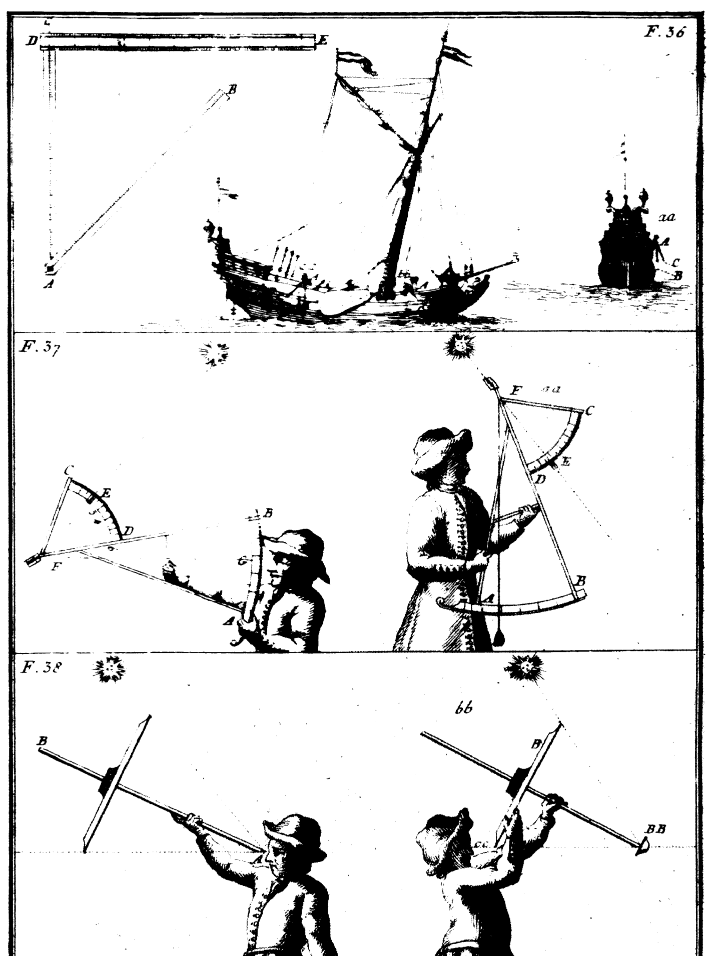
It is Sunday, December 6, 1987. Backstaff is approximately 205 nautical miles south of Bermuda's Gibbs Hill Light. Her DR position is 28-50.0 North, 66-40.0 West in standard time zone +4. She is bound for Bermuda. It is shortly before 1:00 a.m. local time when her navigator proceeds on deck to attempt to get a shot of the Moon in order to determine latitude. Polaris is obscured by clouds to the north, but there is a nice bright full Moon very high in the sky to the south. The navigator wishes to experiment with the extremely high altitude circumstances of the Moon at meridian passage, which he knows will make this a troublesome shot.

At 0500 GMT the Moon's declination is 28-16.0 North, and her GHA is 66-40.5 West. If Backstaff's DR is reasonably accurate, meridian passage of the Moon will occur very nearly at 05-00-00 GMT (01-00-00 standard time), and the GP of the Moon will be only 34 nautical miles due south of Backstaff's DR.

(a) Theoretically, what corrected altitude (HO) would the navigator expect to measure with the sextant if the DR position is accurate?

(b) HO turns out to be 89-20.4. What is the calculated latitude, and what distance is the vessel north or south of her DR?

(c) Would the normal meridian passage technique be used with the sextant, and would the normal plotting technique be used if the navigator wanted to plot the vessel's LOP on his chart?



MARINE INFORMATION NOTES

by Ernest Brown

Automated Notices to Mariners

The Navigation Information Network Users Manual, May 1987, is the user's guide to the Automated Notice to Mariners System (ANMS). The material in the manual is organized into the following topics: available data, costs of using ANMS, accessing ANMS, getting data from ANMS, and exiting ANMS.

ANMS currently contains information on chart corrections, Broadcast Warnings, MARAD Advisories, DMAHTC List of Lights, USCG Light Lists, anti)shipping activities, oil drill rig locations, and corrections to DMA hydrographic products catalogs. The user's manual will be added to ANMS.

The only costs incurred by the user are those charged by the provider of the telecommunications service. The Defense Mapping Agency WILL NOT under any circumstance pay telecommunications costs for any user of ANMS. DMA provides the data within ANMS free of charge. To minimize the cost the user should:

1. Using the program execution section of the manual, design checklists for specific needs. The checklists should insure that the user has all information needed before connecting to ANMS.
2. Type carefully to avoid error messages.
3. To avoid getting a large amount of unwanted data, be very specific about information requested from ANMS.
4. Log out of ANMS and disconnect the terminal from the telecommunications link without delay. Telecommunication networks charge for total connect time whether the user is actually using ANMS or not.
5. Be sure you want ALL before you key that request option.

ANMS can be accessed through the U.S. domestic telephone network and any other dial-up voice grade telephone system that interfaces with it. The telephone number depends upon the modem speed (300, 1200, or 2400 baud). For the two available CITT V.21 standard international modems (300 baud), there are two telephone numbers for international users.

Western Union Telex teletypewriter (record) network can be used to access ANMS through the Navigation Information Network (NAVINFONET). Any International Record Carrier (IRC) can be used through interconnection to Telex.

Ships at sea can access ANMS through the international Maritime Satellite (INMARSAT) system, either via Telex or over dial-up voice grade circuits, if a computer terminal with a modem or similar equipment is available.

Telephone Access

Data Terminal Equipment (DTE) and Data Communication Equipment (DCE) are necessary for telephone access. DTE may consist of a teletypewriter, portable dumb terminal, or a personal computer. DCE consists of a modem and, in the case of a personal computer, a communications software package. The terminal used must have a full or partial ASCII keyboard. The modem used may be internal or external to the terminal. The modem should be configured to a baud rate of 300, 1200, or 2400, full duplex, parity off, 8 bit words and 1 stop bit. The 300 bps modem must be compatible with the Bell 103 standard for low speed modems. The 1200 bps modem must be compatible with either the Bell 212 or Racal-Vidic 3400 modulation standards. The 2400 bps modem must be compatible with the Bell 201 modulation standard.

To be continued.

NOTE: For information and assistance, the ANMS staff can be reached by mail at:

DMA Hydrographic/Topographic Center, ATTN: MCN/ANMS, Washington, D.C. 20315-0030, or by telephone at (301) 227-3296 or by Telex at 898334 DMAHTC WSH DC (indicate in the message to pass to MCN).

Aug 1987, 874/87(97). JAPAN, NANSEI SHOTO
Derelict waterlogged fishing vessel, about 30 tons, adrift in 21-41N. 125-11E.

(041930Z Aug 1987) 875/87(19,83). TAHITI TO HAWAII
32 foot S/V EMMIRIUS, white with blue trim, persons on board, reported overdue Tahiti to Hawaii. Reports to Coast Guard Honolulu.

(042204Z Aug 1987) 876/87. Canceled.

877/87(76). NEW ZEALAND , NORTH ISLAND.
Chart 76050. Radiobeacon at Burgess Islet (Moko Hinau) Light 35-54S. 175-07E. Inoperative.

(051308Z Aug 1987) 878/87 thru 880 87. Canceled.

881/87(95). JAPAN SEA. ROCKETS.
1. Gunnery/rocket firing exercises 2230Z to 0800Z daily 10 to 12 August alternate 122230Z to 130800Z August in area bound by 37-17N. 135-40E., 36-57N. 135-40E., 36-35N. 135-00E., 36-55N. 135-00E.
2. Cancel this message 130900Z August.

(051430Z Aug 1987) 882/87. Canceled.

883/87. Index of HYDROPAC messages in force refers.

884/87. Canceled. (051430Z Aug 1987)

882/87. Canceled.

883/87. Index of HYDROPAC messages.

BOOK REVIEW

by Roger H. Jones

Fundamentals Of Kayak Navigation

by David Burch

Pacific Search Press
222 Dexter Avenue, North
Seattle, Washington 98109 (1987)

288 pages; $13.95.

Fundamentals of Kayak Navigation provides a marvelous look into a surprisingly different world where the deck is only a foot above the water and the captain's eye only a foot and a half above the deck. David Burch does a masterful job of creating a new awareness of the special problems and techniques of navigation from that radically altered perspective. This book, like his preceding work, Emergency Navigation (which itself was reviewed in an earlier edition of the Newsletter), is loaded with the intriguing insights that are the hallmark of experience. Rooted in fundamentals, it also carries its reader far beyond into many fascinating practical realms where, for example, the kamal, the hand and the fingers replace the dividers and the sextant. This fare is not for kayakers alone. It is for all serious coastal navigators, novice and old hand alike.

The kayak focus in the name should not mislead serious sailors and power boaters into believing that this is elementary material for "mere paddlers". To the contrary, the kayak navigators to whom this book is addressed may rightfully command the respect of a host of self-styled blue water salts who have never even contemplated some of the navigational challenges faced by the voyagers whose bodies must do the work of sails and diesels, and whose eyes often cannot see farther than the crest of the nearest wave. That Burch sees them as true voyagers there can be no doubt. He speaks for and to those who, like himself, have gone upon the open waters and the high seas in craft that many a sailor would hesitate to ride from ship to shore in mild harbor chop.

There are ten chapters, the last six of which deal with dead reckoning, piloting, tides and currents, crossing currents, special topics, and navigation planning. The first four deal with types of navigation, charts, navigational aids and compass use. All are interesting, but it is the last six which transport the reader into that special world where the deck is only a foot above the water.

The lessons offered by Burch are many. Most are of value to those whose decks are many feet or even yards above the water. For example: how many sailors could accurately determine the speed of a current using the width of a hand and a given time period as tools of measurement? How many know how to use an outstretched arm and the width of a hand or a finger to measure an angle? How many know how to estimate wind speed by the specific clues that waves virtually fling in the face of a kayaker, but which might go unnoticed by one perched eight feet higher on a cockpit coaming? These and many, many more are the special insights of this new book. It is well written. It presents fresh perspectives. It is worth the price.

Address all correspondence to:
The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850
Telephone 301-622-6448

Sample table from The Navigator's Almanac. For ordering information see below.

JANUARY 1988

Day	Sun				Aries	Venus				Mars				Jupiter				Saturn				Day
	GHA	d	Dec	d	GHA	GHA	d	Dec	d	GHA	d	Dec	d	GHA	d	Dec	d	GHA	d	Dec	d	
1	17914	-7	-2305	+5	9953	14452	-16	-1856	+21	22711	+19	-1832	-10	8042	+56	+643	+2	19447	+52	-2215	-0	1
2	17907	-7	-2300	+5	10052	14437	-15	-1835	+22	22729	+18	-1842	-10	8138	+56	+645	+2	19538	+52	-2215	-0	2
3	17900	-7	-2255	+6	10151	14422	-15	-1813	+22	22748	+18	-1852	-10	8234	+56	+646	+2	19630	+52	-2215	-0	3
4	17853	-7	-2250	+6	10250	14407	-15	-1751	+23	22806	+18	-1902	-10	8330	+56	+648	+2	19722	+52	-2216	-0	4
5	17846	-7	-2243	+7	10349	14352	-14	-1728	+23	22824	+18	-1912	-9	8425	+55	+650	+2	19813	+52	-2216	-0	5
6	17840	-7	-2237	+7	10448	14338	-14	-1705	+24	22843	+18	-1921	-9	8520	+55	+652	+2	19905	+52	-2216	-0	6
7	17833	-7	-2230	+7	10547	14324	-13	-1641	+24	22901	+18	-1931	-9	8616	+55	+654	+2	19957	+52	-2216	-0	7
8	17827	-6	-2222	+8	10647	14311	-13	-1617	+25	22919	+18	-1940	-9	8710	+55	+656	+2	20049	+52	-2217	-0	8
9	17820	-6	-2215	+8	10746	14258	-13	-1552	+25	22936	+18	-1949	-9	8805	+55	+658	+2	20140	+52	-2217	-0	9
10	17814	-6	-2206	+9	10845	14245	-12	-1528	+25	22954	+18	-1958	-9	8860	+54	+660	+2	20232	+52	-2217	-0	10
11	17808	-6	-2158	+9	10944	14233	-12	-1502	+26	23012	+18	-2006	-9	8954	+54	+702	+2	20324	+52	-2217	-0	11
12	17802	-6	-2148	+10	11043	14221	-12	-1436	+26	23029	+17	-2015	-8	9048	+54	+704	+2	20416	+52	-2217	-0	12
13	17756	-6	-2139	+10	11142	14209	-11	-1410	+27	23047	+17	-2023	-8	9143	+54	+707	+2	20508	+52	-2218	-0	13
14	17750	-6	-2129	+10	11241	14158	-11	-1344	+27	23104	+17	-2032	-8	9236	+54	+709	+2	20560	+52	-2218	-0	14
15	17745	-5	-2118	+11	11341	14147	-11	-1317	+27	23121	+17	-2040	-8	9330	+54	+711	+3	20652	+52	-2218	-0	15
16	17739	-5	-2107	+11	11440	14136	-10	-1250	+28	23139	+17	-2048	-8	9424	+53	+714	+3	20744	+52	-2218	-0	16
17	17734	-5	-2056	+12	11539	14126	-10	-1222	+28	23156	+17	-2056	-8	9517	+53	+717	+3	20836	+52	-2218	-0	17
18	17729	-5	-2045	+12	11638	14116	-10	-1154	+28	23213	+17	-2103	-7	9610	+53	+719	+3	20928	+52	-2218	-0	18
19	17724	-5	-2033	+12	11737	14106	-9	-1126	+28	23230	+17	-2111	-7	9704	+53	+722	+3	21020	+52	-2219	-0	19
20	17719	-5	-2020	+13	11836	14057	-9	-1058	+29	23247	+17	-2118	-7	9756	+53	+725	+3	21112	+52	-2219	-0	20
21	17715	-4	-2007	+13	11935	14048	-9	-1029	+29	23303	+17	-2125	-7	9849	+53	+728	+3	21205	+52	-2219	-0	21
22	17711	-4	-1954	+14	12035	14039	-9	-1000	+29	23320	+17	-2132	-7	9942	+53	+730	+3	21257	+52	-2219	-0	22
23	17706	-4	-1941	+14	12134	14030	-8	-931	+30	23337	+17	-2139	-7	10034	+52	+733	+3	21349	+52	-2219	-0	23
24	17702	-4	-1927	+14	12233	14022	-8	-901	+30	23353	+17	-2145	-6	10127	+52	+736	+3	21442	+53	-2219	-0	24
25	17659	-4	-1912	+15	12332	14014	-8	-832	+30	23410	+16	-2152	-6	10219	+52	+739	+3	21534	+53	-2219	-0	25
26	17655	-3	-1858	+15	12431	14006	-8	-802	+30	23426	+16	-2158	-6	10311	+52	+742	+3	21627	+53	-2219	+0	26
27	17652	-3	-1843	+15	12530	13959	-7	-732	+30	23443	+16	-2204	-6	10403	+52	+746	+3	21719	+53	-2219	-0	27
28	17649	-3	-1827	+16	12629	13951	-7	-702	+30	23459	+16	-2210	-6	10455	+52	+749	+3	21812	+53	-2219	-0	28
29	17646	-3	-1812	+16	12728	13944	-7	-631	+31	23515	+16	-2216	-6	10546	+52	+752	+3	21904	+53	-2220	+0	29
30	17643	-3	-1756	+16	12828	13938	-7	-601	+31	23531	+16	-2221	-5	10638	+51	+755	+3	21957	+53	-2220	-0	30
31	17641	-2	-1740	+17	12927	13931	-6	-530	+31	23547	+16	-2226	-5	10729	+51	+759	+3	22050	+53	-2220	-0	31

ORDER FORM

The Navigator's Almanac, 1988

Clip and send with check to The Navigation Foundation, Book Order Dept., P.O. Box 1126, Rockville, MD 20850.

Please send me _____ copy(ies) of The Navigator's Almanac, 1988. I have enclosed my check for $5.50 per copy ordered ($5.00 special members price, plus 50¢ postage and handling).

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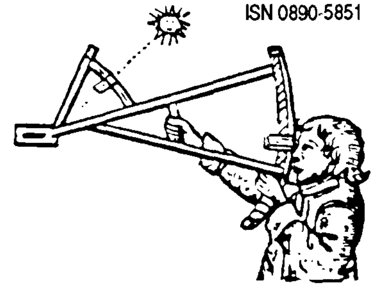


THE NAVIGATOR'S NEWSLETTER

FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

ISSUE TWENTY, SPRING 1988

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

by T. D. Davies

Navigator's Almanac Available

As some of you already know the new Navigator's Almanac was mailed in December. A number of copies were sent to reviewing agencies and in January orders began to arrive from members. The birth of this new baby was not without a few birth pains. In January I noted with some horror that we had neglected to update page 19, the Stars. They were still given for 1987! This error has been corrected by promulgating an entire new page with Star locations for 1988 (and including the Polaris Table). The new page has been mailed to all recipients of the Almanac and hopefully is in hand by the time that you read this. The new page is printed on pressure sensitive paper and is slightly smaller than the original page, which should make it easy to lay down the new page over the old and press it on.

We have begun to receive comments on the document (which we encourage) and one of these is in the Reader's Forum. The writer points out another (but not cataclysmic) error. He points out that the sample calculations refer back to the 1987 Almanac rather than the 1988. We will correct that herewith (see page 16) by tabulating a set of samples based on 1988.

These corrections will be inserted in Almanacs from now on. I hope that the interest is sustained through actual use at sea and for actual sights. Such users please give us reactions and comments.

Journal of the Royal Institute of Navigation

We are also now in possession of 3 copies of the Journal of the Royal Institute of Navigation. Various members of the Board will review these and keep our members informed of interesting items therein. We expect to keep our subscription up and will establish a file of these journals for reference.

Progress On At-Sea Opportunities

For some time we have been considering ways and means to provide opportunities for at-sea experience in both piloting and celestial navigation. As we have envisioned this effort it would require access to a vessel capable of accommodating a number of people and capable of operating in appropriate areas. It now appears that we may have two such yachts nearly in hand. We are negotiating one charter for a boat on the East coast and another on the West coast. It will be some time before we have everything organized, but we look forward to being able to offer a chance to get some real at-sea navigating experience, under an experienced instructor. We will keep you advised of progress as we go.

The Indirect Horizon Scope

There has been some interest in the indirect-horizon scope, as you can see in the Reader's Forum. Director Luykx's tests have been held up by the cold weather, but he advises that he will have some results for our next issue.

READERS FORUM

George E. Wood of Blackwood, NJ, writes:

Plans for making a backstaff, requested by Dr. Robert E. Brummett in issue nineteen of The Navigator's Newsletter, can be obtained from the National Maritime Museum in Greenwich London S E 10.

Thomas E. Dalby of Crystal River, FL, writes:

I was very interested to learn of the development of the Indirect-Horizon Scope outlined in issue 18.
I'm wondering if there are plans to produce the accessory commercially. We teach students on the West Coast of Florida with only a western horizon available, and only about 210° to 340° of that clear locally.

Availability of eastern bodies to shoot "over the shoulder" at altitudes more than usable on a back sight would be helpful indeed. Any information you can offer on the projected availability would be most appreciated. *(Ed Note: None available as yet, but perhaps after further evaluation we may attempt production. Readers will be kept advised.)*

James Bodurtha of Ridgefield, CT, writes:

Your earlier publication of my interest-need for a part to an old Bendix bubble sextant resulted in two nice letters—Celestaire and J. M. Luykx. Perhaps because he was geographically nearer, I wrote Mr. Luykx with now the result of having the part—and I think quite adaptable though a bit different (improved, it appears). Meanwhile Mr. Luykx' interest, cooperativeness service, and cordiality could not have been more pleasing. Thank you very much for your help.

George Lear of N. Chevy Chase, MD, writes:

As a subscriber-member of the Foundation, I've found the articles in the newsletter both educational and entertaining. The opportunity to keep involved in navigation via your publication is welcomed and encouraged.

If possible I'd like you to mention, in the next edition of the Newsletter, the fact that I will again teach a course in "Celestial Navigation" starting January 12, 1988. The "flier" which describes the course is enclosed. If you have questions,please call (301) 986-0314 or 427-4391. Thanks.

Norman Cubberly writes from the USNS PERSISTENT (T-AGOS-6):

Several comments concerning your fall newsletter.

First: Excellent work on everything but am especially delighted with the PERSONALITIES column. It might be possible to get more into historical personalities in the instrument makers world. I refer to the excellent article in NAVIGATION concerningone of the first sextant makers and even think that the art of inscribing the arc using geometric means as described therein would be of modern use. I have an interesting antique telescope by one Troughton of London, circa 1780, who is far morefamous for sextants, survey instruments and an arc ruling engine. Troughton might be a good candidate as may be some of the early chronometer makers.

Second: I would be very interested in a copy of the 1988 compact almanac. This could be sent as above or to my home address for forwarding. Will, with mates, attempt to wring it out thoroughly and make a report. Need cost and handling charges.Could be sent to my home address only if it comes out late as I may get the ship home for a bit early in the year.

Third: I can use some more information on both 90° and 180° indirect horizon scopes. At one time I did numerous back sights (in desperation) and find these sights and probably the use of these scopes can have one very aggravating problem. This be that the ship's structure gets in the way and the quietcorner, out of the wind, that the navigator normally uses is no longer available. On larger and faster ships the only available spot may be on a lower deck completely blocked over most of thecompass, a spot which also causes heartburn when using The Assumed Altitude Method. Even the slight obstruction caused by a stay or a stanchon can be seriously disturbing.

Fourth: The Naval Institute recently had an article by Professor Luria concerning the use of an eye patch to keep a submariner's periscope eye night adapted amongst the glaring confusion of radar scopes, waterfall displays and LED readouts. I havereplied in a letter asserting my method of simply closing my right eye when going in to record a sight and recover chronometer time, a method which also works when being called to the bridge by a panicked mate or when making head calls across boobytrapped staterooms on nasty nights. When both eyes are finally opened either in the light or dark the effect is passing weird, but is passing.

It raises an odd question, in that my right eye has gotten more and more near sighted while my left eye has remained near normal, all occurring since I began heavy use of the sextant, including thousands of day and night horizontal angles. Of course,the use of any telescope removes completely any near sighted problems as the focus is at infinity.

Fifth: When Captain of a USCG 95 foot patrol boat many years ago out of New London I ran across two mines, per your comments on the danger of mines in your Marine Information Notes. Both were moored in the Race at the East end of Long Island Soundin the deep water and strong current North-east of Valiant rock. The first turned out to be a dummy mine astray from the practice mine field at the eastern end of Fisher's Island and when the Navy tug bounced off it and the hairy boatswain happilypounded away at it with a large reeving hook we all kind of winced and eased back. However the second was of the original German WWII moored submarine launched variety and I had to physically block and divert a coastwise tanker clear.

In the failing light of sunset and with the tide about to drag it under, accurately locating it with a swinging magnetic compass was almost impossible. The use of îanyï two objects in range, or even nearly in range was brought into use. Horizontal angles were tried but the USN "Lionel Trains" sextant could not handle the dusk. We also noted a star directly over Race Rock and another directly over Little Gull Island plus all we could get from a heads up, fixed range ring radar.

While awaiting USN response from the Sub Base (it was Sunday) I hit on the idea of marking it with a floating depth charge marker, a 200 yard long light line and a second float. The marker was lit and dropped about 25 yards up current where thecurrent would set it by about 10 yards off. When about 50 yards of line had been played out with us holding position, we secured a shackle to the line to make it sink and with slight tension on the line to get it below the mine we eased across thecurrent until we were sure that we were up against the mooring with the line below the mine and then eased below it so that we could toss the other end with float across the line above the marker. As expected, they tangled and we had the mine marked. To no avail: No one could be reached. Sink it. Use the 40mm. With the prospect of also taking out Montauk Pointlight on the second skip (ect) we opted to blast away with an M1 rifle from about 100 yards with all WT closures secured. It was nowdark. Neither the gunners mate nor I could hit the damn thing with that non adjusted peep sight and after about 50 rounds were ready to give up. However I had a 357 Magnum Revolver well sighted at 50 yards for a two hand hold and at least I couldsee the open Patridge sights in the glare of the spotlight. I executed it with 4 out of 5 shots just as it was about to be dragged under and the proof was when the whole jury marker rig rapidly followed.

Blowing it away was my Coast Guard duty which I would not recommend to casual passersby. However marking it with a plastic bottle, line and shackle 100 yards clear would be very useful. Using the method I used could be dangerous but when working an8 knot current in 300 feet of water could be the only way.

Note that the taking of a "blind" azimuth in range with a charted object is not impossible. However we were pretty lucky to have two low enough and properly in line at dusk. They were actually noted about 1/2 hour apart but since the running fix hadzero velocity this was perfectly OK. I have not had to use this since but expect it might be good for anchor bearings in isolated spots or when attempting a good departure bearing off a distant shore as when leaving Bermuda when magnetic anomaliescan be expected.

Also in passing note that the name "Backstaff" is not nonexistent (although it may have been a pseudonym) as "W. Cliff Backstaffe" who was a major contributor to a small semi-monthly magazine, now gone, but hardbound and printed as a book. It is"Steamboats and Modern Steam Launches" Circa 1961-63, Howell-North Books, Berkeley, CA, ISBN 0-8310-7100-2

John Armitage of Walden, NY, writes:

Thank you for sending the copy of Newsletter 18, with your article on the Indirect-Horizon Scope. Through correspondence with John Luykx, I have become especially interested in this subject.

I see what could be a substantial improvement in the Indirect-Horizon Scope, and I wonder if this has already been proposed. It is something very obvious to an optical engineer, so I suspect that it must have been.

If the scope is made longer and rotated upward, so the path is over the top of the sextant rather than alongside it, then the two 45-45-90 prisms can be replaced with two 90-degree deviation penta-prisms. A penta prism has the property that in oneplane, the angle of deviation is constant at twice the prism base angle, independent of the angle of incidence on the prism. Therefore, the accuracy to get exactly 180-degrees on the scope is built into the scope, and there are no adjustments to bemade to get this critical angle, nor will it go out of adjustment. I should think this would greatly increase the practical utility of the scope. However, there is a cost difference: a pair of 10-Asec 10x10mm penta prisms (from an expensive source)cost $350, compared to the $50 for a pair of simple 45-45-90 prisms. But the remainder of the scope could be made much less rugged and heavy, practically of cardboard! From your sketch, it appears that one of the 45-45-90 prisms is a roof prism,which in principle is as expensive as a penta prism, except that they are mass-produced for binocular use. So perhaps the cost difference would not be so great.

Are there any Indirect-Horizon Scopes available commercially now? Do you know of any which will be made available in the near future? Or is it build-your-own?

I enclose my application to become a member of the Navigation Foundation, with great pleasure. Do you know if there is any possibility of examining copies of the back issues of the Newsletter?

(Ed. note: Without the Roof-Prism the Scope is extremely sensitive torocking motion, and almost impossible to use at sea. Back Issues of the Newsletter are available at $ 2 each).

Allen Thompson of MAP CENTRE, INC., writes:

Are you aware of what a fouled up system the new D.M.A. pricing policy is? They have shifted many charts and pubs to new price codes. This is a disaster as there are at least 100,000 catalogs in circulation with the old price codes. See example on sailing directions. We also will lose several dollars on each General, Int'l, Loran and Omega charts bought at the old higher prices. This is also true on many other charts and pubs where they lowered the prices. Example: Bowditch Vol. 1 paid $13.50 and sell at $8.00.

Enclosed are copies of my correspondence with D.M.A. about this. Look it over and if you agree, write to following with your protest:

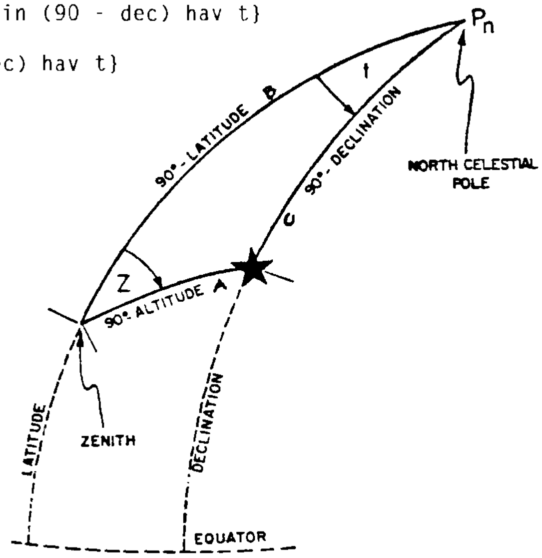
Mr. Lee Banjanin
Director D.M.A.
Attn: P.P.D.
Washington, D.C. 20305

If they can afford to lower prices why not raise our discount back to 40%?

Jeffrey A. Ward of Lawrence, KS, writes:

As a complement to the well done article on the haversine by Mr. Pegg (summer 1987 p. 6), I would like to offer the derivation of the haversine formula as used by a navigator. I shall start with the law of cosines.

```
cos A = cos B cos C + sin B sin C cos a
1 - cos x = ver x
1 - (1 - cos A) = cos B cos C + sin B sin C [1 - (1- cos a)
1 - ver A = cos B cos C + sin B sin C (1 - ver a)
1 - ver A = cos B cos C + sin B sin C - sin B sin C ver a since cos B cos C +
sin B sin C = cos (B - C)
then 1 - ver A = cos (B - C) - sin B sin C ver a
1 - ver A = 1 - [1 - cos (B - C)] - sin B sin C ver a
ver A = ver (B - C) + sin B sin C ver a
1/2 ver A = 1/2 ver (B - C) + 1/2 sin B sin C ver a
since 1/2 ver x = hav x
then hav A = hav (B - C) + sin B sin C hav a
A = arc hav {hav (B - C) + sin B sin C hav a}
B = 90-lat    C = 90 - dec    a = t
A = arc hav {hav [(90 - lat) - (90ºo - dec)] + sin (90 - lat) sin (90 - dec) hav t}
A = arc hav {hav (dec - lat) + cos (lat) cos (dec) hav t}
90 - A = Hc = 90 - arc hav {hav (dec - lat) + cos (lat) cos (dec) hav t}
```



Since the haversine is symmetrical about 0, it makes no difference whether the declination is subtracted from the latitude or vise versa, thus (dec lat).

If possible, would you please announce in the readers forum that I am interested in purchasing two books on navigation by Charles H. Cotter. They are:
1) "The Complete Nautical Astronomer," Charles H. Cotter, American Elsevier Pub. Co., New York, 1969.

2) "A History of Nautical Astronomy," Charles H. Cotter, London, 1968.

If any would be interested in selling either or both books please write me a postcard (2337 Murphy Dr. 5, Lawrence, KS 66046) stating the price and condition of the book(s). Thank you for your consideration.

Macey Casebeer sends the following information on CALNAV Institute of Davis, CA:

Dr. Macey Casebeer, Director of CALNAV Institute, has agreed with Captain John Denham, Director of Continuing Maritime Education (CME) at the California Maritime Academy (CMA), to offer high quality affordable courses for recreation boaters inNorthern California.

CALNAV courses will be taught by Dr. Casebeer, LCDR USN (Ret.)©©a seasoned world navigator, deck officer and certified naval instructor with over twenty years at sea.

Today's CALNAV courses were developed by Macey while teaching nautical science to yachtsmen, boaters and sailors at the University of California (UNEX) in Davis during 1985©1986.

Marvin Sebourn of Enid, OK, writes:

I would like to order all available copies of the îNavigator's Newsletterï published prior to my membership, if possible. If these are available, please notify me of the charges, and the procedure for ordering.

Does the Foundation have a historical division? I am seekinginformation on Captain Thomas Sumner, and looking for a copy of his book, A New and Accurate Method of Finding a Ship's Position at Sea by Projection on Mercator's Chart. (See Newsletter Issue 15).

It is quite pleasing to find an active organization, as the Foundation seems, that encourages the novice navigator to know the basics. I am strictly a neophyte navigator, or "buff," and the Newsletter and membership expertise is very muchappreciated.

Don Wild of Farmington, CT, writes:

My copy of your 1988 Navigator's Almanac has been received, and I am very pleased with its neat and handy compactness.

However, the fact that the sample calculations, as given on pages 11, 15 and 18, are obviously for 1987 data render these samples practically useless, since the verification of extracted data cannot be properly accomplished. And such verification is,of course, vital to one's confidence in proper use of the tables.

Could you be kind enough to issue errata for these Sample Calculations, as they would reflect the 1988 tables? Thank you in advance for your consideration of this.

(Ed. Note. See Page 16)

Capt. H. F. Van Der Grinten of Plano, TX, sends a copy of his letter to Capt. Douglas Hard in which he asks a question, as follows:

You will recall that I spoke to you several times by telephone from Norfolk during my Reserve Active Duty for Training at the Naval Amphibious School Shiphandling Course, 04 JAN to 15 JAN 88, where I was serving as an instructor. We discussed a shiphandling technique which has been referred to as "laying against the wind." I am still attempting to find a definition of this technique and understand how it is used. One possible answer to this question was provided by LT Stuart Smith, USN, anactive duty instructor at the school.

He told me that his father, a retired Panama Canal pilot, believes that the term may apply to the technique used by pilots to kill time without dropping the anchor. They head into the wind and "fish-tail" with the rudder and minimum engine thrust tokeep the ship more or less in one spot.

Another possibility was related by Capt. Daniel H. MacElrevey. He suggests that the term may apply to the technique used by pilots in approaching some locks during the dry season in the Panama Canal. Sometimes, he says, the wind will bounce off thelock wall and will provide a cushion against which a ship may be stopped or aligned prior to entering the lock.

I find that either technique is worthy of the name but I don't think it should be applied to both of them. I'd be most interested in learning about it, if you ever find an authoritative way to define these techniques. Perhaps you could interest someMidshipman at the Academy in researching this question.

NAVIGATION BASICS REVIEW

The Sailings

by John M. Luykx

A. General

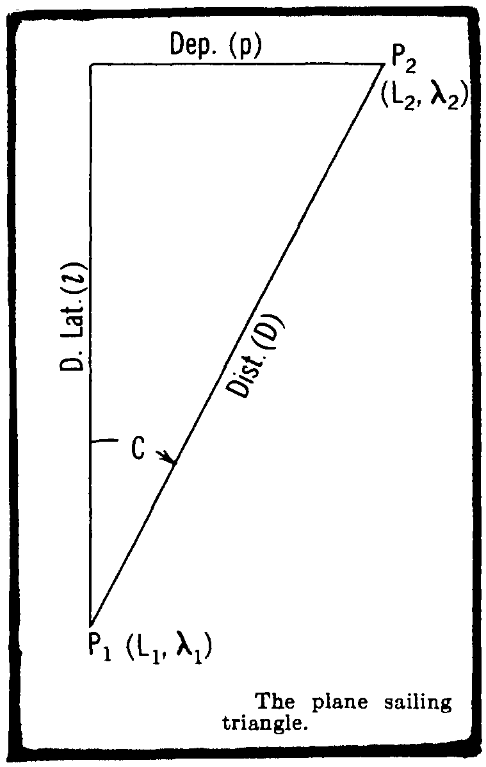
1. When preparing for a voyage, one of the principal duties of the navigator is to establish the itinerary and to lay down the Dead Reckoning (DR) Track for the intended voyage on a chart or plotting sheet.

The DR Track consists of a course and distance or a series of courses and distances from the point of departure to the point of arrival. The Sailings are, basically, mathematical solutions to the problems of computing the required course(s) and distance(s) for each leg of the established DR track.

In this issue Plane Sailing, Traverse Sailing and Parallel Sailing will be considered.

B. Plane Sailing

1. Plane sailing is a solution by plane trigonometry involving course (C), distance (D), difference of latitude (l)(distance in a North/South direction) and departure (p) (distance in an East/West direction). (Figure 1)



The plane sailing triangle.

Figure 1

For example: If it were found from a chart that the point of arrival (B) was located 35 miles north of the point of departure (A) and 65 miles east of it, the course and distance from A to B would be found using the following formulas: (Figure 2)

To find True Course from A to B:

$$\text{Tan } C = \frac{p}{l} = \frac{65}{35}$$

$$\text{Tan } C = 1.857143$$

$$C = 061°9T$$

To find Distance from A to B:

$$\text{Sin } C = \frac{p}{D}$$

$$D = \frac{p}{\text{Sin } 061°9}$$

$$D = \frac{65}{.88199}$$

D = 73.7 miles

332° | 028° / 208° | 152° — TABLE 3 — Traverse 28°

Dist.	D. Lat	Dep.	Dist.	D. Lat.	Dep.	Dist.	D. Lat.	Dep.
1	0.9	0.5	61	53.9	28.6	121	106.8	56.8
2	1.8	0.9	62	54.7	29.1	22	107.7	57.3
3	2.6	1.4	63	55.6	29.6	23	108.6	57.7
4	3.5	1.9	64	56.5	30.0	24	109.5	58.2
5	4.4	2.3	65	57.4	30.5	25	110.4	58.7
6	5.3	2.8	66	58.3	31.0	26	111.3	59.2
7	6.2	3.3	67	59.2	31.5	27	112.1	59.6
8	7.1	3.8	68	60.0	31.9	28	113.0	60.1
9	7.9	4.2	69	60.9	32.4	29	113.9	60.6
10	8.8	4.7	70	61.8	32.9	30	114.8	61.0
11	9.7	5.2	71	62.7	33.3	131	115.7	61.5
12	10.6	5.6	72	63.6	33.8	32	116.5	62.0
13	11.5	6.1	73	64.5	34.3	33	117.4	62.4
14	12.4	6.6	74	65.3	34.7	34	118.3	62.9
15	13.2	7.0	75	66.2	35.2	35	119.2	63.4
16	14.1	7.5	76	67.1	35.7	36	120.1	63.8
17	15.0	8.0	77	68.0	36.1	37	121.0	64.3
18	15.9	8.5	78	68.9	36.6	38	121.8	64.8
19	16.8	8.9	79	69.8	37.1	39	122.7	65.3
20	17.7	9.4	80	70.6	37.6	40	123.6	65.7
Dist.	Dep.	D. Lat.	Dist.	Dep.	D. Lat.	Dist.	Dep.	D. La

298° | 062° / 242° | 118° — 62°

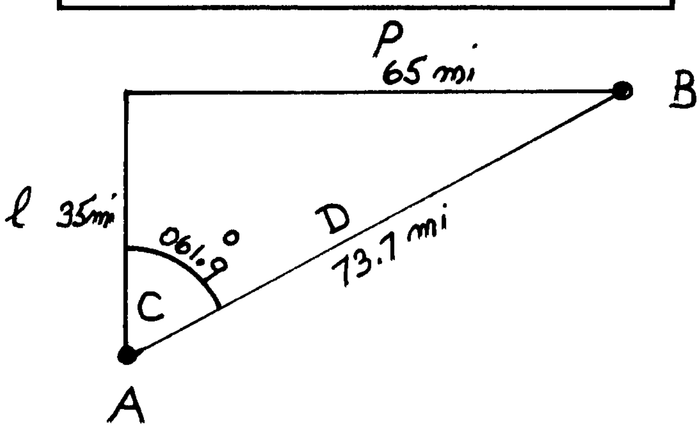


Figure 2

Similarly, if the values C = 061.9 and D = 73.7 miles, were given to find l and p, the following solutions would be required:

To find l:

l = D cos C

To find p:

p = D sin C

The plane sailing method of solution for C, D, l and p is based on the assumption that the earth is a plane surface. The solution does not allow for the convergence of the meridians and therefore can only be used for relatively short distances of generally less than 200 miles. Difference of longitude cannot be computed by the plane sailing method.

Solutions to dead reckoning problems by the plane sailing method date from the late 15th century (or early 16th century) when the plane chart was in general use by navigators. On the plane chart, the parallels of latitude were equidistant horizontal lines and the meridians were equidistant vertical lines. The plane sailing solution was well-suited to this type of chart in which the computed course was laid down by protractor and the computed distance measured off by a pair of compasses.

C. Traverse Sailing

Because of wind shifts it often became necessary for sailing vessels to make frequent changes of course during the day's run. The problem of determining the resultant daily course and distance made good required the solution of a series of trigometric problems; one for each course change. These course changes were normally recorded in the log along with an estimate of the distance made good on each course. The total distance made good north or south each day (l) was combined with the total distance made good east or west each day (p) to determine the resultant course and distance made good for that day.

Traverse sailing is a solution for the sum of all the individual plane sailing solutions for l and p. It is a method for computing the equivalent course and distance made good for a series of individual courses and distances recorded during the day's run.

The trigonometric solutions for l and p for each individual course change was supplanted by the Traverse Table first developed during the middle of the 15th century and later perfected by Edmund Gunter in the early 17th century. The traverse table provides a solution in tabular form for problems in plane trigonometry.

The Traverse Table in Volume II of Bowditch, Table 3, is an example of a modern traverse table based on Gunter's computations. Table 3 provides values of l and p for course angles 00 to 90 (courses from 000 to 360) and for distances up to 600 miles.

The following is an example of a traverse sailing solution by Traverse Table.

During a day's run a vessel sails the following courses and distances: (See Table A)

Table A			Table B	
Time	Course	Distance	l	p
00-04	065	19.0 mi.	8.0 N	17.2 E
04-12	136	37.0 mi.	26.6 S	25.7 E
12-17	177	26.0 mi.	26.0 S	1.4 E
17-24	143	33.0 mi.	26.4 S	19.9 E
		Total:	71.0 S	64.2 E

What was the course and distance made good from 00 to 24 hours?

To solve this problem the Traverse Table (Examples shown in Figures 3-6) is entered with each course and distance sailed and l (North/South) and p (East/West) extracted from the table in each case. The total sum of l (N/S) and p (E/W) is then computed (See Table B). The Traverse Table is then reentered with these total values of l and p to obtain the resultant course made good: 138 T and the resultant distance made good: 96 miles. (Figure 7)

In modern practice, traverse sailing methods are used to update the daily DR position by small vessels, particularly those that do a great deal of maneuvering in a local area, such as fishing vessels and trawlers.

Rather than plot each change of course on the chart, these are recorded in the log and the resultant course and distance made good computed by traverse table at the end of the day's activities. The resultant daily course and distance made good is then plotted on the chart to show day to day position changes.

Given the latitude and longitude of the point of departure and the course and distance, plane and traverse sailing solutions provide the latitude of the point of arrival but not the longitude of this point. A spherical solution (allowing for the convergence of the meridians) is required to obtain the longitude. The spherical solution known as Parallel Sailing converts departure (p) to difference of longitude (Dlo) thus solving for longitude.

D. Parallel Sailing

When a vessel is proceeding due east or west, the parallel sailing method of solution converts p to Dlo and vice versa. The formulas are:

$$\text{Dlo} = \frac{p}{\cos L}$$

$$p = \text{Dlo} \cos l$$

$$L_1 \pm l = L_2$$

$$\lambda_1 \pm \text{Dlo} = \lambda_2$$

The methods of plane sailing combined with those of parallel sailing provide a complete solution to the dead reckoning problem in which both the latitude and the

335° | 025° / 205° | 155° — TABLE 3 — Traverse 25°

Dist.	D. Lat.	Dep	Dist	D. Lat.	Dep.	Dist.	D. Lat.	Dep.
1	0.9	0.4	61	55.3	25.8	121	109.7	51.1
2	1.8	0.8	62	56.2	26.2	22	110.6	51.6
3	2.7	1.3	63	57.1	26.6	23	111.5	52.0
4	3.6	1.7	64	58.0	27.0	24	112.4	52.4
5	4.5	2.1	65	58.9	27.5	25	113.3	52.8
6	5.4	2.5	66	59.8	27.9	26	114.2	53.2
7	6.3	3.0	67	60.7	28.3	27	115.1	53.7
8	7.3	3.4	68	61.6	28.7	28	116.0	54.1
9	8.2	3.8	69	62.5	29.2	29	116.9	54.5
10	9.1	4.2	70	63.4	29.6	30	117.8	54.9
11	10.0	4.6	71	64.3	30.0	131	118.7	55.4
12	10.9	5.1	72	65.3	30.4	32	119.6	55.8
13	11.8	5.5	73	66.2	30.9	33	120.5	56.2
14	12.7	5.9	74	67.1	31.3	34	121.4	56.6
15	13.6	6.3	75	68.0	31.7	35	122.4	57.1
16	14.5	6.8	76	68.9	32.1	36	123.3	57.5
17	15.4	7.2	77	69.8	32.5	37	124.2	57.9
18	16.3	7.6	78	70.7	33.0	38	125.1	58.3
19	17.2	8.0	79	71.6	33.4	39	126.0	58.7
20	18.1	8.5	80	72.5	33.8	40	126.9	59.2
Dist.	Dep.	D. Lat	Dist	Dep.	D. Lat.	Dist.	Dep.	D. Lat.

295° | 065° / 245° | 115° — 65°

Figure 3

316° | 044° / 224° | 136° — TABLE 3 — Traverse 44°

Dist.	D. Lat.	Dep.	Dist.	D. Lat.	Dep.	Dist.	D. Lat.	Dep.
31	22.3	21.5	91	65.5	63.2	151	108.6	104.9
32	23.0	22.2	92	66.2	63.9	52	109.3	105.6
33	23.7	22.9	93	66.9	64.6	53	110.1	106.3
34	24.5	23.6	94	67.6	65.3	54	110.8	107.0
35	25.2	24.3	95	68.3	66.0	55	111.5	107.7
36	25.9	25.0	96	69.1	66.7	56	112.2	108.4
37	26.6	25.7	97	69.8	67.4	57	112.9	109.1
38	27.3	26.4	98	70.5	68.1	58	113.7	109.8
39	28.1	27.1	99	71.2	68.8	59	114.4	110.5
40	28.8	27.8	100	71.9	69.5	60	115.1	111.1
41	29.5	28.5	101	72.7	70.2	161	115.8	111.8
42	30.2	29.2	02	73.4	70.9	62	116.5	112.5
43	30.9	29.9	03	74.1	71.5	63	117.3	113.2
44	31.7	30.6	04	74.8	72.2	64	118.0	113.9
45	32.4	31.3	05	75.5	72.9	65	118.7	114.6
46	33.1	32.0	06	76.3	73.6	66	119.4	115.3
47	33.8	32.6	07	77.0	74.3	67	120.1	116.0
48	34.5	33.3	08	77.7	75.0	68	120.8	116.7
49	35.2	34.0	09	78.4	75.7	69	121.6	117.4
50	36.0	34.7	10	79.1	76.4	70	122.3	118.1
51	36.7	35.4	111	79.8	77.1	171	123.0	118.8
52	37.4	36.1	12	80.6	77.8	72	123.7	119.5
53	38.1	36.8	13	81.3	78.5	73	124.4	120.2
54	38.8	37.5	14	82.0	79.2	74	125.2	120.9
55	39.6	38.2	15	82.7	79.9	75	125.9	121.6
56	40.3	38.9	16	83.4	80.6	76	126.6	122.3
57	41.0	39.6	17	84.2	81.3	77	127.3	123.0
58	41.7	40.3	18	84.9	82.0	78	128.0	123.6
59	42.4	41.0	19	85.6	82.7	79	128.8	124.3
60	43.2	41.7	20	86.3	83.4	80	129.5	125.0
Dist.	Dep.	D. Lat.	Dist.	Dep.	D. Lat.	Dist.	Dep.	D. Lat.

314° | 046° / 226° | 134° — 46°

Figure 4

357° | 003°							TABLE 3	
183° | 177°					Traverse		3°	
Dist.	D. Lat.	Dep.	Dist.	D. Lat.	Dep.	Dist.	D. Lat.	Dep.
1	1.0	0.1	61	60.9	3.2	121	120.8	6.3
2	2.0	0.1	62	61.9	3.2	22	121.8	6.4
3	3.0	0.2	63	62.9	3.3	23	122.8	6.4
4	4.0	0.2	64	63.9	3.3	24	123.8	6.5
5	5.0	0.3	65	64.9	3.4	25	124.8	6.5
6	6.0	0.3	66	65.9	3.5	26	125.8	6.6
7	7.0	0.4	67	66.9	3.5	27	126.8	6.6
8	8.0	0.4	68	67.9	3.6	28	127.8	6.7
9	9.0	0.5	69	68.9	3.6	29	128.8	6.8
10	10.0	0.5	70	69.9	3.7	30	129.8	6.8
11	11.0	0.6	71	70.9	3.7	131	130.8	6.9
12	12.0	0.6	72	71.9	3.8	32	131.8	6.9
13	13.0	0.7	73	72.9	3.8	33	132.8	7.0
14	14.0	0.7	74	73.9	3.9	34	133.8	7.0
15	15.0	0.8	75	74.9	3.9	35	134.8	7.1
16	16.0	0.8	76	75.9	4.0	36	135.8	7.1
17	17.0	0.9	77	76.9	4.0	37	136.8	7.2
18	18.0	0.9	78	77.9	4.1	38	137.8	7.2
19	19.0	1.0	79	78.9	4.1	39	138.8	7.3
20	20.0	1.0	80	79.9	4.2	40	139.8	7.3
21	21.0	1.1	81	80.9	4.2	141	140.8	7.4
22	22.0	1.2	82	81.9	4.3	42	141.8	7.4
23	23.0	1.2	83	82.9	4.3	43	142.8	7.5
24	24.0	1.3	84	83.9	4.4	44	143.8	7.5
25	25.0	1.3	85	84.9	4.4	45	144.8	7.6
26	26.0	1.4	86	85.9	4.5	46	145.8	7.6
27	27.0	1.4	87	86.9	4.6	47	146.8	7.7
28	28.0	1.5	88	87.9	4.6	48	147.8	7.7
29	29.0	1.5	89	88.9	4.7	49	148.8	7.8
30	30.0	1.6	90	89.9	4.7	50	149.8	7.9
Dist.	Dep.	D. Lat.	Dist.	Dep.	D. Lat.	Dist	Dep.	D. Lat.
273° | 087°							87°	
267° | 093°								

Figure 5

longitude of the point of arrival may be computed from given values of the latitude and longitude of the point of departure and values of course and distance.

The complete solution to dead reckoning problems will be considered in greater detail in the next issue in which Middle atitude sailing and Mercator sailing will be discussed.

Note: All the figures are taken from the American Practical Navigator, Vol. II. (Bowditch) 1981 edition.

323° | 037°							TABLE 3	
217° | 143°					Traverse		37°	
Dist	D Lat.	Dep	Dist.	D Lat.	Dep.	Dist	D Lat	Dep
31	24.8	18.7	91	72.7	54.8	151	120.6	90.9
32	25.6	19.3	92	73.5	55.4	52	121.4	91.5
33	26.4	19.9	93	74.3	56.0	53	122.2	92.1
34	27.2	20.5	94	75.1	56.6	54	123.0	92.7
35	28.0	21.1	95	75.9	57.2	55	123.8	93.3
36	28.8	21.7	96	76.7	57.8	56	124.6	93.9
37	29.5	22.3	97	77.5	58.4	57	125.4	94.5
38	30.3	22.9	98	78.3	59.0	58	126.2	95.1
39	31.1	23.5	99	79.1	59.6	59	127.0	95.7
40	31.9	24.1	100	79.9	60.2	60	127.8	96.3
41	32.7	24.7	101	80.7	60.8	161	128.6	96.9
42	33.5	25.3	02	81.5	61.4	62	129.4	97.5
43	34.3	25.9	03	82.3	62.0	63	130.2	98.1
44	35.1	26.5	04	83.1	62.6	64	131.0	98.7
45	35.9	27.1	05	83.9	63.2	65	131.8	99.3
46	36.7	27.7	06	84.7	63.8	66	132.6	99.9
47	37.5	28.3	07	85.5	64.4	67	133.4	100.5
48	38.3	28.9	08	86.3	65.0	68	134.2	101.1
49	39.1	29.5	09	87.1	65.6	69	135.0	101.7
50	39.9	30.1	10	87.8	66.2	70	135.8	102.3
51	40.7	30.7	111	88.6	66.8	171	136.6	102.9
52	41.5	31.3	12	89.4	67.4	72	137.4	103.5
53	42.3	31.9	13	90.2	68.0	73	138.2	104.1
54	43.1	32.5	14	91.0	68.6	74	139.0	104.7
55	43.9	33.1	15	91.8	69.2	75	139.8	105.3
56	44.7	33.7	16	92.6	69.8	76	140.6	105.9
57	45.5	34.3	17	93.4	70.4	77	141.4	106.5
58	46.3	34.9	18	94.2	71.0	78	142.2	107.1
59	47.1	35.5	19	95.0	71.6	79	143.0	107.7
60	47.9	36.1	20	95.8	72.2	80	143.8	108.3
Dist.	Dep.	D Lat	Dist.	Dep	D Lat	Dist.	Dep	D. Lat
307° | 053°							53°	
233° | 127°								

Figure 6

318° | 042°							TABLE 3	
222° | 138°					Traverse		42°	
Dist.	D. Lat.	Dep.	Dist.	D. Lat.	Dep.	Dist.	D Lat	Dep.
31	23.0	20.7	91	67.6	60.9	151	112.2	101.0
32	23.8	21.4	92	68.4	61.6	52	113.0	101.7
33	24.5	22.1	93	69.1	62.2	53	113.7	102.4
34	25.3	22.8	94	69.9	62.9	54	114.4	103.0
35	26.0	23.4	95	70.6	63.6	55	115.2	103.7
36	26.8	24.1	96	71.3	64.2	56	115.9	104.4
37	27.5	24.8	97	72.1	64.9	57	116.7	105.1
38	28.2	25.4	98	72.8	65.6	58	117.4	105.7
39	29.0	26.1	99	73.6	66.2	59	118.2	106.4
40	29.7	26.8	100	74.3	66.9	60	118.9	107.1
41	30.5	27.4	101	75.1	67.6	161	119.6	107.7
42	31.2	28.1	02	75.8	68.3	62	120.4	108.4
43	32.0	28.8	03	76.5	68.9	63	121.1	109.1
44	32.7	29.4	04	77.3	69.6	64	121.9	109.7
45	33.4	30.1	05	78.0	70.3	65	122.6	110.4
46	34.2	30.8	06	78.8	70.9	66	123.4	111.1
47	34.9	31.4	07	79.5	71.6	67	124.1	111.7
48	35.7	32.1	08	80.3	72.3	68	124.8	112.4
49	36.4	32.8	09	81.0	72.9	69	125.6	113.1
50	37.2	33.5	10	81.7	73.6	70	126.3	113.8
51	37.9	34.1	111	82.5	74.3	171	127.1	114.4
52	38.6	34.8	12	83.2	74.9	72	127.8	115.1
53	39.4	35.5	13	84.0	75.6	73	128.6	115.8
54	40.1	36.1	14	84.7	76.3	74	129.3	116.4
55	40.9	36.8	15	85.5	77.0	75	130.1	117.1
56	41.6	37.5	16	86.2	77.6	76	130.8	117.8
57	42.4	38.1	17	86.9	78.3	77	131.5	118.4
58	43.1	38.8	18	87.7	79.0	78	132.3	119.1
59	43.8	39.5	19	88.4	79.6	79	133.0	119.8
60	44.6	40.1	20	89.2	80.3	80	133.8	120.4
Dist	Dep.	D. Lat.	Dist	Dep.	D. Lat	Dist.	Dep.	D. Lat
312° | 048°							48°	
228° | 132°								

Figure 7

NAVIGATION PERSONALITIES

William Thomson, Lord Kelvin

by T. D. Davies

William Thomson, Baron Kelvin (Lord Kelvin) is a name widely associated with the field of Physics, in which he was responsible for some of the most significant advances of the 19th century. However he was also active in many related fields and, indeed, could be called a "Renaissance Man." These included the field of navigation, and consequently this article deals with him as a Navigation Personality.

William, the second son of James Thomson, LL.D., was actually born in 1824, in Belfast, Ireland, although he was always considered a Scotsman. His father was a teacher of mathematics at the Royal Academical Institution. In 1832 the father accepted the chair of mathematics at Glasgow and the family moved to Scotland. William entered Cambridge, taking his degree in 1845 at which time he won the first "Smith's Prize."

Because there were few facilities in England for the study of experimental science Thomson moved to Paris to the laboratory of Regnault, who was engaged in the study of the thermal properties of steam. By 1846 he was back at Glasgow, where he accepted the chair of Natural Philosophy which he occupied for the next 53 years. A few of his most notable contributions are mentioned below.

One of his earliest papers dealt with the age of the Earth which led to a long controversy with the Geologists. Kelvin's concepts survived. In 1848 he proposed his absolute scale of temperature, used today when "degrees Kelvin" are mentioned. In 1851 he presented his classic paper on thermodynamics to the Royal Society of Edinburgh. From this the principle of the conservation of energy emerged and the second law of thermodynamics was first stated.

In electricity his first interest was in communication by means of submarine cable telegraphy. As a result of his analysis he vastly improved these cables and developed a family of instruments addressed to the measurement of many of the aspects of the communication industry. In 1861 he was central to the establishment of electrical standards in both telegraphy and radio. He was knighted in 1866, and in 1892 was named Baron Kelvin of Largs (Largs was the town of his residence throughout most of his life).

In the field of navigation he made many contributions. In 1873 he undertook to write a series of articles on the mariner's compass. In doing so he completely redesigned the compass, providing for the compensation of both the permanent and temporary magnetism of the ship. He reduced the weight of the compass card while increasing the period of its swing. He essentially produced the mariner's compass as we know it today.

Kelvin then invented the mechanical sounding device for both shallow and deep water. He also invented a tidal gauge for the measurment of tidal levels and finally a tidal computer for tidal prediction, that represented a milestone in the early history of computers. In the course of these herculean efforts he published more than 300 original papers bearing upon nearly every branch of physical science.

In 1876 he published a table of trigonometric data for use at sea to solve sights by the longitude method. The table was only 9 pages long and was entitled "Tables for Facilitating Sumner's Method at Sea." He was the first to solve the celestial triangle by dividing it into two right triangles. He dropped his perpendicular from the celestial body to the celestial meridian of the observer. One enters the tables with half of the co-latitude (to an integral degree) and searches for two numbers, one agreeing with the altitude and the other with the declination, using a pair of dividers as an "aid."

In 1887 Kelvin became interested in the wakes generated by ships as they move through the water. The analysis of these depends upon a thorough knowledge of the nature of water waves, about which there was inadequate knowledge. He developed a complete theory of waves and of wakes, including a new method of analysis by the "method of constant phase." The method is used today. In 1890 Kelvin became president of the Royal Society, and received its "Order of Merit" in 1902. After resigning his chair at the Glasgow he retired and spent most of his time reducing his lectures on the Wave Theory of light to writing for publ ication. He died in 1907 and a statue was raised to him in Glasgow in 1913. He left an unsurpassed heritage to the world of science and to the navigators of the world.

HISTORY OF NAVIGATION

Early Altitude Measuring Instruments: The Cross-Staff

by John M. Luykx

A. GENERAL

The earliest reference regarding the use of the cross-staff to measure altitudes at sea is contained in Pedro de Medina's Arte de Navegar published in Seville in 1545. It appears, however, that the cross-staff was first used by the Portugese some years earlier during the voyages of discovery and exploration in the South Atlantic and Indian Oceans.

Some historians believe that the cross-staff was adapted from the Jacob's Staff utilized by late medieval astronomers while others believe that its design was based on the principle of the Kamal used by Vasco da Gama's Arab pilot in the Indian Ocean during the voyage of 1497-99.

The cross-staff was a significant improvement over the seaman's quadrant and the mariner's astrolabe because the reference for measuring altitudes was the natural sea horizon rather than the uncertain "vertical" established by the force of gravity acting on a hanging or suspended instrument influenced by the force of the wind and accelerations caused by the sea.

The cross-staff was the first altitude measuring instrument which could be used with accuracy at sea and which was relatively unaffected by the motion of a ship at sea.

B. DESCRIPTION

The earliest cross-staves were made of hardwood and consisted of two parts; the staff about 3 feet long and 3/4 to 1 inch square, and the cross piece or transom the width of which was 2 to 3 inches. The transom was designed with a square aperture at its center through which the staff was fitted. At one side of the transom a thumb screw was installed to permit clamping the transom to the staff during observation. One side of the staff was graduated in degrees of altitude (or Zenith Distance) usually from 20 to 60 . (Figure 1)

C. OBSERVATION WITH THE CROSS-STAFF

To measure altitude of the sun, for example, the observer faced toward the sun, placed the eye end of the staff on the cheekbone below the sighting eye (or some other convenient comfortable position close to the eye) and with the transom oriented vertically (not canted to right or left) adjusted it along the staff until its lower edge was aligned with the horizon and its upper edge just covered the upper limb of the sun. This method of operation required the observer to shift the eye rapidly back and forth from horizon to sun when making the observation. The altitude was read on the altitude scale engraved on the staff at the point of intersection of the transom with the altitude scale.

Because the time of the sun's meridian passage could not be predicted with accuracy during the early 16th century, many observations had to be taken before the observer noted that maximum altitude had been reached. Under these circumstances the observation for meridian latitude was a very laborious and fatiguing process often requiring the observer to look directly at the sun for extended periods of time. Lower limb observations of the sun especially on a bright clear day were particularly difficult andtiring.

D. IMPROVEMENTS TO THE CROSS-STAFF

To improve accuracy and reduce eyestrain later cross-staves included up to three additional transoms and also provided means for the installation of a piece of colored or smoked glass at the upper edge of each transom to allow more comfortable and more accurate lower limb observations of the sun. The use of 4 transoms of differing lengths permitted, for example, the use of the first or shortest transom for altitudes of 5° to 15°, the second for altitudes 10° to 30°, the third for altitudes 20° to 60° and the fourth for altitudes 50° to 90°. The four separate and expanded altitude scales were engraved on the four sides of the staff. Extending the altitude scales from one to four greatly improved the accuracy and range of the instrument; on some cross-staves Zenith Distance scales were also engraved on the shaft.

Star observations were made in the normal manner as long as the horizon below the star was visible.

E. BACK SIGHTS

To avoid the problems associated with direct observations of the sun, Dutch navigators of the 17th and early 18th centuries preferred to take "back sights" with the cross-staff, a procedure which was later adapted by others.

To take a "back-sight", a fixed vane with horizontal slit was fitted to the eye end of the staff and the appropriate transom installed. With the sun at his back, the observer reversed the cross-staff in his hands and holding the transom vertically (not canted to either right or left) he adjusted the transom along the staff until the shadow of the upper edge of the transom was aligned with both the slit of the fixed vane (and the horizon beyond) and the line of sight of the observer's eye along the lower edge of the transom to the slit of the fixed vane. (Figure 2) experience has shown that the "back sight" with the cross-staff is frequently more accurate than the more normal fore sights. During the "back sight" the observer is required to look in one direction only—toward the horizon. In addition, the strain and eye-fatigue associated with direct observation of the sun is eliminated.

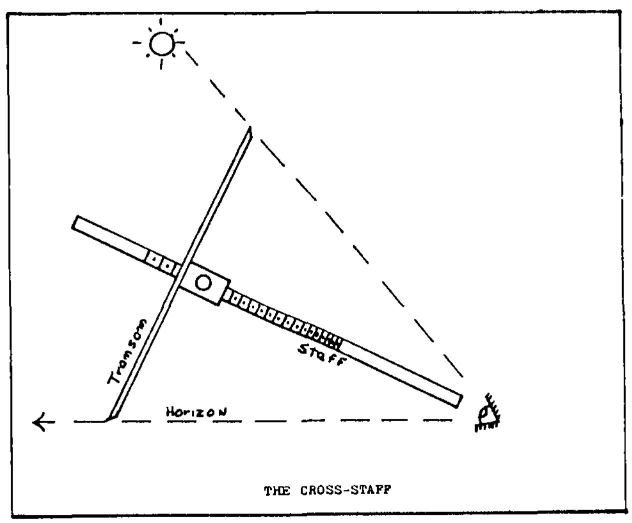


Figure 1

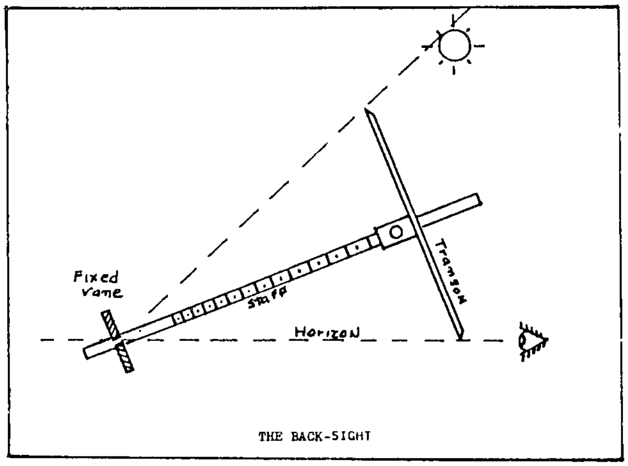


Figure 2

It was the greatly improved accuracy and relative ease of the "back sight" with the cross-staff that eventually led John Davis near the end of the 16th century to develop the back-staff or Davis quadrant which he described in his *Seaman's Secrets* published in 1607.

In the next issue of the Newsletter we will discuss in detail the back-staff or Davis Quadrant and its later developments.

F. OBSERVATIONAL ACCURACY WITH THE CROSS-STAFF

To check the accuracy of the cross-staff from a position ashore two sets of fore sights and one set of back sights were taken with a replica cross-staff from the author's collection. The replica cross-staff is constructed of plain cedar and consists of:

1. The staff: 5/8 square - 35" in length
2. Four (4) transoms:
#1 40° -85° 26" length
#2 25° -50° 15 1/2" length
#3 10° -30° 6 1/4" length
#4 5° -15° 3" length
3. One (1) horizon vane for back sights
4. One (1) "shoe" for positioning the eye end of the staff comfortably at the eye
5. One (1) neutral density filter which may be fixed to the upper end of each one of the transoms.

The results of the accuracy test of the replica cross-staff were as follows:

1. Date:	24 Feb 1988	25 Feb	25 Feb
2. Body:	SUN	SUN (UL)	SUN (LL)
3. Observation Type:	Backsight	Foresight	Foresight
4. No.of Observations:	15	10	17
5. Mean Error:	1.4	1.2	2.5
9. Standard Error:	2.0	1.7	3.3
10.95% Error:	3.8	3.3	6.3
11.Range of Error:	-5.2/+2.5	-5.9/-0.2	-4.2/+7.2

During the observations altitude corrections were applied as follows:

1. Backsight

\+ Dip
± I.C.
\- Refraction
\- Semi-diameter

2. Foresight — upper limb of sun

\- Dip
± I.C.
\- Refraction
\- Semi-diameter

3. Foresight — lower limb of sun

\- Dip
± I.C.
\- Refraction
\+ Semi-diameter

NAVIGATION NOTES

Notes On Shiphandling

by Capt. H. F. Van Der Grinten, USNR, MMR

These notes document some observations and recommendations concerning various aspects of shiphandling which may be of general interest to those involved in navigating and maneuvering ships. They are prepared as part of the ACDUTRA service of the author.

WIND EFFECTS

Shiphandling instructors use a rule-of-thumb which equates 30 knots of wind to the effect of 1 knot of current on a maneuvering ship. This relationship is based on Bernoulli's Theorem as applied to the difference in the densities of air and water.It puts the effect in knots (C) equal to the square of the wind velocity in knots (V) divided by 900 knots:

C = V Squared/900 knots

This relationship can be very useful to navigators in estimating the effects of wind on the course and speed of a ship, but this fact does not seem to be generally known or applied by them. It is not mentioned in any of the standard navigationreference books. The author proposes to promulgate this information to appropriate publishers of navigational information.

MAN OVERBOARD MANEUVERING

Traditional doctrine on maneuvering to recover a man overboard teaches that the rudder should be immediately placed hard over to kick the stern away from the side over which the man fell. Because high speed ships will be well clear of the man beforethe rudder takes effect, this automatic response is no longer advocated. Conning officers are now encouraged to evaluate all conditions which will effect the recovery before putting the rudder over.

A maneuver which will rapidly return most ships to the position of a man overboard is the Anderson one turn method. This method is particularly useful if the man is in sight. One thing which has been consistently overlooked in describing how toexecute this maneuver is: how best to keep the man in sight. The author has learned from running drills that it is extremely important to avoid losing sight of the man in the glare of the sun. Losing sight of the man overboard while executing thisturn can double the time required to maneuver. This can easily be prevented by always turning the ship towards the sun. If this is done, the sun will remain behind the conning officer as he faces the man overboard. Consequently it will be morelikely that he will be able to check the swing of the vessel and commence backing down at the right moment (see Figure 1).

TWIN SCREW VESSELS

The great difference in the handling characteristics of inboard turning verses outboard turning twin screw vessels is not clearly presented in standard texts on shiphandling. These differences should not be overlooked by any who are authorities onshiphandling.
There are four separate forces which effect the maneuvering of a ship.

1. Screw thrust: force of the propeller directed either ahead or astern.
2. Screw side force: force of the propeller directed to port or starboard depending on direction of rotation.
3. Screw offset: force developed by the off center application of screw thrust.
4. Rudder force: force developed by rudder application.

These four forces may be combined in such a way so as to make it possible for a vessel with conventional inboard turning screws to walk sideways. Walking a ship side-

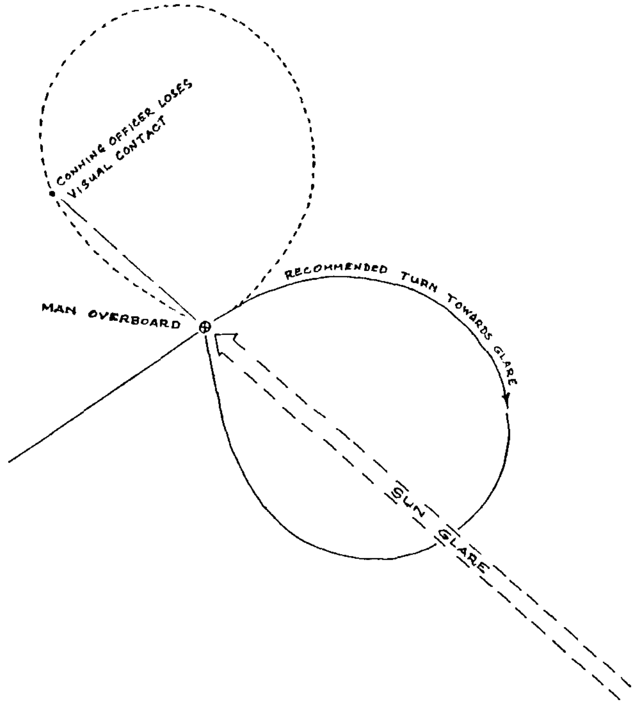


Figure 1
Turning towards the glare keeps the sun at the conning officer's back and prevents him from losing sight of the man overboard during the turn.

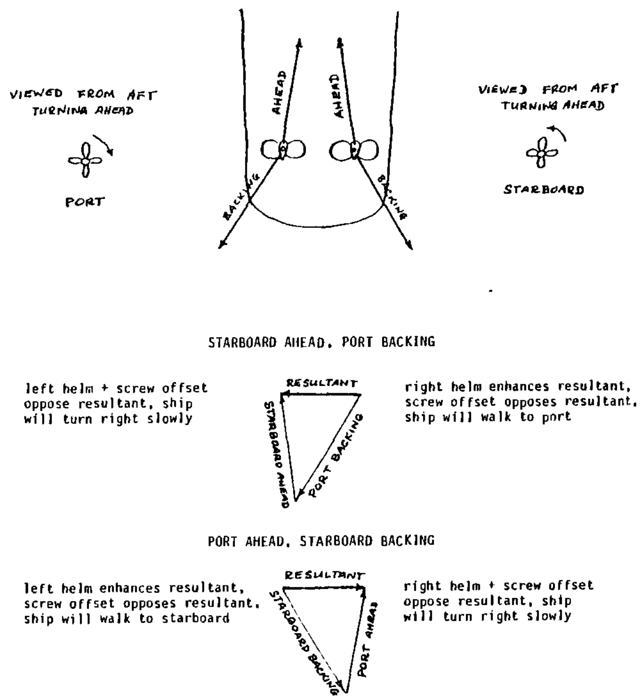


Figure 2
Analysis of forces for inboard turning screws. Ahead and backing arrows represent the sum of screw thrust and side force.

ways means that, without using thrusters of any sort, movement is caused which isdirected to port or starboard, and which is without any significant fore or aft movement, or twisting about the turning point. Ships with outboard turning screws or controllable reversible pitch propellers cannot be made to walk sideways in thismanner.

To make an inboard turning ship walk to port: place the rudder hard right, back on the port engine, and come ahead on the starboard engine. To make her walk to starboard: rudder hard left, back on starboard, ahead on port. The forces which createthis movement are summarized in Figure 2. The rule to remember is that you back on the side to which you wish to move, and you put the rudder on the side which is going ahead.

A ship with outboard turning screws will twist much more rapidly than a similar ship with inboard turning screws. Some shiphandlers may consider this capability more advantageous than walking sideways. Figure 3 shows how the four forces act on thistype of ship.

A Navigation Problem

by Roger H. Jones

Solution to the problem presented in Issue Nineteen.
21. Answer

(a) If the vessel is at 28-50.0 North when the Moon's declination is 28-16.0 North, the difference is only 34.0 minutes of arc. That arc is the zenith distance, and the expected HO would be 90 degrees minus zenith distance or 89-26.0.

(b) Since HO turns out to be 89-20.4 rather than 89-26.0, the zenith distance is 39.6 rather than 34.0. Backstaff is 5.6 nautical miles farther north from the Moon's GP than her navigator believed her to be in terms of her DR latitude. Her latitude is 28-55.6 North rather than 28-50 North'is 28©55.6 North rather than 28©50.0 North.

(c) Measuring such a high altitude is troublesome. Determining the highest point of the Moon, or its meridian passage, by tracking the celestial body visually in the sextant's optics is nearly impossible. It is so high that differences between thealtitude at meridian passage and the altitudes before and after passage are imperceptible. Hence, in these circumstances the observer makes no attempt to wait for the body to appear to reach its highest altitude. He takes a sight at an exact time, as he would with any other non-meridian passage shot, and he determines HO in the normal manner. Then, he plots the GP of the body directly on the chart; in this case the GP is 28-16.0 N, 66-40.5 W. Then, the zenith distance (39.6 minutes of arc =39.6 nautical miles) is used as the radius of an arc centered on the GP. That arc is drawn on the chart. The vessel is on that arc of position. (Remember that a straight line of position drawn at a right angle to the azimuth in the normal plottingpractice is nothing more than a straight line approximation of a small segment of arc on the circumference of the circle of equal altitude surrounding the GP of the body.)

Astute followers of Backstaff's progress will also note that this was a night shot of the Moon, and that brings to mind all of the additional problems with distinguishing the true horizon. However, it is a full Moon almost exactly overhead, and inthese circumstances there may be less glare on the water. The horizon will tend to be equally illuminated in all directions, and if atmospheric conditions are favorable there may be less of a problem with a false horizon.

Problem No. 22

Since December 6, 1987, the date of problem number 21, Backstaff has crossed her outbound track (see Issue Eight, Spring, 1985), and has completed her circumnavigation of the world. In this Issue and succeeding ones, Backstaff's navigator will be dealing with some useful "emergency" techniques that have been culled from the "bags of tricks" of many celestial navigators who have practiced their art in this century and in bygone times as well.

We now suppose that Backstaff is again at sea, but the ship's sextant has been damaged. (Therein lies a lesson. Every vessel should be equipped with at least two sextants.) The navigator has been without a fix for several days, and the vessel isapproaching the notorious shoals to the east of Cape Hatteras on a westerly heading. An update on longitude is desperately needed in anticipation of a course change to the north. The ship's chronometer is functioning. It is shortly before sunriseat the ship's longitude, and there is a visible sea horizon in the east.

(a) What "celestial" method can be used to gain a useful approximation of longitude without using the sextant?

(b) What practical accuracy will this method be expected to yield?

MARINE INFORMATION NOTES

Digest of Notice to Mariners

by Ernest Brown

Annual Notice To Mariners

Beginning with the first issue to be published on 2 January 1988, the Special Notice to Mariners paragraphs heretofore found in Notice to Mariners Number 1, will be produced as a separate publication. This new separate assembly of informationdetailing various marine related subjects which are of special interest to the mariner will be published coincident with Notice to Mariners No. 1 with the new title of "Annual Notice To Mariners."

Certain DMA charts and publications contain notes or warnings or both that refer to Notice to Mariners No. 1. Upon publication of the Annual Notice to Mariners, 1988 edition, all such references should be understood to refer to the Annual Notice toMariners of the current year until such time as all charts and publications can be corrected to reflect this improvement.

New Prices For HydrographicCharts And Publications Sold By The Defense Mapping Agency (DMA)

New prices for charts and publications sold by DMA are in effect as of 1 December 1987. The following is an explanation of the DMA pricing format: Charts and publications of the same price are grouped into 18 price categories. Each price category has been assigned a letter code. For example, Sailing Directions, Light Lists and RadioNavigational Aids have been assigned a letter code "K". Code "K" represents a price of $13.00. (See box below.)

New Edition Of Distances Between United States Ports

Distances Between United States Ports, 1987 (7th) Edition, is ready for issue and may be obtained from Distribution Branch N/CG33, National Ocean Service, 6501 Lafayette Avenue, Riverdale MD 20737-1199, and authorized sales agents of the National Ocean Service. Price $2.75.

This publication, which cancels the 1978 edition, contains distances from a port in the United States to other ports in the United States, and from a port in the Great Lakes in the United States to Canadian ports in the Great Lakes and St. Lawrence River.

DMA PRICES FOR NAUTICAL PRODUCTS
Effective 1 December 1987

CHARTS	PRICE CATEG.	PRICE
Coastal Charts - Harbor and Approach Charts	A	$11.50
Coastal Charts - Harbor and Approach Charts (Foreign Reproductions)	B	$12.00
LORAN Plotting Charts - LORAN Reliability Diagrams	C	$ 9.00
World General Nautical Charts - World International Chart Series - OMEGA Plotting Charts - Display Plotting Charts (Border Strips) - Ice Surveillance Products - Geophysical Data Charts	D	$ 6.50
Great Circle Sailing and Polar Charts	E	$ 5.50
Pilot Charts - Radar Plotting Sheets and Maneuvering Boards - Great Circle Tracking Charts - Display Plotting Charts	F	$ 5.00
Reference Charts (Symbols, Abbreviations, Ensigns, (Flags) - Chart Correction Template - Compass Roses - Whale Chart - LORAN Coverage Diagram - Plotting Diagrams - Antarctica Plotting Charts - North Polar Basin Chart - North Atlantic (Training Chart) - Plotting Chart, Southeast Coast of North America - Plotting Chart, Pacific Yacht Races - Special Bathymetic Chart of the Mediterranean	G	$ 2.50
Universal Plotting Sheet (pad of 50)	H	$ .75
PUBLICATIONS		
Gazetteer of Undersea Features	I	$26.00
Sailing Directions	J	$15.00
Light Lists - Radio Navigational Aids - Notice to Mariners Summary of Corrections	K	$13.00
DoD Glossary of Mapping, Charting, and Geodetic Terms	L	$11.00
Radar Navigational Manual	M	$ 9.00
LORAN Rate and Correction Tables - American Practical Navigator Volumes - Sight Reduction Tables - International Code of Signals - Tables of Distances Between Ports - Maneuvering Board Manual - Handbook of Magnetic Compass Adjustment - World Port Index - Sailing Direction Changes	N	$ 8.00
OMEGA Lattice Tables - OMEGA Propagation Correction Tables	O	$ 6.50
Atlas of Pilot Charts	P	$ 5.00
Catalog Volumes	Q	$ 2.50
Chart Publication Correction Record Card (per 100)	R	$ 1.50

LORAN-A CHARTS AND TABLES
The only Loran-A stations still in operation are those in Japanese and Chinese waters. The rates in operation are:
CHINA - 1L0, 1L1, 1L4, 1L5, 1S1, 1S2, 1S3, 1S4, 1S6
JAPAN - 2S0, 2S1, 2S2, 2S3, 2S4, 2S5, 2S6, 2S7, 2H5, 2H6
DMAHTC will maintain Loran-A tables and charts for the rates listed above.

WARNING:POSSIBLE DANGER FROM UNLABELED DRUMS.
1. With the many exotic chemicals being transported in drums as deck cargo, increasingly more reports are received of loss overboard of these potentially dangerous containers. Even empty drums may contain residues which are extremely hazardous to touch or smell, and a few vapors may be explosive.
2. When coming upon derelict drums, whether afloat or from the sea bottom, this danger should be considered. Identifying labels will give adequate warning, but containers are more likely to be found with caution labels washed off. Avoid direct contact and notify U.S. Coast Guard of any sightings in U.S. coastal waters (24-HR TOLL FREE reporting number 1-800-424-8802), or government authorities of the nearest port state if sighting is near any foreign shores.

ANNUAL NOTICE TO MARINERS
DMAHTC announces that due to scheduling difficulties the Annual Notice to Mariners will not be published on 2 January 1988. The Special Notice to Mariners paragraphs will be published again in Notice to Mariners Number 1 on 2 January 1988.

BOOK REVIEW

by Roger H. Jones

The Log of Christopher Columbus

by Robert H. Fuson
International Marine Publishing Company, 21 Elm Street Camden, Maine 04843 (1987), 252 pages; $29.95

Robert Fuson's interest in the sea voyages of Christopher Columbus was stimulated while he was engaged in research in Panama in 1955, looking for the site of Columbus' only attempt to settle the mainland. Holding a Ph.D. in geography from Louisiana State, he is acknowledged to be one of the foremost international Columbus scholars. He chaired the First International Columbus Symposium in Miami in 1982, and he was a consultant to the National Geographic Society in its 1986 Columbus project that dealt with the evidence pertaining to the much disputed location of Columbus' first landfall in the New World.

A substantial portion of this very attractive new book is actually a translation of an abstract of a copy of the Columbus log. It is the first modern translation to reflect the authoritative new theories as to Columbus' landfall that were advanced b ythe National Geographic Society in 1986, which located the landing at Samana Cay, and not at Watling's Island (San Salvador) as was previously the prevalent belief.

The original of the log, a very detailed daily account kept by Columbus, was presented to Queen Isabella in the Spring of 1493 upon his return from the first voyage. She commissioned a scribe to prepare a copy for the great navigator, which waspresented to him just prior to the start of his second voyage. That copy, known as the Barcelona copy, and the original have disappeared in the depths of time. Fortunately, however, a contemporary Dominican friar, Bartolome de Las Casas, had accessto the Barcelona copy. He made it a lifetime work to prepare a *Historia de las indias* and an abstract of the Barcelona copy of the log. That abstract, known today as the *Diario* (Journal) (1566), is all that we have. Las Casas died in 1566 at theage of 92. The service he performed for subsequent historians, including Fuson, is of incalculable value.

As noted in the dust cover of Fuson's book, the author/translator "effectively combines sound scholarship with a brilliant ear for the vernacular to create a lively, credible and deeply moving rendition of Columbus' original log." "The reader can follow, day by day, in Columbus' wake and share his vivid impressions of the New World, as yet untouched by European civilization."

It would be difficult to improve upon that accurate assessment of the book. Richly illustrated with facsimile renderings of contemporary 15th and 16th Century drawings, charts, and portions of the Las Casas abstract, it is a fascinating English translation in which Fuson has repeated the events as they unfolded from August 3 to October 10, 1492 (the outward voyage). The subsequent daily voyages of discovery in the Bahamas, to Cuba and Espanola (Haiti and the Dominican Republic), and thehomeward journey from January 16 to March 15, 1493, are likewise presented, day by day.

In addition, there are fascinating chapters on the history of the log, Columbus the man, and the three ships of Columbus' fleet and the methods of their navigation. finally, there are seven equally rich appendices dealing with the various landfall theories, the crews of the Columbus ships, the death and burial of Columbus, and other matters of absorbing interest.

Every armchair and blue water sailor should have a copy of this book. Every navigator, novice and professional alike, will find in its pages entertainment, inspiration, and the opportunity for vivid reflection that lurks within the soul of those who would put to sea.

Address all correspondence to:
The Navigation Foundation
P.O. Box 1126
Rockville, Maryland 20850 (tel. 301-622-6448)

New Sample Calculations for The Navigator's Almanac. For ordering information see below.

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Page 11
To find:
GHA & Dec, Saturn 14 Aug, 88
GMT 19-35-42  GHA    d     Dec   d
      00h     56-48+61 -22-22 0
      19h    285-48          0
      35m      8-46
      42s        11
      Sum    351-33    -22-22

Shaula, 7 Mar 88, at 7-43-17
Aries,00h   164-56 (d=59)
      07h   105-17
      43m    10-46
      17s       04
      Sum   281-03
      SHA    96-48    S 37-06
      Sum   377-51
     -360    17-51    S 37-06
Page 15
Moon, 27 July 88,at 10-49-28
08h 144-30+23-27-47+39
 2h  28-44        51
49m  11-43       - 4
28s      07Sum 28-34
Sum 185-04    -01
GHA 185-04  S 27-34

Page 18
Rise/Set 30 Mar 88, Lat 49 N
Rise D=4N LHA 264 Set LHA 264
GHA Sun 00h  -179        +179
GHA at rise    85         443
         5h   -75         720
        sub    10        -443
        40m   -10   sub   277
                    18h  -270
                    sub     7
                    28m    -7
GMT sunrise 05-40, set  18-28
Civ Twilite 05-08, end  19-00
Naut Twlt.  04-29, end  19-39
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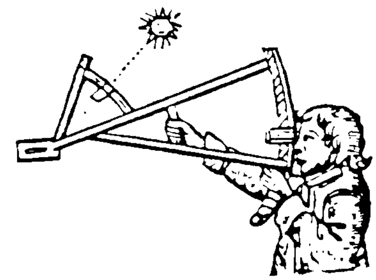
THE NAVIGATOR'S NEWSLETTER



FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

ISSUE TWENTY-ONE, SUMMER 1988

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

by T. D. Davies

Awards

As is customary at this time we announce the winners of two Navigation Foundation awards. On 24 May I had the pleasure of presenting the Dutton Award for excellence in the study of navigation to Midshipman 3/c Alexander Meissel. He was selected by the faculty at the Naval Academy from among all of the students of that class. At the Gould Academy in Bethel, Maine, the winner of the Foundation's award was student Frank Blanken of Ganderkesee, Lower Saxony, West Germany.

Missing Data

We continue to receive orders for the *Navigator's Almanac* and expect more when the several magazine reviews now in the mill get to their readers. As you will note in the Readers' Forum alert readers turned up another goof. The data for February 29th was missing. This did not effect any other data and was simply the result of an oversight in applying the 1987 formating to the 1988 data. The programs and formats have been changed to prevent this from occurring again in 1992. I hope this is the last mistake.

Books

Members should note that the *1989 Nautical Almanac* is now available at a list price of $ 17.00.

Correspondence

Some members are still putting stamps over the indicia on our business reply envelopes. The Post Office ignores these and charges us the regular amount anyway. If you want to save us the cost of the return mail, please put your message in a plain envelope with a stamp and address it to the Foundation. This will avoid wasting the stamp. Also using your member number when corresponding is a big help to us.

Overseas Banks

Finally I again request our overseas members to try to send checks on banks that have a U.S. affiliate, if they can. The cashing of checks on overseas banks is a lengthy and costly process that is greatly improved if the bank has a U.S. affiliate.

READERS FORUM

Director Ernest B. Brown writes:

Regarding Allen Thompson's comment in READERS FORUM, please note that Notice to Mariners 6/88 changed each volume of Bowditch to price category J ($15). Apparently this change got lost in the mail to you. My guess is that DMA adopted the price categories for two reasons: (1) To avoid the work involved in setting a fair price, particularly when the price would be in accordance with guidelines such as those of the Congressional Joint Committee on Printing. (2) To simplify changing the price of the publication.

But it may be that the limited number of categories precludes not having outrageous prices for some products. With even a limited number of categories perhaps a better job could be done in making assignments to categories.

Frederick D. Coleman of Mexico City writes:

As a new member of the Foundation I would like to compliment you both on the two excellent newsletters I have received as well as your efforts on behalf of the advancement of the science and more important, the art of navigation. I share with you the feeling that it is most important that somehow we preserve the craft of getting from here to there without electrons, diodes, and LED's. I say this even though I spend my working days staring at three inertial navigation units in the cockpit of a 747. Know that I wish I were upon the ocean below with sextant in hand. As have others, I learned of your organization from the Appendix in David Burch's fine book, Emergency Navigation .

Despite my U.S. P.O. box mailing address I live in Mexico City and from here it is rather difficult to know which charts are available either through NOAA, DMA, or yourselves. I would therefore appreciate your advising me as to whether I might be able to order catalogs of available charts and publications through you.I am also enclosing a photocopied catalog from the Secretaria de la Marina, the Mexican equivalent of our DMA. They have a series of excellent publications such as their DERROTERO's, a cross between our Coast Pilots and the DMA sailing directions for those who speak Spanish and very well done charts and a 1988 Nautical Almanac which appears to be an exact copy of ours only with Mexican covers and explanation pages in Spanish for those who don't. If the Foundation has interest in any of these items please advise me as to how I may be of service.

Ronald F. Krasovec of Burlington, MA writes:

This letter addresses two specific topics, the first one being your recent publication, "Navigator's Almanac for 1988." I recently received my copy of it, and in general, I am pleased with your efforts in its creation.

From my somewhat limited navigational experience, primarily as an instructor in USPS JN and N Courses, I have always felt that a less precise set of almanac data would be sufficient for a small boat navigator. This is especially true given the relatively recent change within the USPS to use the "modified" Ageton (211) Tables. I do intend to compare the sight results of the students in our recently started JN class (for the Minute Man Power Squadron) with those obtained through the use of this "new" almanac. I do plan to inform you of the outcome; however, this will not likely take place until later this year.

Although I have not yet had a chance to fully review this new publication, I do have several comments from my efforts to date.

First, the inclusion of 1987 Sample Calculations was really of no useful benefit in a 1988 almanac; this did not allow for the checking of ones work when trying to learn from the examples. Secondly, I have yet to determine how to use the "black" (reverse printed) values in the several correction tables: for example, the values of 316, 331, and 346 given in the table on page 10. I would appreciate some clarification on the use of these type of entries.

R. E. Street of Camano Island, WA writes:

What happened to Feb. 29 in the new Navigator's Almanac?

Director Ernest B. Brown writes:

Member Byron E. Franklin (QMCM USN Ret.) has been keeping me informed of his ongoing association with an active duty chief quartermaster who is an instructor in the division officer course at the Surface Warfare Officer's School, Newport. The instructor, Chief Kabrick, as described to me by Franklin, is a person of considerable self confidence who is willing to push better methods for inclusion in the curriculum.

Following publication in the Naval Institute Proceedings of Franklin's professional note (Correcting Flaws in the Art of Navigation)July 1987), Chief Kabrick spent 2 hours with Newport resident Franklin and was then ready to evaluate the constant gyro error correction technique in the piloting training of students aboard the YPs. Chief Kabrick has submitted or is about to submit a professional note to the Proceedings on the outstanding results. In brief, the students experienced frustration using the trial and error method; after being introduced to the Franklin technique, the students showed enthusiasm and success in handling even an erratic gyro.

Franklin also brought to Chief Kabrick's attention the simulated radar range ring technique which occurred to me during an admiralty case. I think of it as the pauper's, if not poor man's, chart comparison unit. Franklin, when serving aboard the Intrepid, found this special radar method to be much more accurate than what one might expect from such an apparently crude method. Apparently Chief Kabrick can also attest to the accuracy because he has had it introduced in the curriculum along with the Franklin Piloting Technique.

Simon Spalding of Berkeley, CA writes:

I heard of your organisation from Morter Bruyn, curator of the National Maritime Museum in Amsterdam. As you can see from the overleaf, I'm a teacher of traditional seamanship and navigation, as well as being a fiddler and chantey singer. I put on my "academie" at a Renaissance Festival in California, and it went quite well. I've got quite a range of possibilities for this coming year, including work at Renaissance events in New York, Pennsylvania, and Texas, and events in Holland, France and Japan!

Looks like I'm going to be active in this field a while.Mr. Bruyn tells me you publish books and a journal. I'd like very much to know more about your available materials, particularly Gerald Forty's work with cross-staff and backstaff. I'd also be interested in writing an article on my "academie" for your journal, if you're interested.

E. Tom Child of Findlay, OH writes:

Some months ago I spoke with a very congenial person with your organization. Since then I have mislaid the telephone number and the name of that person.We would appreciate visiting again on the phone. If you would send to me a telephone number I will call whenever you suggest. A post paid envelope is enclosed for your use.

We are scheduled to take delivery of a small sailing boat in England late in August of this year and we intend to sail her back to the USA. I have not done any serious celestial stuff since I was the XO and navigator of a DD during WW Two. So there is much that I need to catch up on.

Stafford Campbell of YACHTING writes:

I very much enjoyed the Spring issue of The Navigator's Newsletter , which arrived recently, and I wanted to write you about a development with which you may be familiar, but which I thought might be of interest to the Newsletter readers.

In my Practical Navigator column in YACHTING of January, 1986, I wrote about several new developments then coming into the field of celestial navigation, one of which was Dr. John Decker's breakthrough in encoder technology which was leading to a truly automated sextant.Just recently I heard from Dr. Decker per the second enclosure that he has further refined his device, obtained the necessary patents, and is getting ready to market it. His use of the HP-41 calculator somewhat parallels mine—and I renew my offer to send any of my programs to anyone interested for the cost of reproduction and postage—but his angle encoder is, to my knowledge, unique, as is the way he has "packaged" his presentation.

If you want further detail, I suggest that you get in touch directly with Dr. John A. Decker, Jr., President, Kuau Technology, Ltd., P.O. Box 1031, Puunene, Maui, Hawaii, 96784.

I send you very best wishes for the continuing success of The Navigation Foundation, as well as for your personal contributions to the field.

Ms. Sharon L. Chapman, Editor of Proceedings Magazine of the U. S. Coast Guard, writes:

Thank you for furnishing us with a copy of The Navigator's Almanac for review in our magazine. I am enclosing two copies of our latest issue. The review of your publication appears on page 114.

Captain John Pettitt of 411 Lake Promenade, Toronto, M8W 1C3 writes that he operates the International Navigation School at that address, but that the school's name was somehow ommitted from the list the Foundation published.

NAVIGATION BASICS REVIEW

Mercator Sailing/Middle Latitude Sailing

by John M. Luykx

General

Mercator Sailing and Middle Latitude Sailing procedures are mathematical solutions to dead reckoning problems on the mercator chart. Solutions are provided for:

The rhumb course and distance between two points on the earth's surface given the LAT/LON coordinates of the two points and:

The LAT/LON coordinates of one point given the LAT/LON coordinates of another point and the rhumb course and distance between them. Both these solutions allow for the convergence of the meridians but are generally limited to distances of 500 miles or less. For greater distances, great circle or composite sailing solutions should be employed to take advantage of the significantly shorter track distances.

The mercator chart is a representation on a flat surface of a section of the earth's surface which is spherical in shape. On the mercator chart the meridians of longitude are represented as equidistant vertical lines and parallels of latitude are shown as horizontal lines separated from each other by meridional difference; i.e., the difference between the meridional parts of the two parallels as tabulated in a table of meridional parts. Bowditch Table 5 is an example of such a table.

The value of" meridional parts" for any given latitude is equal to the length of the arc of a meridian between the equator and the given parallel of latitude (on a mercator chart) expressed in units of 1 minute of longitude at the equator. (See Bowditch Table 5). Tables of meridional parts, primarily used in the construction of mercator charts, date from the end of the 16th Century when Edward Wright published his Certaine Errors in Navigation and mercator charts were first used for ocean navigation in lieu of the plane chart.

Definitions

The following terminology is used in describing mercator and middle latitude sailing procedures and solutions: (Refer to Figure 1)

Pt_1 : Point of Departure
Pt_2 : Point of Arrival
L_1 : Latitude of Pt_1
L_2 : Latitude of Pt_2
λ_1 : Longitude of Pt_1
λ_2 : Longitude of Pt_2
l : Latitude difference: $L_1 \sim L_2$
lm : Middle-Latitude: $\frac{L_1 + L_2}{2}$
Dlo : Longitude difference: $\lambda_1 \sim \lambda_2$
p : Distance in miles between λ_1 and λ_2 measured along a parallel of latitude
M_1 : Meridional parts for L_1 (Table 5)
M_2 : Meridional parts for L_2 (Table 5)
m : Meridional difference: $M_1 \sim M_2$
C : Course angle from Pt_1 to Pt_2
D : Distance in miles from Pt_1 to Pt_2

Mercator, Middle-Latitude and Plane Sailing Relationships

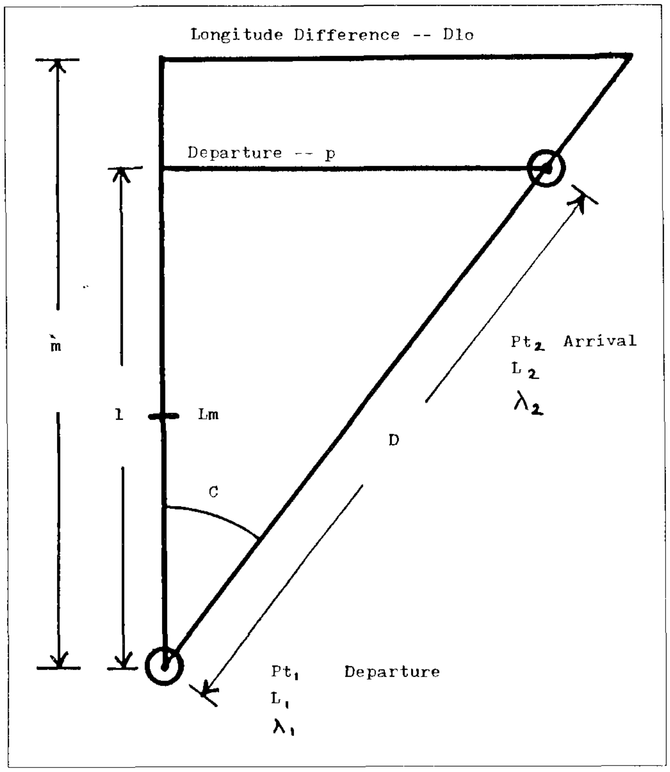


Figure 1

To allow for the distortion caused by the convergence of the meridians, the correct relationship between the length of a degree of longitude and the length of a degree of latitude is obtained, in mercator sailing, from a table of meridional parts. In mercator sailing:

$$\frac{\text{length of a degree of longitude}}{\text{length of a degree of latitude}} = \frac{Dlo}{m}$$

In middle latitude sailing, the correct relationship between the length of a degree of longitude and the length of a degree of latitude is found by reducing the length of a degree of longitude (between any two points of latitude) by a factor equivalent to the cosine of the middle latitude between the two points. In middle latitude sailing:

$$\frac{\text{length of a degree of longitude}}{\text{length of a degree of latitude}} = \frac{Dlo \times \cos lm}{l}$$

Solutions to Problems

Solutions to dead reckoning problems when using a mercator chart may be accomplished by:

- Plotting on a chart
- Mathematical methods including mercator and middle latitude sailing procedures
- Traverse table
- Computer/calculator
- Combinations of the above

This discussion will explain briefly the solutions by mercator and middle latitude sailing.

In the solution by mercator sailing the value of north/south motion is indicated by meridional difference (m) and east/west motion by longitude difference (Dlo).

In middle latitude sailing north/south motion is given by latitude difference (l) and east/west motion by departure (p).

The relationship between the two solutions is:

$$\frac{Dlo}{p} = \frac{m}{l}$$

Mercator sailing and middle latitude sailing methods are used to solve two types of problems:

1) to compute the rhumb course and distance between two points given the LAT/LON coordinates of each of the two points and:

2) to compute the LAT/LON coordinates of a point given the LAT/LON coordinates of another point and the course and distance between them.

The middle latitude sailing method is slightly less accurate than mercator sailing because an approximation is used to compute departure (p) from values of longitude difference (Dlo). The approximation assumes that the value of the cosine of the middle latitude is equal to the mean value of the cosines of the latitudes of both the points of departure and arrival. The assumption is not exactly correct because the rate of convergence of the meridians is not constant at all points from the equator to the pole. The resulting error, in computing p from Do, however, is considered negligible for practical navigation purposes.

Procedure for Solving Mercator Sailing and Middle Latitude Sailing Problems

Mercator Sailing:

Computing the course and distance between two points:

1)Given: Pt_1 and Pt_2
2)Find: C and D
3)Solution: Step 1: $l = L_1 \sim L_2$
Step 2: $m = M_1 \sim M_2$ (Table 5)
Step 3: $Dlo = \lambda_1 \sim \lambda_2$
Step 4: $\tan C = \frac{Dlo}{m}$
Step 5: $D = \frac{l}{\cos C}$

Computing the point of arrival from the point of departure and a course and distance.

1)Given: Pt_1 C and D
2)Find: Pt_2
3)Solution: Step 1: $l = D \cos C$
Step 2: $L_2 = L_1 \pm l$
Step 3: $m = M_1 \sim M_2$
Step 4: $Dlo = m \tan C$
Step 5: $\lambda_2 = \lambda_1 \pm Dlo$

Middle Latitude Sailing:
Computing the course and distance between two points:

1) Given: Pt_1 and Pt_2
2) Find: C and D
3) Solution: Step 1: $Lm = \frac{L_1 + L_2}{2}$

Step 2: $Dlo = \lambda_1 \sim \lambda_2$

Step 3: $p = Dlo \, Cos \, Lm$

Step 4: $l = L_1 \sim L_2$

Step 5: $TanC = \frac{p}{l}$

Step 6: $D = \frac{p}{sinC}$

Computing the point of arrival from the point of departure and a course and distance:

1) Given: Pt_1 C and DPt_2
2) Find: Pt_2
3) Solution: Step 1: $p = D \sin C$

Step 2: $l = \frac{p}{tanC}$

Step 3: $L_2 = L_1 \pm l$

Step 4: $Lm = \frac{L_1 + L_2}{2}$

Step 5: $Dlo = \frac{p}{\cos Lm}$

Step 6: $\lambda_2 = \lambda_2 \pm Dlo$

A series of sample problems have been prepared and worked out using Mercator and Middle Latitude Sailing. These problems are available to our readers upon request. Please send a stamped self addressed envelope.

In order to provide a comparison of the accuracy of these methods of computation, the table below shows various computed values for one of the problems, done by Mercator Sailing, Mid-Lat Sailing and for comparison, done by CN-2000 Computer.

Computation	Mercator Sailing	Mid-Lat Sailing	CN-2000 Computer
Course:	036.°5	036.°4	036.°5
Distance:	372.1mi	377.8mi	373.0mi
Pt_2 LAT:	44°59'.9N	45°00'.0N	44°59'.9N
LON:	64°59'.8W	65°00'.0W	64°59'.8W

The next issue will contain a discussion of great circle and composite sailing which are solutions to dead reckoning problems covering DR tracks from 500 miles to many thousands of miles in length.

NAVIGATION PERSONALITIES

John Davis

by Thomas D. Davies

John Davis whose name was sometimes spelled Davys, was one of the most important of the English explorers under Queen Elizabeth I. He was born about 1550 at Sandridge near Dartmouth, England. He is believed to have made several voyages with an Adrian Gilbert in his early life, which gave him his grounding in navigation and seamanship.

In 1583 he first proposed to search for a northwest passage around North America as a route to the orient. With the backing of certain politically powerful names he was able to find approval and funds. In 1585 he started his expedition, making his first landfall on the east shore of Greenland, which he followed south to Cape Farewell. He then followed the west coast of Greenland for some time before heading northwest "for China." However he intercepted the coast of Baffin Land at 66 degrees north. Although he pressed north along this coast to Cumberland Sound he eventually headed south and returned to England.

He tried again in 1586 and 1587, eventually reaching 73 degrees north. Many of the locations in those areas still retain the names given them by John Davis as he conducted explorations with an expertise that ranks him with Baffin, Hudson and Frobisher as the great explorers of the Arctic. The strait in which he did most of his explorations was named after him.

In the battle of the English against the Spanish Armada he commanded a vessel named the "Black Dog," but was back exploring again in 1591. He accompanied Thomas Cavendish on an expedition to look for the northwest passage from the western side of the american continents. Cavendish and the others in the expedition gave up early, but Davis continued to attempt a passage of the Strait of Magellan. In so doing he discovered the Falkland Islands, a point still noted by the British in their explanation of how they acquired these islands, incident to the Falkland War.

Davis published a most valuable treatise on navigation in 1595 called "The Seaman's Secrets," and a more theoretical one later called "The World's Hydrographical Description."

Probably his greatest contribution to navigation was his invention of the backstaff (see History of Navigation, this issue). This device replaced the Mariner's Astrolabe and the Quadrant, two devices which could really be accurately used ashore and gave very poor results at sea. The matching of the Sun's shadow against the horizon gave the first really accurate results of any navigational device with the ability to be used from shipboard. It remained only for the shadow screen to be replaced by a mirror for it to be useful at night as well as at day. His backstaff and double quadrant were the preferred tools of the navigator long after Hadley introduced his reflecting quadrant. The long period of popularity of his device was the basis of choosing it for the Navigation Foundation logo.

John Davis sailed on a number of expeditions later including that of Sir Walter Raleigh. He was killed by Japanese Pirates off Sumatra in 1605.

HISTORY OF NAVIGATION

Early Altitude Measuring Instruments: The Back-Staff

By John M. Luykx

General

Although the cross-staff provided a significant improvement in accuracy over the seaman's quadrant and mariner's astrolabe in measuring altitudes of celestial bodies at sea (see Navigator's Newsletter, issues 18, 19 and 20), it also had serious disadvantages. It was difficult to hold vertical; it was subject to ocular parallax if the eye end were not placed correctly near the eye during observation; the accuracy of high altitude observations due to the compression of the altitude scale engraved on the staff was poor and fore-sights of the sun could only be obtained with difficulty primarily due to the sun's glare and the necessity to align the tips of the transom with both the upper limb and the horizon at the same instant.

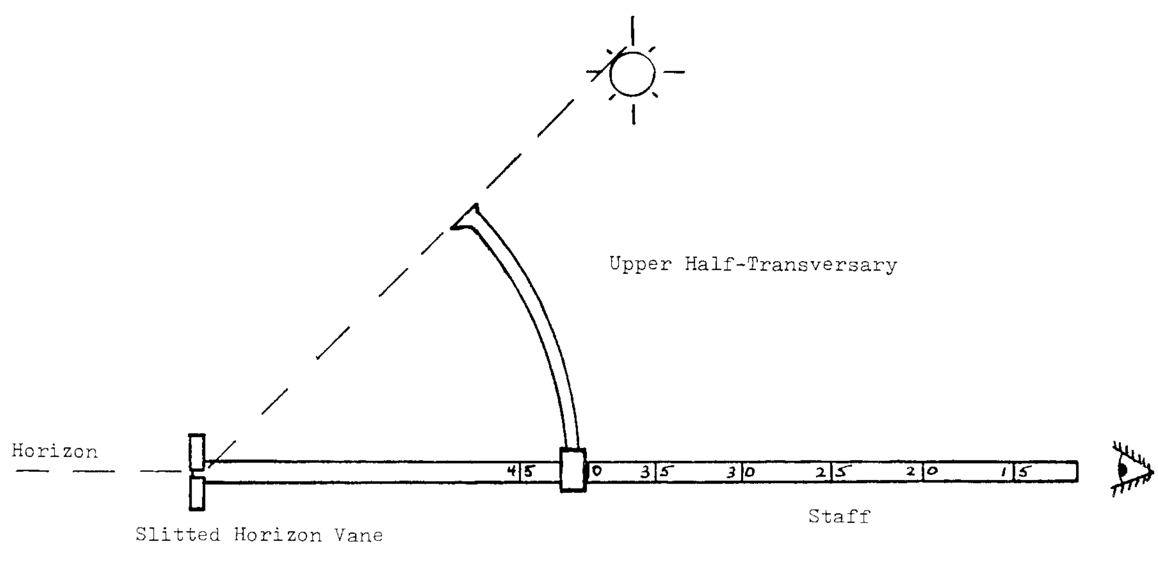
However, many of these disadvantages were overcome when it was discovered that back-sights using the cross-staff provided accurate altitudes without the annoyance of observing the sun directly and without the observer having to look in two directions at once when obtaining an altitude.

Due to the closeness of the scale graduations at the high altitude end of the staff (the eye end), it still was difficult to obtain accurate high altitude readings.

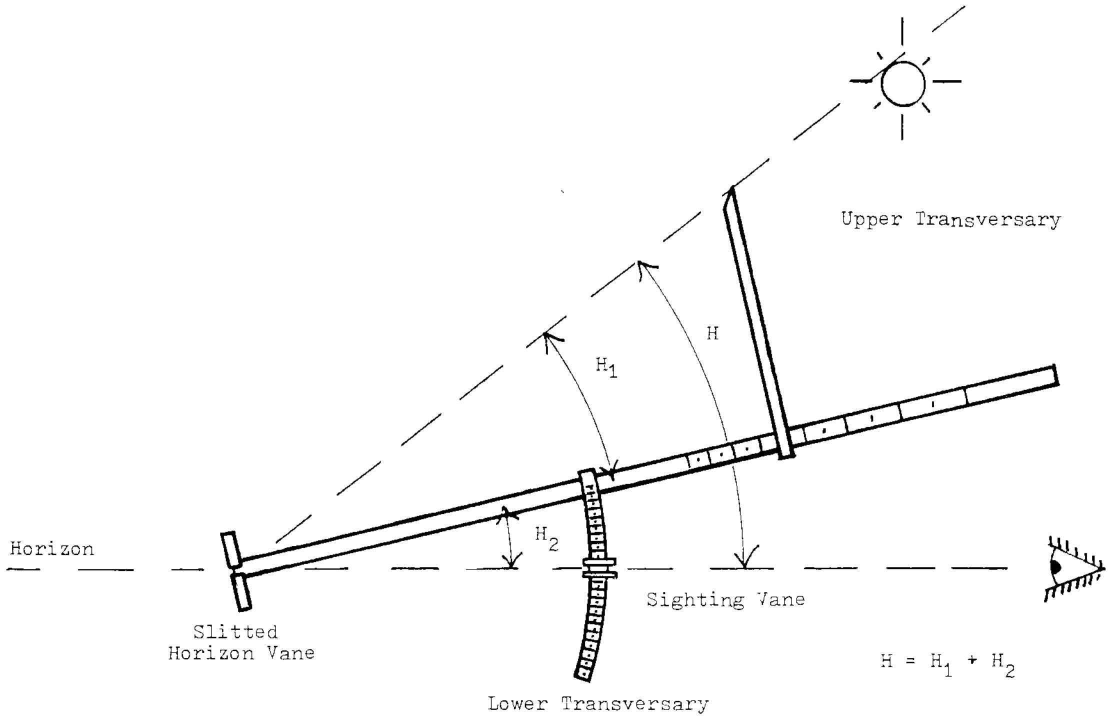
For this reason, along with the problem of ocular parallax, John Davis developed the first of his backstaves which he described in his The_Seaman's_Secrets first published in 1595. This instrument became known as the 45 back-staff. (See Figure 1) Some scholars believe that two of Davis' contemporaries, Thomas Hood and Thomas Harriot, both of whom also produced "shadow" instruments during the same period, may have provided Davis with the idea of the back-staff. Nevertheless, it was Davis, as an experienced and practical seaman with a lifetime spent at sea, who improved and made practical the design of the instruments which may have been suggested to him by others.

The 45° Back-Staff

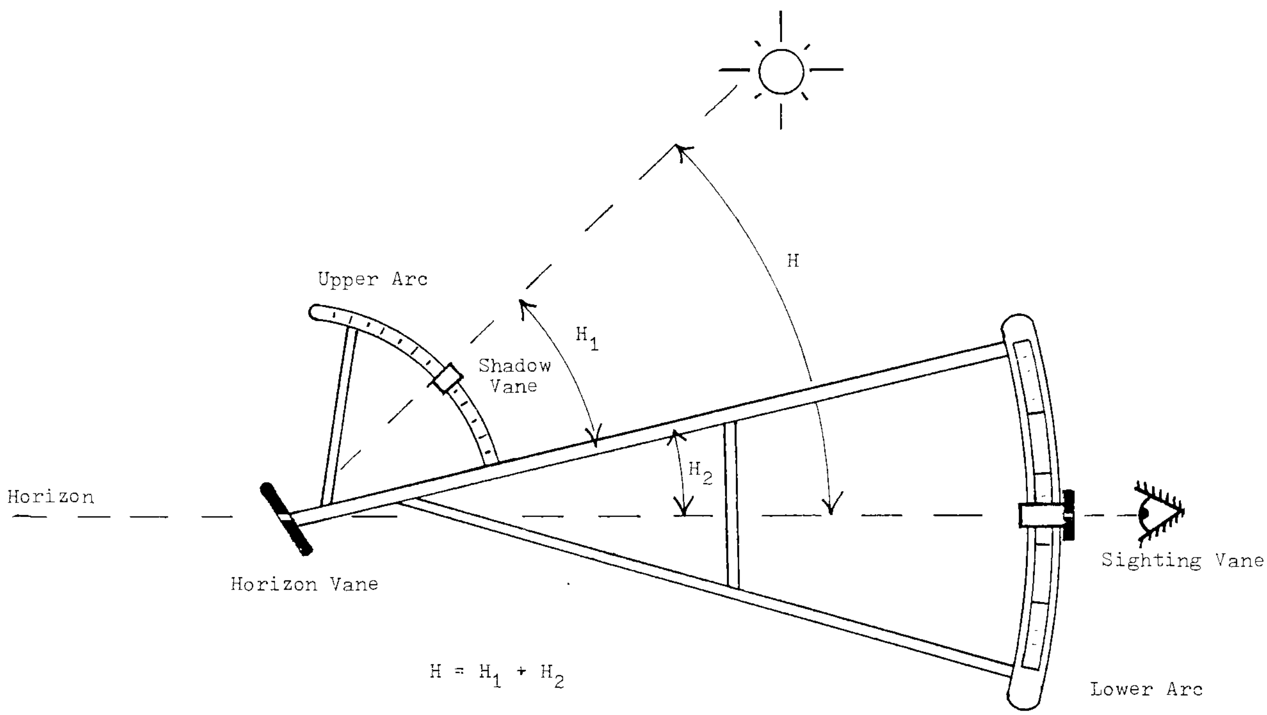
Davis' 45° back-staff consisted of a narrow square staff about a yard long graduated from 15 to 45 altitude. To the staff was fitted a half-transversary in the shape of an arc projecting upwards which could slide along the staff. At the horizon end of the staff was a small brass plate set at right angles containing a slit. To make an observation,



The 45° Back-Staff
Figure 1



The 90° Back-Staff
Figure 2



Davis Quadrant — Back-Staff
Figure 3

the observer turned his back to the sun, pointed the staff toward the horizon, aligned his eye along the side of the staff and moved the half-transversary back and forth until the shadow cast by the tip of the transversary was aligned with the visible horizon seen through the slit at the end of the staff.

The 90° Back-Staff

For operations in northern latitudes, the limitation to 45° altitudes was quite satisfactory. However, when sailing in southern equatorial latitudes, an instrument with greater range became necessary. This requirement led Davis to the development of the 90° back-staff. (See Figure 2). The 90° back-staff was a modification of the 45° back-staff. It consisted of a staff 3 feet long and included 2 half-transversaries. The lower one was in the shape of an arc of a circle. It was fixed to the staff, graduated in degrees and was fitted with a sliding sighting vane. The upper transversary was straight and so attached to the staff that it could slide back and forth as on the 45° back-staff. The eye end of the staff contained a graduated altitude scale. At the horizon end a small slitted brass plate was installed at right angles to the staff. To observe an altitude of the sun with the 90° back-staff, the observer turned his back to the sun, set the upper transversary to a whole degree value of altitude about 5° to 10° less than the sun's actual estimated altitude, pointed the staff at the horizon so that the visible horizon appeared centered in the slit of the brass plate, aligned his eye alongside the staff and adjusted the eyepiece vane along the lower transversary until the shadow cast by the upper transversary was aligned together with the slit and the visible horizon centered in the slit. The altitude was equal to the sum of the scale readings indicated on the staff (upper transversary) and lower transversary.

Observations with the 45° and 90° back-staves were upper limb observations of the sun. I.C. was applied in the normal manner, dip was added, refraction subtracted and the sun's semi-diameter subtracted.

The Davis Quadrant

To further improve accuracy, to improve the rigidity of the instrument and to eliminate the compression of the altitude scale engraved at the eye end of the staff, the last and final major development of Davis' back-staff consisted of a staff, two half-transversaries in the form of two circular arcs, assorted horizon vanes, shadow vanes and sighting vanes and associated braces and supports. (See Figure 3). This instrument was variously known as the "Davis Quadrant", the "Back-Staff" or the "English Quadrant" by foreigners. For sun observations it superceded the cross-staff during the early 17th century as the preferred instrument for observing altitudes of the sun and was used by mariners well into the early 19th century although the reflecting quadrant had already been developed in the early 1730s and the sextant in 1760.

The Davis quadrant could only be used to measure altitudes of the sun. For altitude observations of the stars, the planets and the moon, the navigator usually resorted to either the cross-staff, the seaman's quadrant or the mariner's astrolabe. It is interesting to note, however, that a contemporary writer on nautical affairs and nautical history includes a diagram in his book (1976) showing an observer holding the Davis quadrant in reverse postiion, taking a foresight of the sun.

The characteristics of the Davis Quadrant were as follows: The radius of the lower arc was approximately 22" to 28" depending on the maker, the radius of the upper arc 6" to 7", and a slitted horizon vane made of wood was fitted to the horizon end of the staff. The upper arc was usually graduated in whole degrees and marked at 5° intervals from 0° to 60° . The lower arc was graduated from 0° to 30° and included a diagonal scale to 10' permitting readings to 1' of arc. On many back-staves of the period, both altitude and zenith distance scales were engraved on the two arcs. A sliding shadow vane of wood was installed on the upper arc and a sliding sighting vane with a peep hole, also made of wood, was installed on the lower arc. Ebony or rosewood was generally used for the staff, the braces and the supports while the arcs and vanes were usually made of boxwood or pearwood.

Observation with the Davis Quadrant

To take an observation, the observer:

First: Installed the horizon vane to the horizon end of the staff.

Second: Installed the shadow and sighting vanes on the upper and lower arcs respectively. The shadow vane on the upper arc was usually set to a whole 5° to 10° value of altitude less than the actual altitude.

Third: Faced the horizon with the sun at his back and pointed the instrument at the horizon holding the vertical brace with the right hand and the lower arc with the left.

Fourth: Adjusted the sighting vane with the thumb of the left hand until he saw, through the peep hole of the sighting vane, both the shadow cast by the shadow vane and the visible horizon aligned in the center of the slit of the horizon vane. The sum of the altitudes (or zenith distances) indicated on the two arcs was the altitude/zenith distance observed.

Fifth: The altitude was corrected as follows:

+ I.C.
+ Dip
- Refraction
- Semi-Diameter

Modifications to the Davis Quadrant

Interesting modifications were later made to the Davis Quadrant. For example:

1. Around 1680 a double convex lens (focusing lens of focal length equal to the radius of the upper arc) was installed on the shadow vane. Rather than casting a

shadow on the horizon vane (requiring a correction of -16' for the sun's semi-diameter), a small spot of light was projected to the horizon vane. This was of particular advantage during hazy days when a shadow would be much less distinct than a spot of concentrated light.
2. In 1730 John Elton developed a back-staff based on the John Davis design with two spirit levels as an artificial horizon. During the same year, Captain Hoxton of the ship BALTIMORE took noon observations in Chesapeake Bay with this quadrant. Results reported in the Philosophical Transactions of the Royal Society indicated accuracy to within 10' of arc for Elton's quadrant.
3. In 1730 during research toward the development of a reflecting quadrant Thomas Godfrey of Philadelphia modified a Davis quadrant by installing mirrors. This facilitated the measurement of lunar distances as well as star and planet altitudes.
4. In 1738 Charles Leigh invented a water level to be attached to a Davis quadrant as an artificial horizon. At approximately the same time, he also invented a mercury artificial horizon based on the water horizon principle.

Accuracy of the Davis Quadrant

To check the accuracy of the Davis quadrant from a position ashore, two sets of observations were taken with a replica Davis quadrant from the author's collection.

The quadrant is made of ebony with maple arcs and vanes. The radius of the long arc is 26" and graduated from 0 to 35 altitude. The radius of the short arc is 7" and is graduated from 0 to 70 altitude.

The quadrant is fitted with the following detachable vanes:

1) Horizon vane
2) Shadow vane (short arc)
3) Pinhole vane (short arc)
4) Magnifying vane (short arc)
5) Sighting vane (long arc)

The design of the replica Davis quadrant is based on an instrument built by Benjamin King of Salem, Masschusetts which is in the collection of the Peabody Museum at Salem.

The results of the accuracy test were as follows:

	1	2
Body:	SUN	SUN
No. of Observations:	12	12
	3 shot groups	3 shot groups
Mean Error:	3'2	3'5
Standard Error:	4'2	4'5
95% Error:	8'0	8'7
Range of Error:	13'	11'
	(+4' to +17')	(+13' to +26')

Column 1: Shadow vane in use
Column 2: Pinhole vane in use

In the next issue of the Navigator's Newsletter, the mariner's sea-ring will be discussed.

NAVIGATION NOTES

The Art of the Sextant, Dipping the Star

by Thomas D. Davies

In the fine art of measuring the angular altitude of a celestial body a fundamental objective must be to ensure that the measurement is made in the plane of the vertical, i.e. in the plane perpendicular to the horizon. Figure 1 illustrates this situation, ZH being the perpendicular plane. It is clear that a measurement made in any other plane will give a larger value, so that the true value is the minimum value that can be measured at a given time. The rotation of the Earth ensures that the targeted body is always either ascending or descending, except for the instant of crossing the observer's meridian. Thus the sextant user is shooting at a moving target, and a useful reading can only be one taken at a given (and recorded) instant.

The classical way to address this problem is to perform a manuever known as "dipping the star." The sextant is rotated through a small angle while continuously observing the star and the horizon, so that the star appears to rise above the horizon, move down to touch the horizon and then rise again as the rotation continues. The necessity for keeping the star centered in the telescope field as the sextant is rotated calls for the axis of rotation to be a line from the sextant to the star, which demands coordination of the hands developed only after long experience. Performing this maneuver with precision under at-sea conditions has proven to be the nemesis of many a budding navigator, and even when done by an old hand the movement of the star during the time of the "dip" almost always introduces some error.

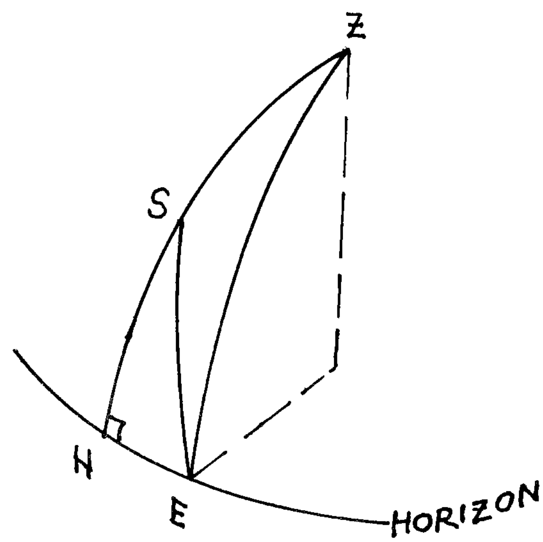


Figure 1

When the angular setting of the sextant is exactly correct for the instant, the rotation will cause the star to just graze the horizon as it moves up and down: a fleeting moment at best, since the star's motion will ensure that on the next "dip" the star will either stay above the horizon or go below. The vagaries of an imperfect horizon and the motion of the observer's vessel ensure that this operation requires the most skill that the navigator can muster.

To calculate the magnitude of error to be encountered in this phase of the navigator's art we examine the diagram of Figure 1. In addition to the correct (perpendicular) plane ZH we have constructed a plane ZE, also perpendicular to the horizon, and from which the plane of the sextant SE deviates by 5 degrees. In other words the angle ZES represents the off-vertical angle of the sextant. The length SE measured from the star to the horizon is clearly longer than the correct value SH, for the value of altitude shown (about 45 degrees). As the star's altitude approaches 90 degrees the difference between these two value grows more and the reverse is true as the star's altitude approaches zero.

To look at a common case we can take a star at 45 degrees measured altitude and assume that the sextant is 5 degrees out of verticle at the time of the sight; a not too unusual case when the observer is on a rolling and pitching craft.

The following relations hold:

```
cos ZS = cos 90 cos SE + sin 90 sin SE cos ZES
or cos ZS = sin SE cos ZES, and  ZES = 5
For this case SE = 45 and then ZS =  45.2176
The true altitude SH = 90 - ZS = 44-46.9
and the error introduced is 45 - 44-46.9
which is 13.1 nautical miles.
```

While this error is less when the star's altitude is lower, at higher values it increases substantially (which suggests that lower altitude stars should be used when available). The error is always positive, so a correction should always be subtracted from the altitude. The value of the correction for various out-of-verticle (OOV) values is shown in this table.

OOV Ho	1	2	3	4	5
30	0	-1	-3	-5	-8
45	-1	-2	-5	-8	-13
60	-1	-4	-8	-14	-23

Under at-sea conditions it is most likely that almost every sight of all but the most skilled navigator will have some error thus introduced, which will therefore always give a larger value for altitude than it should be. Thus when faced with an open triangle of three lines of position it is worth subtracting some minutes of arc, using the table above, from the measured altitude of each sight to see if the result is a smaller triangle. This is accomplished by moving each line of position Away from the star from which it was derived, using the number of minutes estimated as above.

If the triangle does not close, the centrode of the triangle should be used as the fix but if the subtraction does close the triangle it can be assumed that an out-of-vertical error has been introduced. Clearly there are other errors in any sight but since this error is always in one direction such a correction is justified when the correction applied by the subtraction is small. An obvious caution here is that the out-of-vertical error may not be the same amount in each of the three sights however for a given ship's motion and the same observer there is a good probability that the errors will be roughly the same. In any event the paramount importance of Dipping the Star correctly is clear.

It was this analysis, done some years ago, that led me to the research which resulted in the device called the Prism Level as a different, and hopefully easier, way to get the altitude in the vertical plane. Here the observer is presented with an auxiliary horizon at the side of the field which he keeps aligned with the true horizon to keep the sextant vertical. The fact that more than a thousand are now in use suggests that the device does make the job easier and thus reduce errors.

A Navigation Problem

by Roger H. Jones

Solution to the problem presented in Issue Twenty.

22. Answer:

First, the navigator would look in the Almanac and determine, using careful interpolation for his DR latitude, the local mean time (LMT) of sunrise on the Greenwich date that is applicable to his DR position. This is the time at the local standard meridian for his time zone that the rising Sun's upper limb peeks above the horizon as seen by an eye at sea level. Next, the navigator will simply position himself as low in the vessel as possible, and he will watch the horizon with his naked eye. At the exact moment when he can first see the Sun, he will note the LMT by ship's chronometer (corrected for "fast" or "slow" error). That, for practical purposes, is the LMT of sunrise at his longitude.

If the observed time is the same as the Almanac's listing of sunrise time, the vessel is on the standard meridian. More likely, the times will be different, and the vessel's longitude will differ from that of the standard meridian by the time difference converted to arc. If the observed time of sunrise is earlier than the Almanac listing, the vessel is east of the standard meridian. If it is later, the vessel lies to the west of the standard meridian.

Is this very accurate? It depends upon one's point of view. For the navigator on a yacht, the most precise eyeball and Almanac work will yield an answer that, theoretically, is accurate to within one minute of time, which is equivalent to within fifteen minutes of longitude arc. That is chiefly because the Almanac lists sunrise, sunset and meridian passage times to the nearest minute only (although equation of time is given to the second). Also, we are dealing here with an emergency procedure that can be full of pitfalls for the seeker of impossible precision. Nevertheless, if Backstaff's navigator can determine by this method his longitude within a practical accuracy of 15 to 20 minutes of arc, he is armed with very useful information as to how far ahead those Hatteras shoals may lie.

Problem No. 23.

Continuing the focus on useful emergency techniques begun in the last issue, Backstaff's navigator now turns to the problem of recovering Greenwich Mean Time (GMT) when he cannot get a radio time signal or otherwise directly check his chronometer. Suppose for one reason or another the chronometer has run down and there is no radio time signal due to geographic location, defective radio or other difficulty. Further suppose there is no one at hand with a rated chronometer for direct comparison. However, the exact longitude is known, and a sextant and Almanac are at hand.

For example, our navigator is now at Pitcairn Island on a voyage that he wishes to resume immediately, but he has "lost" his time. However, he knows from his chart that he is at 25-04.0 South, 130-05.2 West. The local date is June 25, 1988.

Using the Sun, the sextant and the Almanac , what procedure may he use to set his chronometer?

MARINE INFORMATION NOTES

Digest of Notice to Mariners

by Ernest Brown

DMA Prices for Nautical Products

In the price list on page 14 of issue Twenty, each volume of the American Practical Navigator (Bowditch) is listed as price category N ($8.00). Notice to Mariners 6/88 changed each volume to price category J ($15.00).

GPO Customer Service

If you are experiencing delays in the receipt of your order from GPO, you are advised to contact: Superintendent of Documents U.S. Government Printing Office, Attention: Customer Service, Washington, D.C. 20402, Telephone: (202) 275-3050

Missing Pages in DMA Publication

If you have a 1983 reprint of the 1978 edition of volume 2 of DMAHTC Pub. No. 249, Sight Reduction Tables for Air Navigation, you should check to see if pages 147 through 178 are missing. If your copy is missing these pages, a replacement copy can be obtained at no cost by forwarding the defective product with your return address to any authorized sales agent of the Defense Mapping Agency Combat Support Center.

Annual Notice to Mariners

Due to scheduling difficulties, DMAHTC did not publish the Special Notice to Mariners paragraphs in Notice to Mariners No. 1 as a separate publication with the new title of Annual Notice to Mariners.

DMA Navigation Information Network

The Automated Notice to Mariners System (ANMS) has been replaced by the DMA Navigation Information Network (NAVINFONET) which has been expanded since the issuance of the 1987 User Manual. Highlights of these changes are as follows:

Program 21, "Query by Port" has been expanded from 33 to 92 ports or areas and subdivided into an Atlantic Ocean or Pacific/Indian Ocean list.

Program 23, "Query by Weekly Notice to Mariners" now provides all chart corrections published in a week for as many as five (5) weeks of Notice to Mariners.

Program 42, "Summary of Corrections" was added to the DMA List of Lights routine and provides only the lights that were changed in a series of lights the user selects based on volume and start and stop light numbers.

Program 72, "Query by Weekly NM Numbers" yields corrections to the DMA chart catalog for a particular week requested.

Access to the NAVINFONET is available by voice grade telephone lines using a microcomputer or data terminal and by TELEX. Each user must have a unique password identifier or "user ID" which is available on request by writing:
Director DMA Hydrographic/Topographic Center
ATTN: MCN Washington, DC 20315-0030
More information on the NAVINFONET can be found on page VII of DMAHTC Pub. 117, Radio Navigational Aids, or on Pilot Charts of July/August/September 1986; October/November/December 1986; and April/May/June 1987.

Address all correspondence to:
The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850
Telephone 301-622-6448

BOOK REVIEW

by Roger H. Jones

Weather At Sea

by David Houghton and Fred Sanders

International Marine Publishing Co. Camden, Maine 04843 (1988); 197 pages; $12.95

Weather At Sea is the product of two experienced meteorologists who are also blue water sailors. It reflects their deep professional interest, over a period of more than twenty years, in understanding how weather systems form and work throughout their life cycles and the application of this understanding to the special environment of the North American mariner. The authors acknowledge at the outset that, as in celestial navigation or any of a host of technical subjects, there are two ways to approach the study of marine weather. The first is to seek a working knowledge of clouds, barometric pressure, temperature changes and weather maps without a clear understanding of why weather at sea happens as it does. The second is to know also the "why" of it all.

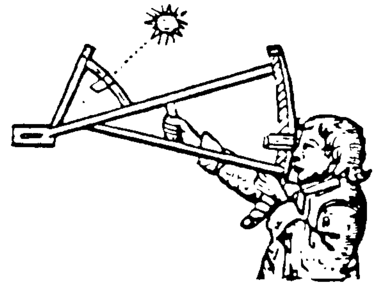
The navigator may use his sextant and tables to gain a line of position without necessarily understanding the theory underlying his procedures. The mariner can take the same approach to clouds, wind and the other elements of weather, but Houghton and Sanders offer him a better choice. They also demonstrate convincingly that just as the navigator does not have to be comfortable in trigonometry in order to grasp the theory, the mariner does not have to be a scientist to understand and use meteorological theory.

Weather At Sea is presented in seventeen chapters, none of which is more than twenty pages long, and most of which are considerably shorter. Chapters 2-5 answer these and other technical questions. Why do low and high pressure systems form, why do they move, and what causes their patterns? What forces shape the winds? How do tropical storms arise? How does the weather aloft interact with that at sea level? The remaining chapters present the working knowledge so useful to sailors. Topics such as the message of the clouds, winds near coasts and over the open ocean, waves and swell, tropical cyclones and weather hazards, and others are all delivered to the reader in useful layman's terms. Each chapter has its own photographs and illustrations that are also easy to comprehend.

This little book is an unabashed romance with marine weather, and it is also one that frankly admits that the state of the science/art has greatly improved in the last twenty-five years. This reviewer, who first studied weather as an airplane pilot more than thirty years ago, was struck by the more precise knowledge that exists today as to dry and wet temperature lapse rates, along with many other "updates" of old rules of thumb. Most appreciated of all, were the new insights gained as to specific tactics aboard a sailing vessel for dealing with friendly and not so friendly weather - tactics that may be employed in advance by any mariner who is interested in what will happen a few hours or days from now, as opposed to tactics for dealing with weather that has arrived.

The early chapters are admittedly technical. They are nicely balanced by the remaining two-thirds of the book. In total, this is a well conceived and well written work that, in the hands of coastal and off-shore mariners alike, will become well thumbed. It has taken up permanent residence next to the primary weather radio aboard this reviewer's vessel. It is recommended to navigators because it should enable them to navigate more efficiently and safely. It is recommended to "mariners" in the larger sense because it deals so well with the total natural environment in which they live and sail.

THE NAVIGATOR'S NEWSLETTER



FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

ISSUE TWENTY-TWO, FALL 1988

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

by T. D. Davies

At Sea on the Tandemeer

Finally our At-Sea-Experience program has borne fruit. In the middle of July our chartered yacht *Tandemeer* set sail from her berth at Galesville, Maryland, (a little south of Annapolis, MD) with four members on board with sextants and timepieces, under the command of our redoubtdable Director, Terry Carraway, who carries a Coast Guard Captain's License as well as being a retired Captain USN. Member Dave Brady was also along as XO or Mate.

As our first attempt at such a training cruise we had only alerted members in the immediate vicinity since our date was a little uncertain as well as such refinements as a navigation instructor (higher priority commitments forced our man to cancel at the last minute). So our instructional framework was a little weak, but *Tandemeer* herself was ready in all respects for sea; the product of many hours of hard work by Carraway and Brady.

Underway at dawn with the members assisting in ship handling work, *Tandemeer* proved herself to be a first class blue water ship. About 320 nautical miles of open ocean sailing with periods of 35 knots of wind with 8 to 12 foot seas proved her sea-keeping ability to be excellent. More or less continuously under double-reefed main and single reefed mizzen she logged about 7 to 8 knots with dry decks and only occasional spray.

Our member-passengers experienced the ultimate in sextant work, sights from a rolling and pitching platform. Important as theoretical experience working out sights is, inability to take accurate sextant sights under at-sea conditions can make celestial navigation almost useless. Gaining such experience and development of that ability is the objective of the program.

With access to a good sea boat (a minor electrical problem encountered has now been corrected) and a top-notch crew we now plan to run another cruise late in September. Members interested in participating should drop us a postcard as early as possible. You will be contacted by phone with more details. Costs are based on reimbursement of expenses only. These ran $ 650 each for the 6 days of the last voyage, but we are evaluating this and some adjustment may be made.

Other Projects

As you will see under Navigation Personalities I was traveling in the Soviet Union for about 3 weeks this summer which interfered with some of my activities. As a result correction of the error in the Indirect Horizon Scope has not been completed but it should be ready for test in another few weeks. Additionally work on the 1989 Navigator's Almanac was slowed, although we are almost ready to go to print. The biggest change will be expanded instructions and sample calculations, plus increased size of print in several tables. We should ready to deliver the new copies by the first of October. Price will remain the same.

READERS FORUM

Robert C. Wornick, N of the Miami Power Squadron writes:

I recently received a copy of your "Navigator's Almanac" for 1988. All of the sample calculations are based on 1987 data. Issue Twenty of the Navigator's Newsletter stated that corrections will be inserted in Almanacs "from now on." I guess you missed me! The corrections on page 16 are not usable as they were on the back of the mailing coupon to order the almanac. Really you should have found a better location for them! Please send me a set of the correct calculations, or a copy of page 16 from the Newsletter which is intact. I did receive the 1988 Star Data. Many thanks.

Forrest W. Gibson of San Pedro, CA writes:

1) I see that my membership is up on 11/06/88. Now, is this Nov. 6 or 11 June of 1988? Wouldn't it be easier to put everybody on the calendar year. (If you join during the middle of the year you pay the full $25.00 and get the back issues of the newsletter for that year.)

2) With respect to "The Navigator's Almanac, 1988" (I have made all the corrections, page 19, and the 1988 examples), I want to suggest that the smaller such tables are, the longer and more detailed the explanations need to be. Also, the print in some cases, such as the refraction and dip tables of the SUN on page 11 are quite small. People may not always have their glasses or a magnifying glass in an emergency. One of the common consequences of an emergency is poor lighting, especially on a lifeboat. The problem with a table of this kind is that there is a disinclination to use it or study it until the need has arrived. Then there is little desire to engage in a detailed study though it is a good way to pass the time on a life raft. My suggestion is that the arrangement of some parts more closely follow that in the N.A. (which we are all used to). Such as putting the FULL SIZE Altitude Correction Tables A2 and A3 of the N.A. on pages 2 & 3 of your book. By the way you don't have the Altitude Correction Tables for 0-10 degrees. Page 20 diagrams should be enlarged and printed one to a page (or one to 2 pages if necessary). A complete Polaris example is needed. Why not give the rules for using the 1988 N.A. in 1989?

As it stands, I'd get 5 or 6 copies of the N.A. and put 3 in my boat, 2 in the life raft and 1 in the emergency pack. (ED. Note: Mr. Gibson makes a number of excellent points which we will take account of in the 1989 Almanac which is now under preparation.)

Gerald C. Rademaker of Woodburn, OR writes:

Enclosed is my contribution for enrollment in the Navigation Foundation. I wonder if you could help me with a closely related matter. I have heard that there is an organization made up of retired navigators that fly light aircraft and navigate using celestial navigation. This is all the information I have. I would appreciate any help in identifying this organization and who I might contact to get information about it.

Sara Weiss at (609) 924-8401 writes:

We are looking for something that may be an odd request for you. If it is we request that you forward this to someone who may be able to help us. Recently we purchased used a cassette tape set entitled "Celestial Navigation" put out in 1977 by the Audio Navigation Institute which is presently out of business. Tape #13 is blank. Our request is can you help us get a copy of this tape? We already spoke to the Narrator, William Presch, who told us the original tapes have been destroyed. We appreciate any assistance in this matter.

George Lear of N. Chevy Chase, MD writes:

Once again this year I will offer a course of instruction in "Celestial Navigation." Beginning in mid September, twelve classes (one each week) on fundamentals using HO 229, the sextant, and also the hand calculator will provide information to the new navigator for offshore sailing. My class earlier in the year was well received and all of us, students and instructor, enjoyed the course. Locations this time are in Bethesda and also in Annapolis. My phone is (301) 986-0314: call for further details. While I realize the Fall edition of the "Navigator's Newsletter" may not be on the street before September, it would be greatly appreciated if you could mention my course of instruction. Teaching is much fun and rewarding, but one must have students.

John A. Decker, Jr., President of Kuau Technology, Ltd., writes:

Our negotiations for the license or sale of our automatic celestial navigation system have broken down, and we need to find another partner to manufacture and market the system globally. To review, our COMPUSIGHT T M Automatic Sextant US PATENT 4,707,926; OTHER US & FOREIGN PATENTS PENDING will take and reduce sights to a Line of Position at the push of a button, and will automatically combine two LOPs to obtain a Fix. Future enhancements will include Multi-LOP Fixes, Sight Averaging, Bad-Sight Elimination, Auto Star Selection and Fully-Automatic Taking & Reduction of Sight Sequences.

Our prototypes utilize Cassens & Plath, the Chinese Astra III or Tamaya "Venus" sextants, a Hewlett-Packard HP-41CX-based compact electronic system, EPROM software and waterproof encoders. Dennis Conner used our encoder technology on board STARS & STRIPES in his successful campaign to reclaim the America's Cup. The system is fully-developed and should retail in volume production for no more than twice the price of a top-of-the-line marine sextant. I enclose a Data Sheet, Instruction Manual and PRACTICAL SAILOR reprint.

However, we are a small company in a remote part of the world, and are acutely aware of the costs of attempting to service a relatively small and diffuse market from Hawaii! We simply must have a partner to manufacture and market the system! Our preference is to sell or license the technology, but we will consider a joint venture or exclusive marketing agreement if it is advantageous. Do you know of anyone who might be interested? I need your help!

Ronald Barr of The Armchair Sailor Bookstore, Newport, RI writes:

We read the recent letter from Frederick Coleman of Mexico City with interest. We are continually searching for good sources for charts, particularly for the Yucatan and Gulf which is sparsely covered by DMA. Could you put us in touch with Mr. Coleman so that we may pursue the matter directly with him? We supply, as you probably know, navigators around the world and have had difficulty in the past obtaining Mexican charts and publications for our customers. Thank you.

(ED. Note: We have supplied Mr. Coleman's LA address).

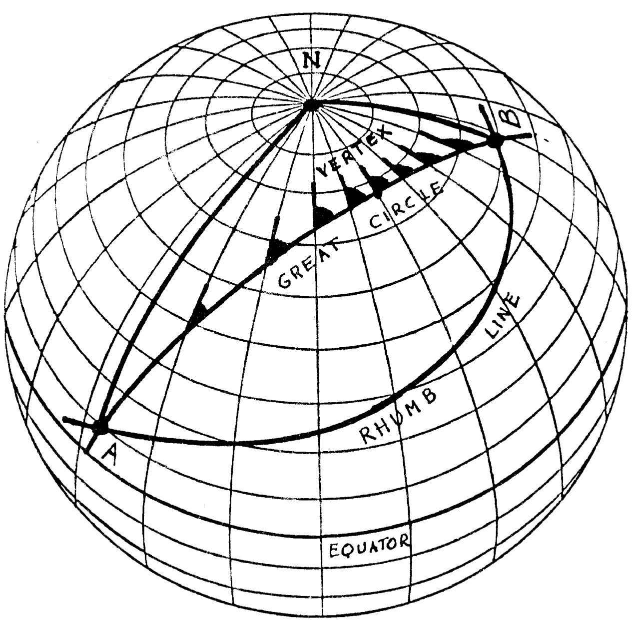
NAVIGATION BASICS REVIEW

Great Circle Sailing

By John M. Luykx

A. General

A great circle on the earth's surface is defined at the intersection of the earth's surface by a plane passing through the center of the earth. A great circle is the shortest distance between any two points on the earth's surface and for long voyages (over 600 miles) a considerable saving in distance may be realized by computing and following the great circle track rather than the longer rhumb line track. See Table 1. To exactly follow a great circle inother than northerly or southerly directions the destination would lie exactly dead ahead throughout the voyage requiring a continually changing course. The great circle track may be considered as a curve intersecting successive meridians of longitude at differing angles, a characteristic which is not readily evident to a navigator accustomed primarily to the mercator chart. Because of distortion on the mercator chart (meridians are shown as parallel rather than convergent) the shortest distance between two points appears as a straight line, i.e., the rhumb line, which intersects the meridians at the same angle. The rhumb line, however, when transferred to a globe (see figure 1) actually becomes a significantly longer curved line spiraling toward the pole in what is called a loxodromic curve.



THE GREAT CIRCLE TRACK

Figure 1

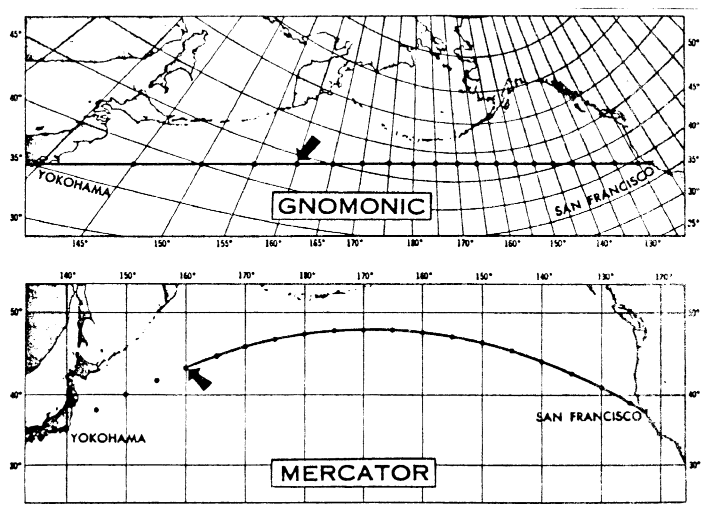
TABLE I

RHUMB TRACK	DISTANCE	GC DISTANCE	COURSE CHANGES REQUIRED
Sydney-Valparaiso	6885	6115	From 144 to 035
Yokohama-San Francisco	4740	4480	From 054 to 123
Cape Town-Fremantle	4970	4750	From 119 to 057

B. Computing the Great Circle Track

Since considerable time and distance may be saved on long voyages by following a great circle track, the navigator should be familiar with the various methods used to compute and plot the great circle track. Rather than compute and plot a continuous curve on the mercator chart, the normal procedure is to compute a series of short distance rhumb lines (each less than 500 miles) which closely follow the great circle. Solutions for the track points may be accomplished:

a. Graphically by great circle chart on the gnomonic or Lambert projection
b. By mathematical computation
c. By sight reduction table
d. By computer



(From Bowditch, Vol I)

Figure 2

Great Circle Chart

Figure 2 shows the use of the Great Circle Chart (gnomonic projection) to compute, as an example, track points for a voyage from San Francisco to Yokohama. The track is first drawn on the Great Circle Chart as a straight line. The coordinates at the intersection of the track with selected meridians (usually either 5 or 10 apart) are recorded and transferred to a mercator chart. The rhumb course and distance for each leg are then determined graphically from the plot on the mercator chart.

Mathematical Computation

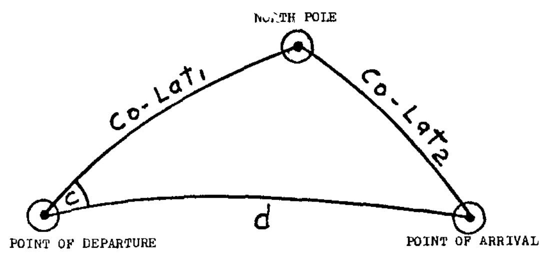
Figure 3 shows the navigation triangle labelled for computation of the Great Circle Track.

$$\text{Distance} = \sin d = \frac{\cos L_1 \times \sin L_2 + \sin L_1 \times \cos L_2 \times \cos DLo}{\cos}$$

$$\text{Course} = \sin C = \cos L_2 \times \sin DLo$$

The computation of the various track points is a complicated procedure too lengthy to describe in this short article. The reader is referred to article 1016 in Bowditch, Vol II.

TRIGONOMETRIC SOLUTION



DEFINITIONS

DLo:	Diff. of LON
C:	Initial Course
L_1:	Lat. of Departure
1:	Lon. of Departure
L_2:	Lat. of Arrival
2:	Lon. of Arrival
d:	Distance (miles)
Co-Lat_1:	$90^\circ - L_1$
Co-Lat_2:	$90^\circ - L_2$

DISTANCE

$$\frac{\sin d = \cos L_1 \times \sin L_2 \pm \sin L_1 \times \cos L_2 \times \cos DLo}{\cos C}$$

INITIAL COURSE

$$\frac{\sin C = \cos L_2 \times \sin DLo}{\sin d}$$

Figure 3

Computation by Table

Sight reduction tables such as H.O. 229, H.O. 214, H.O. 249 and H.O. 211 may be used to compute the great circle track. However, because only integral values of latitude, declination and meridian angle are available with H.Os 229, 214 and 249, it is recommended that H.O. 211 be used if a tabular solution is required. As modified by Allan Bayless, H.O. 211 is compact and without interpolation provides values of latitude, declination and meridian angle to the nearest 1' of arc. Computation of the basic elements of the great circle track listed below are readily accomplished using H.O. 211.:

Great Circle Distance
Initial Great Circle Course
LAT/LON Coordinates of the Vertex
Distance of the Vertex
LAT/LON Coordinates of Track Points
Great Circle Course and Distance Between Track Points

The track points computed using H.O. 211 are then plotted on a mercator chart and the rhumb course and distance for each leg determined graphically.

Computation by Computer

A few small hand-held Celestial Navigation computers on the market today incorporate a capability to automatically compute the great circle track, including track points and the rhumb course and distance for each leg. The CN-2000 system is one of the best of these. From inputs of:

Point of Departure
Point of Arrival
Track interval (or distance of each leg)

the CN-2000 computes:

Initial Great Circle Course
Great Circle Distance
The coordinates of each track point
The great circle course and distance between each track point
The rhumb course and distance between each track point.

While it may take a few hours to mathematically compute the complete great circle track, including intermediate points as well as the rhumb course and distance for each leg, a small hand-held computer like the CN-2000 can accomplish this in a few minutes.

Composite Sailing

Composite sailing is a combination of both great circle sailing and plane sailing procedures. It may occur during voyage planning that the desired great circle track from point of departure to point of arrival may pass through or near intervening land, hazards as well as danger and restricted areas. To avoid such areas, for example, a great circle track would be computed tangent to a limiting_latitude along which the track would be a rhumb line. Once beyond the danger or hazard a new great circle track would be computed to the destination.

A few examples of composite sailing:

a. The great circle track from Chesapeake Bay entrance to Gibraltar passes through the Azores. To avoid these islands the great circle track is computed for a limiting latitude south of the Azores.

b. The great circle track from Hobart to Cape Horn passes through the Antartic ice. To avoid this a limiting latitude of 60 S is established.

c. The great circle track from Seattle to Yokohama passes through the Aleutians. To avoid these islands a limiting latitude of 50 N may be applied to the track.

Conclusion

To mathematically compute the complete great circle track is a laborious process and should only, as a practical navigation matter, be attempted as a last resort. Solutions by tabular methods are also laborious especially if the complete great circle solution is desired using H.O. 229, H.O 249 or H.O. 214. Frequent triple interpolations are required by these publications adding to the complexity of the solution. The author, however, has completed a solution of the great circle track from Chesapeake Bay entrance to the Straits of Gibraltar using Allen Bayless' modified H.O. 211 tables. This was done to provide readers with a sample tabular solution, and it is available to readers upon request along with a comparison solution by the CN-2000 hand-held pocket computer.

The most efficient practical method of computing a Great Circle Track is by computer. For the navigator without a computer, the most practical solution is the graphic one obtained by Great Circle chart. It is rapid and accurate. The two DMAHC Great Circle charts recommended for use in planning voyages are for the Atlantic, WOXZP5101 and for the Pacific, WOPCZ5245.

NAVIGATION PERSONALITIES

Muhammed Targui (Ulughbek)

by T. D. Davies

In this article I discuss a navigation personality almost unknown to the western world; Ulughbek, whose proper name was Muhammed Targui but who is best known as Ulughbek the Astronomer. We sometimes forget that, after the Greeks, the Arabs were early and most prolific astronomers. One is reminded of this when looking at the names of the navigational stars, many of which are arabic

I have just completed a three week journey through the Soviet Union in which I got as far east as Samarkand and there I found the historical artifacts of this moslem astronomer who produced an accurate table of over 1000 stars, data on the members of the Solar system which figured in most european Almanacs, a computation of the Equation of Time, a calculation of the length of the year with an error of only 58 seconds and an early and precise calculation of the apparent movement of the fixed stars due to precession of the equinoxes.

This remarkable man was born in 1394, a grandson of Tamerlane (actually Temur-the-lame) in the town of Sultana in Azerbaijan. Tamerlame's history consisted primarily of conquest although he did establish and beautify his capital at Samarkand. Ulughbek's early years were spent on the campaign trail with his grandfather in Armenia, Afghanistan, India and China.

In 1405 Tamerlane died in China and a power struggle between his heirs ensued. Ulughbek's father succeeded to the throne but established his capital at Herat and gave Samarkand and the surrounding territory (essentially modern Uzbekistan) to Ulughbek to rule. Here Ulughbek ruled for 40 years, a period in which learning was advanced to new heights in the muslim world and the kingdom enjoyed unprecedented peace and prosperity.

Ulughbek"s greatest works were the construction of his great observatory at Samarkand, and the astronomical data that it produced. However he was a most enlightened and progressive ruler who founded a number of schools staffed with the best scientists and mathematicians he could find. In fact he was first a student and then a lecturer at one of his "madrassahs" or schools. The proof of his enlightened view are the words inscribed on the madrassah he founded in Bukhara :"It is the duty of every muslim man and woman to acquire knowledge."

The great observatory of Ulughbek was built on a hill outside the city walls of Samarkand on the road to Tashkent, during the years 1428 and 1429. The ruins today are only what was left by a group of fanatics who tore it down after the death of Ulughbek. They were found and excavatedin 1908 by a Russian archaeologist V. L. Vyatkin, who spent most of his life searching for the observatory.

Apparently the observatory was a circular three story building which was bisected by an enormous vertical arc for the accurate measurement of the angular altitude of stars as they transited the meridian. The radius of the arc was about 133 feet, and its center was at the center of the roof of the building. The lower part of the arc has survived to this day, because it was cut into the solid rock under the building.

The existing part of the arc has a set of steps alongside it, for access, and is covered with plates of marble which have bronze rails set into them for operation of a trolley used to view the stars through the center of the roof. The arc has division marks for degrees, minutes and seconds. The very large radius permitted accurate observations so that the resulting data was widely used by astronomers and in almanacs in the 16th, 17th and 18th centuries.

Ulughbek's book listing the star positions was isued in 1437. He used the basic cosmological system of Ptolemy's Almagest and the constellations tabulated by the arab astronomer al-Sufi (published in 1009) and the star catalogue of Ilkhan published in 1261. Essentially he updated these lists and found that the "fixed" stars were no longer in their old positions. This led him to calculate their movement and regress their posiitons back to the year of the Hegira (841). His tables give the position in 841 and the method to update them to any year. He calculated the precession as 1 degree in 70 years; today this value would be given as about 58.6 minutes of arc in 70 years.

Ulughbek also calculated the distance to the Sun and Moon from the center of the Earth and the length of the year. He showed how to predict eclipses of the Sun and Moon and calculated the Equation of Time. Finally, his tables included the motions of the several planets, conjunctions of the Moon and planets and the latitudes of a number of important cities, including some in Spain, part of which was still under Islamic rule.

The foundations and remains of his great arc at the observatory are impressive reminders of this great man, but also are the size and great beauty of the schools and other buildings he left behind. Last but not least, he should be remembered for his recognition of the importance of education for women at a period in history when women had to wear veils and their education was thought to be indecent.

HISTORY OF NAVIGATION

Early Altitude Measuring Instrument: The Sea-Ring

By John M. Luykx

General

In the Second Part of his *Seamans Secrets* (1595), John Davis briefly mentions "an Astrolabie 10 inches diameter, whose dioptra shall cut his lymbe to right angles and shall performe the complement of 90 degrees as amply and as effectually as by the quadrant it may in any sort be done." This instrument was first described by Pedro Nunes in 1573 and later became known as the "nautical ring," "sea-ring" or "astronomical ring". In France it was called "L'Anneau" (the ring) and described by Bion (1752) in his *Traite.*

Construction

The sea-ring consisted basically of a brass ring 6"-10" in diameter and 1" to 2" in width suspended by a thumb ring. The metal part of the ring was from 1/8 to 1/10" thick with a small hole (pinnule) drilled through it at a point 45 from the thumb ring. The interior circumference was graduated from 0 to 90 , as shown in Figure 1, to indicate either altitude or zenith distance or both. The sea-ring was in correct balance when the exact vertical passed through the point of suspension and the point of altitude 67 30' or zenith distance, 22 30' on the graduated scale. A plumb bob was employed to check the sea-ring for vertical alignment.

Use

To take an observation of the sun with the sea-ring, it was oriented toward the sun to permit the sun's rays passing through the hole to project as a bright spot on the graduated scale on the interior surface. The observer would then note as accurately as he could either the altitude or zenith distance. When ashore, altitudes/zenith distances, to the nearest 0.1 or better were often possible. At sea, however, the observer was required to estimate the altitude/zenith distance by mentally gauging the mean angular value as the ring oscillated about the vertical. The advantages of the sea-ring were that it doubled the accuracy of an astrolabe of equivalent diameter and that it had no moving parts. One of its disadvantages was that accuracy was greatly reduced in all but calm seas. When compared to the seaman's quadrant and the mariner's astrolabe (See Navigator's Newsletter 18 and 19), it had an additional disadvantage; it could only be used to observe the sun, and perhaps the moon when full, but could not be used with stars and planets.

Although the sea-ring was described in several navigation manuals of the 16th through 18th Centuries (Nunes, Davis, Newhouse, Bion, etc.) it seems to have been little used in practice, and the author has so far been unsuccessful in locating one in either a public or private collection.

Accuracy of the Sea-Ring Using a Modern Replica

To check the accuracy of the sea-ring from a position ashore a series of observations was taken using a replica instrument from the author's collection. The observations consisted of sixteen (5 shot) groups (total 80 observations) with the following results:

Mean Error	-8.0 (Index Error)
50% Error	3.7
Standard Error	4.7
90% Error	7.8
Range of Error	15' (0' to 15')

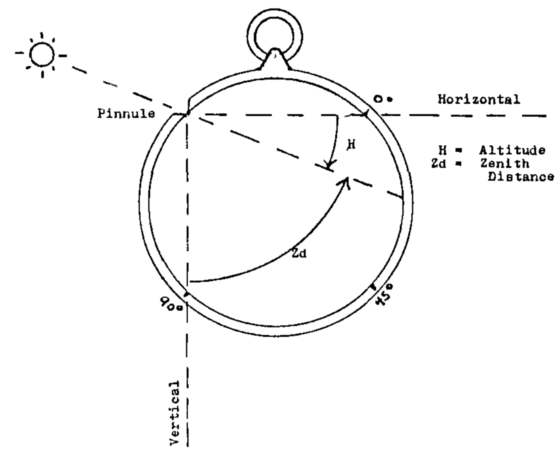
During observation the observer was seated in a chair in an area protected from the wind. Each altitude was estimated to the nearest 5.0 arc/min.

The replica sea-ring is constructed completely of brass, is 200 mm in diameter, 50 mm wide and 2 mm thick. It is engraved from 0 to 90 for the both altitude and zenith distance scales on the interior surface. The design of the replica sea-ring is based on a drawing at the end of the second part of John Davis', Seamans Secrets of 1595.

Although restricted in its use to sun to observations only, the sea-ring, in the author's opinion, is easy to handle and comparatively accurate.

In the next issue, the equatorial ring dial will be described and discussed.

THE SEA-RING



NAVIGATION NOTES

Constant Error Circles Revisited

by T. D. Davies

In issue 13 of the news letter we discussed the fact that a constant error can many times exist in two or more compass bearings taken while coastal piloting. Of course this is particularly probable in the case of smaller boats where compasses may not have been swung or calibrated so that at least for a set of bearings taken while on a constant heading, the compass error remains constant and so is a fixed component of each of the bearings.

Bowditch discusses correction of such errors under the heading of the Franklin Piloting Technique, so named for one of our members, Chief Quarter Master Franklin, USN. The error has crept into plots from other sources than compass error. Chief Franklin once discovered the error in a ship's Azimuth Circle, which normally would be looked on as extremely unlikely. It is my opinion that the constant error is quite frequent in occurance, and the method should be used regularly.

The plotting method which uses the circle common to three points is also applicable to the plotting of horizontal sextant angles, which provide an extremely accurate method of piloting. The use of the Three Arm Protractor is a cumbersome method of plotting and frequently discourages navigators from using this precise piloting technique.

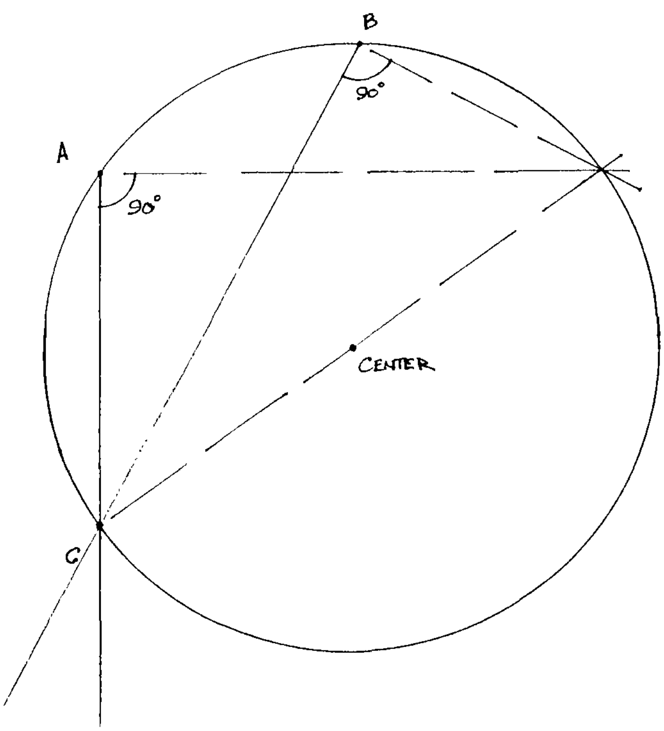


Figure 1

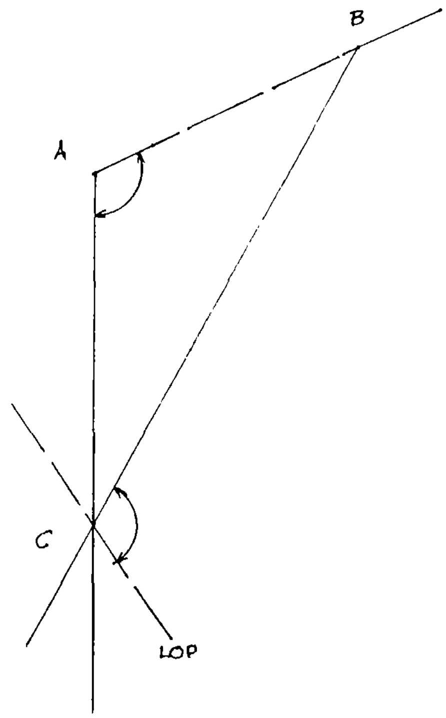


Figure 2

In the previous article on this subject we proposed an alternative to the Bowditch method of plotting. It was based on laying down perpendiculars to each of two bearing lines and noting their intersection. The intersection is the point diametrically opposite to the plotted position, so that a line connecting the two is a diameter of the circle, and a perpendicular to this line approximates the circle for a short distance. For longer distances or greater accuracy the mid-point of the diameter of the circle may be used as the center and an arc swung from it through the initial position. This is shown on Figure 1.

We can now offer another plotting technique which some may find easier than that described above. This involves measuring an angle using the plotter's protractor. In Figure 2, A and B are the two land targets from which bearings have been plotted to C by conventional means. CA and CB are the bearing lines which are suspected of having a constant error. Next plot the line AB and measure the angle CAB. Lay out this angle with the protractor from the line CB, centered at the intersection C. This represents the tangent to the circle of position (regardless of the value of the constant error) and may be used to approximate that LOP for short distances.

Figure 3 shows the introduction of a third target D, and now the line ED represents the bearing line to that target. The constant error causes the intersection E not to coincide with C. If it does coincide on your plot, then no (or very small) error exists and no further plotting is required. However in most cases E will not coincide with C and so the next step is to connect A and D. Measure the angle EAD and lay it out from ED centered at E. Again this line represents the tangent to the circle that contains E and can be used as an LOP for short distances. The intersection of these two tangents F, is the new position with the constant error removed.

By using a compass bearing for one of the lines and adding other horizontal angles taken with the sextant, this construction will produce an appropriate fix for that type of plotting and is less cumbersome than the three arm protractor.

This gives us several ways to handle both constant error cases for compass bearings and horizontal sextant angles for piloting. When your normal plotting produces triangles instead of point positions, checking by these methods is well worth while. Of course horizontal sextant angles always eliminate compass errors and usually produce the best fixes.

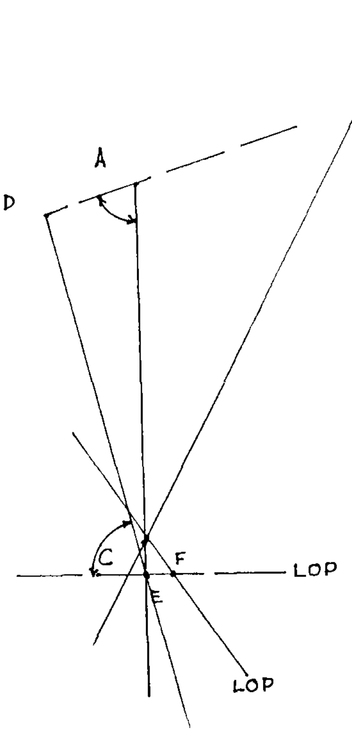


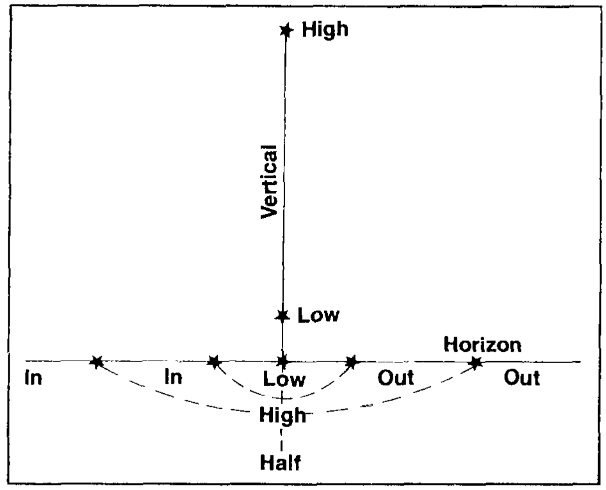
Figure 3

The Vertical Sextant

by Byron Franklin

This tip will enable even the inexperienced celestial navigator to plot celestial fix pinwheels on the chart by using a simple sextant technique.

In 1958 I was stationed on a liberty ship of World War II vintage. For five years the ship was under way approximately 200 miles off the East Coast using Loran A and the sextant to maintain a radar, aircraft and missile tracking station. The duty was a pleasure for a celestial navigation nut like myself because in any month I observed, computed, plotted and evaluated an average of



20 morning and evening star fixes, plus countless sun lines.

The best fixes were always when the horizon was fully lit, toward the day side of twilight. Once the stars became bright, the horizon would darken and become a thick band. The best plan was to sight while the stars were just showing, bring the star to the sharp horizon, swing the star (rock the sextant)and lay the star on the horizon. Many times, especially with a high star, the star would disappear on or near the well-lit horizon.

The sky just above the horizon is lighter than the rest of the sky and the swinging takes away some of the concentration needed to stay locked onto the faint star or the pale disk of a planet. In order to sit that faint star on the distinct horizon, I experimented with bringing the faint star into the relatively darker water and rocking the sextant, watching the star enter and leave (in and out) the water.

I found that I could quickly isolate the exact point under the star "Vertical Sextant," be it high or low. I could concentrate on putting the star on the horizon by halving the "in and out" mentally, and bringing the star above that point on the horizon and then coming down for the mark. It worked so well for me that I started using the same procedure for the sun and bright stars. Very accurate fixes were easy.

I admit that my celestial fixes were not so accurate after a transfer to duty with less demanding celestial navigation practice. When I shifted back to "Vertical Sextant" (in and out of the water) my fixes would improve and tighten with no random near misses. Give the technique a good try.

A Navigation Problem

by Roger H. Jones

Solution to the problem presented in Issue Twenty-One. 23. Answer

Remaining at the known position, the navigator wishes to observe local apparent noon (LAN). He mentally notes that at 130-05.2 West, he is somewhat more than ten degrees west of his time zone's 120 degree standard meridian, and since each degree of longitude is equivalent to four minutes of time, LAN at his position will occur at least 40 minutes after it occurs at the standard meridian. Being in time zone + 8, it will therefore occur at least 8 hours and 40 minutes after it occurs at Greenwich.

He also mentally notes that he is at 25-04 South, and the Almanac tells him that on June 25th the Sun's declination at 2000 GMT is North 23-22.1. In arc terms, the Sun lies somewhat more than 48 degrees (25 + 23 = 48) from his zenith, and at his noon he should find it at an altitude of approximately 42 degrees above the northern horizon (90-48=42). He sets his chronometer to a few minutes before 20-40 GMT, starts it, and sets his sextant to a few degrees less than 42.

Somewhat before noon, he begins to "track" the Sun in its a.m. ascent. When it reaches 40 degrees exactly, he notes the time on the now running chronometer. When it again reaches 40 degrees in its p.m. descent, he again notes the time. Taking half of the time interval and adding that to the time when the Sun was at 40 degrees, ascending, the result should be an acceptably accurate time of LAN. Assume that by this "bracketing" method LAN occurred at 20-40-25.

From the Almanac the navigator learns that on June 25th the equation of time for 12 hours is 2 minutes, 39 seconds. Meridian passage occurred at 12-02-39 at Greenwich. At longitude 130-05.2 West, LAN will occur exactly 8 hours, 40 minutes, 21 seconds after it occurs at Greenwich. Thus, at the Pitcairn location, it will occur at 20-43-00 GMT. The restarted chronometer indicated that it occurred at 20-40-25. It is thus 2 minutes, 35 seconds slow. GMT has been "recovered". Of course, the rate of gain or loss in subsequent days and weeks is not known, but at least the navigator has regained GMT, as corrected for the slow error, with which to resume his voyage.

Problem No. 24

In Problem No. 23, the navigator used the same bracketing technique to determine the time of LAN that was used in Problems 3 and 4 (Issue No. Six). However, in Problem No. 23, the new "wrinkle" of the Equation of Time was added. While the Equation of time is not often used in routine practice today, it can be quite useful when dealing with a variety of time-related problems, especially when no Almanac is available.

Suppose that our hapless navigator has found himself now with an acceptably accurate chronometer, but no Almanac is aboard. Further, suppose he wishes to know the Equation of Time for a given date in order to learn the time of meridian passage of the Sun at Greenwich. What emergency rule of thumb can be used to gain a useful, if not totally accurate, Equation of Time?

MARINE INFORMATION NOTES

Digest of Notice to Mariners

by Ernest Brown

PIPELINE LAYBARGES AND JETBARGES

With the increased number of pipeline laying operations in the Gulf of Mexico and other areas, operators of all types of vessels should be aware of the dangers of passing close aboard, close ahead, or close astern of a jetbarge or pipelaying barge. Pipelaying and jetbarges usually move at 1/2 knot or less and have anchors which extend out approximately 3500 l—5000 feet in all directions, and may be marked by lighted anchor buoys. The exposed pipeline behind the pipelaying barge and the area inthe vicinity of anchors are hazardous to navigation and should be avoided. The pipeline and anchor cables also represent a submerged hazard to navigation. It is suggested, if safe navigation permits, for all types of vessels to pass well ahead of the pipelaying barge or well astern of the jetbarge. The pipelaying barge, jetbarge, and attending vessels may be contacted on VHF l -FM Channel 16 for passage instructions.

IMPROPER USE OF SEARCHLIGHTS & FLOODLIGHTS AT SEA

The Coast Guard has received reports that fishing vessels which use high intensity lights when setting and retrieving gear are routinely leaving them lit at all times when the vessel is underway. Although these lights may make a vessel easier to locate at great distances, improper use could interfere with the safe navigation of vessels. This may constitute a violation of the International Regulations for Preventing Collisions at Sea, 1972 (72 COLREGS) if the glare of such lights:

(a) interferes with the night vision of mariners operating in the vicinity and the keeping of a proper lookout - Rules 5 and 20 (proper lookout);

(b) obscures the navigation lights of the vessel, making it difficult to determine a vessel's heading and type of operation - Rule 20 (impair distinctive character of navigation lights);

(c) makes it difficult for mariners to identify aids to navigation and their geographical location in the vicinity of the vessel using these lights - Rule 36 (mistaken for any aid to navigation or embarrass another vessel).

Several reports indicated a vessel using sodium vapor floodlights was mistakenly reported as a vessel on fire, which resulted in a search and rescue response to a false alarm. The use of these high intensity lights may ultimately reduce the level of vigilance on the part of other mariners which could result in an actual distress situation not being reported or answered.

This notice does not prohibit a vessel from using any lights that cannot be mistaken for the lights specified in the 72 COLREGS. Mariners are cautioned that all types of high intensity lights when used at sea must be properly directed or adequately screened to ensure that under any conditions such lights will not embarrass another vessel, be misinterpreted, or illuminate beyond the immediate vicinity of the vessel. When these lights are not being used for a specific task they should be extinguished.

CAUTION - USE OF FOREIGN CHARTS.

In the interest of safe navigation, caution should be exercised in the use of foreign charts not maintained through U.S. Notice to Mariners.

Foreign produced charts are occasionally mentioned in DMAHTC Sailing Directions when such charts may be of a better scale than U.S. produced charts. The mariner is advised that if or when such foreign charts are used for navigation it is his responsibility to maintain those charts from the Notice to Mariners of the foreign country producing the charts. The mariner is warned that the buoyage systems, shapes, colors, and light rhythms used by other countries often have a different significance than the U. S. system.

BOOK REVIEW

by Roger H. Jones

Somewheres East Of Suez

by Tristan Jones

Hearst Marine Books
William Morrow & Co.
105 Madison Ave.
New York, New York 10016 (1988)
252 pages; $17.95

Some temptations are not to be resisted. This column normally reviews new books that are specifically about navigation and navigational procedures, although occasionally, as in Issue Twenty's review of The Log of Christopher Columbus , we have ventured in the direction of a book that reveals something of the character of the great navigators. This reviewer (no relation to Tris Jones) makes no claim that "Tris" and "Chris" belong in the same hall of fame, but the legion of followers of the chronicles of Tristan Jones know him to be one of the great small vessel navigators of the 20th Century. He is also one of the truly great modern-day adventurers and non-fiction story-tellers. It is not disputed that Jones has traveled more sea miles in sailing vessels than any other known person, and Somewheres East of Suez is now the latest in his series of absorbing books about his never-ending ocean odyssey.

In 1983 Jones lost a leg ashore after a lifetime at sea that began in 1938 when he was fourteen years old. (Truly, it began in 1924 when he was born aboard his father's tramp steamer command not far from the island Tristan da Cunha in the South Atlantic.) At the tender age of sixteen, he graduated from the decks and hold of a North Sea sailing barge to the decks of a British destroyer. He was a "matelot" (enlisted rating) in "the Andrew" (Royal Navy), and was a witness not only to the great loss of HMS Hood but also to the victory over the great German battleship Bismarck. His voyages on the Atlantic convoy and Arctic runs to Russia put him aboard at least two naval vessels that were literally sunk beneath his feet. His adventures had only just begun.

Mustered out of the Navy in 1952 due to injuries, he set upon a life of voyaging that has seen him ice-locked in an Arctic winter and dying of thirst and hunger in the upper reaches of the river Paraguay. He is the only person ever to have taken an ocean, worthy vessel across the continent of South America from the Pacific coast of Peru to the Atlantic coast of Argentina. More recently, he became the first person to navigate a sailing vessel across Europe from the North Sea to the headwaters of the Danube and thence to the Black Sea. His previous ten books have chronicled all those and other voyages, including nine solo trans-Atlantic trips.

This latest chronicle, laden with his inimitable combination of irreverence and humor, is the story of his 8,000 mile journey as the one-legged skipper of the trimaran, Outward Leg, from Istanbul to Thailand. He takes up where he left off after completing his voyage down the entire length of the Danube, which involved not a few adventures with Iron Curtain officials with little imagination or tolerance for his brand of insouciance. Late October, 1985, saw him off. This is the story of what subsequently transpired. I'll not ruin the pleasure of readers who are old or new followers of Tristan Jones. Suffice it to say that this incomparable Welsh navigator and story-teller, now in his sixties but always young at heart, once again reveals something of the special character of a true son of the sea. Those of you who would navigate upon the oceans, go and peek into the heart and soul of one of the great ones!

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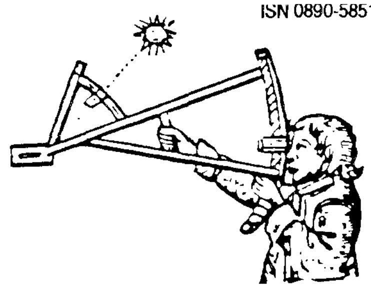
THE NAVIGATOR'S NEWSLETTER



FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

ISSUE TWENTY-THREE, WINTER 1988-89

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

by T. D. Davies

Foundation Investigates Peary Data

Many of our members have probably read with interest the current news items about the revival of the controversy over the Peary North Pole trip of 1909.It appears that your foundation is now involved in this, so a short resume is in order.

The original publicity upon Peary's return to civilzation marked the beginning of the controversy. The fact that another explorer, Dr. Cook, claimed to have attained the pole one year earlier forced Peary's supporters to challenge Cook by challenging the authenticity of the navigational data he offered as "proof." In fact Cook's data had been "manufactured" for him by a merchant sailor who announced this fact when Cook welshed on his payment. Cook was eventually thoroughly discredited, but left a residue of doubt about the authenticity of anybody's data, including Peary's.

It seems obvious that a set of alleged sights can be manufactured, with the aid of an Almanac, which give the appearance of the author's having visited the North Pole, or for that matter any place that they cannot have been observed by a witness. Since the Pole has no land to be "discovered" and described, Peary's navigational data and its authenticity have been the subject of books and articles throughout the intervening 79 years.

Of course Peary's history as a super-achiever in Arctic exploration (he had covered 9000 miles of ice terrain in Greenland and on the polar sea in the previous many years) would seem to require a presumption of credibility. Furthermore he was accompanied to within 130 miles of the pole by the captain of his support vessel, a competent navigator. The assumption that he faked his data requires that he also enlisted others in this scandalous scheme. Nonetheless several writers have found this no obstacle.

Aside from these aspects of the controversy, actual navigational calculations are invoked by both sides of the controversy. As one might expect Peary's data-taking was the minimum necessary to accomplish the drive to the pole. Recently one author has made a remarkable interpretation of some unexplained numbers on a recently discovered slip of paper from the Peary files in the National Archives. This story has gained wide publicity and with it a great deal of criticsm of the National Geographic Society for not doing a thorough analysis in 1910 when they examined Peary's data and certified it as genuine.

Enter the Navigation Foundation. Gilbert Grosvenor, President and Chairman of the Society has requested that the Foundation do a careful and thorough analysis of all available navigational data of the 1909 expedition, leaving "no stone unturned" and present the Society with an objective and expert conclusion.

The Society has agreed to provide logistic and financial support for the project but emphasizes that the final answer, favorable or unfavorable, must be unbiased. After sounding out our board members, who I expect will participate, I have sent an acceptance to Mr Grosvenor. I believe this will be an interesting and important project for the Foundation, and I will keep members advised through the Newsletter. We would welcome letters from members who feel that they have some useful information to contribute.

Navigator's Almanac

The 1989 Navigator's Almanac is now available to members at the $4.00 price. The new version has a number of improvements, based on comments received on the 1988 model. Pages have been increased to 24 and the space used to provide expanded instructions and enlarge some tables which were in very small type. There has also been some rearrangement and simplification of the tables. Each year of the 4 year calendar cycle will have a different color cover to make it easy to distinguish.

Tandemeer

For the moment it looks as though the winter weather will close down our at-sea operations on Tandemeer, however we will be organized for an early start in the spring. Interested members should express their interest early on to assist our planning.

READERS FORUM

Member Bill Land, of Norristown, PA, sends in a copy of news article on his navigation courses from the Philadelphia Inquirer of August 28, 1988. The article "Letting the Stars Chart Your Course", describes the history of his very successful courses in Celestial Navigation.

Anthony Kelley of Hicksville, NY, writes:

I have had several items published in the Foundation's Newsletter.

a. Letter concerning the Buckley error in using the inverted sextant

b. Request for Star Finder information

c. Article about the origin of the "v" correction in the Almanac.

I have redesigned the Rude Star Finder to be more applicable to the nautical environment. I am a technician; I need assistance to direct me in getting it into a market. I am willing to make a trip to your location to show you the benefits of the device. Would you please call me to set up an appointment.

(Editor's Note: Assistance was provided).

Forrest W. Gibson of San Pedro CA, writes:

Why don't you officially change your name to "The Navigation Foundation"? It seems odd to have a nickname.

(Editor's note: We will take this under advisement.)

NAVIGATION BASICS REVIEW

The Sextant Altitude Corrections

By John M. Luykx

I. GENERAL

A. The tabulated values of computed altitude (Hc) found in sight reduction tables such as H.O.229 and H.O.249 and in many computer programs is a value which represents the altitude of the center of a celestial body above the celestial horizon for an observer located at the center of the earth. In modern celestial navigation practice the altitude method of sight reduction is primarily used to obtain the line of position. The method is so-called from the procedure developed in 1875 by Marcq St. Hilaire, a French naval officer. It is known as the altitude intercept method in which the difference between computed and observed values of altitude; the altitude intercept, is computed to determine the line of position.

B. The raw altitude measured by a sextant is called the sextant altitude (Hs) and is subject to many errors which are described in the following paragraph. The sextant altitude (Hs) cannot be compared to the computed altitude (Hc) to obtain altitude intercept until and unless all the proper corrections have been applied to eliminate these errors. The various errors and their correction are discussed in all navigation textbooks. They are explained in especially great detail, however, in Bowditch Chapter XVI (Pub. No. 9, Vol I, 1984, published by DMAHC, Washington, DC) to which the reader is referred.

II. THE CORRECTIONS

A. The Instrument Correction (I) - A correction for non-adjustable errors of the sextant such as non-parallelism of shades and filters, scale graduation errors and centering error where the index arm is not pivoted at the exact center of the curvature of the sextant arc. The correction is given by the manufacturer in the sextant certificate. The correction is + or -.(1602)

B. The Index Correction (I.C.) - A correction due to lack of parallelism of the index and horizon mirrors. The error and correction is determined by observation and applied by the observer. The correction is + or -. (1603)

C. The Personal Correction (PC) - A correction to observational errors peculiar to the observer and determined normally from long experience in observation. The amount of the correction is determined by the observer. The correction is + or -.(1604)

D. The Dip Correction (D) - A correction for the height of eye of the observer above the level of the water. The correction varies also with the difference in water and air temperature at the observer's position. For standard conditions, the correction is computed using Table A2 in the Nautical Almanac. Except for backsights the correction is always -.(1605) (Fig. 1)

E. Refraction Correction (R) - A correction for errors caused by the bending of light rays entering the earth's atmosphere (a denser medium) from space. The correction is found in Table A2 of the Nautical Almanac under the title Stars and Planets. The correction is always -. (1606) (Fig. 2)

F. Air Temperature Correction (T) and Atmospheric Pressure Correction (B) - Additional corrections for non-standard air temperature and pressure conditions. Corrections are tabulated in Table A4 of the Nautical Almanac. The corrections are + or -. (1607) (1608)

G. Irradiation Correction (J) - A correction for the physiological effect where a brighter surface on a dark background appears to be larger than it actually is and where a darker surface on a bright background appears smaller. The correction (when applied) is applied to upper limb observations of the sun only. The correction is -. (1609)

H. Semi-diameter Correction (SD) - A correction equal to half the angular diameter of the celestial body. This

SEXTANT ALTITUDE CORRECTIONS

DIP CORRECTION

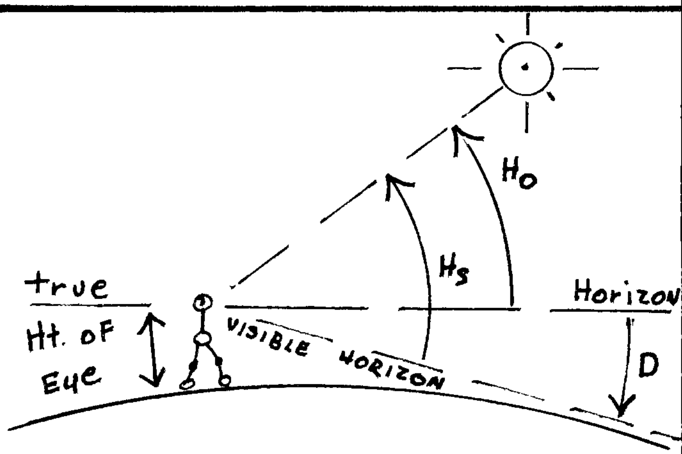


Figure 1

REFRACTION CORRECTION

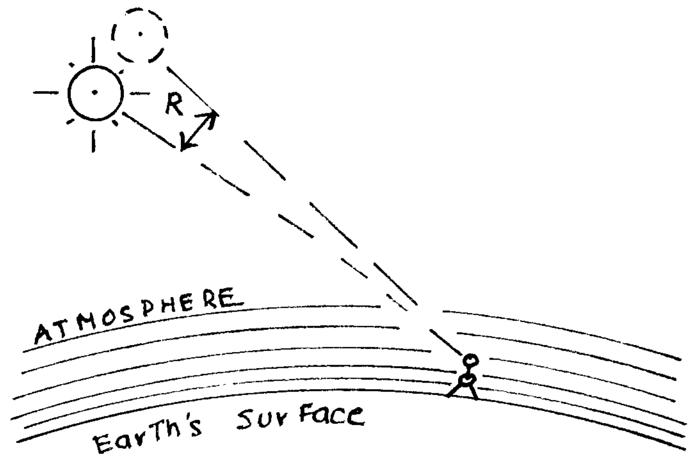


Figure 2

SEMI-DIAMETER CORRECTION

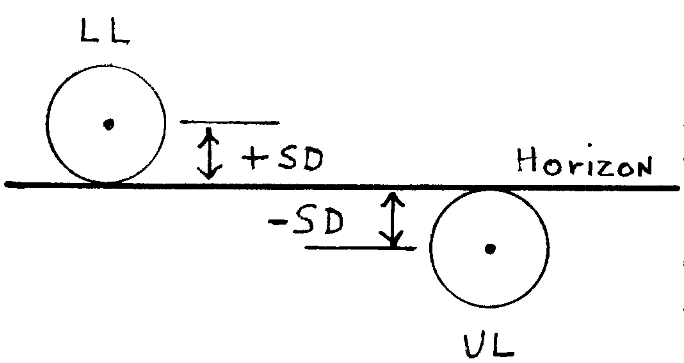


Figure 3

PARALLAX CORRECTION

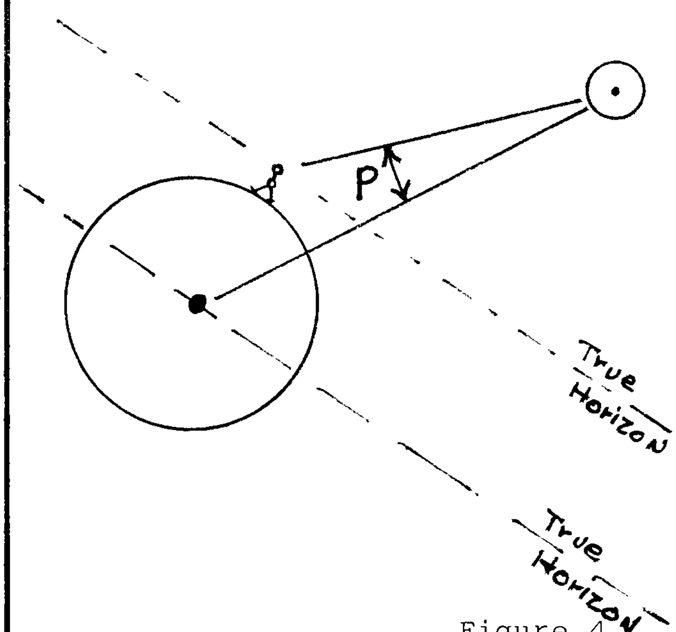


Figure 4

correction applies primarily to the sun and moon but may apply to the planets Venus and Jupiter. Semi-diameter is part of the sun and moon's correction tabulated in Tables A2 and the moon correction tables in the Nautical Almanac. For an upper limb observation, the correction is - and for a lower limb observation the correction is +. For the sun and moon the semi-diameter correction is incorporated and combined with other corrections. (1610) (Fig. 3)

I. Phase Correction (F) - A correction caused by the fact that the observed center of the moon and planets may differ from the actual center. The correction is not generally applied. The correction (when applied) is + or -. (1611)

J. Augmentation Correction (A) - a correction caused by the semi-diameter of a celestial body when it increases as the altitude increases. Applied to the moon only and is incorporated in the moon correction tables in the Nautical Almanac. If applied separately the correction is + or -. (1612)

K. Parallax Correction (P) - a correction for the difference in apparent position of a celestial body when observed from the center of the earth and a position on the earth's surface. The closer the celestial body is to the earth, the greater the parallax correction. The correction applies primarily to moon observations and is a correction for geocentric parallax. Because of geocentric parallax, a body appears too low in the sky. The correction is included in the moon altitude correction tables found inside the back cover of the Nautical Almanac. The correction is always +. (1613) (Fig. 4)

III. APPLYING SEXTANT ALTITUDE CORRECTIONS

A. All the sextant altitude corrections are described and analyzed in Sections 1601-1613 of Bowditch and summarized in Section 1614. Section 1615 discusses the order of applying the corrections. The altitude correction tables are also explained in some detail on pages 258-260 of the current 1988 Nautical Almanac. The Nautical Almanac (page 259) also provides examples of the application of corrections to sun, moon, planet and star observations. Examples of the application of sextant altitude corrections are also given in great detail in Bowditch sections 1619-1627.

B. Before the various corrections are applied to a sextant observation of any celestial body, the apparent altitude (Ha) of the body must be computed by applying the instrument correction (I), the Index Correction (I.C.) and the Dip (or Height of Eye) correction (D). Hs + I, + I.C. - D= Ha.

C. In normal sight reduction practice the sextant altitude corrections are taken from tables in the Nautical Almanac and applied to the apparent altitude to obtain Observed Altitude (Ho).

1. For the Sun: Ha + Sun correction in Table A2 (a combination of SD and R corrections) = Ho

2. For a Star: Ha - star and planet correction in Table A2 (the R correction)=Ho

3. For a Planet: Ha + star and planet corrections in Table A2 (a combination of the R, F and P corrections) = Ho

4. For the Moon: Ha + the two part moon altitude correction tables on the inside back cover pages of the Nautical Almanac (combined SD, R, F, J and P corrections) = Ho.

The Observed Altitude (Ho) when compared with the Computed Altitude (Hc) yields the difference between the two: the altitude intercept used in plotting the line of position. (See Navigators Newsletter issue 16, page 5 right-hand column.)

In the next issue of the Navigator's Newsletter, the personal equation, the variations in the Dip correction and the computation of random sextant observation errors will be discussed.

NAVIGATION PERSONALITIES

Radler de Aquino

by Thomas D. Davies

To most of our readers Radler de Aquino will be a name that rings no bells, but reference to the section of Bowditch on Comparison of Various Methods of Sight Reduction will show that he played an important part in the history of the development of navigation in the early part of the century. I am now in possession of a summary of his career provided by the Ministry of Marine of Brazil through the good offices of Captain Max Justo Guedes.

Radler de Aquino was born January 23, 1878. The record shows that he was born in the United States although we have no explanation as to the circumstances or why his family, who were Brazilians were here. Apparently they returned to brazil shortly thereafter, where he spent his childhood years.

At the age of 17 he entered the Brazilian Navy as a cadet, known in their navy as an "Aspirante." This rank was preliminary to that of Midshipman which he attained in 1897. The rank system of the Brazilian Navy was similar to that of the U. S. Navy at the time which had a period after graduation from the Naval Academy where the graduate was called a "Past-Midshipman." In any event de Aquino entered the full officer ranks as a Second Lieutenant in 1899.

Radler de Aquino progressed through the ranks to be expected of an outstanding officer, being selected for Flag rank in 1951. During his career he served on many ships as well as numerous committees and special missions. His sea commands started with destroyers and included cruisers and battleships. He also served as a naval attache in the Brazilian Embassy to the United States on three separate tours; in 1908, 1912 and 1925.

The United States for many years maintained a Naval Mission in Rio de Janeiro which participated in many joint projects with the Brazilian Navy. Admiral de Aquino was several times assigned as liaison officer with that mission, and worked closely with a number of U. S. naval officers. He was also the author of several articles in the Naval Institute Proceedings and other publications in the United States.

A listing of his navigational works covers two and one-half legal-size sheets, the best known of which start with his 1910 "Altitude and Azimuth Tables." He continued to work in the field of navigation until his death in 1953. Many of his papers were first published in the United States and almost all had English translations and were available in this country. In 1927 the Naval Institute published his "newest" sea and air navigation tables for solving all problems by inspection. These were characterized as the simplest safest and most exact tables available at the time. Such works were widely used by most of the navys of the world as well as other mariners of the period.

Admiral de Aquino was a brilliant and imaginative writer who contributed importantly to the development of navigational methods. For the first third of the century his name was well known to navigators and his contributions ranked with other famous names of the period such as Weems, Ageton, Dreisonstok and Rust.^Zn to navigators and his contributions ranked with other famous names

HISTORY OF NAVIGATION

Early Time Measuring Instruments: The Ring-Dial

By John M. Luykx

I. GENERAL

Prior to the invention of mechanical clocks, chronometers and watches the primary means of measuring time at sea was by nocturnal at night and by ring dial and sand-glass during the day.

The ring-dial known also as the astronomical ring dial,the equatorial ring-dial and the universal ring dial is based on an original design attributed to Gemma Frisius in the Netherlands during the first half of the 16th Century. The ring dial was one type of a large number of portable sundials in use during this period most of which were of little practical use at sea because of the difficulty in orienting them in the plane of the observer's meridian.

II. DESIGN

The design of the ring-dial is based on the principle of the gnomon and its shadow whereby the passage of time is indicated during daytime by means of the sun's shadows cast by a rod onto either a flat or curved surface. The apparent motion of the sun is indicated by the movement of the sun's shadows across the surface. If a rod of fixed height (gnomon) is placed vertically in the ground, for example, the apparent sun's motion during the day can be followed by noting not only the direction of the sun's shadow but also its length. The rod will cast the longest shadows during early morning and late afternoon, shorter shadows in late morning and early afternoon and the shortest shadow at noon. (See figure 1) Due to the changing value of the sun's declination, however, the length and direction of the shadow cast by such a gnomon would vary appreciably during the year. The reasons for this follow:

a. At the time of the equinoxes when the sun's declination is 0 (March 21 and September 23) the apparent sun rises due east at 6 AM, crosses the meridian at noon and sets due west at 6 PM.

b. In the spring and summer (in the northern hemisphere) when the sun's declination is northerly, the sun rises north of east before 6 AM, crosses the meridian at noon and then sets north of west after 6 PM. In the autumn and winter (in the northern hemisphere) when the sun's declination is southerly, it rises south of east after 6 AM, crosses the meridian at noon and sets south of west before 6 PM.

From the variable characteristics of the sun's apparent motion throughout the year it is apparent that the sun's shadow cast by the gnomon, in the example above, will vary in accordance with the latitude of the observer and the season of the year.

III. CONSTRUCTION

The ring dial employs the principle of the gnomon to indicate apparent solar time. The dial consists of two brass rings and a brass plate containing a movable declination indicator with pinnule (pinhole gnomon) as shown in Figure 2. The outer ring represents the meridian of the observer on one quadrant of which is engraved a latitude scale from 0 to 90 in one degree increments. An adjustable (movable) suspension ring is attached to the latitude scale on the meridian ring to set the latitude and hold the instrument during observation. The inner ring is fitted so that it can be aligned in a plane at right angles to the meridian ring. The inner ring represents the equator and is engraved on its upper surface in 24 equal divisions to represent 24 hours; 0 to 12 AM on one semicircle and 0 to 12 PM on the other. The inner ring is also referred to as the hour ring. Attached to the polar axis of the meridian ring is a brass plate (the declination scale) containing a movable conical pinnule adjustable for the sun's declination or month and day of the year.

IV. OBSERVATION WITH THE RING DIAL

To take a time reading with the ring-dial:

a. Hold the instrument suspended from the suspension ring and set the latitude of the observer on the latitude scale engraved on the meridian ring.

b. Adjust the movable pinnule on the declination scale to the correct value of sun's declination (or date and month of the year).

c. Align the inner equatorial or hour ring at right angles to the plane of the meridian ring.

d. Holding the instrument by its suspension ring orient the meridian ring of the instrument freely to the meridian of the observer; i.e. north or south. A spot of light passing through the conical pinnule on the declination scale will then be projected on to the inner surface of the equatorial or hour ring. The position, on the inner ring, of the small sun spot projected by the pinnnule is the local apparent time of day.

The time indicated by the ring dial is apparent solar time and does not account for the equation of time or the difference in longitude between the longitude of the observer and that of the standard meridian of the observer's time zone.

To obtain the correct standard or zone time from the local apparent time as mesured by the ring dial apply corrections for longitude difference and equation of time as follows:

a. When the longitude of the observer is west of the standard meridian convert the longitude difference to time (1 = 4 minutes) and add to the ring dial reading. When the observer is east of the standard meridian subtract the time difference.

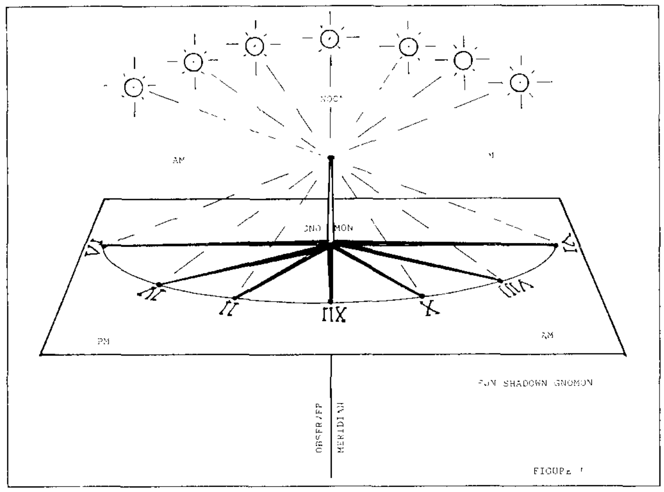
b. The equation of time (Eqt) is tabulated in the daily pages of the nautical almanac for each day of the year in minutes and seconds. When the time of the sun's meridian passage tabulated in the nautical almanac is earlier than noon (12-00) subtract the Eqt in minutes from the ring dial reading. When the time of meridian passage is later than noon, add the value of Eqt.

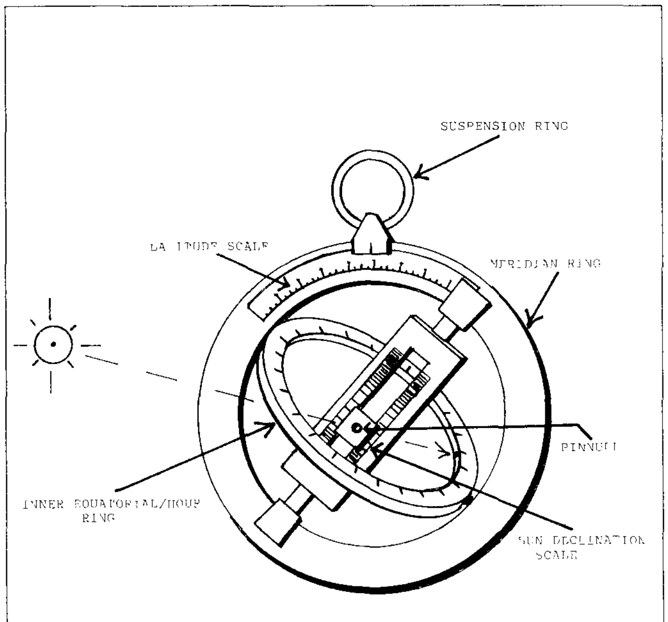
Standard time is equal to the ring-dial reading: (local apparent time) and the algebraic sum of longitude correction and equation of time correction. If an instrument correction (I.C.) exists, this correction must also be applied. (The instrument correction (I.C.) is applied in the same manner as watch correction is applied to a mechanical time piece.)

V. ACCURACY

To check the accuracy of the ring-dial from a position ashore, a set of 10 observations was made with a replica ring-dial in the author's collection.

The replica ring-dial is made completely of brass. The diameter of the meridian ring is 4" (102 mm), the diameter of the hour ring is 3-1/4" (80 mm), the length of the brass declination plate is 2-3/8" (59 mm), and the weight of the instrument is 8 oz. The results of the accuracy test were as follows:





THE RING DIAL

No. of Observations:	10
Date of observations:	Nov 1988
Approx. Location:	Wash.D.C.Area
Mean Error:	-6.0 minutes
Standard Error:	2.3 minutes
95% Error:	4.4 minutes
Range of Error:	7 minutes (-1 min. to -8 min)
Mean Index Corr:	+6 minutes

Note: Time readings were observed to the nearest 1/10 of an hour and then converted to minutes of time.

VI. OBSERVATIONAL HINTS

Practical experience with the instrument shows that the most accurate readings during the day occur when the vertical component of the sun's motion (early in the morning and late in the afternoon) is greatest and least accurate during the late morning, noon and early afternoon period when the horizontal motion of the sun is greatest and vertical motion least. To obtain the time at meridian passage several observations should be made by orienting the instrument first to the right and then left of the meridian and computing the mean of several sets of double (AM - PM) readings.

In windy weather it was found that suspending the instrument with one hand and holding a shield with the other is helpful in reducing the amplitude of swing caused by the wind. At sea the instrument loses its effectiveness because of combined wind and vessel motion but it is possible for a patient observer to obtain reasonably good readings by mentally averaging a long series of observations.

Because accurate time observations with the ring dial require that it be oriented exactly north and south, it is also possible on a calm day to determine the variation of the compass by using the ring-dial. This is done by comparing the orientation of the meridian ring of the ring-dial, during a time observation, with the compass card of a magnetic compass, and is best accomplished in early morning or late afternoon when the most accurate observations are possible. For best results the mean of several readings should be obtained.

In the next issue of the Navigator's Newsletter, the nocturnal will be described.

NAVIGATION NOTES

A Navigation Problem

by Roger H. Jones

Solution to the problem presented in Issue Twenty-Two.

24. Answer

David Burch, in his Emergency Navigation (reviewed in Issue No. 11), provides a useful little addition to the emergency bag of tricks. On Valentine's Day, February 14, the sun is late arriving at the Greenwich Meridian by 14 minutes. LAN (Local Apparent Noon) is at 1214. Three months later it is early by four minutes; LAN is at 1156. On Halloween, October 31, the sun is early by 16 minutes (LAN is at 1144), and three months earlier it is late by six minutes (LAN is at 1206).

These four dates in any year mark the turning points in the equation of time. The values at the turning points remain reasonably constant for two weeks on either side of the turn, and for other dates between the four turning points, the variation in the equation of time is proportional to the change in the date. Thus, for example, on April 20, the equation of time is such that LAN occurs at 1159. The time of LAN has shifted by 15 minutes from 14 minutes late on February 14th to one minute early.

February 14 plus two weeks = February 28. May 14 minus two weeks = April 30. February 28 to April 30 = 61 days. Fourteen minutes late to four early = 18 minutes. Eighteen divided by 61 = the slope of the curve. April 20 is 51 days after February 28. The correction is thus 51 x 18/61 = 15 minutes.

How accurate is this? It is accurate to within about a minute of time. Many a navigator has been in a situation where he or she would have gladly settled for this. This, of course, postulates the emergency where the navigator has a chronometer or other means of telling time, but has no Almanac or other means of determining the GHA of the sun. It's unusual, but not totally improbable.

Problem No. 25.

The lore of the sea is replete with simplifications of the astronomer's stock in trade. For example, many navigators know that any celestial body with a northern declination always rises north of due east and sets north of due west, and the opposite is true for a body with a southern declination. This is true regardless of where the observer is on the surface of the Earth. How far north or south of due east or west the rising or setting sun (or other body) appears is a function of the declination of the body and the observer's latitude.

The sun, the most easily observed celestial body, can be used to point the way to due east or due west if one knows a simple rule or two. There are two cases worthy of special note:

Case One is the situation where the navigator is within the Tropics (within the area from 23)27 North to 23)27 South latitude).

Case Two is the situation where the navigator is at a higher latitude than 23-27 north or south of the Equator.

In this problem, the navigator will be dealing with Case One. The problem that will appear in Issue Twenty-Four will deal with the Case Two situation.

Our navigator finds himself without a reliable compass. He is using the stars to steer at night. During the day he resorts to steering by wave and swell patterns, and by determining the direction of due east and due west from eyeball observations of the sun at rising and setting. Using knowledge of the Greenwich date and the declination of the sun, what procedure does he follow? For example, for a Greenwich date of December 24, the sun (viewed from anywhere in the Tropics) will rise and set how many degrees south of due east and west respectively?

A Simplified Technique for Coastal Piloting

by Edward J. Nesbitt

This article offers a simple way to solve the frequent problem of determining how far offshore one is during coastwise sailing, or what is the distance to a lighthouse or a buoy being passed.

Take two compass bearings in degrees on the point selected. The first should be when it's forward of the beam and the second when it's abaft the beam. Also record the times each was taken and then determine the rate at which the degrees changed per minute by dividing the difference in the bearings in degrees by the number of minutes between the readings.

You can find the answer to "how far away you are", in nautical miles, by simply dividing that number into the speed of your boat (over the bottom) in knots.

I've used the procedure for over five years but have never met anyone who knew of it before. I worked it out on an airplane flight after wondering how far away a particular mountain peak was and reasoning that there must be some way to compute it based on how fast the angle to it through the planes window was changing. I'd thought of this before on a sailboat but didn't then have time to doodle about it.

There is a slight error (about 10 percent) due to this simplification, which one could correct for by reducing the distance in the answer by 10 percent, and he'd be "bang on." But who knows a boat's speed that accurately anyway?

This method has two advantages over the procedure usually employed: it does not depend upon the boat maintaining a steady course (which no small boat does) and you don't have to make your readings when the point in question is at a precise angle to your course. You can start and end when you think of it, although to keep the error to 10 percent, its best to be within 10 to 30 degrees of abeam on both readings. But even if one reading was 40 degrees from abeam and the other 10 degrees, the error (still high) would be only 18 percent, and a conscientious navigator could compensate for it if he wanted.

A compass bearing is easily taken by a hand held compass, or by one on an RDF, or taken over the binnacle. Even if there is an error in the compass, it will be the same on both readings since they are only 30 to 60 degree apart. The boat can even deliberately change its course by 10 to 20 degrees between readings with neglible effect on the accuracy of the answer.

To the scientifically curious who may be wondering how this simplfied procedure works, it is due to the fortuitous coincidence that the rate of change of the trigonometric function of both the sine and the tangent, in units per degree, when the degrees are small, is .0175 (2 pi divided by 360), and that by 24 degrees, which is in the expected range of angles before and aft of the beam used in this procedure, the tangent rate of change is only .0185 which is only about 10 percent greater than 1/60. The procedure uses the boat's speed in nautical miles per hour, and the degrees change minute. The 60 minutes in each hour exactly cancels this out, at least with the 10 percent that the answer is high. This procedure is not therefore a discovery but rather the result of a simple observation. Just remember: divide the boat's speed by the degree change per minute.

MARINE INFORMATION NOTES

Digest of Notice to Mariners

by Ernest Brown

SPECIAL WARNING NO. 29

1. Mariners are advised to use extreme caution in transiting the waters surrounding Cuba. Within distances extending in some cases upwards of 20 miles from the Cuban coast, vessels have been stopped and boarded by Cuban authorities. Cuba vigorously enforces a 12-mile territorial sea extending from straight baselines drawn from Cuban coastal points. The effect is that Cuba's claimed territorial sea extends in many cases beyond 12 miles from Cuba's physical coastline.

2. The publication of this notice is solely for the purpose of advising United States Mariners of information relevant to navigational safety and in no way constitutes a legal recognition by the United States of the validity of any foreign rule, regulation, or proclamation so published. (March 1, 1962 updated January 1, 1982).

GEOGRAPHIC NAMES USAGE FOR DMAHTC PRODUCTS.

Whenever possible names used on DMAHTC charts and in DMA publications are in the form approved by the United States Board on Geographic Names. Generally, local official spellings are used for those features entirely within a single sovereignty, while names of countries and those features which are common to two or more countries or which lie beyond single sovereignty carry Board-approved conventional spellings (i.e. names in common American usage). When alternate names would be of value to the user, they may be shown for information purposes within parentheses. Important individual name changes are made to all revised charts as the opportunity permits. Geographic names or their spellings do not necessarily reflect recognition of the political status of an area by the United States Government.

CAUTION REGARDING APPROACH OF SINGLE VESSELS TOWARD NAVAL FORMATIONS AND CONVOYS.

A formation of warships or a convoy is more difficult to maneuver than a single ship. Therefore, the attention of masters is called to the danger of all concerned which is caused by a single vessel approaching a formation of warships or convoy so closely as to involve risk of collision, or attempting to pass ahead of, or through such a formation or convoy. All ships are therefore cautioned to employ the customary manners of good seamanship and where there is ample sea room, adopt early measures to keep out of the way of a formation of warships or convoy. The fact that in the interests of safety a single vessel should keep out of the way of a formation or convoy does not entitle vessels sailing in company to proceed without regard to the movements of the single vessel. Vessels sailing in formation or convoy should accordingly keep a careful watch on the movements of any single vessel approaching the squadron or convoy and should be ready, in the case the single vessel does not keep out of the way, to take such action as will best aid to avert collision.

PILOTAGE

1. Effective 01 Oct 88 Trinity House of London transferred the responsibilities for pilotage to the harbor authorities it once served. Pilot boarding grounds, regulations and ordering instructions will be subject to substantial change. Mariners are cautioned that the harbor authorities will advise how and where to obtain a pilot. Harbor authorities should be contacted directly or through the vessel's agent.

BOOK REVIEW

by Roger H. Jones

Small Craft Piloting & Coastal Navigation (Second Edition) by A.E. Saunders

Alzarc Enterprises Box 134, Bridlewood Mall 2900 Warden Avenue Scarborough, Ontario M1W (1988) 287 pages; (price not indicated in prepublication copy)

Al Saunders grew up sailing on the Detroit River and Lake St. Clair. For over ten years he was coxswain on a Canadian rescue cutter out of Frenchman's Bay, Ontario, and he taught the Canadian Power Squadron courses, from basic to celestial, for many years. He is an officer in the select Navigator's Club of Toronto, and is currently teaching the Canadian Yachting Association Celestial Navigation Course. With a strong engineering and science background at Ford and IBM, he has taken into his retirement a full)time devotion to teaching and writing about all aspects of navigation.

This second edition of Small Craft Piloting and Coastal Navigation takes its readers, in eighteen chapters, from basic regulations and rules of the road through position finding to a final cruise that illustrates and applies the many navigation topics covered. It is a book with especially well executed illustrations by John Sarafian. Author and illustrator have collaborated in a work that is a joy to read because it is complete but definitely not tedious. Not without its own wry humor and wisdom, it makes its points in often memorable style. For example, Saunders starts right off with ten words loaded with meaning (and he patiently explains the meaning): Keep Right! Give Right! Big Is Right! Nobody is Right! Any navigator who has ever pondered the rules of the road will recognize the basic truths in those ten words.

The same succinct, yet balanced, approach is taken with respect to buoyage systems, charts, compass work, plotting, bearings and fixes, leeway and drift, tides and currents, and the use of the sextant in coastal piloting. Saunders assumes nothing about his readers. Rather, he seems to assume that his job is to rethink all of the pitfalls that await a coastal navigator, to be meticulous where others have been vague, and to be succinct where other have been verbose. A nice case in point: his presentation of the running fix from bow and beam bearings includes an element that is often glossed over - precisely the specific sequential steps to use in employing the pelorus. It's a nice touch that is definitely a plus. Many readers can visualize the simple geometry of the situation, but how many have a clear mind's eye view of actual use of the pelorus as they repose in their fireside chairs?

This reviewer likes the seven Appendices also. The first deals with compensating a compass and with a simple home-made device for using the sun's shadow to place the vessel on exact reciprocal courses. The second deals with developing a deviation table, and others deal with elementary electronic navigation, methods of plotting and speed curves. These are nice, brief appendices which, like the text proper, are loaded with the wisdom born of experience. None of the seven is more than a few pages in length. Each is what an appendix should be (but often isn't): a useful addition that doesn't outweigh the text.

Here is a book that goes back to basics and then bridges the gulf to extend to more advanced aspects of coastal navigation. Its subject matter is timeless. Its style is fresh. It should be welcomed on either side of the U.S. - Canadian border and in far flung precincts as well. For those attracted to the Saunders style, in late 1988 he will publish a new work on celestial navigation using H.O. 249 and the planned new tables in the Almanac . This work will also include an appendix on sight reduction by non-programmable calculators as a back-up method.

NAVIGATION COURSES

This a new addition to the Newsletter in which we will announce various navigation courses from time to time as people write in asking us to do so.

1. John M. Luykx, a member of the Board of Directors, is offering a 12-hour course in Basic Celestial Navigation using the hand-held CN-2000 Celestial Navigation computer system.
It will be held in the Washington/Baltimore/Annapolis area during February and March. Please write or call for further details.

2. Mr. Luykx also has available for both students and practical navigators the ASTRA III sextant and a variety of bubble attachments which may be used with the following sextants:

Ebbco (plastic)
Davis (Plastic)
ASTRA III
Tamaya
Freiberger
Plath

Please write or call for description and price list.

J. M. Luykx
InfoCenter, Inc.
Box 47175
Forestville, MD 20747
301-420-2468

Address all correspondence to:
The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850
Telephone 301-622-6448

ORDER FORM

The Navigator's Almanac, 1989

Clip and send with check to The Navigation Foundation, Book Order Dept., P.O. Box 1126, Rockville, MD 20850.

Please send me _____ copy(ies) of The Navigator's Almanac, 1989. I have enclosed my check for $5.50 per copy ordered ($5.00 special members price, plus 50¢ postage and handling).

Name ________________________________

Address ________________________________

____

The Navigator's Almanac 1989

SAMPLE PAGE

For order information see coupon on facing page.

14 POLARIS CORRECTIONS
for Ho and AZIMUTH, 1989

GHA Aries (deg and min)
Column determines sign, upper row dHo, lower dAz

dHo	− / −	+ / −	+ / +	− / +	Azimuth Increment at Latitude of 0	30	50	55	60 (degrees)
0	125	125	305	305	0.8	0.9	1.2	1.4	1.6
1	124	126	304	306					
2	123	127	303	307					
3	121	129	301	309					
4	120	130	300	310					
5	119	131	299	311	0.8	0.9	1.2	1.4	1.6
6	118	132	298	312					
7	116	134	296	314					
8	115	135	295	315					
9	114	136	294	316					
10	113	137	293	317	0.8	0.9	1.2	1.3	1.5
11	111	139	291	319					
12	110	140	290	320					
13	109	141	289	321					
14	108	142	288	322					
15	106	144	286	324	0.7	0.9	1.2	1.3	1.5
16	105	145	285	325					
17	104	146	284	326			1.1		
18	102	148	282	328		0.8			
19	101	149	281	329					1.4
20	100	150	280	330	0.7	0.8	1.1	1.2	1.4
21	98	152	278	332					
22	97	153	277	333					
23	96	154	276	334					
24	94	156	274	336					
25	93	157	273	337	0.7	0.8	1.0	1.2	1.3
26	91	159	271	339				1.1	
27	90	160	270	340	0.6	0.7			
28	88	162	268	342					
29	87	163	267	343					1.2
30	85	165	265	345	0.6	0.7	0.9	1.1	1.2
31	84	166	264	346				1.0	
32	82	168	262	348					
33	80	170	260	350		0.6			1.1
34	78	172	258	352	0.5		0.8	0.9	
35	77	173	257	353	0.5	0.6	0.8	0.9	1.0
36	75	175	255	355					
37	74	177	253	357				0.8	
38	71	179	251	359		0.5	0.7		0.9
39	69	181	249	1	0.4				
40	66	184	246	4	0.4	0.5	0.6	0.7	0.8
41	64	186	244	6		0.4			
42	61	189	241	9	0.3		0.5	0.6	0.7
43	58	192	239	12				0.5	0.6
44	55	195	235	15		0.3	0.4		0.5
45	51	199	231	19	0.2	0.3	0.3	0.4	0.4
46	46	204	226	24	0.1	0.2	0.2	0.3	0.3
47	35	215	215	35	0.0	0.0	0.0	0.0	0.0

The closest value to GHA Aries is located in the table of altitude and azimuth corrections above. The row determines the corrections for altitude (dHo) and Azimuth (dAz). The sign of each correction is taken from the top of the column in which the GHA Aries is found. In this table the "preceeding value" specified by the dashes is always above.

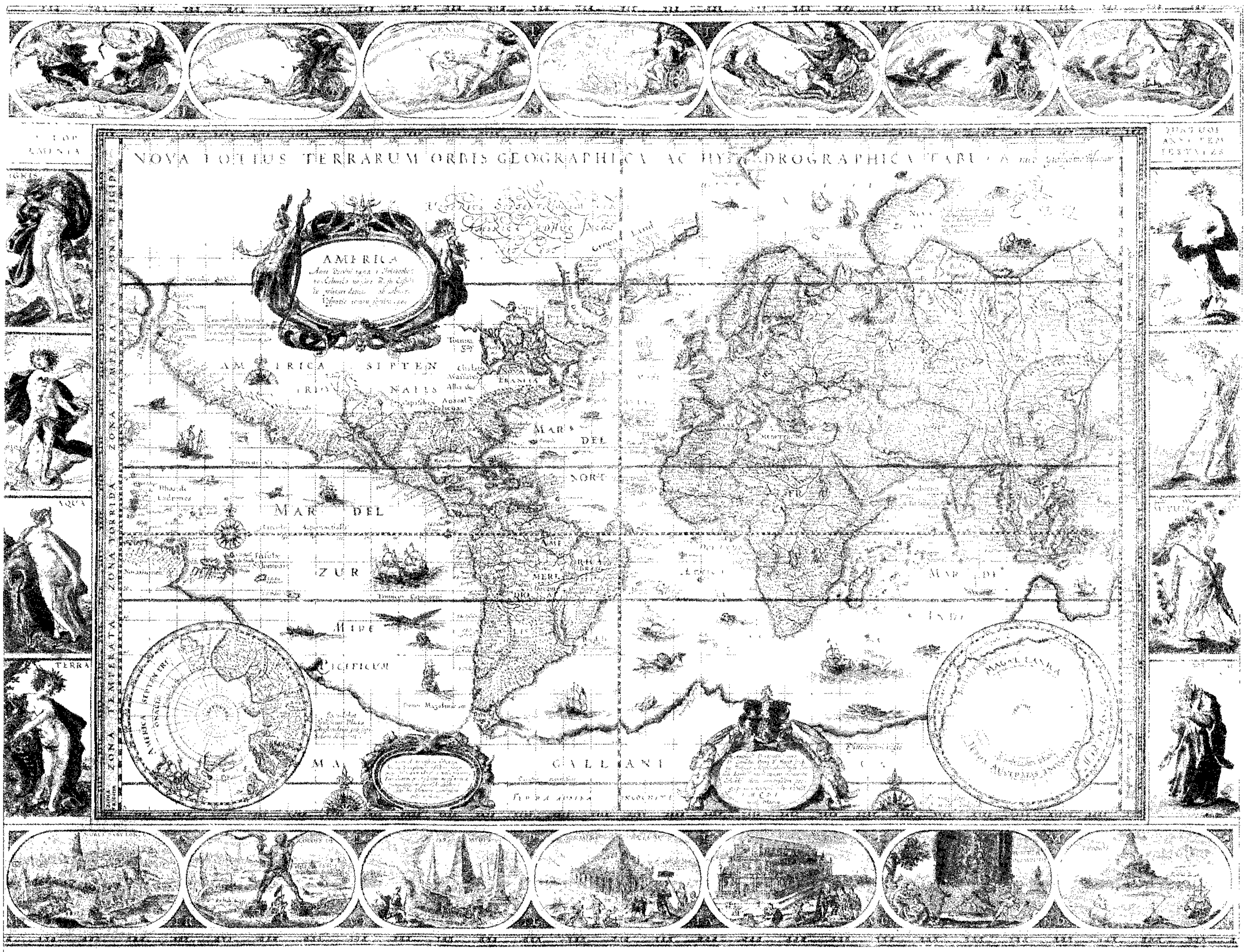
SUN

OCT.—MAR. App. Alt.	Lower Limb	Upper Limb	APR.—SEPT. App. Alt.	Lower Limb	Upper Limb
° ′	′	′	° ′	′	′
9 34	+10.8	−21.5	9 39	+10.6	−21.2
9 45	10.9	21.4	9 51	10.7	21.1
9 56	11.0	21.3	10 03	10.8	21.0
10 08	11.1	21.2	10 15	10.9	20.9
10 21	11.2	21.1	10 27	11.0	20.8
10 34	11.3	21.0	10 40	11.1	20.7
10 47	11.4	20.9	10 54	11.2	20.6
11 01	11.5	20.8	11 08	11.3	20.5
11 15	11.6	20.7	11 23	11.4	20.4
11 30	11.7	20.6	11 38	11.5	20.3
11 46	11.8	20.5	11 54	11.6	20.2
12 02	11.9	20.4	12 10	11.7	20.1
12 19	12.0	20.3	12 28	11.8	20.0
12 37	12.1	20.2	12 46	11.9	19.9
12 55	12.2	20.1	13 05	12.0	19.8
13 14	12.3	20.0	13 24	12.1	19.7
13 35	12.4	19.9	13 45	12.2	19.6
13 56	12.5	19.8	14 07	12.3	19.5
14 18	12.6	19.7	14 30	12.4	19.4
14 42	12.7	19.6	14 54	12.5	19.3
15 06	12.8	19.5	15 19	12.6	19.2
15 32	12.9	19.4	15 46	12.7	19.1
15 59	13.0	19.3	16 14	12.8	19.0
16 28	13.1	19.2	16 44	12.9	18.9
16 59	13.2	19.1	17 15	13.0	18.8
17 32	13.3	19.0	17 48	13.1	18.7
18 06	13.4	18.9	18 24	13.2	18.6
18 42	13.5	18.8	19 01	13.3	18.5
19 21	13.6	18.7	19 42	13.4	18.4
20 03	13.7	18.6	20 25	13.5	18.3
20 48	13.8	18.5	21 11	13.6	18.2
21 35	13.9	18.4	22 00	13.7	18.1
22 26	14.0	18.3	22 54	13.8	18.0
23 22	14.1	18.2	23 51	13.9	17.9
24 21	14.2	18.1	24 53	14.0	17.8
25 26	14.3	18.0	26 00	14.1	17.7
26 36	14.4	17.9	27 13	14.2	17.6
27 52	14.5	17.8	28 33	14.3	17.5
29 15	14.6	17.7	30 00	14.4	17.4
30 46	14.7	17.6	31 35	14.5	17.3
32 26	14.8	17.5	33 20	14.6	17.2
34 17	14.9	17.4	35 17	14.7	17.1
36 20	15.0	17.3	37 26	14.8	17.0
38 36	15.1	17.2	39 50	14.9	16.9
41 08	15.2	17.1	42 31	15.0	16.8
43 59	15.3	17.0	45 31	15.1	16.7
47 10	15.4	16.9	48 55	15.2	16.6
50 46	15.5	16.8	52 44	15.3	16.5
54 49	15.6	16.7	57 02	15.4	16.4
59 23	15.7	16.6	61 51	15.5	16.3
64 30	15.8	16.5	67 17	15.6	16.2
70 12	15.9	16.4	73 16	15.7	16.1
76 26	16.0	16.3	79 43	15.8	16.0
83 05	16.1	16.2	86 32	15.9	15.9
90 00			90 00		

DIP

Ht. of Eye (m)	Corrn (′)	Ht. of Eye (ft.)
2.4	−2.8	8.0
2.6	−2.9	8.6
2.8	−3.0	9.2
3.0	3.1	9.8
3.2	3.2	10.5
3.4	3.3	11.2
3.6	3.4	11.9
3.8	3.5	12.6
4.0	3.6	13.3
4.3	3.7	14.1
4.5	3.8	14.9
4.7	3.9	15.7
5.0	4.0	16.5
5.2	4.1	17.4
5.5	4.2	18.3
5.8	4.3	19.1
6.1	4.4	20.1
6.3	4.5	21.0
6.6	4.6	22.0
6.9	4.7	22.9
7.2	4.8	23.9
7.5	4.9	24.9
7.9	5.0	26.0
8.2	5.1	27.1
8.5	5.2	28.1
8.8	5.3	29.2
9.2	5.4	30.4
9.5	5.5	31.5
9.9	5.6	32.7
10.3	5.7	33.9
10.6	5.8	35.1
11.0	5.9	36.3
11.4	6.0	37.6
11.8	6.1	38.9
12.2	6.2	40.1
12.6	6.3	41.5
13.0	6.4	42.8
13.4	6.5	44.2
13.8	6.6	45.5
14.2	6.7	46.9
14.7	6.8	48.4
15.1	6.9	49.8
15.5	7.0	51.3
16.0	7.1	52.8
16.5	7.2	54.3
16.9	7.3	55.8
17.4	7.4	57.4
17.9	7.5	58.9
18.4	7.6	60.5
18.8	7.7	62.1
19.3	7.8	63.8
19.8	7.9	65.4
20.4	−8.0	67.1
20.9	8.1	68.8
21.4		70.5

Ht. of Eye	Corrn
m	′
1.0	−1.8
1.5	2.2
2.0	2.5
2.5	2.8
3.0	−3.0
See table ←	
m	′
20	7.9
22	8.3
24	8.6
26	9.0
28	9.3
30	9.6
32	10.0
34	10.3
36	10.6
38	−10.8
40	11.1
42	11.4
44	11.7
46	−11.9
48	12.2
ft	
2	1.4
4	1.9
6	2.4
8	2.7
10	3.1
See table ←	
ft	
70	8.1
75	8.4
80	8.7
85	8.9
90	9.2
95	9.5
100	9.7
105	9.9
110	10.2
115	10.4
120	10.6
125	10.8
130	11.1
135	11.3
140	11.5
145	11.7
150	11.9
155	12.1



AMERICA
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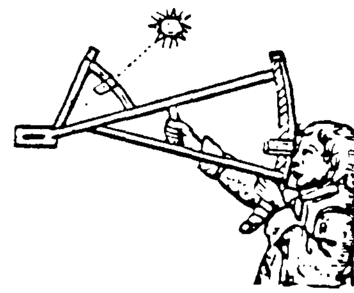
// THE NAVIGATOR'S NEWSLETTER

FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

ISSUE TWENTY-FOUR, SPRING 1989



This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

by T. D. Davies

Peary Investigation Continues

The period since the last Newsletter has been largely devoted to work on the Peary project commissioned by National Geographic. On 1 February we held a press conference at the Planetarium at the U. S. Naval Academy which received wide coverage, probably noted by most of our members. The story behind that follows.

The controversy over Peary's claim to have attained the North Pole started upon his return to civilization. He was confronted with a claim of earlier attainment made by a certain Dr. Frederick Cook. Peary had good reason to believe this was a fraud and set about destroying Cook's claim to protect his own. Cook's was indeed finally considered fraudulent, but the residue of this was a challenge of the credibility of his own achievement.

None of the other explorers who had been "racing" to get to the Pole for several centuries had ever had their claims of "farthest north" challenged. So it was no surprise that Peary, whose enterprise entailed major risk of not returning at all, did not keep detailed and verified records in the bound volumes that a scientific experimenter would have done. His navigation was simply that essential to getting there and back alive. Record keeping was minimal.

As a result Congressional hearings convened to consider honoring his achievement by promotion to Rear Admiral dragged out through 1911 and 1912 and provided a not very convincing record. Under some very hostile questioning almost all of the doubts that were the basis of the later controversy were brought out. Thus the hearings were the basis of a number of books challenging his attainment.

Our initial review of the vast amount of literature and information from the last 80 years seemed to indicate that none of this really "proved" that he was not at the Pole. The widely publicized article by Professor Dennis Rawlins, on the other hand, if true, did offer such proof. Consequently we took a hard look at that so-called suppressed document as our first step.

With a little research it became clear that Rawlins had badly misconstrued the data on the document, and that it actually was a worksheet of two time sights taken by Peary (in 1906) to calibrate his chronometers. The clincher was that one set of numbers, which Rawlins had deciphered and averaged as compass readings, were actually the serial numbers of Peary's watch-type chronometers. The other numbers included readings of time (to the nearest half-second) which had been considered as arc (sextant altitudes of the Sun), clearly impossible to read or measure with that accuracy.

With the importance of the document (had it been true) and our knowledge that it was completely wrong, I felt it was essential that we set the record straight at the earliest opportunity. Therefore we issued an interim report which set forth the facts and carefully dealt with every aspect of the earlier Rawlins stories. This was the basis of the press conference. The result is that Rawlins has now publicly conceded his error.

We now have commenced researching the considerable volume of data of the rest of the controversy with a view to thoroughly analyzing each aspect and leave "no stone unturned" as the charter we have from the Geographic calls for. I expect this will continue for several more months but we intend to turn out the most complete and authoritative report that we can, and hopefully eliminate further controversy by bringing to bear the most modern information and methodology.

The members of the Board have all contributed in one way or another and as you will see in the Reader's Forum we have one important contribution from a member. We will welcome others.

READERS FORUM

Andrew S. Horton of Springfield VA, Radio Operator of the Plaisted Expedition writes:

Enclosed, in response to your request in the last Newsletter, is Gerry Pitzl's account of navigating our expedition, Plaisted North Polar Expedition 1968, to 90 degrees north and another by him and our doctor on ice conditions encountered.

If you'd like further information Gerry's address is 1412 Fairmount St., St. Paul, Minnesota 55105. (Other names, addresses and phone numbers are also listed). You might like to touch base with men who've been there.

The controversy seems to have shifted from Peary-Cook to Peary-Plaisted as to who was first at the Pole (I expect Cook's admirers will be hiring someone to try to bolster his case) It will probably go on forever - discovery of data rebutting Peary, then data to rebut that, then data rebutting that data, etc., etc.

I don't believe sight reductions even if perfect and placing Peary at the Pole will settle it. "Figures don't lie but liars can figure" it's said, although Freidsen said Cook was "a gentlemean and a liar, and Peary was neither."

You have to look at what Peary said he did - the incredible mileage on the return trip. That is a big factor in assessing credibility of claims and computations. I don't know - or expect to - if Peary made it. I just know that we did and feel that priority at the Pole should go to him who can prove it - Plaisted.

(Ed. Note: We are happy to have a member of that intrepid expedition as a member of the Foundation. The information on Ice Conditions and navigation will be very useful. Hopefully we will be able to shed light on this long term controversy, in which case the resolution of priorities may be resolved).

Norman G. Cubberly of 115 Marine Circle, Grafton, VA, 23692 writes:

I have just turned in my ancient TI-59 calculator for a new TI-95. This was done after much soul searching as I have so many programs running off the TI-59 Navigation module. However, the '59 is almost unrepairable and its turn in to Texas Instruments for a TI-95 returns about a 58% price cut for the new model. It is a super calculator for navigation using the same system, much modernized, as the '59. However it has, as yet, no navigtion cartridge. I would be interested in contacting persons who are using this calculator for navigation. One program, using over 1000 steps from the Marine Navigation module, is germane to the below comments.

I noted recent comment on the use of Great Circles and have a few remarks:

The use of the initial great circle course in navigation is faulty. The initial course is useful only for long distance bearings, such as for positioning a radio antenna or for determining the direction of Mecca. A quick inspection on any chart projection will quickly convince the student that he is on a tangent to the great circle and not on a cord. When one plots points in longitude on a great circle, one connects them with cords. The tangent instantly puts one poleward of the track. Years ago on the old AFRICAN STAR, neither the Master nor the Navigator (2nd Mate) could understand why the vessel drifted more and more poleward of the original great circle after setting the ship on its daily "initial course." This angle should probably be called "Great Circle Bearing" or some such. Actual practice in great circle sailing has shown that I can simply steer about 4 degrees equatorward and approximate the cord. Of course by the terms cord and tangent, I refer to their appearance on a projection. On the real ball they are loxidromes that spiral the "right way" (toward) or the "wrong way" (away) from the desired great circle track. Nowadays it is easy to cheat by using your Satnav or Loran C set by changing course continuously as the set does all the hard work continuously.

I seldom see mentioned the use of the "image curve," although it has appeared on the back of pilot charts more than once. Years ago I set up a TI-59 calculator program to easily determine the image curve on the large scale of a plotting sheet and it paid off handsomely. Briefly, the image curve is the mirror "image" of the rhumb line plotted to poleward of the great circle. So sailing between the rhumb line and the image curve simply insures that the distance travelled will never be greater than the rhumb line distance and may never approach the great circle distance.

In one case, I was responsible for a small 8.5 knot research vessel sailing from south of Hawaii to San Diego. Currents and winds at the starting point were all adverse but became moderate to favorable the further north the vessel sailed. By allowing the ship to be set northward but by staying within the bounds of the image curve, the more favoring conditions were met several days early and 36 hours was saved on the passage. The difference between the rhumb line and the great circle was about 40 miles, but the difference in latitude at the mid-point to the image curve was about 180 miles. I now sail much of the time in extreme northern latitudes where the difference between these three curves is of exaggerated proportions.

D. B. Ziegler of Frankfort, MI, writes:

I am looking for help and information with respect to celestial sights and the sextant/eyeglasses combination.

I am an eyeglasses wearer and find it unsatisfactory and almost mechanically impossible to get consistently good sights wearing glasses. As a consequence I remove my glasses for and rely on some correction from the scope magnification. This is fine for the sun, moon and most planets but the stars are becoming more of a problem. Uncorrected right eye is 20/200 and a focal condition makes any concentrated light source appear double. You can appreciate the problem of trying to guess which bouncing pinpoint of light to bring down to an oftentimes uncertain horizon.

It would seem there are two possible solutions. One would be a single contact lens and the other being a scope optically ground to the sighting-eye correction. I would appreciate any information, comments or other solutions you or your staff might have.

Thank you for your attention to the above.

(Ed. Note: Normally eyeglass-wearers should remove them and adjust the focus of the telescope to compensate for near or farsightedness. The description of the right eye as 20/200 with a double image is hard to deal with. It would seem that a method of holding the Sextant to permit using the left eye might be necessary. Any readers have this problem ?)

William O. Land of Norristown, PA, writes:

I want to thank you for including me in your news conference at the Naval Academy last Wednesday. The material you presented cleared up all questions I had about the Washington Post article, and I look forward to the results of your further research into the archives.

I know you were extremely busy last Wednesday when I gave you the work forms for the Concise Sight Reduction Tables, 1989 Nautical Almanac pages 284 to 318, so I'm explaining my thoughts on why I made them.

I designed them for beginning students in my Celestial Navigation classes. Therefore they are detailed to help them eliminate errors. They are solved by starting at the top and proceeding every step and half-step to the bottom. Experienced navigators may want to skip lines or do some of the steps "in their heads."

Since this work form is new it may have a few bugs or typos. I'll be pleased to have any comments or corrections you wish.

(Ed. Note: the form is included in reduced form).

SIGHT REDUCTION WORK FORM. For use with the Concise Sight Reduction Tables, 1989 Nautical Almanac pages 284 to 317. Given: Lines 1, 2, 3, 11, 15, 36, 37, 40. Solve for Azimuth and Intercept Lines 34 and 45. Refer to Steps 1 thru 8, pages 284 and 285.

Step	Entry	Line	Value		Instructions
	STAR	1			
	G.M.T. Date	2			
	G.M.T.	3	h m s		
Step	G.H.A. ♈ (h)	4	° . '		Enter N.A. with Lines 2 and 3(h).
	G.H.A. ♈ (m)	5	° . '		Enter N.A. with Line 3 (m).
	S.H.A. ☆	6	° . '		Enter N.A. with Lines 1 and 2.
	G.H.A. ☆	7	° . '		Add Lines 4 + 5 + 6.
	Correction	8	° .		Need ± 360°?
	Correction	9	° . '		Need ± 60'?
	G.H.A. ☆	10	° . '		Add Lines 7 + 8 + 9.
	Assumed Long.	11	° . '		(W = -)(E = +).
	L.H.A. ☆	12	° 00.0'		Add Lines 10 ± 11.
	Correction	13	°		Need ± 360°?
	L.H.A. ☆	14	° 00.0'		Add Lines 12 + 13.
	Assumed Lat.	15	° 00.0'		Whole nearest integral °
Step 2	1st Entry	16	Enter Sight Reduction Table with Lat. (Line 15) and L.H.A. (Line 14).		
	A	17	° '	A° °	A° nearest whole °
	B (see note)	18	° '	A' 0° '	A' Same as A minutes in Line 17.
Step 3	Dec. ☆(see note)	19	° '	Z_1 . °	Z_1 Same sign as B (Line 18).
	F (Add 18±19)	20	° '	F° °	F° = Nearest whole ° of F.
	(See #20 note)	21		F' 0° '	F' = Same minutes as F (Line 20).
Step 4	2nd Entry	22	Enter Sight Reduction Table with A° (Line 17) and F° (Line 20).		
	H	23	° '	P ° ' ‖ P° °	P° = Nearest Whole ° of P.
		24		Z_2 . ° ‖ $Z_2°$ °	$Z_2°$ = Nearest Whole ° of Z_2.
Step 5	1st Entry	25	Aux. Table N.A. Page 316 enter with F' (Line 21) and P° (Line 23).		
	Correction₁	26	'		See note below for ± information.
		27	° '		Add Lines 23 ± 26.
6	2nd Entry	28	Aux. Table N.A. Page 316 enter with A' (Line 18) and $Z_2°$ (Line 24).		
	Correction₂	29	'		Correction is (-) if A' (Line 18) < 30'.
7	Hc	30	° '		Add Lines 27 ± 29.
Step 8	Z_1	31	. °		From Line 19.
	Z_2 (See note)	32	. °		From Line 24.
	Z	33	. °		Add Lines 31 ± 32.
	Zn	34	. °	Zn °	Same as H.O.229 method. (See note).
Sextant Correction	Sextant Corr'n.	35	+ ‖ -		
	Dip (')	36	xxx ‖ . '		Feet or Meters?
	I.C.	37	. ' ‖ . '		(On = -)(Off = +).
	Totals	38	. ' ‖ . '		Add Lines 36 ± 37.
	Difference	39	. '		Don't forget the + or - sign.
	Hs	40	° . '		Sextant reading Hs.
	Ha	41	° . '		App. Alt. Add Lines 39 ± 40.
	☆ Ha Corr'n.	42	. '		From App. Alt. ☆ Table in N.A.
	Ho	43	° . '		Add Lines 41 ± 42.
	Hc	44	° . '		From Line 30
	(a) Intercept	45	. '		A or T? Ho Larger = T

NOTE Line 18. B is (-) if LHA (Line 14) is greater than 90° and less than 270°.
Line 19. Dec. is (+) if Lat. (Line 15) and Dec. (Line 19) are SAME name. CONTR = (-).
Line 20. Add Lines 18 ± 19. Do NOT include Line 17 in addition. If F > 90° it is (-).
Line 26. Correction is (-) if F° is less than 90° and F' is greater than 29'. Line 20 &21.
And is (-) if F° is greater than 90° and F' is less than 30'. All else = (+).
Line 32. Z_2 (Line 32) is (-) if F (Line 20) > 90°. If F is (-), Z_2 = 180° - Z_2.
Line 34. N.Lat. LHA greater than 180°..Zn=Z. LHA less than 180°..Zn=360°-Z. ‖ S.Lat. LHA greater than 180°..Zn=180°-Z. LHA less than 180°.....Zn=180°+Z.

Workform by W.O. Land 1521 W. Main St.(F-3) Norristown Pa. 19403

NAVIGATION BASICS REVIEW

The Personal Equation, Variation in the Dip Correction, Random Error in Sextant Observations

by John M. Luykx

The two major sources of error in celestial observations are a) the observer's personal error in actually measuring the the altitude of a celestial body with the sextant and b) the variations from normal dip caused by changes in refraction due to air/sea surface temperature.

Personal Error

It is known that the technique, quality and accuracy of observation will vary from observer to observer. Each individual observer, however, can determine the quality of his observations by conducting a comprehensive series of tests over, generally a long period of time and with several celestial bodies. Such tests will provide significant results when the observer is satisfied that:

a. the sextant I. C. is correctly computed
b. the sextant was in correct adjustment
c. the observer's height of eye is accurately known
d. the sextant was not "canted" during observation

e. a "good" observation was made
f. the most accurate sight reduction method was em ployed
g. no computational errors were made

A series of tests under the above conditions should be conducted by the observer:
a. with different celestial bodies
b. at various altitudes
c. under various conditions of weather and sea
d. at different places

The altitudes obtained during the test should then be compared with computed values obtained by computer, sight reduction tables or mathematical computation. The difference between the two (observed and computed values) may be considered the personal error and applied with sign reversed to future observations as a personal correction.

Dip Error

The dip correction (height of eye) tabulated on the inside front cover of the Nautical Almanac is based on the following formula which incorporates a standard value for atmospheric refraction;

$$D=0.97\sqrt{h}$$

where D = minutes of arc
h = height of eye in feet

Significant variations in dip error caused by non-standard refraction may be experienced when large differences between sea and air temperatures at the surface occur. Because non-standard refraction is probably the single most important source of error in sextant observations, a considerable amount of research has been conducted to determine the mean values of refraction (used in the Dip tables), the conditions under which values differ from the mean and the value of such differences.

The results of this research indicate generally that:

a. When the surface air temperature is less that the surface water temperature, the value of dip is greater than normal.

b. When the surface air temperature is greater than the surface water temperature, the value of dip is less than normal.

When significant variation in air/sea surface temperature exists, corrections to the standard value of dip in the Nautical Almanac may be applied as follows (h. of e. 10' - 30'):

1) For every ten degree decrease of the surface air temperature below the value of the surface water temperature, the value of the tabulated dip is to be increased by 1 minute of arc.

2) For every ten degree increase in the surface air temperature above the value of the surface water temperature, the value of dip is to be decreased by 1 minute of arc.

Dip meters of varying types have been developed during he past 100 years to measure the actual value of dip for normal heights of eye and for any instant of time. These instruments are optical instruments which measure the vertical angle from a point on the horizon through the observer's zenith to the opposite point of the horizon. This angle subtracted from 180 and divided by 2 is equal to the actual value of dip at the time of observation. An instrument of this type developed by Admiral Davies, President of the Foundation, is described on pages 7 - 8 of issue 18 of the Newsletter (Fall 1987).

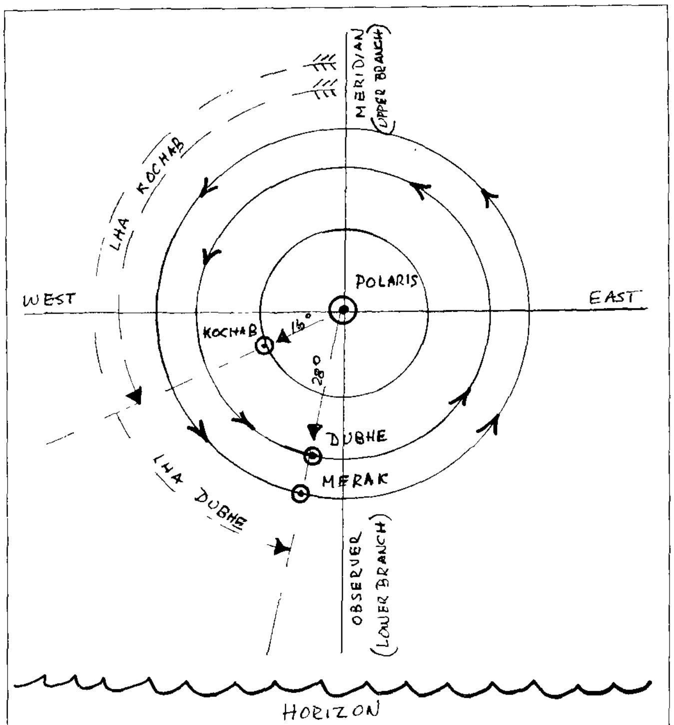
Random Error

Individual observations by sextant taken on board a rolling, yawing, pitching vessel often contain large values of random observational error.

To improve the reliability of position lines from such sextant observations, it is often recommended that a series of observations be taken and the results averaged to reduce random error. The mean time of observation and the mean value of altitude for the series of observations are then computed and used in sight reduction. Individual obsrvations of the series may be plotted on cross section paper (altitude versus time) and a curve "faired" through the series of plotted points of observation. Unless the observations were made at or near the time of meridian passage, the faired curve should be nearly a straight line. Any point along the curve may be used as the observation. The slope of the curve of observations when compared with the slope of a curve of altitude change, computed for the time of observation will further indicate the accuracy of individual observations in the series.

The average of a series of observations was standard practice for celestial observations taken from aircraft. Accurate and reliable mechanical averaging devices for aircrafty sextants especially during World War II by C. Plath in Germany, Henry Hughes in England and by Bendix and Kollsman in the Unted States.During World War II, the Japanese sextant manufacturer, Tamaya, developed a mechanical averager which was installed as an integral part (not removeable) of a marine sextant of the Gago Coutinho type.

HISTORY OF NAVIGATION



a. The circumpolar paths of Kochab, Dubhe and Merak are counter-clockwise.
b. In one solar year, the three stars make one complete revolution along their circumpolar paths.
c. The Local Hour Angle (LHA) of a star is measured counter-clockwise from the upper branch of the observer's meridian.

Figure 1

Early Time Measuring Instruments: The Nocturnal

By John M. Luykx

During the 16th, 17th and 18th centuries one of the principal instruments used to determine time at night was the Nocturnal. It was described in general terms (and occasionally in great detail) by many of the well-known contemporary writers of the period including Martin Cortes (1560), Michiel Coignet (1581), Lucas Janszoon Wagenaer (1588), Thomas Blundeville (1590) and Edmond Gunter (1607).

The operating principle of the Nocturnal was based on the continually changing positions of the pointer or "guard" stars, Dubhe and Merak, in the constellation Ursa Major (Great Bear - Big Dipper) and the pointer star, Kochab, in the constellation Ursa Minor (Little Bear - Little Dipper), all three of which are circumpolar stars which follow an apparent counter-clockwise rotational path about the pole star, Polaris. This circular circumpolar path is approximate since the pole star then, as now, is not located exactly at the north celestial pole (Figure 1). Kochab and Dubhe are the two closest bright stars to Polaris. The polar distance of Kochab is approximately 16 and that of Dubhe approximately 28 .

Many years prior to the first use of the Nocturnal, astronomers, as well as many navigators, had already become familiar with methods of roughly reckoning time at night by the stars, especially Kochab in Little Bear. The midnight position of Kochab relative to Polaris was first memorized for each month of the year. The actual observed position of Kochab about Polaris was then compared with the memorized midnight position. The difference in position provided a rough estimate of the time. This so-called sky-clock contained Polaris at its center and the passage of time was indicated by the rotation of the stars, Dubhe, Merak and Kochab, in their circular circumpolar path counter-clockwise about Polaris. An imaginary vertical line drawn through Polaris represented the meridian of the observer. The upper branch of the observer's meridian extended upward above Polaris and the lower branch extended downwards below the pole star. An imaginary horizontal line drawn through Polaris indicated east to the right and west to the left. Since time at sea was based on the solar day (Solar Time), the pointer stars, Dubhe, Merak and Kochab, made one complete revolution about Polaris each solar year.

Based on the above data available during the 16th and 17th centuries,

1. that in mid and high northern latitudes the stars, Kochab, Dubhe and Merak, followed a visible complete (though approximate) apparent counter-clockwise circumpolar path about the pole star each solar year, and

2. that the midnight position (at any location on the earth's surface) of any one of these stars could easily be predicted for any time of the year,

It became possible to construct a basically simple device or instrument using this information which could tell the time at night to significantly greater accuracy than ordinarily possible with the unaided eye. The resulting device was the Nocturnal, first used during the mid-16th century by the Spaniards and Portugese.

The typical Nocturnal (Figure 2) was made of wood or brass and consisted of a) a circular calendar baseplate with handle, b) a rotating outer time dial and c) a pointer alidade. The outer dial and pointer alidade rotated about a common shaft set into the baseplate which was hollow and contained a sighting hole 1/4 to 3/8" in diameter. The circular baseplate was appoximately 6" to 7" in diameter, the circumference of which was engraved in 12 monthly divisions (counter-clockwise) with each month further divided into six 5-day intervals. The date 1 January was marked at the upper end of the baseplate

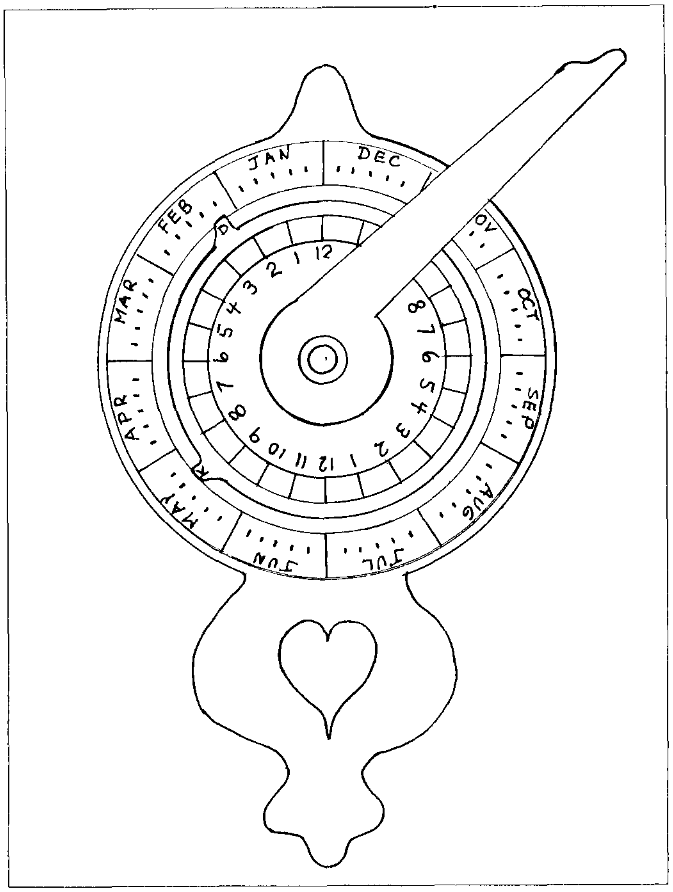


Figure 2

opposite the handle. The periphery of the outer dial approximately 5" in diameter was marked by a scale divided into 24 hourly segments, each further subdivided into 1/4 hour intervals. The hour scale was engraved 1 to 12 and then 1 to 12 again. The outer edge of the outer dial was marked with a small "horn" or projection in two places representing the right ascension (RA) or Sidereal Hour (SHA) of the pointer stars of the two constellations, Great Bear and Little Bear; i.e. Dubhe, Merak, and Kochab. The pointer alidade was fitted on top of the outer dial to rotate about the common hollow shaft.

Observation with the Nocturnal

To make a time observation with the Nocturnal, the observer:

FIRST: Selected the constellation to be observed, then rotated the outer dial and set the "horn" representing that constellation (located on the periphery of the outer dial) to the correct date on the baseplate.

SECOND:. Held the Nocturnal at semi-arm's length facing the pole star such that the star Polaris was visible through the sighting hole in the center of the instrument. During operation the observer also held the plane of the instrument perpendicular to the line of sight as best he could with the instrument axis oriented vertically; i.e. aligned with the observer's meridian.

THIRD: While holding the instrument as above, the observer rotated the pointer alidade along the outer "time" dial and aligned it with the pointer star (or stars) of the selected constellation. The time (solar time) was then indicated by the alidade on the outer or time dial. Although time could be read or estimated to 5 minutes, normal accuracy was to approximately 1/4 hour.

Technical Data

The replica nocturnal in the author's collection is made of bass wood and is similar in design to the three instruments described below:

Fig. 19, Page 147 of Taylor's, The Haven-Finding Art (1971)

Page 115 of Hewson's, A History of the Practice of Navigation
(1951)

Pages 164 and 165 of Randier's, L'Instrument de Marine (1977)

Dimensions:
Baseplate diameter: 6", thickness 1/4"
Baseplate length including handle: 10"
Outer time dial diameter:4-1/2" with horns 5-1/2"
Length of pointer alidade from shaft: 6"
Weight:5 oz.
Diameter of sighting hole: 1/4"

The Nocturnal was also employed as a device to compute the altitude correction applied to the apparent altitude of Polaris to obtain the latitude of the observer. For this purpose an additional horn or mark was installed on the outer time dial marked to show the right ascension or sidereal hour angle of Polaris. At the time of observation, the difference in RA or SHA of Polaris with that of the pointer stars (used to compute time), when converted to time and applied to the time of observation, provided a means to compute this correction. As long as the polar distance of Polaris was accurately known, the error in computing this correction using the Nocturnal was not much more than approximately 5 minutes of arc.

NAVIGATION NOTES

Notes on the Sextant

By Paul M. Anderton

I. The index mirror should be adjusted by aligning the reflected image of the arc with the arc generally according to the illustrations in Bowditch, p. 408, and Dutton, p. 473. The fine point is to look into the mirror at a large angle with the plane of the glass so that, as nearly as possible without producing an excessively long horizontal gap between the reflected and direct arcs, you bring the reflection of the 120 degree end into continuity with the zero end. The adjustment is made more accurately thus than by looking into the mirror at a small angle with its plane.

Keeping in mind Raper's precept that "The adjusting screws are never to be touched except from necessity," p. 182, you may verify this note by experimenting on a hand mirror.

The theory is given in Simms, p. 9. The better to visualize Simms's geometry—his book is not readily available—consider the case as though it were the plane of the sextant that is out of perpendicular to the index glass. Now imagine the glass and plane of the instrument to remain where they are in space as the ghostly image of the arc is eased into perpendicularity to the glass. The planes of the original arc and ghost meet as on a hinge wherever your line of sight strikes the arc. The farther from that vertex the greater the linear distance subtended by the angle of error, that is, the angle at the hinge between the real arc out of adjustment and the ghostly arc in adjustment. Therefore to perceive the error at its greatest manifestation put your vertex, or hinge, near the zero end and juxtapose the reflection from the most distant point on the arc.

Simms also shows that it is well to place the eye as low and near the glass as possible.

II. The instructions on collimation found in Bowditch, p. 410, and other works on navigation being given now exclusively in terms of the telescope adjustment, there is a lack of emphasis on the generality of the requirement that the line of sight be parallel to the plane of the arc; and a yachtsman or small ship navigator who observes sans telescope cannot be blamed for failing to recognize that a principle applies here. It used to be that where one would make the telescope parallel the plain sight tube would evidently be parallel too, and all the more that was necessary was in both[1] instances to observe in the center of the field. Inasmuch as modern sextants do not come equipped with the sight tube, one either struggles with the telescope or substitutes the big hole in the rising piece, untaught in the error latent in the use of the hole.

The error is readily demonstrated: bring two stars a large angular distance apart, say 110 degrees, into coincidence at the center of the hole; then shift the instrument so that you see the stars through the hole near a side of it. The theory[2] is set forth in Simms, p. 14, and, more simply, in Chauvenet, p. 112.

The writer engaged a machinist to turn and thread a brass plug with a one-quarter inch hole drilled in the longitudinal axis of the plug, to be screwed into the rising piece in place of the telescope. The center of the hole is set the same distance off the plane of the instrument as the edge of the silver on the horizon glass, the contact being made on the edge of the silver.

---

1. Shift the rising piece if necessary, to maintain the contact in the center of the telescope field albeit off center of the horizon glass.

2. The excellent Captain Lecky erred at p. 721, where he seems to have assumed that only the star telescope is subject to mis-collimation.

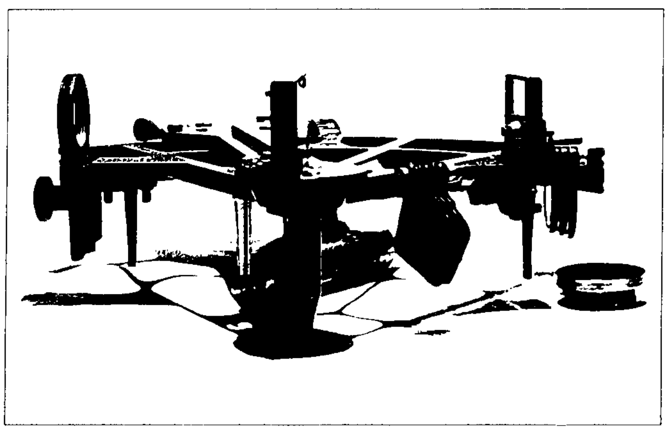


Figure 1
Wrong Method
Note aperture-plug lying on table. (Photo: August H. Kruelle).

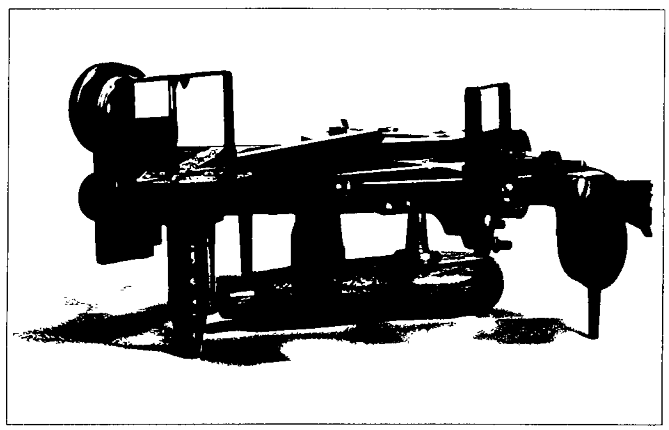


Figure 2
Right Method
Note aperture-plug shipped for use (Photo: August H. Kruelle).

Distance by the Graphic Method

by Anthony L. Kelley

(Another Answer to Problem #18 from the Spring '87 Issue #16)

The Spring 1987 BACKSTAFF Navigation Problem #18 was to find the distance and course from DR L 35 degrees 30'S and Lo 17 degrees O'E. to L 3 degrees 51'S and Lo 33 degrees 49'W. The problem was: What non-chart method may be used to determine the initial great circle course, the great circle course changes on succeeding days, and the distance to the destination?

While more accurate methods can be used to determine the Initial Course and Distance, it can be done by a graphical method also. The method uses the Diagram on the Plane of the Celestial Meridian. The departure is the Observer's location, and the destination is the GP of the body and the Local Hour Angle is the Difference in Longitude (LHA = DLo) between the two locations. If you have never seen one of these, or wish a review, read Bowditch H.O. #9 article 1432 and 1433, or a shorter Dutton article 1917.

To construct such a diagram we take a graduated circle of a small area plotting sheet, and label it with the fixed elements that make up the Horizon System — N, S, Ze and Na— for the North Horizon, South Horizon, Zenith and Nadir. These positions are shown in the attached figure.

Next we add to this diagram the elements common to the Celestial System — Pn, Ps, Q and Q' — for the North Pole, the South Pole, the Equator on the Upper Branch of the local medidian and the Equator on the Lower Branch. The positioning of these celestial components involves certain of the values from our point of departure. The Latitude value is used to rotate the elevated pole up from its horizon. In our case, Ps is positioned 35.5 degrees up from the Southern Horizon, the line from there through the center will set the North Pole Pn, at 35.5 degrees depressed below the North Horizon. With this line in place, we can draw the Equator at right angles to it through the center. Label the portion of the Equator that is above the Horizon with the letter Q and the portion of the Equator below the Horizon as Q'.

We have now set the diagram and must proceed to use other information to add lines and curves. In sight reduction, the regular usage of this diagram, we calculate the LHA value of a body from our celestial meridian and draw in its Hour Circle. In our case we have to determine the angular distance from our meridian to the meridian of the destination. The difference in Longitudes (DLo) is the value we seek and we must add the Eastern Longitude to the Western Longitude to get the total angular distance. Knowing this we measure from Q counter-clockwise by DLo degrees and draw a dotted line perpendicular to a position on the Equator. This position is normally on the Hour Circle, but in our case

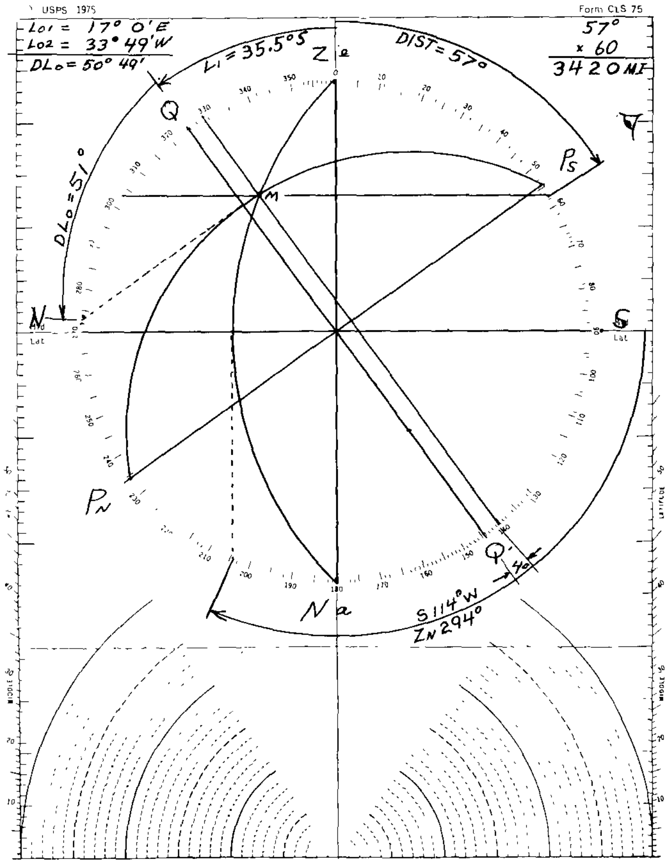


Figure 1

it is on the Meridian of our destination. Draw a smooth curve which passes through Pn, Ps and that point on the Equator. On this curve is the location of the destination. To place the city exactly, we use its latitude as the final input value. Construct a line parallel to the Equator at an angular distance equal to the latitude of our destination. This is 3.5 degrees to the South — towards Ps. Where this line intersects the curve is our destination.

Our next drafting task is to add a curve through the Ze, the destination and Na. This curve would be the vertical circle in a sight reduction process, but for us it will be used to determine the initial course and the distance. After it is drawn, drop a perpendicular from the curve's intersection with the horizon to the other edge of the circle.

Our next activity will determine the distance using values from the Horizon System. Normally the distance from an observer (located at Ze) to any celestial body is D=90-H. H is the altitude measured from the horizon to the body. In our case the destination's location is used and a horizontal line is drawn through it to the outer edge of the circle. Measure the angular distance up from that line to the Zenith — it is 90 degrees - H. Convert that value to Nautical miles by multiplying by 60. All mathematical feats are shown on the top of the diagram.

Lastly we must determine the initial course in the Horizon System. Z is always measured from the local meridian to the vertical circle, so we start at the South Horizon 'S' and measure to the perpendicular dropped from the Horizon. The value of 114 degrees is obtained. The usual conversions must be made from Z to Zn, and in our case we are in the Southern Hemisphere and Z = S nnn DLo or S 114 W. To get a direction from North we would add 180 degrees to the value to get Zn = 294 degrees.

So far we have determined our initial course and distance. The daily change in course could be determined by redrawing the diagram every day — a most onerous task. One degree of longitude change (60 miles at the Equator, less at 35 degrees South), would produce a small change in the course, i.e., less than a degree per day. It may be wiser to redraw every few days to determine a new course and distance.

As you may guess, the limiting condition comes as you approach your destination. With a decreasing DLo the meridian of the destination approaches Q and a small change in DLo creates a large change in Azimuth Angle. It may be better to go to the destination's latitude and run down the Latitude on the final few days of the journey.

A Navigation Problem

by Roger H. Jones

Solution to the problem presented in Issue Twenty Three
Answer

In "Case One", the navigator, "embarrassed" by the lack of a reliable compass, would employ the "Tropics Rule". This is restricted to the tropics because generally the direction of a rising or setting body depends upon the latitude of the observer and the declination of the body. However, for one who is in the tropics (within 23 degrees, twenty—seven minutes of either side of the Equator) the change in direction due to the observer's latitude is so slight that it may be generally ignored. The rule is simple. From anywhere within the tropics (north or south), the sun's declination (or that of any other body) will be equal to the number of degrees that it rises or sets north or south of due east or west.

On December 24th, the declination of the sun is between 23–25.3 and 23—24.0 South. For practical purposes, it will rise and set 23.4 degrees south of due east and due west. At sunrise, the navigator may find due east by using his sextant or any other angle measuring device to measure any angle of 23.4 horizontal degrees north of where the sun rises on the horizon.

For one who is steering during the day without a reliable compass, the rising and setting directions of the sun may be complemented by the LAN direction due north or south. Any cardinal or intercardinal course will be "maintained" by reference to the relative angle of constant swells, wind, waves and a straight line trailed in the wake. While the measurement of the horizontal angles at sunrise or sunset using a sextant is precise, there is a practical back—up way to do it that has accuracy commensurate with or even better than the level of precision of maintaining the course. It is the "finger-wink" method. Simply hold your arm out straight in front of you and point with an extended finger while keeping one eye closed. Then open the other eye and close the first one. Your "pointer" will shift about six degrees, and this shift will be a constant. It is governed by your personal eye to pointer distance and the distance between your eyes. Every navigator should determine his own shift value. Assuming a six degree shift for the navigator in the problem, at sunrise on December 24th, due east would be just slightly less than four shifts north of where the sun rose on the horizon.

Problem No. 26.

As noted in Problem No. 25, there are two cases worthy of special note in regard to the point of rising or setting of the sun on the horizon. In case one, presented in the last issue of the *Newsletter*, the navigator was within the tropics. As seen in the answer above, the sun will rise and set north or south of due east and west by the number of degrees that equals its declination at the time of the observed rising or setting. When viewed from within the tropics, its "amplitude" equals its declination.

In case two the observer is above the latitude of the tropics. Assume that on April 30, 1989, he is at 40 degrees North. Viewed from the northern latitudes, the sun will rise north of east and will cross over due east on its way to the southern part of the sky at mid—day, and then in the afternoon it will cross over due west on its way to a setting that is at a point north of due west on the horizon. The question is: at what time will the summer sun bear due east or west from a latitude of 40 North? There is a simple procedure to determine the time, and it will work equally well in the winter when viewing the sun from southern latitudes. What is the procedure?

NAVIGATION PERSONALITIES

Nevil Maskelyne

by T. D. Davies

A most basic tool of the navigator has long been his almanac. Historically various collections of astronomical ephemeris data have existed since the "Alphonsine Tables" of 1239 published by Alphonse X (el sabio) of Spain. However none were specifically designed for the navigator, although some were useful when in the hands of a sufficiently astute sailor; for example the Ephemeris of Montereggio as used by Amerigo Vespucci. The first real "Nautical Almanac" designed to be used at sea was the product of Nevil Maskelyne, 5th Astronomer Royal at Greenwich.

Maskelyne was born in London in 1732 and educated at Trinity College, Cambridge. After graduation (1754) he was ordained, but he had developed a consuming interest in astronomy during his student days, which set the direction of his long and distinguished career. The eclipse of July 25, 1848 apparently inspired his imagination, which was further excited by the transit of Venus of 1761.

The Royal Society sent him to the island of St. Helena that year, to observe the Transit for them, on the recommendation of the Astronomer Royal. This entailed a lengthy sea voyage which provided the opportunity for practical at-sea navigation. During the voyage he experimented with the method of Lunar Intercepts for the determination of longitude. Subsequently he published the "British Mariner's Guide" (1863) in which he introduced the use of Lunars for this purpose.

In 1765 he was appointed Astronomer Royal and made his chief aim the practical improvement of the art of navigation. When he came across the tables of Tobias Mayer of Gottingen he recognized that with some additional information they could provide a basis for tables of Lunar intercepts for practical determination of longitude at sea. He then proposed that they be incorporated in a new publication designed for navigators rather than astronomers, to be known as the Nautical Almanac. This proposal was approved and the first issue appeared in 1766 (for the year 1767).

The Nautical Almanac was continued under his supervision until his death in 1811. After his death the supervision of the work degraded and with it the accuracy and consequently the reputation and usefulness. It was later revived by the establishment (1830) of a commission by the Royal Astronomical Society, which established its format and details of publication which were only revised in 1923.

Maskelyne produced many contributions to astronomy as well as to navigation. His first major astronomical paper was entitled "A Proposal for Discovering the Annual Parallax of Sirius." He also proposed a plan to the Royal Society for determination of the density of the Earth. In 1774 he carried out the plan and produced observations from which the density of the Earth was deduced to be 4.5 times that of water.

In a curious epilogue to this distinguished career two later descendents, John Nevil Maskelyne and his son Nevil Maskelyne became famous as magicians specializing in the art of gigantic stage illusions, in the late 19th and early 20th centuries.

MARINE INFORMATION NOTES

Digest of Notice to Mariners

by Ernest Brown

EXPANSION OF THE TERRITORIAL SEA OF THE UNITED STATES OF AMERICA

On December 27, 1988, the President, by Presidential Proclamation, proclaimed the extension of the territorial sea of the United States of America, the Commonwealth of Puerto Rico, Guam, American Somoa, the United States Virgin Islands, the Commonwealth of the Northern Marianas, and other outlying areas over which the United States exercises sovereignty.

The territorial sea of the United States henceforth extends to twelve nautical miles from the baselines of the United States determined in accordance with international law.

In accordance with international law, as reflected in the applicable provisions of the 1982 United Nations Convention on the Law of the Sea, within the territorial sea of the United States, the ships of all countries enjoy the right of innocent passage and the ships and aircraft of all countries enjoy the right of transit passage through international straits.

Nothing in this proclamation:

(a) extends or otherwise alters existing federal or state law or any jurisdiction, rights, legal interests or obligations derived thereform; in particular, the boundary between state waters and the Exclusive Economic Zone for the purposes of the Magnuson Fishery Conservation and Management Act does not change; or

(b) impairs the determination, in accordance with international law, of any maritime boundary of the United States with a foreign jurisdiction.

Official nautical charts for the coastal United States, which are published by the Department of Commerce, National Ocean Service, will, as revised, depict the new United States territorial sea boundary. Depiction of the old territorial sea boundary (three nautical mile limit) will continue .

CAUTION ON ANNOUNCEMENT OF NEW CHARTS AND PUBLICATION

Caution: Do not use a new chart or publication until it is announced in Notice To Mariners. There are occasions when a new edition of a chart or publication may be received prior to the official announcement of its release being published in Notice to Mariners. Since Notice to Mariners corections are for specific editions of products, it is imperative that the user not discard the previous editon nor use the new edition until this official announcement is received. Further, since Notice to Mariners corrections are for specific editions of products, it is critical that the user update only the specifically referenced product edition.

ANTI-SHIPPING ACTIVITIES MESSAGE

The Anti-Shipping Activities Message (ASAM) system, a part of the Navigation Information Network (NAVINFONET) is a Defense Mapping Agency service for mariners providing reports of hostile actions directed against ships. The ASAM system was developed at the request of the U.S. Interagency Working Group on Piracy and Maritime Terrorism. It contains random reports of various forms of aggression against shipping around the world. Events are categorized by date and by geographic area and are based on the DMA subregion system. The user enters NAVINFONET with the full particulars of an incident to be reported and this report is then autumatically transmitted to DMA via the ANMS mailbox subsystem. Upon recept of the ASAM at DMA, the text is reviewed and evaluated for further action, edited, and stored in the ASAM data file for access by all NAVINFONET system users. The system can be used as a voyage planning tool by providing cautionary information to ship owners and masters concerning security conditions in and near ports and narrow channels around the world. Examples of ASAM Reports in this file include the ACHILLE LAURO incident, robberies of ships transiting the Malacca Straits, attacks on fishing boats and merchants ships coasting off Western Sahara, and certain events occurring in and around the Persian Gulf. When sending a hostile action report the user of ASAM should provide DMAHTC with as much of the following information as is possible:

1. Date of Occurrence; 2. Geographic Location; 3. Known or Suspected Aggressor; 4. Victim (Ship's) Name; 5. a detailed description of the occurrence being reported.

Further information on NAVINFONET/ASAM can be found in Radio Navigational Aids, Pub 117, page IX, or by calling (301)227-3296 or writing:
Director
Defense Mapping Agency
Hydrographic/Topographic Center
Attn: MCN (NAVINFONET/ASAM)
Washington, DC 20315-0030

Address all correspondence to:
The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850
Telephone 301-622-6448

NAVIGATION COURSES

Offered by : PAUL PEAK, INC., 7833 East Hampden Circle, Denver, Colorado 80237, (303)773-2555

Celestial Navigation: A course for boaters
May 1 - June 19, 1989

Course Objective:
Provides understanding of use of a sextant to obtain the altitude of a celestial body, and practice with the Nautical Almanac and H.O. 249 to plot lines of position and obtain a fix.

Schedule:

May 1	Getting Started, plus	Ch 1 & 2
May 8	Sextant, Star Sights	Ch 9 & 3
May 15	Star Sights, plotting	Ch 3
May 22	Sun Sights	Ch 4
May 29	Sun Sights	Ch 4
June 5	Planet Sights	Ch 5
June 12	Moon Sights	Ch 6
June 19	The Navigator's Day	Ch 7

Plan: The class will meet on eight successive Monday evenings at 7833 East Hampden Circle, Denver. Each session will include time on practical work (sextant, plotting, use of almanac and tables) as well as lecture and discussion. Students will need to furnish dividers and parallel rule (or equivalent). Course fee includes the text, two volumes of H.O. 249, the 1989 Nautical Almanac, and a practice sextant. (If a student already has any of these five items, the fee will be adjusted).

Materials included:
How to Navigate Today , by Leonard Gray, Cornell Maritime Press, Centerville, MD, 1986.
Sight Reduction Tables for Air Navigation (H.O. 249), Vol. 1 (Stars)
Sight Reduction Tables for Air Navigation (H.O. 249), Vol. 2 (Sun for latitude 0-39), Defense Mapping Agency, Washington, DC.
The Nautical Almanac, 1989 , U.S. Naval Observatory, Wash., DC.
Davis Mark 3 Practice Sextant.

Instructor:
Captain Paul Peak returned to Denver, his home town, when he retired from the U.S. Coast Guard in 1974. During his 33-year Coast Guard career he served in Coast Guard High Endurance Cutters as cadet, deck watch officer, navigator, executive officer, and commanding officer. He has sailed in the Mediterranean, North Atlantic, Gulfs of Mexico and Alaska, and the North Pacific.

Course Fee:
$130.00. The class will be limited to eight students. $65 will reserve a place, the remainder is due on May 1.

BOOK REVIEW

by Roger H. Jones

One Day Celestial Navigation For Offshore Sailing (Fourth Edition1988)

by Otis S. Brown

Distributor: Liberty Publishing Co., Inc., 50 Scott Adam Road Cockeysville, Maryland 21030, 133 pages; $9.95

One Day Celestial Navigation is a small volume, attractively bound with a hard paper cover. Now in its fourth edition, it was first published in 1979. Its author designed and wrote it for the individual with no experience in celestial navigation. His aim was simple: to provide a book that "will find you your island" if you have enough experience to navigate yourself out of the harbor, and to "give you immediate capability with a sextant."

Otis Brown tackles his objective in just five little chapters, each of which is nicely illustrated. The print is large, and the illustrations are among the most legible to be found in any book on navigation.

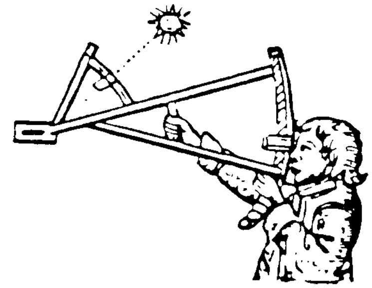
Brown starts at a very logical point: the finding of latitude. That is the subject of his first chapter. His premise is that one can do a lot of sailing with nothing more than the local apparent noon shot of the sun, perhaps the easiest of all the celestial procedures to master. He covers the entire topic, from when to shoot, to altitude corrections, to the how and why the noon shot of the sun will lead to knowledge of latitude. He finishes his succinct presentation with a practice problem, and his work forms are simple and uncluttered.

Chapter II is on practical aspects of shooting the sun, with emphasis on the use of the sextant, the rule for adding or subtracting the sun's declination, and the equal altitude shots before and after local apparent noon in determining longitude. At this point, Brown is confident that his reader will be able to determine latitude and cross check it against longitude using nothing more than the simple procedures available once each day as the sun approaches and crosses the observer's meridian. Brown tells his readers to pause, because they now have enough in their arsenal to navigate to virtually any destination. In a sense he is right.

However, in Chapter III, he goes on to lay the foundation and fill in the details of the longitude shot at any time of day. He deals now, of course, with the expanded navigational triangle and the method that employs an assumed position and the altitude intercept. He is now focused on hour angles, azimuths and the full range of data in both the *Almanac* and the 249 tables, and he adds the use of the universal mercator plotting sheet. He is a little apologetic at this point, because he is aware that it may no longer be a case of "one day celestial navigation". Nevertheless, it is a nice succinct presentation, although this reviewer would prefer to see just a bit more explanation. Local Hour Angle is nothing more than the "included angle" in the spherical navigational triangle, and the geographical position of the sun and assumed position of the navigator provide the lengths of the two sides of the triangle that enable one to determine the length of the third side and the azimuth from the observer to the sun. The length of the third side is, of course, distance. Distance plus azimuth to a known location enable one to determine one's own position.

Chapter IV is chock full of "special techniques": the running fix, strategies for use of the line of position in special cases, checking the compass accuracy, what to do if there is no DR position to start with, and checking the accuracy of the sextant with star angles. In the last chapter, Brown presents moon, planet and star shots. He tends to down play them, but again his presentation is succinct yet complete. In all, his little book is quite adequate for the job intended. For one with limited space on board, it may be just the thing. This reviewer found it to be well conceived for the absolute beginner, and it should be of interest to the seasoned navigator as well.

THE NAVIGATOR'S NEWSLETTER



FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

ISSUE TWENTY-FIVE, SUMMER 1989

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

by T. D. Davies

The Dutton Award

On the 27th of May I had the pleasure of making the Benjamin Dutton Award for excellence in navigation, at the U. S. Naval Academy. This year the award was won by a very bright and energetic young lady, Midshipman third class Elizabeth Fitzpatrick of New Jersey. The faculty of the Naval Academy noted that she had received the highest grade in recent history in the Practical Work of the Navigation Department. It is clearly no accident that Midshipman Fitzpatrick won the award. She has a starring (3.5 grade point average) record for all her academics and won a letter in Track as well. The good fortune of the navy to have such an outstanding midshipman is augmented by the fact that her twin sister is also a midshipman in the same class. She certainly deserves our congratulations. It is clear that the navigation department continues to provide excellent training and development for our potential naval officers.

Tandemeer

With the arrival of spring (rather late here in Washington) Captain Carraway has brought the Tandemeer to a high state of readiness and we are considering another sea trip for navigation experience for members. At the moment no date has been set but we will do so soon. Meanwhile anyone interested in going along should drop us a card or phone and give us a date or time period that would be convenient. As soon as we have a date we plan to notify all who have expressed interest plus others in the general area (within about 300 miles). The expenses of last year, $ 650, worked out well, so the cost will remain the same for the one week voyage. Tandemeer is based at Galesville, Maryland, about 20 miles south of Annapolis and our usual schedule is for passenger arrival on Saturday evening for departure at first light Sunday. The return will be the following Saturday.

Peary Project

Work on the analysis of the 1909 north pole claim of Robert B. Peary continues. Directors Terry Carraway, Dale Dunlap and John Luykx have completed the examination of the 225 cubic feet of papers comprising the Peary archive of the National Archives. This rather large task has netted a sizeable file of new material which we are now engaged in pulling together and digesting. Most recently we discovered that there was also a substantial amount of material in the archive of the Explorers Club of New York. Two of us did a one-day screen of this source and found a number of additional documents. Additionally we have documents coming in from other archives which relate to the object of our research. We also continue to get letters from members which provide useful information. We still hope to have our report out by mid-September.

READERS FORUM

Jose A. Santos Romero, Chief Officer, writes from Peru (translation below):

My fraternal salute to each and every member of the Foundation. My sincere compliments for your excellent efforts in the work of the "Art of Navigation." For we mariners this institution is a pillar and an axis for discussions about the problems of life at sea. Please consider me an applicant for membership in your organization; my statistics are the following:

Name: Jose Arturo Santos Romero
Title: First Officer, Merchant Marine of Peru
Age: 34 years
Address: Urb. Santa Luisa II Etopa MzC Lote 30
Area Code: Callas -4. LaPerla
City: Lima
Country: Peru

Hoping to continue a correspondence, accept my highest regards.

William E. Molett of Frankfort, KY writes:

Here's a couple more minor tidbits to support Peary's claim. You're going to need every argument you can muster.

You have noticed Peary was travelling at midnight during the last few days of his trip north despite the fact this placed the low, glaring, sun in his face. There can be little question but that he was carefully observing the time of lower transit. Reference the diary entry for April 21-22: "Sun so hot and blinding now practically impossible to travel in day time . . ."

I don't have any way of getting moon declinations for his travel dates, but if the moon just touched the northern or southern horizon at any time on his trip north Peary would have a good compass check and could figure out his longitude if he needed it.

You may have already turned these stones, but I just want to make sure you don't miss anything appropriate.

Mr. Ronald Braff, Editor of the ION Journal, has done a lot of meticulous and helpful editing of my paper. As soon as he lets me know it is ready to go I'll send you a copy.

Here is a quote from a letter Mr. Braff sent me recently: "Your paper has stirred considerable interest. It was formally reviewed by two ION members who are well versed in celestial navigation. One of the reviewers has taught celestial for 17 years at one of the academies. The other reviewer is a well known astronomer, who is involved in celestial. Both reviewers have endorsed the technical correctness of your analysis. That paper has also been reviewed in great detail by another member who expressed great appreciation for your discovery and analysis. . . . The editor has spent a considerable amount of time studying your paper, and although I know little about celestial, I feel I was able to understand and appreciate what you have done." It's nice to hear 3 people well versed in celestial agree my paper is technically correct. I consider my findings of much importance, but favorable response has been so meager I was beginning to think maybe my theories might be wrong.

Capt. Tom Frink of Staunton, VA writes:

It just hit me that my mailing to you of April 7 was misaddressed and may not reach you. Even properly addressed letters in or out of here disappear totally sometimes. It reflected a fair amount of work and if it fails to reach you, I'll try to reconstruct it. It's very unlikely that I've made any points you haven't already evaluated but I feel you wish to leave no stone unturned. It matters not a whit whether Adm. Peary missed by 1/10 mi. or 1/4 mi. or even 1 mi., but it matters much to me and to his descendants whether he is falsely labeled incompetent or dishonest.

The scenario in my Apr. 7 mailing permits plausible answers to such questions as:

1. Why did he go off after 0640 Apr. 7 at right angles to his direction after 1840 Apr. 6?
2. Why did he look chagrined after reducing the 0040 Apr. 7 sight?
3. Why did he write of his triumph on a loose sheet of paper later inserted in the bound journal? and
4. Why did he express uncertainty as to his position on returning noon Apr. 7 from pole dash but acquire enough confidence after the 1240 Apr. 7 sight to break camp without another pole dash?

I think I can answer these from my Apr. 7, 1989 mailing scenario.

Sorry to be a nuisance. Enclosed is $25 check to give me some phone credit pending NG Soc. reimbursing you if I have to call your people collect ever (only way I can call) or for membership if you accept me, or just a donation.

[Ed. Note: Captain Frink's letter did arrive and is a complete analysis of the polar sights which is too long to print in the newsletter, but has been useful in the project.]

Harry C. Nottebart, Jr. of Richmond, VA forwards this copy of his letter to DMA and their reply:

Dear Ms. Varoutsos (DMA):

With your help my books arrived February 21. Thank you very much. I shall be ordering again soon.

In Bowditch Pub. No. 9 Volume II (1981) on page 6 the discussion of Table 9 gives the formula used in computing the values of Table 9. Used as printed this formula gives results way out of line with those in the Table. It is my impression that the last term, i.e., -tan alpha/0.002419 should be outside the square root sign and the denominator should be 0.0002419. Would you please refer this to the appropriate person? Thank you again for your help.

And from DMA:

Thank you for your letter of 23 February 1989, indicating discrepancies in the formula as printed on page 6, Vol II of the 1981 Edition of the American Practical Navigator. Your letter was forwarded to us by the Defense Mapping Agency Combat Support Center. You are indeed correct in your observation, and the formula should read as indicated in your letter. The error will be corrected in the next edition of American Practical Navigator, Vol II which is scheduled for print in the 1994 time frame.

We appreciate your interest and effort in making the American Practical Navigator a better publication.

David A. Nelson of Salford, PA writes:

I have been following your Peary investigation with great interest. Andrew S. Horton's letter, "You have to look at what Peary said he did - the incredible mileage on the return trip," struck a chord in my memory. Many many years ago I read a children's Book of the Month Club about Fridtjof Nansen's expedition in the Fram. The Fram was designed to resist ice pressure with a heavily constructed hull shaped so that horizontal pressure forced the ship vertically upward. The Fram deliberately entered the Arctic ice and drifted with it. The ship reached 84 degrees N on 14 March, 1895. Nansen and one companion made a dogsled dash for the North Pole reaching 86 degrees 14'N before retreating south to one of the islands north of Norway. Nansen aborted the dash because the ice pack started drifting south faster than he was able to travel north. His book "Farthest North" describes this trip.

A comparison of Nansen's data with Peary's would seem more appropriate than using a relatively modern expedition with a much longer time lapse.

A. Carey S. Stead of Dorval, Quebec writes:

Thank you very much for the following, shipped on the 5th of April and received here in the Montreal area, in very good time, on the 10th of April, 1989:

Coast Pilot, Vol. I; Nautical Almanac, 1989; Abbreviated Nautical Almanac 1989; Publication 249, Vols. I, II &III; A supply of Foundation Brochures; A draft of Admiral Davies' recruiting letter.

I await the receipt of an account for these books and,in the meantime, enclose copies of:

(a) A letter to the editor of the "Wheelhouse", a publication of the Lake St. Louis Squadron, Canadian Power and Sail Squadrons;

(b) A short memorandum adapted from the recruiting letter.

The squadron has 400 members of whom about 10% have completed the Canadian Power and Sail Squadron Junior Navigation or Navigation courses. The squadron is a unit of the Canadian Power and Sail Squadrons, an organization of about 25,000 members in Canada which is loosely related or affiliated to the United States Power Squadron organization.

I estimate that about 5% to 10% of the membership of the Canadian Power and Sail Squadrons shall have studied celestial navigation at a basic level (the junior navigation course) or on a more advanced level (The Navigation course).

The organization publishes a magazine under the name of the "Port Hole" three or four times a year containing editorial matter and paid advertising.

When I have an idea of the interest shown in whatever I can have published in the Wheelhouse, I will see if the editor of the National publication "The Port Hole" would be willing to publish a more extensive article on the Foundation. If the editor would be willing to do this, I believe that the article itself should be drafted by you or a member of the Foundation staff. I do not know enough about the Foundation or its operations to do it justice in an article addressed to a readership of about 25,000.

The United States Power Squadrons have, I believe, about 100,000 members of whom 5% to 10% will have studied celestial navigation at a basic or more advanced level. It occurs to me to ask if any thought has been given to recruiting members for the Foundation from amongst the members of this organization. It, too, publishes a national magazine for its membership.

I remain with my thanks for your very prompt response to my telephone call.

NAVIGATION BASICS REVIEW

Averaging Sextant Observations

By John M. Luykx

In an article in the previous issue of the *Navigator's Newsletter* (Issue 24, Spring 1989, page 4) random sextant observation error was discussed and some suggestions presented to reduce or eliminate this error. Significant observation error with the sextant is caused at sea by excessive vessel motion, by an unclear or indistinct horizon and by human error. Additional error, when using a bubble or other artificial horizon sextant at sea, is generated by the acceleration effects of vessel motion in and across the sextant line of sight, causing the bubble (or other artificial horizon element) to dance about in the field of view.

Relatively large errors occurring in individual observations taken from a small vessel at sea may be reduced to a great extent, by taking a series of observations and either a) recording the median (middle) values of time and altitude for the series b) arithmetically averaging the results; i.e. computing the mean values of time and altitude for the series or c) plotting the observations (time versus altitude) on cross section paper, "fairing" a line of best fit through the points and then selecting a point on this line (time and altitude) for sight reduction.

The following example (sample problem) will illustrate these methods of computation and graphic solution for a series of eleven (11 observations taken at sea using a bubble sextant:

GIVEN:

1. BASIC DATA

a. Body:	Sun
b. Date:	1 June 1989
c. DR LAT: *	N 36° 40'
d. DR LONG:*	W 75° 10'
e. Course:	115° T
f. Speed:	5.0 kts
g. H of E:	6.0 feet
h. Sext. I.C.	-1'.5
i. Dec at 14-10:	22° N
j. LHA at 14-10:	318°
k. Meridian Angle (t) at 14-10:	42° E

* Note: The DR position is given for the mid time of the series of observations (below): GMT = 14-10

2. SUN OBSERVATIONS

OBS. NO. (Hs)	GMT	SEXTANT ALTITUDE
1	14-06-15	50° 24'.2
2	14-06-53	50° 36'.6
3	14-07-36	50° 40'.1
4	14-08-16	50° 38'.0
5	14-08-55	51° 00'.7
6	14-09-42*	51° 10'.0*
7	14-10-32	51° 19'.8
8	14-11-09	51° 02'.0
9	14-11-49	51° 00'.0
10	14-12-36	51° 07'.3
11	14-13-20	51° 10'.0
	TOTAL 2463s	TOTAL 593'.7

3. COMPUTATIONS

	GMT	Hs
a. Median	14-09-42 *	51° 10'.0* (Obs.No.6)
b. Mean:	= 2463 s	= 593'.7
	= 2463 s / 11	= 593'.7 / 11
	= 224 s	= 53'.97
	= 3m 44 s	= 54'.0
	= 14-06-00	= 50° 00'.0
	+ 03-44	+ 54'.0
Mean:	GMT= 14-09-44	Hs =50 54.0

Note: The sun's altitude when observed by bubble sextant is not corrected for semi-diameter.

c. From the data above:
1. The median (middle) time and sextant altitude of the series are: GMT: 14-09-42 and Hs: 51 10.0
2. The mean (arithmetic average) time and sextant altitude of the series are: GMT: 14-09-44 and Hs: 50 54.0.

d. A graph of the series of observations plotted on cross-section paper is given in Figure 1. In Figure 1, the line AB represents the slope of actual values of altitude change versus time obtained by sight reduction table or by computation for the given values of SUN LHA, SUN DEC and observer LAT. The rate of actual altitude

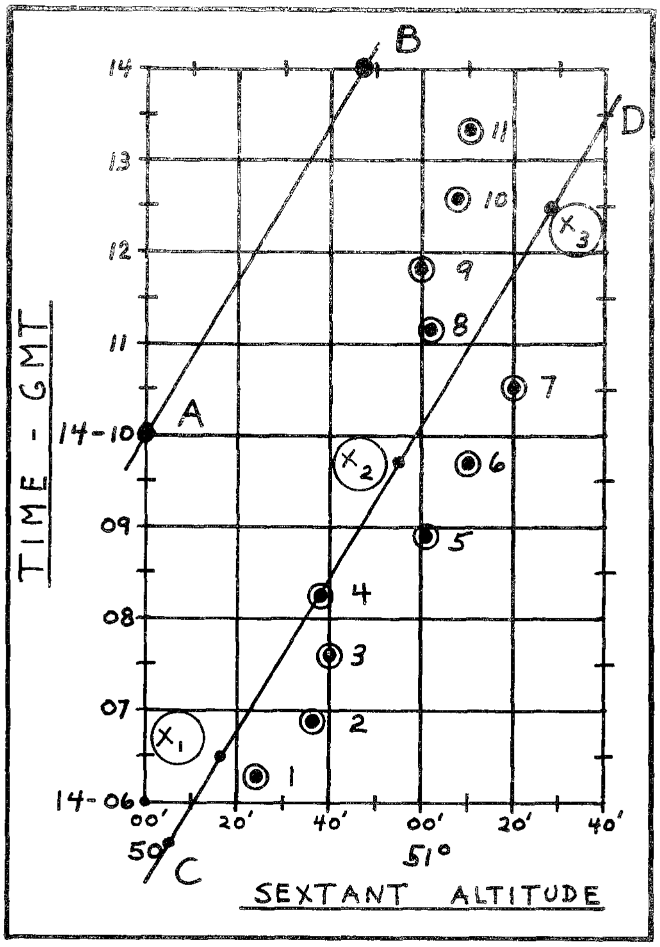


Figure 1

change is 47' of arc per 4 minutes of time; (i.e., 12' per minute of time) obtained from Page 225 of H.O. 249, Vol. II from values of Sun LHA: 318,° LAT: 37° N, Sun Dec: 22° N. A line of best fit, CD, is then drawn through the points of the graph and oriented parallel to line AB in a position among the points, which is a best fit or estimate. Any point along line CD represents a specific value of time and altitude for the series which then may be used in sight reduction as a single observation. As an example, if the mean time of the observation were selected; i.e., GMT 14-09-44, the corresponding sextant altitude on line CD is 50° 55'.0 almost exactly the computed mean value of altitude for the series of observations, 50°54'.0. To test the accuracy of line CD, three points along line CD were selected and the altitude error for each point, using the DR position as a reference, was compared. The results are shown below:

POINT	GMT	Hs	Hs ERROR
X_1	14-06-30	50° 16'.7	-0'.2
X_2	14-09-44	50° 55'.0	-0'.5
X_3	14-12-30	51° 28'.5	0'.0

The results of this test indicate a very small variation in the error of observation from the three points. This data also emphasizes the validity of the concept that accuracy of observed data may be significantly improved by graphing a series of observations and "fairing in a line of "best fit" through the plotted points.

In order to reduce observational error when fixing a vessel's position by celestial observation in rough weather or during conditions when the observer believes an individual observation may have significant error, it is always advisable to take a series of observations (an odd number is recommended; i.e., 5, 11, or 15 observations in the series) and either compute the arithmetic mean of time and altitude of the series or plot the observations on cross section paper and "fair in" a line of best fit through the points as explained in II above. Although computing mean values for the series of observations may be the more rapid method, this procedure includes poor observations as well as good in the computation. Graphically plotting a series of observations may take more time and effort but the advantage of recognizing poor observations which may then be rejected from consideration is an advantage of this method in obtaining maximum accuracy. Recording and reducing the median time and sextant altitude is not recommended.

HISTORY OF NAVIGATION

Early Dip-Measuring Instruments: The Navigator's Prism

by John M. Luykx

As mentioned on Page 3 of the NAVIGATION BASICS REVIEW article in Issue 24 of the Navigator's Newsletter, one of the two major sources of error in celestial observations is the variation from normal dip caused primarily by changes in refraction due to air/sea surface temperature differences.

The dip-correction (for height of eye) tabulated on the inside front cover of the Nautical Almanac is based on the formula:

$$D = 0.97 \sqrt{h}$$

where: D = minutes of arc
h = height of eye in feet

which incorporates a standard value for atmospheric conditions, particularly refraction.

When atmospheric conditions, however, are non-standard, especially when the atmospheric temperature is well above or below 50° F, atmospheric pressure markedly above or below 29.83 (1010 millibars) or when large variations exist between sea and air temperatures, it will be found that significant difference will occur between the value of dip tabulated in the Tables and the actual value of dip. Generally, when the sea water is colder than the air, the visible horizon is raised and the value of dip is decreased. When the water is warmer than the air, the horizon is depressed and the value of dip is increased.

The effect on dip caused by variations in atmospheric conditions was described and discussed by LCDR John B. Blish, U.S.N. in an article published in the U.S. Naval Institute Proceedings of March 1903, pp. 175-184 (USNIP, Vol. 29, No.1). In the article, Cdr. Blish described how, during cable laying operations in the summer of the year 1900 aboard the steam cable layer Faraday, nine experienced navigators were exclusively employed during the laying operations to take celestial observations from dawn to dusk to fix the vessel's position. On one day during these operations Cdr. Blish notes, however, that "...There came a bright day with a seeming perfect horizon when every "line of position" was bad and although the nine sextants gave the same meridian altitude to within a half a minute, yet the noon latitude was nearly three miles north of the line on which the ship was supposed to be....All these scientific appliances and all the care and skill of these trained navigators had been bowled over by a change in the atmosphere whereby the sea horizon was raised above its normal place and the actual "Dip of the Horizon" was less than that taken from the Dip Table...."

Based on this experience, Cdr. Blish conceived the idea of the Navigator's Prism by which the dip of the horizon could be easily, rapidly and accurately measured without reference to values of height of eye, air/sea temperature or barometric pressure.

The Navigator's Prism is a plain glass square cross-section dove prism from 3" to 6" in length and 3/4 to 1" square mounted in a bracket which is attachable to the upper part of a marine sextant. Both ends of the prism are cut to a 45° angle such that a ray of light entering one end is reflected 180° and returned in a path parallel to the entering ray. The Navigator's Prism bracket is attached to the upper of the sextant's three legs in such a manner that the prism during observation is held vertically with its lower end positioned just forward of the sextant index mirror and its upper end facing to the rear, above the observer's head, to reflect the back horizon into the sextant telescope field of view. (See Figure 1.) During an observation for dip, the sextant (set to zero) is held in the normal manner and both the front (erect) visible horizon and the back (inverted) visible horizon are seen on the sextant telescope field of view. The angle between the two horizons observed in the telescope field of view is equal to twice the dip-angle. (See Figure 2.)

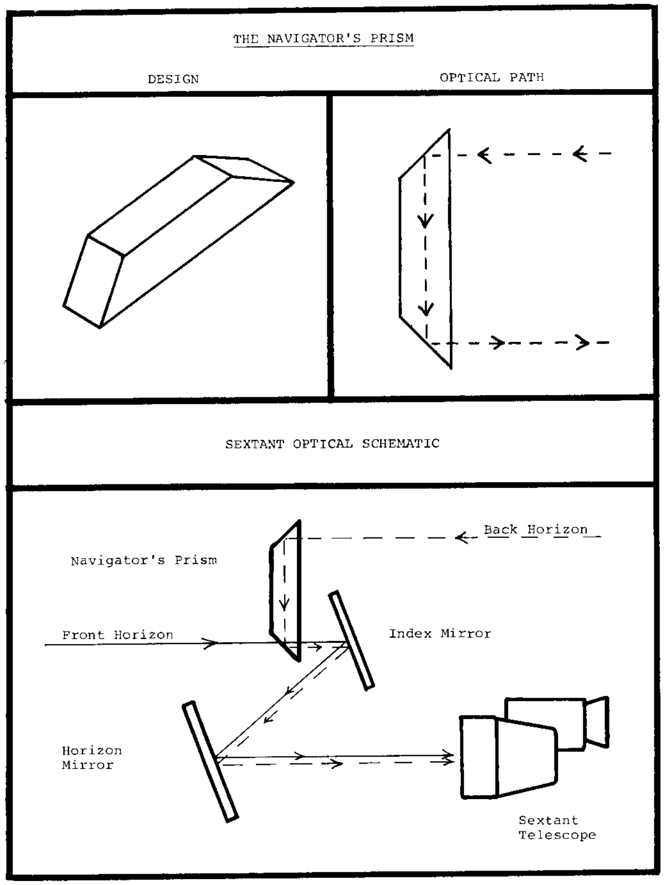


Figure 1

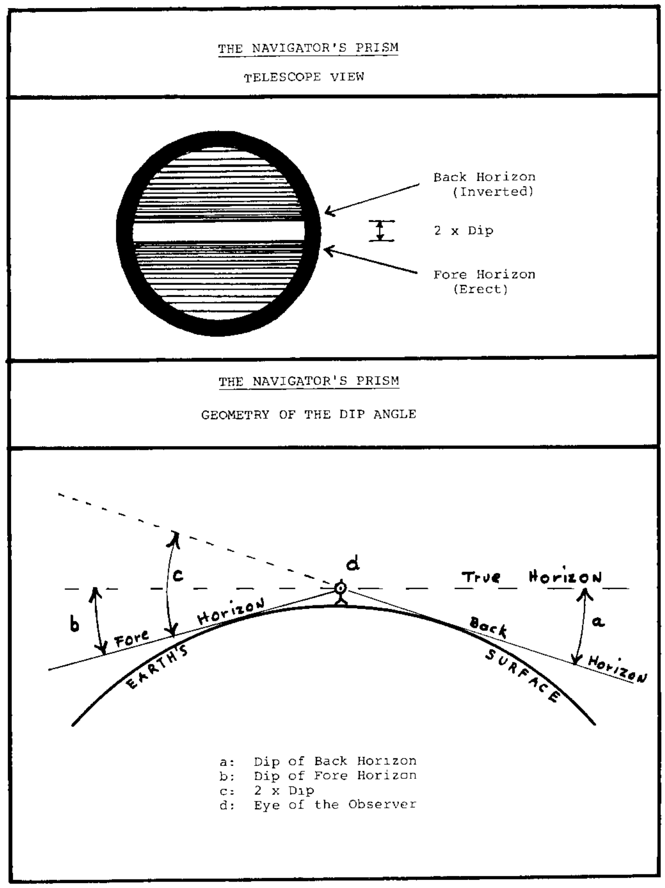


Figure 2

To measure dip with the Navigator's Prism:

First: Measure and record the index correction of the sextant in the normal manner.

Second: Clamp the Navigator's Prism bracket to the upper leg of the sextant and position the prismfor observation as shown in Figure 1.

Third: Set the sextant index arm and micrometer to 00°00'.0, hold the sextant in the normal manner for observation and rotate the micrometer so that both the fore (erect) horizon and the back (inverted) horizon are brought to coincidence in the telescope field of view.

Fourth: Record the sextant reading and then apply both the sextant index correction (I.C.) and the prism correction* to the sextant reading. Divide this corrected angle reading by two to obtain the true angle of dip.

Note: * The prism correction is supplied by the manufacturer or may be computed (prior to use) by comparing measured values of dip using the Navigator's Prism with known values of dip as measured by other means; i.e. by a) levelling or b) transit or c) theodolite or by a dip-meter with known or corrected error.

As an example of the variation of the actual value of dip compared to tablular values, Cdr. Blish in his article reports that in October 1901, off the coast of Southern California, officers of the USS ALERT took a series of dip observations with a Navigator's Prism (the series took several days) to compare observed values of dip with tabulated values. Extracts of data resulting from these observations are as follows:

	1	2	3
Date:	22 Oct	22 Oct	22 Oct.
Air Temp:	75° F	75° F	69° F
Water Temp:	67° F	67° F	66° F
Sext.Reading:	03'40"	10'20"	16'25"
Sext. I.C.:	-3'00"	-3'00"	-3'00"
Prism Corr:	-2'25"	-2'25"	-2'25"
True Dip:	-0'53"	-2'28"	-5'30"
H of E:	22.7 ft.	22.7 ft.	22.7 ft.
Table Dip: *	-4'40"	-4'40"	-4'40"
Dip Table Error:	+5'33"	+2'12"	-0'55"

Note: * The Dip Table used for comparison purposes was Table 14 of the effective edition of Bowditch based on the formula:

$$D - 0'.97 \sqrt{h} \quad \text{or} \quad D = 58''.8 \sqrt{h}$$

where D= The dip angle in minutes/seconds of arc
h= Height of eye in feet.

Similar results were obtained with a Navigator's Prism built by the author in 1985 based on the Blish design shown in Figure 1. and tested using sun observations in the Chesapeake Bay area during the late summer of that year. The tests were conducted from a position ashore at

Sandy Point State Park on the western shore of Chesapeake Bay located one mile north of Chesapeake Bay Bridge. From this point, a natural visible sea horizon is available both to the north and south, 180° apart in bearing. For the purpose of the tests, the Navigator's Prism was attached to a Plath sextant with a 6 x 30 prismatic monocular telescope installed. The error of the Navigator's Prism was determined prior to the test by comparing the true values of dip with those obtained by a Gavrischeff Dip-meter (without error) from the author's collection. The results of three of the tests conducted on 9, 19 and 25 September 1985 are as follows:

Date:	9 Sept.	19 Sept.	25 Sept.
Water Temp:	95F	72 F	71 F
Air Temp:	83 F	78 F	72 F
H of E:	5.0 ft	5.0 ft.	5.0 ft
Weather:	Hot, Sunny Hazy	Sunny Hazy	Sunny Clear
Sextant Readings:	10'.1 *	14'.0 *	13'.6 *
Prism Corr.	-5'.6	-5'.6	-5'.6
2 Dip:	-4'.5	-8'.4	-8'.0
Dip:	-2'.3	-4'.2	-4'.0
Dip by Gavrischeff:	-2'.4 *	-4'.1 *	-4'.0
Dip by N.A. Table:	-2'.2	-2'.2	-2'.2

Note: * Denotes the mean value of 10 observations

The results of these tests show, as do those published by Cdr. Blish in 1903, that under apparent standard atmospheric conditions significant difference may well exist between tabulated values of dip found in official navigation publications and actual values of dip.

Although it is well-known that variations from standard atmospheric conditions and particularly changes in water temperature compared to the air temperture at the water surface will generally result in variations in the values of refraction and dip angle, it is impossible to predict with certainty the magnitude of these variations or to determine the exact extent of the changes to refraction and dip which would result from the changes in atmospheric conditions.

The published dip tables in the Nautical Almanac are based on a standard air temperature of 50° F and barometric pressure of 29".83 (1010 millibars) and an average value for air/sea surface temperature difference.

Extensive research has shown that when the sea surface temperature is cooler than the air above it, the visible horizon is raised and the value of dip decreased, and when the water is warmer than the air, the horizon is depressed and the dip angle increased.

Other scientific data has also shown that in certain cases a numerical correlation exists between height of eye, air/sea temperature difference and the value of dip angle. Some of these studies for example suggest that for heights of eye of 10 to 30 feet:

1. for every ten degree decrease in the water temperature compared to the air temperature, the value of dip is to be decreased by one minute of arc; and,
2. for every ten degree increase in the water temperature compared to the air temperature, the value of dip is to be increased by one minute of arc.

Readers are reminded, however, that when non-standard atmospheric conditions do occur at sea the effect on refraction and dip may be extensive and unpredictable and that the accuracy of sextant observations may be affected more or less seriously by these conditions.

The Navigator's Prism, a form of early dip-meter was conceived and developed by LCDR Blish at the turn of the century to provide a means of optically measuring the actual value of dip angle at any time in the vicinity of a vessel at sea without reference to tables or the requirement to record the values of air and sea temperature or barometric pressure. Other more sophisticated dip-meters have been developed since the Navigator's Prism was first devised by LCDR Blish and these will be described in later issues of the *Navigator's Newsletter.*

NAVIGATION NOTES

Bowditch: The Art of Navigation in His Day

by Erving Arundale

Mariners skilled inthe technique of modern marine navigation, have often wondered how the early sea captains handled their navigational endeavors in the age of wooden ships and iron men. Recently, and quite by accident, I was able to obtain some answers to this question. While browsing through a dark corner in our town library, I came across an old, well-worn and leather-bound copy (5" x 8 1/2" x 2" thick) of the Sixth Edition of BOWDITCH which was published in the year 1826 and given to the library by the estate of Captain Bray, a 19th century Cape Cod captain. Since this edition clearly represented the state of the art at the time Bowditch made his important contributions (1794-1838), a brief review of its contents, and some excerpts therefrom, may give present day mariners an appreciation of the navigational techniques available in the early 1800's and used by our seagoing forefathers when sailing to seaports all around the world.

The frontispiece is interesting in its own right since it provides a good summary of this sixth edition. (It may be noted that the publisher of this edition, Edmund Blunt, is also the early author of the well-known American "Coast Pilot".) Also of interest, the Foreword to the publication contains a "Report" by a committee of five men appointed by the East India Marine Society of Salem (Massachusetts) to "examine a work called The New American Practical Navigator by Nathaniel Bowditch F.A.A." It reads: "After a full examination of the system of navigation presented to the society by one of its members (Mr. Nathaniel Bowditch), they find that he has corrected many thousand errors in the best European works of the kind, especially those in the tables for determining the latitude by two altitudes, in those of difference of latitude and departure, of the sun's right ascension, of amplitudes, and many others necessary to the navigator. Mr. Bowditch has likewise, in many instances, greatly improved the old methods of calculation, and added new ones of his own. He has much improved the table of latitude and longitude of places and has added those of a number on the American coast hitherto very inaccurately ascertained. This work therefore is, in the opinion of the committee, highly deserving of the approbation and encouragement of the society, not only as being the most correct and ample now extant, but as being a genuine American production and, as h)such, they hesitate not to recommend it to the attention of navigators and to the public at large."

Salem, May 13, 1801

Thereafter, in the Preface, Bowditch describes the objectives of his work and some of the new navigational techniques presented in this sixth edition. He states: "In the preface to the first edition of this work, it was observed that the object of the publication was to collect into one volume, all the rules, examples, and tables necessary for forming a complete system of practical navigation. In performing the above, eight thousand errors were discovered and corrected in Moore's Practical Navigator and about two thousand in the second edition of Maskelyne's Requisite Tables. An entirely new article is given in this edition on the method of finding the latitude by two altitudes of the same, or of different, objects; the solutions being direct and simple. This is an important addition to the present work and it is recommended to the consideration of navigators."

THE
NEW AMERICAN
PRACTICAL NAVIGATOR:
BEING AN
EPITOME OF NAVIGATION;
CONTAINING ALL THE TABLES NECESSARY TO BE USED WITH THE
NAUTICAL ALMANAC,
IN DETERMINING
THE LATITUDE, AND THE LONGITUDE
BY
LUNAR OBSERVATIONS:
AND
KEEPING A COMPLETE RECKONING AT SEA:
ILLUSTRATED BY
PROPER RULES AND EXAMPLES:
THE WHOLE EXEMPLIFIED IN A JOURNAL,
KEPT FROM BOSTON TO MADEIRA,
IN WHICH ALL THE RULES OF NAVIGATION ARE INTRODUCED.
ALSO,
THE DEMONSTRATION OF THE USUAL RULES OF TRIGONOMETRY:
PROBLEMS
IN MENSURATION, SURVEYING AND GAUGING:
DICTIONARY OF SEA-TERMS:
AND THE MANNER OF
PERFORMING THE MOST USEFUL EVOLUTIONS AT SEA.
WITH AN
APPENDIX,
CONTAINING
METHODS OF CALCULATING ECLIPSES OF THE SUN AND MOON, AND OCCULTATIONS OF THE FIXED STARS: RULES FOR FINDING THE LONGITUDE OF A PLACE BY OBSERVATIONS OF ECLIPSES OR OCCULTATIONS: AND A NEW METHOD FOR FINDING THE LATITUDE BY TWO ALTITUDES.

BY NATHANIEL BOWDITCH, LL. D.
Fellow of the Royal Societies of London, Edinburgh, and Dublin; of the American Philosophical Society, held at Philadelphia; of the American Academy of Arts and Sciences; of the Connecticut Academy of Arts and Sciences; of the Literary and Philosophical Society of New-York, &c.

SIXTH STEREOTYPE EDITION.

NEW-YORK:
PUBLISHED BY EDMUND M. BLUNT, PROPRIETOR,
AND AUTHOR OF THE AMERICAN COAST PILOT,
No. 202, WATER-STREET.
John Gray & Co. Print.
1826.

Frontispiece

Treatises

The first 50 pages of the volume contain treatises on basic arithmetic, geometry, the use of the "sliding rule", logarithms, plane trigonometry, astronomy, and geography. (The appendix also contained some of Napiers Rules and a few equations for solving spherical trigonometric problems.) There follows sections on plane, traverse, parallel, mid-latitude, and mercator sailings (as used today) with many examples and with the necessary tables for use therewith (such as the traverse sailing table (3) and the meridional parts table (5) as given in the current edition of Bowditch). He highlights the use of mid-latitude sailing for short runs where the difference of latitude is small in comparison with the difference of longitude. He suggests mercator sailing for situations wherein the places differ greatly in latitutde and longitude, particularly in high latitudes.

No mention is made of great circle sailing. Moreover, very little attention (only a few examples) is devoted to what we call "coastal piloting" while the main focus of Bowditch's work is on the off-shore navigational needs of the early mariners. Sections were also included on winds, tides, currents, and on surveying (on both land and sea). An excellent glossary of "sea terms" and a treatise on "Evolutions at Sea" (loading, rigging, anchoring, and sailing evo-lutions) were also included.

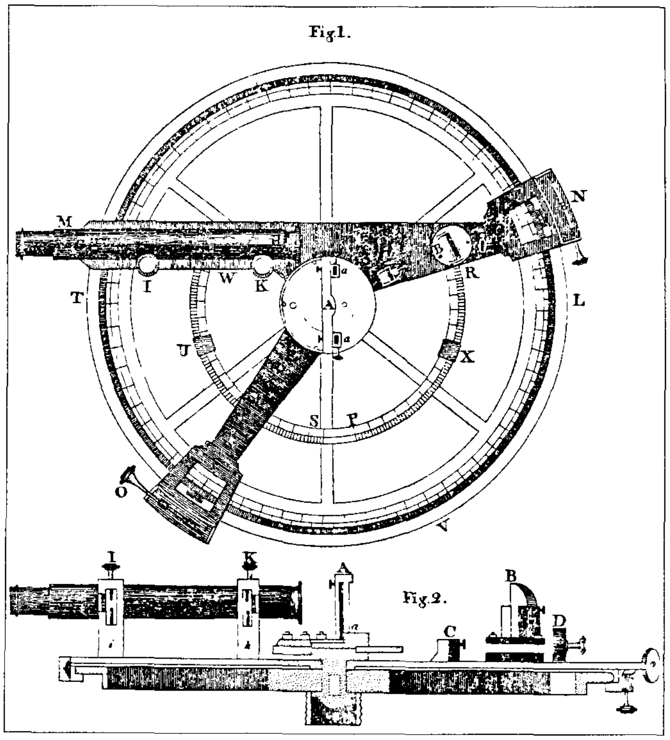
Variation

In our day and age, and using our nautical charts or other available sources, we can readily ascertain the magnetic variation at any location on the earth's surface. However, at the time Bowditch published his sixth edition (1826), and as shown in a table contained therein, the variation was recorded for only 20 different locations throughout the world and 25 h)positions at sea. In his chapter on the subject, Bowditch states:

"It was many years after the discovery of the compass, before it was suspected that the magnetic needle did not point accurately to the north pole of the world. But about the middle of the 16th century, observations were made in England and France which fully proved that the needle pointed to the eastward of the true north. This difference is called the variation of the compass and is named East when the north point of the compass (magnetic north) is to the eastward of true north; but west when the north point of the compass is to the westward of true north. The quantity of the variation may be found by observing with a compass the bearing of any celestial object when on the horizon (called amplitude). The difference between this and the true amplitude by calculation will be the variation." In the accompanying brief table, it is reported that, in 1742, the variation at Boston was found to be 8 degrees 0' West. In 1985, the variation at the same location was 16 de-grees West, an incr-ease of 2 minutes/year (which is the same as the current rate of increase).

Celestial Navigation

At the beginning of his coverage of celestial navigation, Bowditch gives a description (and outlines the use) of the marine quadrant, the sextant, and the so-called circle of reflection (Figure 1), a circular disc graduated in 360 degrees and containing two arms, a mirror, and a telescope. He states that the circle of reflection is used to observe the meridian altitude of an object, as with a quadrant or sextant, and that (I quote): "it has a decided superiority over the sextant in measuring the distance of the moon from the sun (called lunar distance), or a star, on account of its correcting in a great measure, the errors arising from a faulty division of the sextant limb, want of parallelism in the surface of



mirrors, and entirely avoiding the bias which might arise in a sextant from the mirrors not being parallel when the index is set at 0)." (As we all know, modern sextants do not have these limitations).

Bowditch also discussed the necessity for correcting altitude observations for refraction, dip of the horizon, parallax, and in the cases of the sun and moon, semi-diameter. He provided tables to facilitate these corrections. He also suggested a means for obtaining the apparent time at sea, when the ship was not making way, by obtaining an altitude of the sun in the morning, and again the same altitude in the afternoon, and noting the watch times. The middle of the period is of course the sun's meridian passage (local apparent noon). To permit the calculation of local mean time, he provided a table giving the equation of time for the years 1824 through 1837. The same table gave the sun's declination for the same years, while another table provided the declinations and right ascensions of the stars and their annual rates of change.

EXAMPLE I.

Being at sea in latitude 46° 30′ N. by account, when the sun's declination was 11° 17′ N. at 10h. 2m. per watch, in the forenoon, the sun's correct central altitude was 46° 55′, and at 11h. 27m. per watch, in the forenoon, the correct central altitude was 54° 9′. Required the true latitude?

Subtracting 10h. 2m. from 11h. 27m. gives the elapsed time 1h. 25m.

Col. 1.		Col. 2.	Col. 3.
Elap. time [P.M.] 1h.25m. co-sec.	10.73430		
Declination 11° 17′ N. ..sec.	10.00848		.... co-sec. 10.70850
A ....co-sec.	10.74278	co-sine 9.99278	.... co-sine 9.99278
½ sum alts. 50 32 .....co-sine	9.80320	co-sec. 10.11239	B 11° 28′ N. co-sec. 10.70128
½ diff. alts. 3 37 .....sine	8.79970	sec. 10.00087	[B less than 90°, named N. or S. like decl.]
C ....sine	9.34568	co-sine 9.98907	.... co-sine 9.98907
Z [Less than 90° and N. or S. like bearing of Zenith]		sec. 10.09511	Z 36 33 N.
[E is *sum* of B, Z, if of *same* name, *difference* if of *different* name.]			E 48 01 N. sine... 9.87119
			Latitude 46 27 N. sine... 9.86026

Latitude Determination:

(A) By Meridian Transit

In this early edition, Bowditch gave a clear description of the conventional method for finding latitude by meridian transit observations of the sun, moon, or planets (including back sights), but the same methods still in widespread use today. He also described the determination of latitude ashore (using the artificial horizon) and at sea by an altitude observation of Polaris (along with a Polaris sight correction table) again all currently used procedures.

(B) By Double Altitudes

As mentioned in his preface, the sixth edition of Bowditch contained a new procedure for finding latitude by what he called "double altitudes" of the sun, moon, or planets. The following description, in Bowditch's own words, outlines the method involving two observations of the sun. I quote:

"When by reason of clouds, or from other causes, a meridian altitude cannot be obtained, the latitude may be found by two altitudes of the sun, taken anytime of the day, the interval or elapsed time between the observations being measured by a good watch or chronometer, noticing the second if possible, or estimating the times to a third or a quarter of a minute, if the watch is not furnished with a second hand. The observed altitudes must be corrected as usual for semi-diameter, dip, refraction, and para-llax. When great accuracy is required, the declination (from the Nautical Almanac) must be found at the time of each observation. When the sun's declination varies slowly, or the elapsed time is small, it will generally be sufficiently accurate to find the sun's declination for the middle time between the two observations.

"This manner of finding the latitude is in general most to be depended on when the sun's meridian zenith distance is great. The nearer the sun is to the meridian at the time of one of the observations, the more correct the result will be. In general, the elapsed time ought to be as great or greater than the time of the nearest observation from noon."

As shown in the following example (excerpt), this method of calculating latitude is based on the elapsed time between the two sights (note: where 1 hour of elapsed time equals 7.5 degrees of arc), the sun's declination, and the sum, and the difference, of the two observed altitudes. The calculations were made using logarithms of trigonometric functions and great care had to be taken to avoid mathematical errors.

This technique of "double altitudes" was, no doubt, of some use in the last century. However, with the current availability of modern sight reduction tables (e.g. HO229, HO249, the Davies and Nautical Almanac Concise Tables) and the widespread use of scientific calculators and programmable computers, the above method finds little current utility.

242 JOURNAL OF A VOYAGE

H.	K.	F.	Courses.	Winds.	L W	Remarks on board, Monday, April 5, 1824.	
1	3		S. E.	E.N.E	1	First part of these 24 hours small breezes,	
2	3					and calm; latter part fresh gales.	
3	2					At 4 P. M. got out the boat and tried the	
4	2					current; found it running E. 1 mile per	
5						hour, and suppose the ship has been in this	
6			Calm.			current these 24 hours.	
7							
8							
9							
10						Mer. alt. sun's lower limb	61° 39'
11						Correction for semi-diam. &c.	0 12
12							
1	3	4	E. S. E.	N.N.E		Sun's correct altitude	61 51
2	3	4				Subtract from	90 00
3	4	6					
4	4	6				Sun's zenith distance	28 9 N.
5	5	5				Sun's declination	6 12 N.
6	5	5					
7	6	5				Observed latitude	34 21 N.
8	6	5					
9	7						
10	7						
11	8						
12	8					Variation 1¼ point westerly.	

Course.	Dist.	Diff. Lat.	Dep.	Lat. by D. R.	Lat. by Obs.	Diff. Long.	Long. in.	Bearing and Dist.
S.83°36'E	101	S. 11	E. 100	N. 34° 24'	N. 34° 21'	E. 2° 1'	W. 38° 15'	Funchal S 84° 30' E distance 1073 miles.

TRAVERSE TABLE.

Courses.	Dist	N.	S.	E.	W.
S. E. ¼ E.	10		6.7	7.4	
E. ¾ S.	70		10.3	69.2	
E.N.E.¾E.	24	5.8		23.3	
		5.8	17.0	99.9	Dep.
			5.8		
	Diff. Lat.		11.2		

In addition to the courses sailed, I also allow 24 miles for the set of the current in the direction of east per compass, or E. N. E. ¾ E. true course.

With the difference of latitude 11.2 and the departure 99.9, the course is found to be S. 83° 36' E. and the distance nearly 101 miles.

Yesterday's latitude	34° 35' N.
Difference of latitude	0 11 S.
Latitude in by account	34 24 N.

With the middle lat. 34° 28', and the dep. 99.9, I find the diff. of long. to be 121 miles = 2° 1' E.

Yesterday's longitude	40 16 W.
Longitude in	38 15 W.

To find the bearing and distance of Funchal.

Latitude in	34° 21' N.	Longitude in	38° 15' W.
Funchal's latitude	32 38 N.	Funchal's longitude	16 54 W.
Difference of lat.	1 43 = 103 miles.	Difference of long.	21 21
Sum of latitudes	66 59		60
Middle latitude	33 30 nearly.	In miles	1281

Hence by Case I. of Middle Latitude Sailing, the bearing of Funchal is found to be S. 84° 30' E. and its distance 1073 miles.

Longitude Determination

Bowditch gave considerable attention to lunar observations for determining longitude and I quote:

"Almost all the methods of determining the difference of longitude between any two places depends on the general principle of finding the difference between the times of taking any observation, estimated under the meridians of both these places. It follows that, if at the time of taking an observation, the corresponding time was known at Greenwich, the longitude of the place of observation would be found by allowing 15 degrees for every hour of difference between those times (the longitude being East when the time at Greenwich is earlier than the place of observation, otherwise West)."

"One method of determining the time at Greenwich is by a watch regulated to Greenwich time; for it is evident that if a watch so constructed as to go uniformly at all times and in all places, an observer would only have to compare the time at the place of observation with the time at Greenwich shown by the watch and the difference in time would be the difference in longitude. This method is useful in a short run but, in a long voyage, implicit confidence cannot be placed in an instrument of such a delicate construction and liable to so many accidents."

Bowditch then goes on to describe other methods of determining longitude (e.g., by observing eclipses of the moon) along with their shortcomings but concludes: "There is not one of such practical utility as that by measuring the angular distance of the moon from the sun, or from certain fixed stars, usually called a Lunar Observation. To facilitate this method, there is annually published by the Commissioners of Longitude of England, a Nautical Almanac, containing the declination of the moon and the true angular distances of the moon and certain fixed stars for the beginning of every third hour calculated for the meridian of Greenwich (intermediate times by proportional parts). Hence an observation of these angular distances being taken in any place, and the corresponding time at Greenwich found by the Almanac and compared with the time at the ship, their difference will be the longitude of the place."

Further on in the text, Bowditch states, after again mentioning the use of a "perfect" chronometer as a tool for determining longitude:

"The moderate price of a good chronometer now, in comparison with their values many years since, together with the various improvements in their construction, have caused this method of determining longitude to be much more used within a few years (around 1826) than it was when the first edition of this work was published (in 1802)." He then goes on to explain the use of the chronometer for determining longitude in the way it is currently employed.

The Journal

As a final yet important part of his work, Bowditch describes a method for keeping a "ship's reckoning", or journal, at sea and provides in detail such a journal for a 16 day voyage from Boston to the island of Madeira in March-April of 1824. Taking departure from off Cape Cod Light, he calculated, by mercator sailing, the overall course to be S 76 degrees 44' E with a distance to Funchal of 3063 miles. Each day, if the sun was available, he determined the vessel's latitude by a meridian transit observation and, thereafter, made mercator sailing calculations (first 5 days) and mid-latitude calculations (thereafter) for course and distance to the final destination. Daily traverse sailing logs were also compiled. On the 9th day, he obtained a lunar observation (distance of moon from Pollux) and on the 13th another observation (distance of moon from sun) to determining longitude. As can be seen in the excerpt, the daily en-tries also included the courses steered (in compass points), speeds (K), winds, leeway (LW) (from angle of ship's wake), weather, variation, and the days run.

After reading this early edition of what, over the years, has become the navigator's main reference work, one cannot help but be impressed with the knowledge of celestial navigation which existed almost 165 years ago, and the fact that very significant portions of this early knowledge are still used so effectively today. All navigators are indebted to Nathaniel Bowditch for his important contributions to the art of navigation and for the ever-useful text whi-ch still bears his name.

Note: Since its inception in 1802, the "American Practical Navigator" has been issued in over 70 editions and is currently published in two volumes by the Defense Mapping Agency Hydrographic/Topographic Center.

Celestial Sights Near the Pole

by T. D. Davies

In the course of the analysis of data for the Peary project we have had to look at the taking of sights in the area of the pole. It is apparent that the old faithful latitude/longitude grid fails us in that area. Most members will be familiar with Grid Navigation and the fact that it simplifies this problem. However it was developed essentially for aircraft navigators after they started flying over the pole frequently and may not be well known to everbody. It seems clear that none of the Peary critics, either modern or old have a familiarity with the system or the meridian convergence problem which created it.

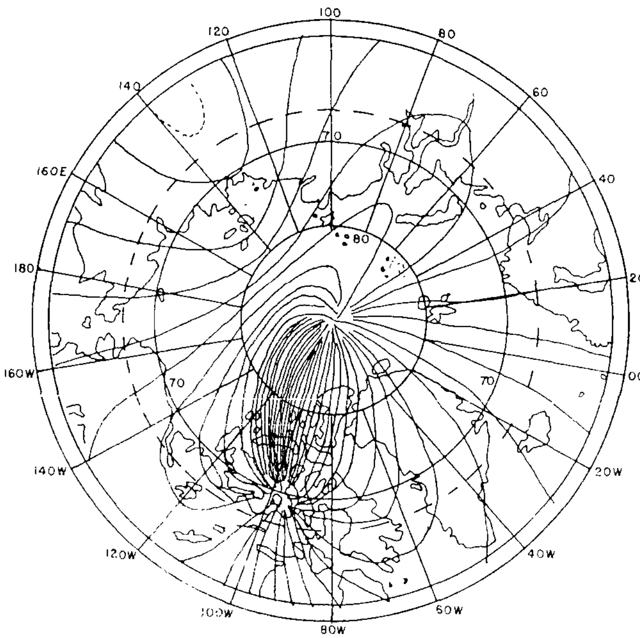
At least one modern polar explorer appears to have been ignorant of the problem and attempted to use Marcq Ste. Hilaire very close to the pole. Wally Herbert the distinguished British arctic explorer, in 1968-69 quotes his position in latitude and longitude when within seven miles of the pole! It appears that he then attempted to use the longitude to determine the direction to head to get to the pole. Obviously he could easily have been 60 degrees out in his longitude because of the size of a degree compared with the normal error of his sights. This seems to be what happened since his sight after moving 7 miles showed him still 7 miles away.

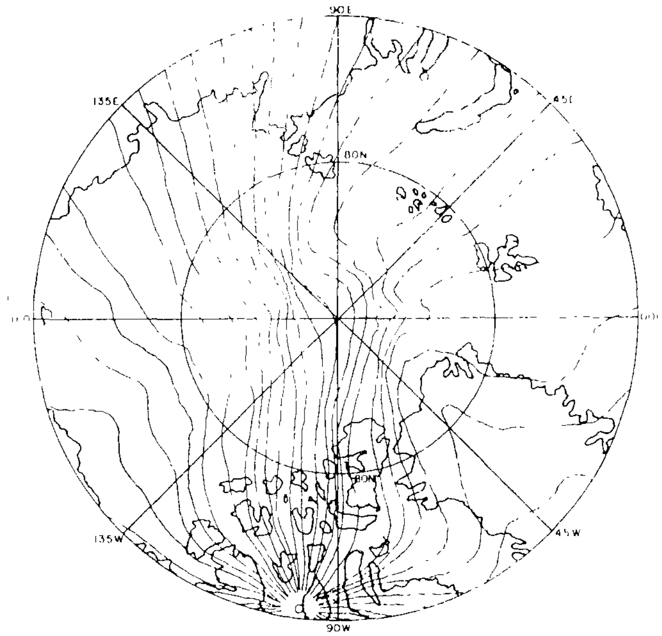
In taking longitude sights reduced by Marcq Ste. Hilaire the convergence of the polar meridians impose a problem. With a sight uncertainty of about 5 minutes of arc (a not unusual uncertainty in those areas), the following table shows the equivalent uncertainty in longitude degrees for various latitudes:

Latitude	85	86	87	88	89	
longitude uncertainty	1	1.2	1.6	2.4	4.8	degrees

At 89.9 N the longitude uncertainty would be 48 degrees. The additional factor is that the celestial body's azimuth is plotted from the meridian as the base of its direction. Thus the EP and the LOP will both be displaced by the longitude uncertainty. Any resulting fix would certainly be of dubious value. Further using the longitude as direction information would also be useless.One of the faults found with Cook's navigation data which he submitted as "proof" of his attainment of the pole was that he presents a position 29 miles from the pole, in which he not only specified longitude, but tabulated it to seconds of arc. If grid navigation is not used then longitude must be specified only grossly and not be used to determine direction nor to plot azimuths from.

In 1909 it is probable that most navigators would prefer the time sight rather than Marcq Ste. Hilaire. Here one must first have a latitude and enter the calculations with latitude, declination and altitude. The calculation





yields the hour angle of the body from which the correct time must be deducted to yield longitude. In the light of the uncertainties of time after a long absence from correction sources, it is noteworthy that an incorrect time will produce an incorrect longitude, but using that longitude with that time will produce the correct time of local apparent noon at the location. Thus the time sight for direction to the pole is self-correcting for incorrect time. A more conventional Marcq Ste. Hilaire sight will also have the same independence of correct time. However note that the positional uncertainties associated with the measurment of low altitudes and the corresponding high and variable refractions are still there and result in considerable uncertainty in any direction obtained this way.

The meridian convergence also distorts the appearance of the lines of magnetic variation. The isogonals change with the changing meridians and so produce a large number of lines which give the appearance of a rapidlychanging compass direction. The grid navigators have produced a map called a Grivation Map, where the compass direction is related to the rectangular grid rather than meridians. This map shows a relatively low rate of change of compass direction in the north polar area. The illustration shows two such maps for comparison.

Notes on the Accuracy of the Nocturnal Based on Observations Taken in April 1989

By John M. Luykx

In the last issue of *The Navigator's Newsletter* (Issue Twenty-Four, Spring 1989, pp. 5 and 6), a description of the nocturnal was given including the dimensions of a replica instrument made of wood in the author's collection. Although no opportunity was available to test the accuracy of this replica prior to the publication of the Nocturnal article, a series of eighteen (18) observations were made with the instrument subsequent to publication of the article and with gratifying results. The observations were taken during the month of April over a period of five (5) evenings from a point ashore in the Washington, D.C. area. A bit of practice was required with the instrument prior to recording the test data in order to develop an acceptable technique for proper and accurate observation.

For the test, time indicated by nocturnal (estimated to the nearest 5 minutes) was compared to the nearest minute of local mean time (zone time corrected for longitude difference) to obtain instrument error. The results of the test were as follows:

Number of observations:	18
Mean Instrument Error:	+8 minutes
Standard Error:	5 minutes
95% Error:	10 minutes
Range of Error:	17 minutes (+16 min to -1 min)

As a result of this accuracy test, the instrument correction (I.C.) of the replica Nocturnal was determined to be -8 minutes.

Errors of observation during the test were basically caused by a) difficulty in holding the instrument steady enough to keep the star Polaris continutally visible in the center of the sighting hole during observation and b) the additional difficulty, because of darkness, of holding the vertical axis of the instrument aligned with the true vertical; i.e. the observer's meridian.

From the deck of a pitching, yawing and rolling vessel, however, it would be almost impossible to hold the instrument vertical or steady enough to keep Polaris visible in the sighting hole for any length of time. Accuracy of the noctural when used on board a small vessel at sea is estimated to be only within 15 to 30 minutes.

A Navigation Problem

by Roger H. Jones

26. Answer.

Look up the time of sunrise for 40 North on April 30th; the time is 0503. Then look up in the Almanac the time of sunrise for April 30th at a latitude that is 90 degrees south of your latitude. In this case, it would be 50 South, and the time is 0703. The difference in the two times is the time it will take the sun to reach due east after rising. The difference here is two hours. The sun will bear due east two hours after rising, and will bear due west two hours before setting.

The sunrise tables list times for latitudes up to 60 South and 76 North. This means that the procedure works in the north only when the observer is at 30 North or higher, and only when he is at 14 South or higher. However, the sunrise times are symmetric in date and latitude, and the limit for northern latitudes can be extended down to 14 North by assuming that you are at a southern latitude and by using a date that is six months later than the present date. (For a more complete description of this procedure, see David Burch's Emergency Navigation, which was reviewed in Issue No. 11.)

Problem No. 27.

In the last several problems, the hapless navigator has been concerned with determining fairly accurate direction by reference to the point of rising (or setting) of a body on the horizon, and by reference to the body when it bears due east or west. He is now faced with the task of steering throughout the day. Of course, he may do so by reference to the sun at Local Apparent Noon, and by reference to steady swells. However, he wishes to use a solar time method to determine the direction of the sun at successive points in time throughout the day.

What method may he employ, and what is a vital consideration respecting the maximum height of the sun if his solar time method is to be of practical utility?

NAVIGATION PERSONALITIES

Simon Newcomb

by T. D. Davies

Simon Newcomb is a name probably not familiar to most modern navigators, yet he was a major force in the generation of the planetary data used by navigators today. Born in Wallace, Nova Scotia, March 12, 1835 he became a resident of the U.S. in 1853. He graduated from the Lawrence Scientific School of Harvard University in 1858 and entered service in the Almanac Office in 1857. He was commissioned in the navy's Corps of Professors of Mathematics, a branch of the officer corps which dated back to the days when midshipmen were trained aboard ship by these officers. It was the problem of trying to accomplish a good education program in this fashion that led to the establishment of the Naval Academy at Annapolis in 1845.

At that time the Almanac Office was separate from the Observatory and was under its own Superintendent. In 1877 Newcomb was made Superintendent and shortly thereafter started his complete revision of the data and organization of the Almanac. The reorganization of data and methods he established was the most sweeping in the history of the Almanac Office. Many considered that his genius helped started a revolution in astronomy.

Among his most notable achievements are his researches in connection with the theory of the motion of the Moon. In doing this he undertook the reduction of every observation made before 1750 which appeared to be worthy of confidence. The results were published in 1878. The observations used in this work covered an extreme range of time of about 2,600 years. The work was only completed about three months before his death in 1909.

At the international conference, which met in Paris in1896 for the purpose of elaborating a common system of constants and fundamental stars to be employed in the various national ephemerides, Newcomb took a leading part and undertook the task of determining a definite value of the constant of precession, and of compiling a new catalogue of standard stars. The results were published in 1899 and were in general use for a quarter of a century.

He was retired in 1899 with the rank of Rear Admiral in his corps and was the recipient of innumerable medals and honors from almost every scholarly institution in the world. To him navigators as well as astronomers, owe the scope, accuracy and reliability of the ephemeral data upon which our very lives sometimes depend.

MARINE INFORMATION NOTES

Compiled by Ernest Brown

Chart Exchange Program

York River - Yorktown and Vicinity - Chart 12241 - Scale 1:20,000 - 15th Edition - November 19, 1988, and Chesapeake Bay - Mobjack Bay and York River Entrance - Chart 12238- Scale 1:40,000 - 28th Edition - September 3, 1988. The location of fixed aid Daybeacon "2A" and floating aid buoys "2" and "5A" in Wormley Creek were incorrectly positioned on these charts. New editions will be distributed to replace these charts. Free exchange of these editions will be available through chart agents by April 1989. Exchange copies may also be obtained by telephone at (301)436-6990 or by writing to: The Exchange Program, NOAA Distribution Branch, N/CG33, 6501 Lafayette Avenue, Riverdale, Maryland 20737-1199.

Catalog of Agents for Sale of Charts (mp-009)

The 'Catalogue of Agents for Sale of Charts', Fourth Edition, is distributed free of charge to the IHO Member States Hydrographic Offices. All other users may obtain copies from the IHB (price per copy 75 French francs, plus postage) at the following address:

International Hydrographic Bureau
B.P. 445
MC 98011 MONACO Cedex
Principality of MONACO

Telex: 479164 MC INHORG
Telefax: (33) 93 25 20 03

Notice to Mariners No. 1

In 1987 DMAHTC announced that it would publish the Special Notice to Mariners paragraphs in Notice to Mariners No. 1 as a separate publication with the new title Annual Notice to Mariners. In 1988 DMAHTC announced that Annual Notice to Mariners was not published because of scheduling difficulties, Now in 1989 we find that Notice to Mariners No. 1 still contains the special Notice to Mariners paragraphs.

DMAHTC Representative Los Angeles/Long Beach

The Terminal Island representative is now designated the Los Angeles/Long Beach representative. The telephone number has been changed to (213)514-6177.

Mariana Islands Charting Responsibility

In 1988 the charting responsibility for the Mariana Islands was transferred from DMA to NOS. In 1989 NOS will publish new editions of Saipan Harbor and Plans in the Mariana Islands.

BOOK REVIEW

by Roger H. Jones

The Atlantic Crossing Guide

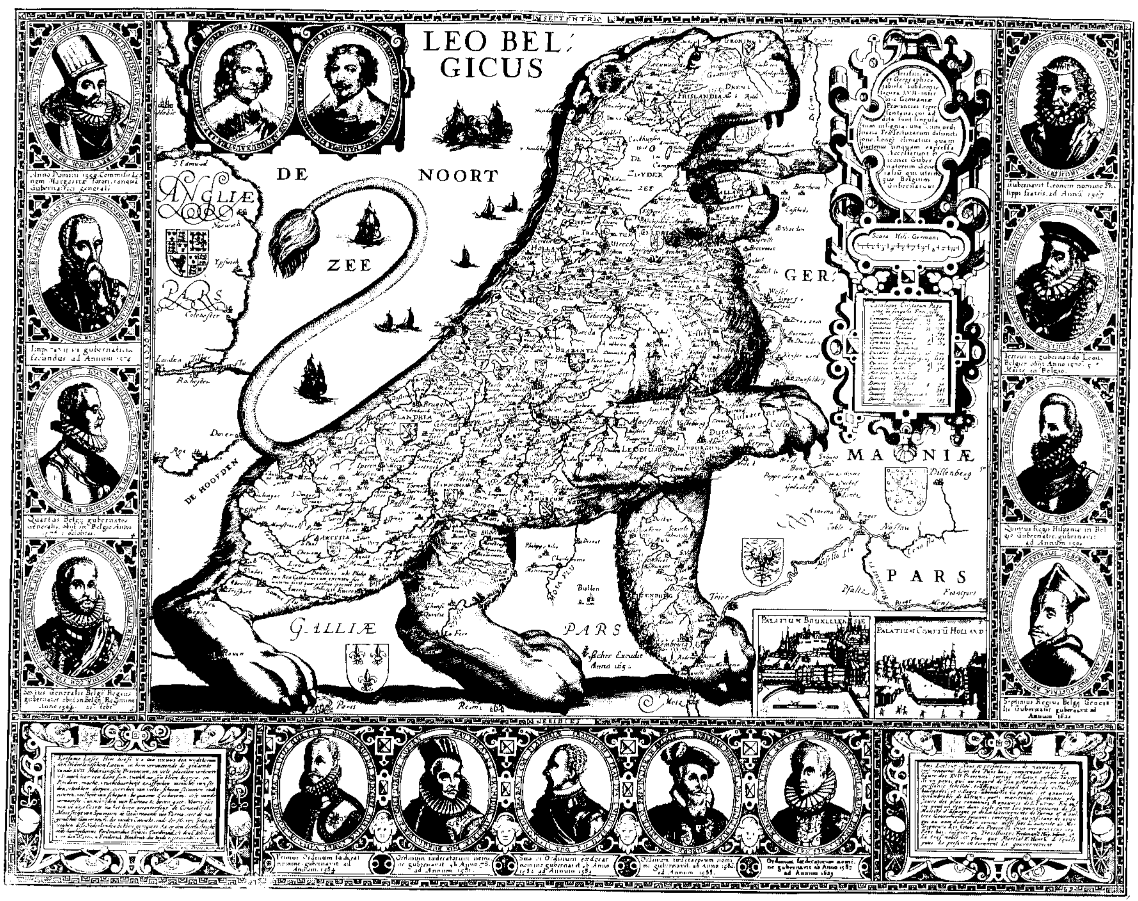
Second Edition (1988)
Royal Cruising Club Pilotage Foundation
Edited by Philip Allen
International Marine Publishing Co., 21 Elm Street
Camden, Maine 04843, 278 pages; $29.95

In Issue No. Eighteen (Fall 1987), we reviewed Jimmy Cornell's new World Cruising Routes, comparing it to the older classic, Ocean Passages for the World. In this Issue of the Newsletter, the focus is once again upon the subject of voyage and navigation planning, and a new comparison is in order.

The Atlantic Crossing Guide was first published in Great Britain in 1983 by Adlard Coles. It was an instant success, and was republished with amendments in 1984 and 1985. Now the Second Edition has appeared, a sure sign that this work is finding its own place in the minds and hearts of voyagers.

Like Cruising Routes and Ocean Passages, The Atlantic Crossing Guide is an enormously useful compendium of information on sailing routes, in this case those that encompass the eastward and westward crossings of the North Atlantic in their respective latitudes, the intermediate passages from the U.S.

Address all correspondence to:
The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850
Telephone 301-622-6448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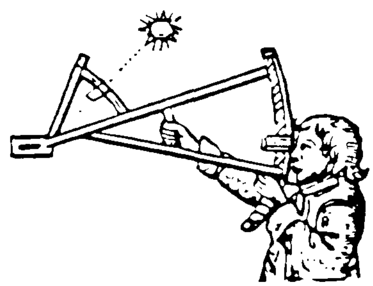
// THE NAVIGATOR'S NEWSLETTER

FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

ISSUE TWENTY-SIX, FALL



This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

by T. D. Davies

The Peary Project

The board members continue their efforts on the Peary Project. The date of delivery of the final report has been set back to 15 December because of the substantial amount of additional data to be digested and analyzed. While the majority of the search of the National Archives has been done by three board members, the draft sections of the report are being routed to all members for comment. Thereafter each section is revised and reissued. Before the final issuance of the report we will have a meeting of the entire board in Washington during which it will be given a complete review. Thus the report will be a product of the whole board.

We expect that the report will receive a certain amount of publicity and should be of fairly wide interest. We intend to make copies available to our members at a discounted price which will be announced in the next issue of the Newsletter.

Navigation Awards

In the last issue of the Newsletter we announced the winner of the Dutton Award at the Naval Academy but neglected to mention the winner at the Gould Academy in Bethel, Maine. That winner was Ms. Andrea Pillsbury. Congratulations!

It seems that instructors in navigation might also be encouraged by an award for excellence in instruction and we have been planning for such an award. If we are successful in establishing an appropriate time and place we plan to make a first such award to Chief Kabrick who has proven an inspiring teacher of navigation at the Officer Candidate School at Newport. A citation for Chief Kabrick from the Secretary of the Navy is shown under Marine Information Notes in this issue.

Publication Problems

Thus far we have had minimum response to the call for interest in a summer cruise in Tandemeer. This is not too surprising in view of the late publication of the Summer Newsletter.

The delay in publication resulted from problems incident to shifting to a new and more modern Computer. We accumulate text from several different softwares and have to convert finally to the Macintosh used for editing and printing. This has sometimes been a problem but with the advent of the new computer and new software our system blew up. We believe all that has been corrected and that this issue will be more or less on time. However we have our fingers crossed.

As part of our conversion problem Roger Jones' book review was short-changed and not picked up in the proofing. We have therefore repeated the previous review in this issue.

READERS FORUM

Dr. Robert L. Wenninger of Kasempa, Zambia writes:

I am interested in learning more about celestial navigation and wonder if your organization can be of some help. Would you please send me whatever promotional material you have. Please send it by air mail, since surface mail takes 4 months. I am an American physician working in this developing country. Thank you for your assistance.

Robert Young of Huntsville, AL writes:

I have been practicing celestial navigation for almost a year. The most useful book on navigation I have read is "Common Sense Celestial Navigation" and as a result I use Pub #249 for most of my sight reductions, but I have used the Basic Spherical Trigonometric Equations also. Using a pocket calculator with these equations is quick and accurate. A friend of mine has a textbook on spherical trigonometry (1905) by Wentworth that has a section on celestial navigation with some useful and interesting equations. The reason I am writing is to inquire about the Lunar Distance Method for determining longitude. This method is mentioned in Bowditch's *American Practical Navigator* but is not explained. Which book do you think best explains this method? My most accurate fixes are from star sights. Is this common for most navigators or just a coincidence for me? Any information you can provide about the Lunar Distance Method will be greatly appreciated. Thank you!

Editor Note: For Lunar Distances Mr. Young was sent the explanation pages and some pages from the Lunar Distance section of The 1909 Almanac, the last year which tabulated that information.

Dr. John A. Decker, Jr. of Maui, Hawaii writes:

You asked me to let you know how our license negotiations on the COMPUSIGHT TM Automatic Sextant Patents 4,707,926 &4,763,418; Foreign Patents Pending went. Unfortunately, we were never able to reach an agreement, primarily, I think, because of another project competing for my potential partner's time and resources. So, I'm back looking for a suitable marketing partner again. As we now see it, the COMPUSIGHT TM on dealers' shelves will: Use a built-in microcomputer for all functions; have our proprietary reflective photosensor angle sensing; and be built around a custom-designed plastic sextant. This total system should now retail for around $500, or about half the cost of a good metal sextant. My company, KUAU Technology, Ltd., brings to the table patent coverage - U.S., German & Japanese; technical expertise; in-depth understanding of the problem; and familiarity with the market and the players. We do not have, and therefore urgently need Marine-instrument marketing experience, financial backing, microcomputer design & manufacturing technology, injection-molding production knowledge, and production facilities. If you know anyone who fits this prescription, please let me know!

Andrew S. Horton of Springfield, Virginia writes:

Attached is a press release and statement by our expedition's leader Ralph Plaisted, April 19, 1989, our 21st anniversary, claiming priotity at the north pole. It is valid and appropriate as the only proven claim to date, leaving others to prove their priority if they can, something the Foundation's report may or may not do for Peary. The references in the press release to Peary are nothing new and should have been omitted. These are submitted for whatever help they may be. Thank you for your phone call some weeks ago commenting on my letters and explaining your operation.

Editor Note: Our study will try to cover all available information, and certainly Ralph Plaisted's views are useful and important. This data is particularly useful since we have been unable to discover any publication in which they are set forth (as they have been in the case of Herbert).

NAVIGATION BASICS REVIEW

The Most Probable Position From Celestial Observations

By John M. Luykx

All navigation observations including celestial observations are subject to the probability of error. Most of the error occurring in navigational observations may be categorized as either systematic error or random error.

Systematic errors are errors which can be predicted, hence eliminated or allowed for. Examples of systematic errors are: sextant index error, error caused by compass deviation, sextant "tilt" error, personal observation error, etc.

Random errors are unpredictable and are governed by the laws of probability. For example, if the altitude of a celestial body is observed, it may be either a) correct b) too great (+) or c) too small (-). If a large number of observations are made, the probability of altitude readings which are too great is equal to the probability of altitude readings which are too small and the probability of error of the mean value of all the observations would be equal to zero.

The Most Probable Position (MPP) of a vessel at sea is the position determined by an evaluation of all available navigation information recognizing the fact that probability of error exists in all navigation information. For practical purposes at sea, the navigator generally evaluates for accuracy all data used to establish position, assigning relative values to the various factors involved. Based on observational experience the navigator should evaluate each observation taken and assign a probability of error in miles for each line of position. Similar evaluations should also be made concerning the accuracy of steering and the estimation of speed and/or distance made good. When probability of error is assigned to the various factors involved in position determination, a more accurate evaluation of the MPP of the fix will result.

To illustrate this point, an example may be given. If a vessel follows a specific course and speed from an accurate Dead Reckoning (DR) position, the uncertainty of future DR positions would increase in all directions if equal value, over time, was assigned to both course and speed errors. In such a case, the MPP of a vessel would be within a circle of uncertainty whose diameter would increase with time. (Fig.1) If, on the other hand, the navigator evaluated speed errors to be greater than course errors, the MPP would be within an ellipse of uncertainty whose major (long) axis would coincide with the direction of the track. (Fig. 2) Further, if some time later a line of position (LOP) were obtained, the MPP of the vessel would be established as follows:

A circle or ellipse of uncertainty would be drawn about the DR position and a band of uncertainty (an area of probable error extending on either side of the LOP) drawn parallel to and on either side of the LOP. The vessel's MPP would then lie in the area of overlap in the DR and LOP areas of uncertainty. (Fig. 3)

If two (2) LOPs are employed to establish position, the area of uncertainty would be an ellipse unless the LOPs crossed at right angles and equal probability of error were assigned each LOP, in which case a circle of uncertainty would be the result. (Fig. 4 and 5)

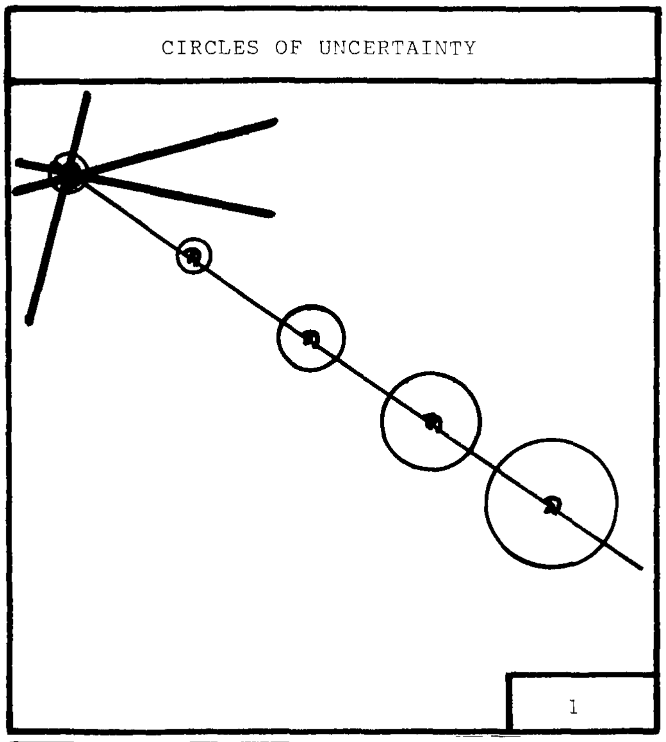
In the case of a simultaneous three body fix whose azimuths vary by more than 180°, all with equal probability of error, the MPP would be located in the interior of the triangle formed by the three LOPs, equidistant from each side. (Fig. 6) If unequal probability of error is assigned to each LOP, the MPP would then lie closer to the intersection of the LOPs with the lesser probability of error. (Fig.7)

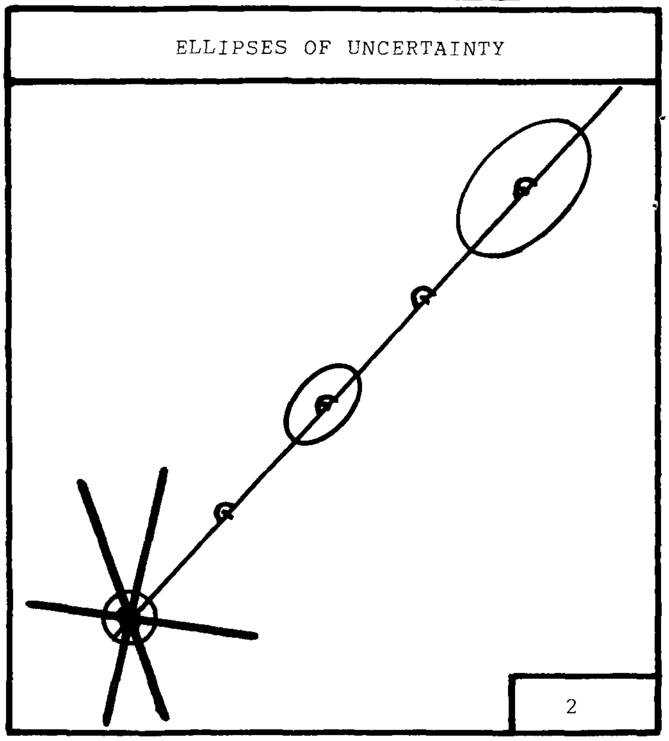
If a systematic error, unknown to the observer, were also included in each of the three observations, the MPP of the fix would remain at the same point although the size of the triangle formed by the three (3) LOPs would increase or decrease depending on whether the systematic errors were (+) or (-). (Fig. 8)

The MPP of a vessel determined from simultaneous observations of three or more celestial bodies whose azimuths vary by less than 180° is located in the center of the figure formed. For three LOPs of equal probability of error, this would be the center of the triangle, equidistant from each side. (Fig. 9) If a systematic error is assumed, the MPP may be found by applying a correction for this error. Two additional and differing MPPs would result:
an MPP located outside the triangle (Fig. 10) with positive systematic error present; an MPP also located outside the triangle (Fig. 11) with negative systematic error present. When no systematic error is present the MPP would be within the triangle formed by the LOPs as shown in Figure 12.

It is recommended that the following factors be considered when taking near-simultaneous observations of several celestial bodies, such as those normally taken at morning and evening civil twilight. Although many additional factors could also be included in the listing, it is felt that those listed here are basic and well worth noting by the careful navigator.

1. A probability of error should be assigned by the observer to each observation and LOP. This value should be applied when determining the MPP of the resultant fix. Although the value of error is a subjective matter which varies from observer to observer, experience will generally indicate poor observations as opposed to good





observations. Experience at sea will also indicate how best to evaluate errors in steering (course errors) as well as errors in estimating the distance and speed made good.

2. For simultaneous observations it is generally advisable to advance and retire LOPs as necessary such that the time of the fix may be established on the whole, half or quarter hour. This results in a more convenient time for the fix and simplifies basic chart work.

3. Whenever possible first magnitude stars should be observed. They are brighter and generally more easily

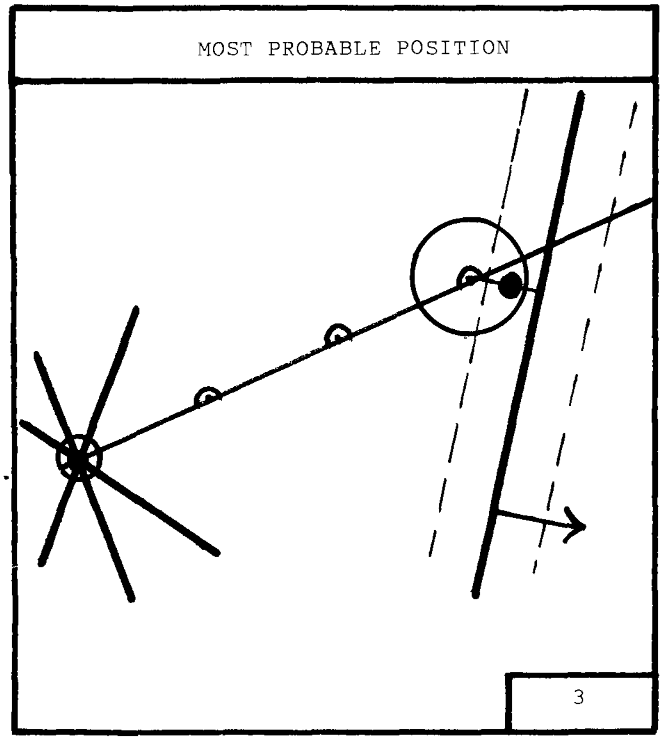
and accurately observed especially with an indistinct horizon. Observational error is reduced when the brighter planets and first magnitude stars are observed.

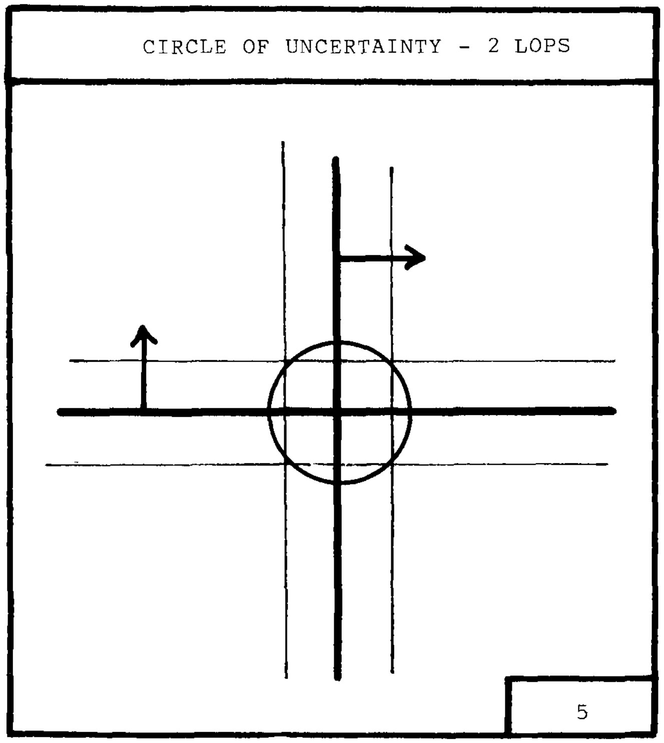
4. For a two (2) body fix, bodies 90° apart in azimuth should be selected.

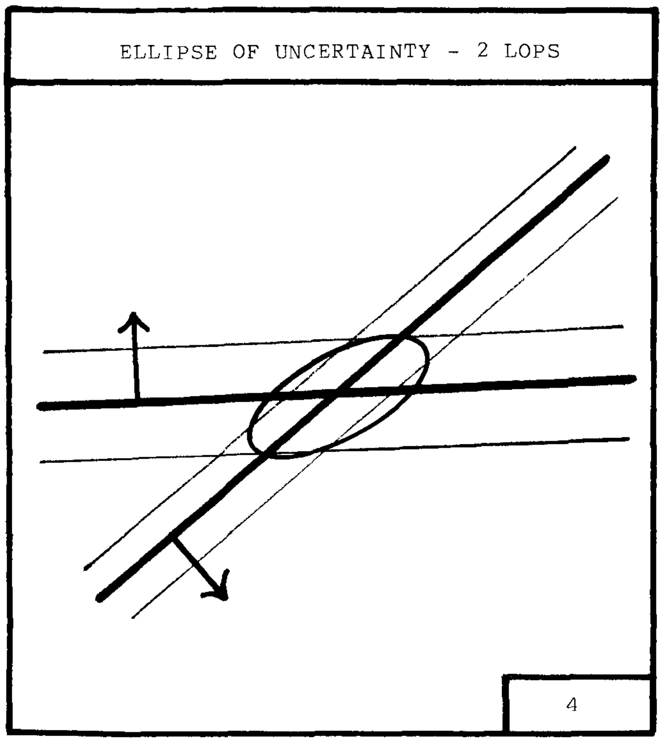
5. For a three (3) body fix, bodies 120° apart in azimuth should be selected. Unknown systematic error, if present, is thus eliminated. If the azimuths vary by 60° or less or have a spread of less than 180°, a large unknown systematic error would place the actual position of the vessel in either of two positions both outside the triangle formed by the LOPs.

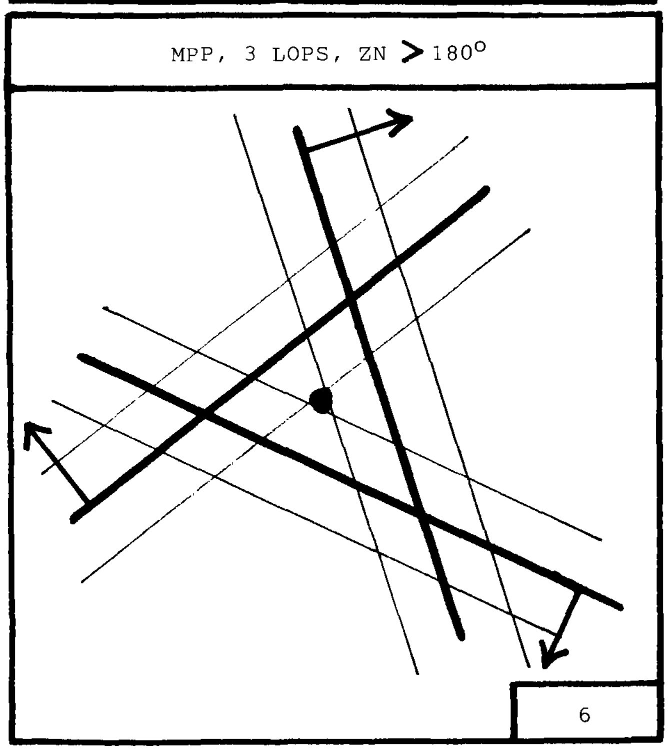
6. For a four (4) body (or more) fix, bodies 90° apart should be selected. An unknown systematic error in the observations would be eliminated by using the mid-point of the fix.

7. Accuracy of observation is increased when a series of observations is taken of each body and the altitudes plotted against time on graph paper. Fairing a line of correct slope through the plotted points provides a locus of points which may be used for sight reduction. (See the *Navigator's Newsletter*, Issue 25, Summer 1989)









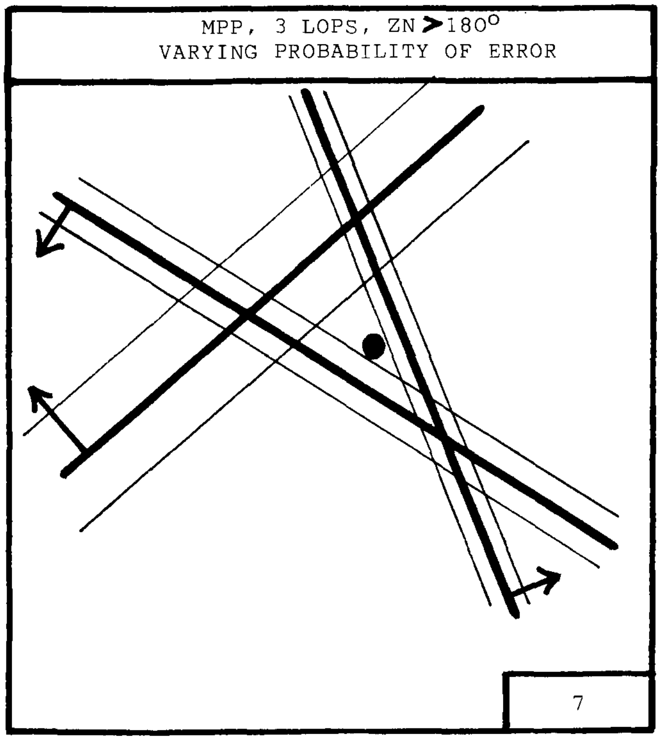
8. To eliminate errors caused by uncertain values of refraction, bodies below 15° in altitude should not normally be used for observation.

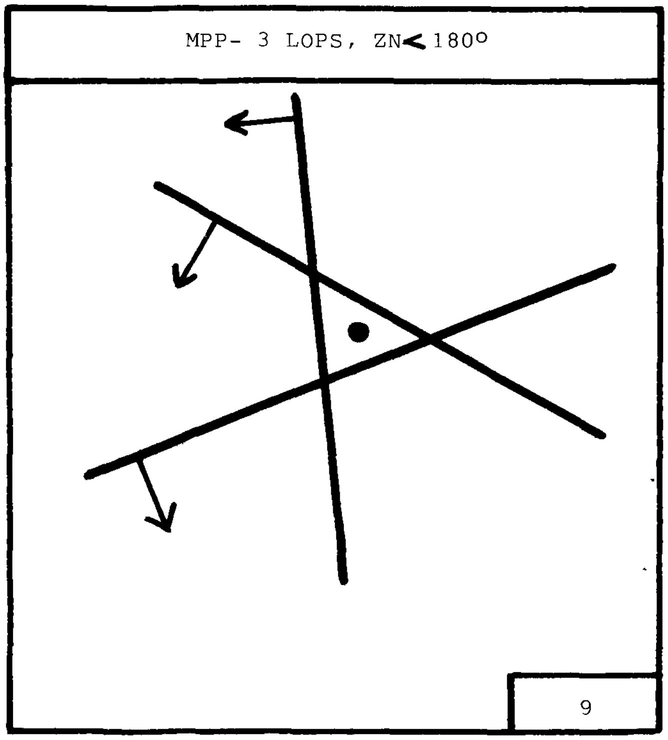
9. For altitudes above 50°, it becomes more and more difficult to determine exact sextant vertically during observation. It is recommended, where possible, that bodies above 50° in altitude not be used for observation.

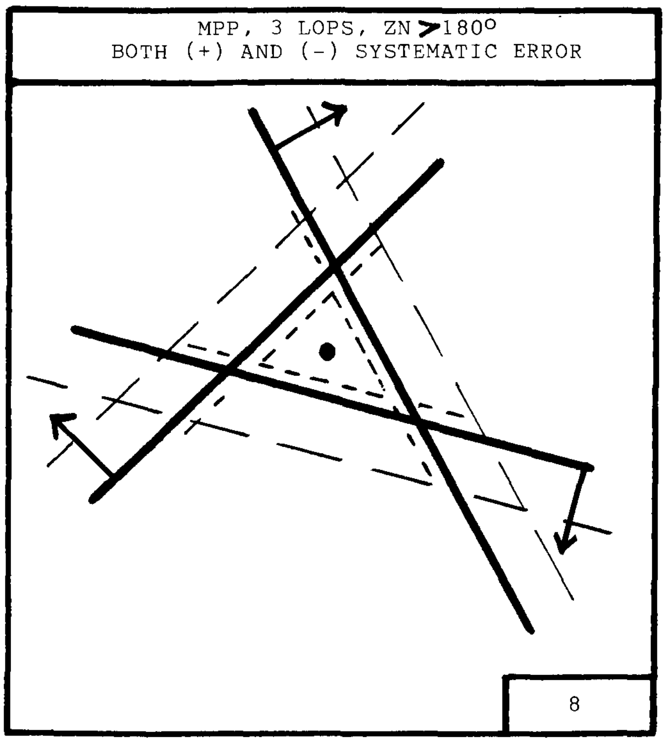
10. An observation taken of a body located dead ahead or dead astern in azimuth will provide a check of progress along the track.

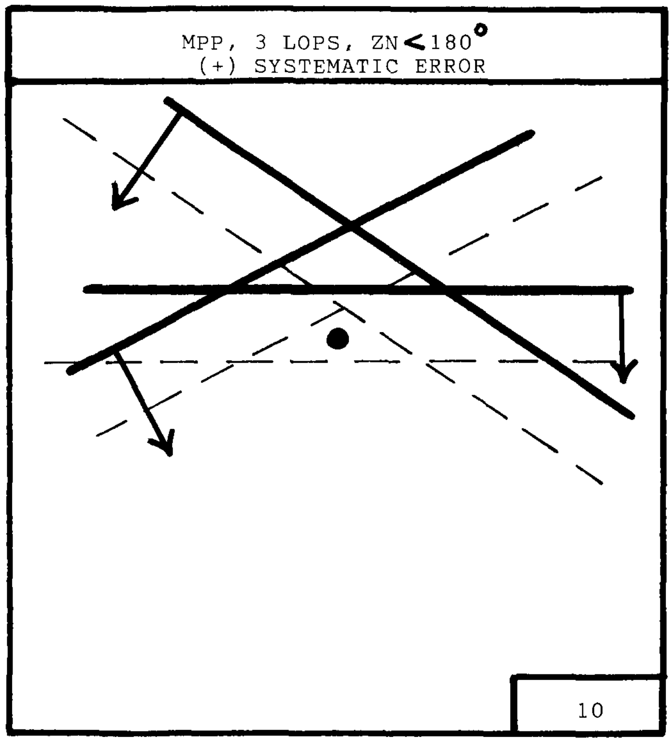
11. Similarly, an observation taken of a body located at right angles to the track in azimuth will provide a check of the vessel's position either to the left or right of the track.

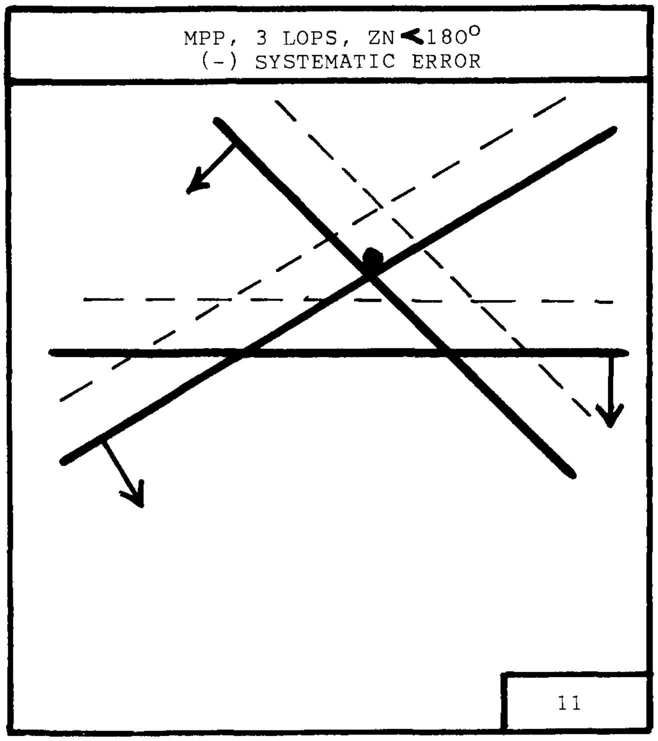
12. During morning civil twilight, when simultaneous observation of the stars and planets are planned, observe the stars to the east first; then shift around to the western sky. Stars will disappear from the eastern sky earlier than those in the western sky. The same is true at evening twilight. In the evening, the eastern horizon disappears first so that initial observations should be made in the eastern sky. This is not a hard and fast rule, however. For

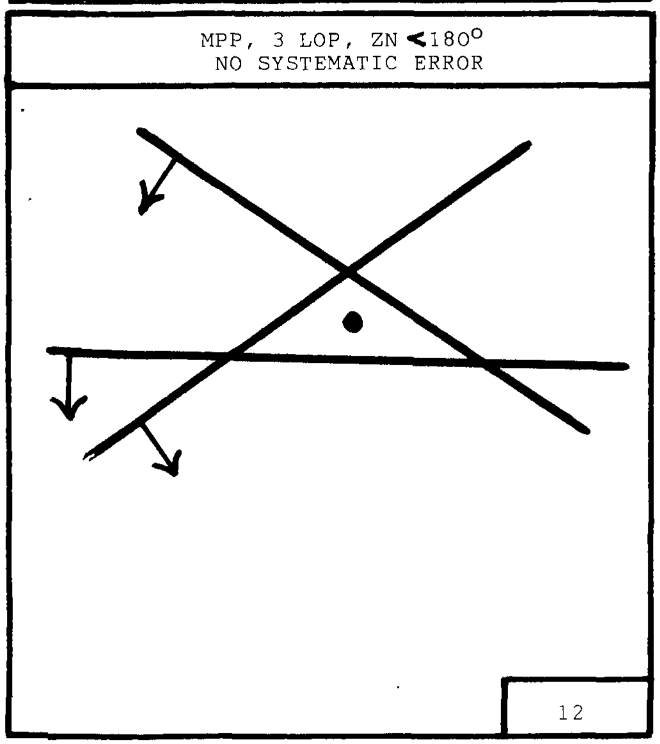












example, a night star or planet in the quadrant of the sun may be observed last due to clear definition of both body and horizon.

13. If a sextant with split horizon mirror (half clear-half silvered) is used at twilight for star and planet observations, shift the position of the telescope toward the plane of the sextant when observing a dim body over a distinct horizon. This adjustment permits more of the silvered half of the horizon mirror to be reflected into the telescope field of view. Conversely, when observing a bright body over an indistinct horizon, shift the position of the telescope outward from the plane of the sextant thereby permitting more of the horizon to be reflected into the telescope field of view. When using a sextant with "full-view" horizon mirror, adjusting the position of the telescope is not necessary.

14. When observing the sun during the day, the telescope selected for use should provide the clearest definition of both limb and horizon. 6x30 and 7x35 prismatic monocular telescopes are recommended. For the observation of stars and planets at night the light gathering power of the telescope is of prime importance. 2x20, 3x30 and 4x40 telescopes are recommended because they provide a wide exit pupil. An additional consideration is field of view. The ideal telescope for twilight or night use would provide superior light gathering power as well as wide field of view.

NOTE For a detailed discussion of navigational errors including the laws of probability as they affect the determination of a vessel's most probable position, the reader is referred to Appendix Q of the latest edition (1984) of Bowditch, Volume I. Chapter 29 of the latest (1985) of Dutton's is also recommended.

HISTORY OF NAVIGATION

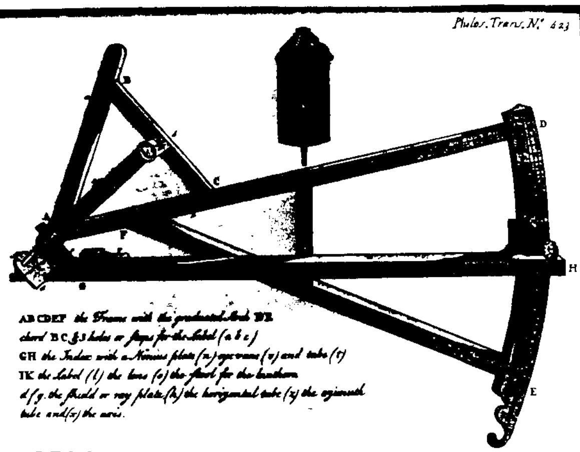
The Artificial Horizon Sextant

By John M. Luykx

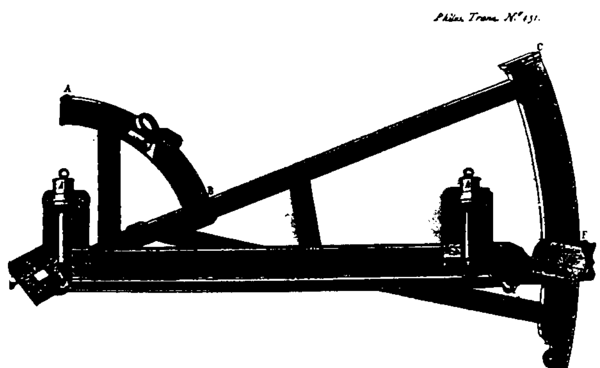
Ever since the visible sea horizon was first used by mariners as a reference for measuring the altitude of a celestial body, there has existed, particularly since the early 17th Century, a concurrent interest in the development of an instrument which could measure altitudes without reference to the visible or actual sea horizon. Very often at sea, the horizon is invisible due to fog, haze or darkness. During these conditions of visibility, instruments such as the cross-staff, the back-staff and the sextant which depend on the visible horizon could not be used.

Although the seaman's quadrant, the mariner's astrolabe and the sea-ring (employed by mariners primarily during the late 15th through the 17th centuries, a period which spanned the age of exploration) cannot be truthfully considered as artificial horizon instruments, they, in actual use, served that purpose. (See Navigator's Newsletter, Issues 18, 19 and 22) For the 17th and 18th century mariner who could not use his cross-staff or back-staff for a noon sight due to a poor or non-existent horizon, the astrolabe, or pendulum quadrant or even the sea-ring was the only alternative if he absolutely needed a noon-latitude.

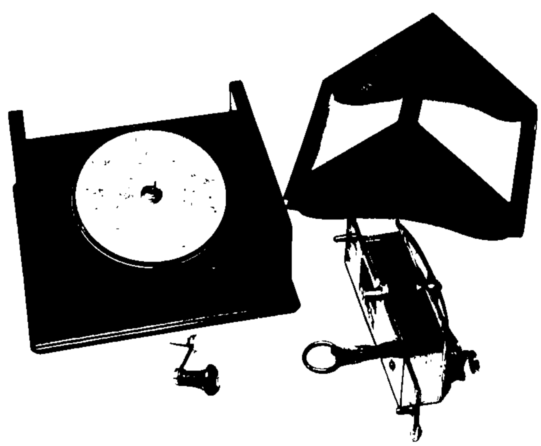
Experience at sea with all three of these instruments clearly demonstrated, however, that they were



ELTON
QUADRANT SPIRIT LEVEL (1732) Fig.1



LEIGH
QUADRANT MERCURY LEVELS (1738) Fig.2

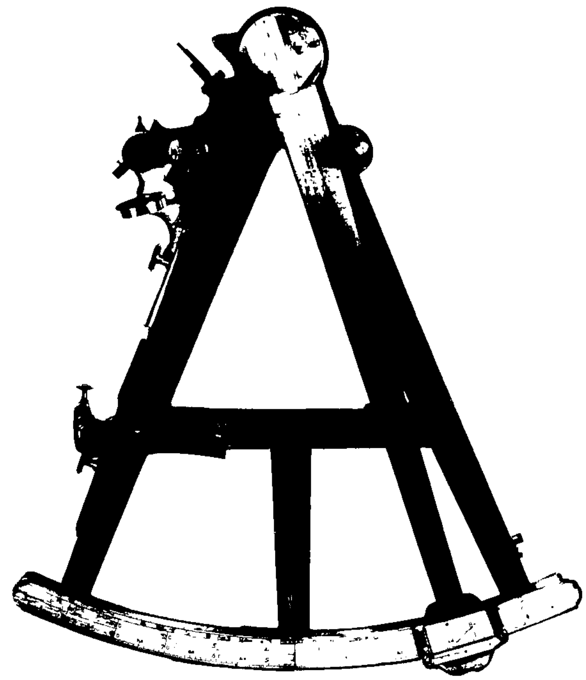


JOHN SERSON's HORIZONTAL SPECULUM (1743)

Fig. 3

unsuitable in any kind of sea-way because of their often erratic and awkward pendulum motion. A new and different system had to be found to establish the artificial horizon as a reference; preferably a device which could be fitted or installed on a back-staff or early form of quadrant, octant or sextant. Such a device would have the added advantage of also permitting night observations of the moon, the stars and the planets.

Among the first artificial horizons were spirit, water

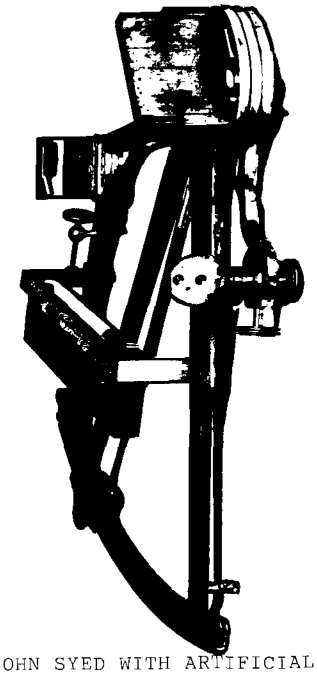


OCTANT BY BENJAMIN COLE WITH SPIRIT LEVEL (1760)

Fig. 4

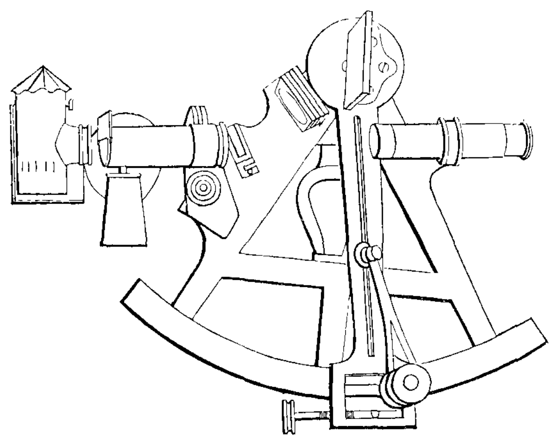
and mercury levels fitted to the back-staff by John Elton and Charles Leigh in the 1730s in England. Two curved spirit levels were fitted at right angles to each other on the Elton quadrant; one level indicated the horizontal, while the other indicated the vertical. (Fig.1) In the Leigh quadrant, only horizontal levelling was provided by a water and later by a mercury level. The mercury level eliminated some of the problems experienced with the water levelling system. (Fig. 2)

A few years later John Serson developed a hand-operated "whirling top" (the horizontal speculum) which, when rotating at high speed, provided a stable horizontal reflecting surface. This device was the first gyro type artificial horizon. The altitude of the celestial body was measured (from its reflection in the horizontal speculum) with a Hadley octant and the measured angle halved to obtain the altitude. (Fig. 3) Initial tests indicated some success. Later developments of the Serson design by John Smeaton were not so successful. In 1760 Benjamin Cole of London installed a spirit level to the frame of a Hadley octant. The bubble was reflected upward to a 45° inclined circular mirror which in turn reflected the bubble into the observer's field of view. This instrument is unique in that the radius of curvature of the spirit level closely approximates the distance of the optical path from spirit level to octant eyepiece; perhaps the first example of an artificial horizon collimated to infinity; i.e. the first true artificial horizon attachment. (Fig. 4) In 1791 John Syed mounted an artificial horizon on a brass framed octant. It is of interest because of its unusual design. (Fig. 5) Although the well-known



OCTANT BY JOHN SYED WITH ARTIFICIAL HORIZON (1791)

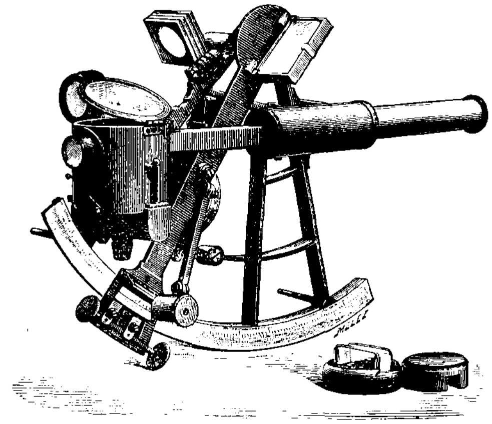
Fig. 5



BECHER'S ARTIFICIAL HORIZON (1843)
attached to a Sextant.

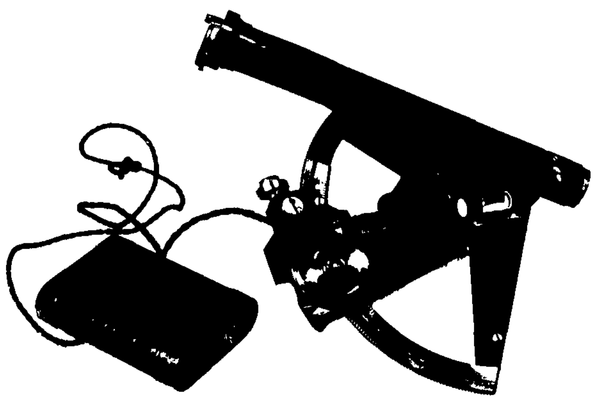
Fig. 6

English instrument makers, Dollond and Troughton, manufactured various artificial horizon devices around the turn of the 19th Century, the next major development was the pendulum horizon developed in 1843 by Commander A.B. Becher, Royal Navy. The pendulum was installed forward of the horizon mirror of the sextant and fitted with a horizon vane which indicated the true horizon as the sextant was tilted in the vertical plane. (Fig. 6) The pendulum was dampened in its motion by being enclosed in a cylinder of oil. Although extensive practice in its use was necessary, practical accuracy was attainable with this instrument so long as the vessel was



THE FLEURIAIS GYROSCOPIC HORIZON (1886)
attached to a sextant.

Fig. 7

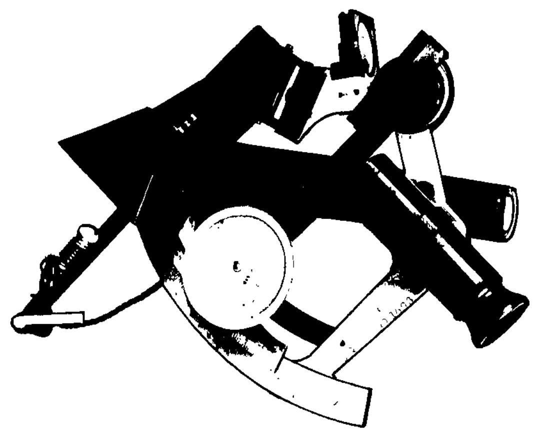


BUTENSCHÖN BALLOON SEXTANT (1894)

Fig. 8

not in "violent motion." A spirit lamp was attached to the pendulum housing to provide illumination for night observations.

In 1886 Captain G. E. Fleuriais of the French Navy invented the first practical air-driven gyro stabilized artificial horizon attachment to a marine sextant. The air-driven turbo-rotor located in a housing positioned forward of the horizon mirror was set in motion by forced air from a hand-operated air pump. When up to speed (about 2500 to 4000 rpm) the rotor erected in about 5 minutes and remained in operation for about 40 minutes. Once erect, a source of light located forward of the rotor housing was projected through a lens system attached to the top of the rotor to form the true horizon which was visible in the sextant telescope field of view. The artificial horizon was projected as a vertical scale measuring 200' of arc graduated from -100' at the bottom and +100 at the top of the scale. The value of 0' (the true horizon) was located in the center of the scale. To obtain an altitude reading, the sextant index arm was adjusted to center the celestial body at the 0' index mark on the artificial horizon. The sextant reading was then



SCHWARZSCHILD BALLOON SEXTANT (1913)

Fig. 9

recorded. In a sea-way the gyro-rotor would precess following a spiral motion which, in the field of view, was indicated as a slow vertically oscillating motion of the index. An average of 3 to 5 readings provided an accurate measured altitude. The Fleuriais sextant was continuously improved with gyro sextants of his design being offered by two leading Paris firms well into the second decade of the 20th Century during World War I. (Fig. 7)

The period 1890 to 1920 also witnessed rapid developments in air-ship/dirigible design which resulted in increased interest in air navigation for long distances at high altitudes above the clouds and over the ocean. Many small, handy artificial horizon "balloon" octants and sextants were introduced during this period. Most employed the spirit level for establishing the artificial horizon. Instruments designed or manufactured by Butenschon (Fig. 8), Schwarzschild (one of the first modern artificial horizon sextants with an optical system collimated to infinity) (Fig.9), Hartmann, Lindt and Marcuse in Germany are some of the more famous of these. Other well-known practical balloon sextants were also developed by Andre of Sweden and by Fave, Mixte and Ponthus et Therrode of France.

The end of World War I saw the rapid development of long range aircraft as well as the introduction of specially designed aircraft artificial horizon sextants. These as well as the improvements in artificial horizons for use at sea during the period 1920 to 1950 will be described in the next issue of the Navigator's Newsletter.

Credits for Illustrations

Fig. 1 Philosophical Transactions of R.S., 1732
Fig. 2 Philosophical Transactions of R.S., 1738
Fig. 3 Courtesy, Science Museum, London
Fig. 4 Courtesy, National Maritime Museum, Greenwich
Fig. 5 Courtesy, Science Museum, London
Fig. 6 Courtesy, Science Museum, London
Fig. 7 Courtesy, Science Museum, London
Fig. 8 Courtesy, Smithsonian Institute, Washington, DC
Fig. 9 Courtesy, Smithsonian Institute, Washington, DC

NAVIGATION NOTES

The Land Navigators

by T. D. Davies

During the course of the Peary Project we have encountered something not always appreciated by navigators. One of the critics of Peary in 1913 noted that he was not a Naval Academy graduate and not even a sea-going naval officer and therefore could not be expected to be knowledgeable of navigation. This view was fairly widespread at the time, particularly among active duty naval officers.

In fact Peary was a graduate of Bowdoin College in Maine, with a major in Civil Engineering. He graduated number 2 in his class and was elected Phi Beta Kappa. Of course an important course in that specialty was *surveying*. What is generally not recognized by people outside the specialty is that surveying is essentially navigation on dry land. While the ice pack in the Arctic Ocean is always moving and even "rocks" very, very slightly, it closely corresponds to dry land. Both Peary and Marvin, his number 1 assistant, were competent surveyors, Marvin being a professor at Cornell when not on polar expeditions with Peary.

The surveyor uses navigational astronomy just as the seagoing navigator does. Today more sophisticated (satellite) methods are largely used for baseline determinations, but books such as *Astronomy for Surveyors* are still available and used. In Peary's day celestial navigation was the basis for all exploratory mapping and baseline work, and he used it extensively in his mapping work in Greenland. Of course some of the celestial was actually done at observatories using large telescopes and transit instruments, but a great deal of it was done in the field. There is an interesting book, published in 1902 by the Department of the Interior, on the standards for the survey of United States lands.

The instrumentation of the surveyor took advantage of the fixed platform from which they were operated. The precisions that were expected and obtained would startle the maritime navigator. The transit instrument was equipped with a pair of orthogonal bubble levels which could have, on the finest instrument, an accuracy of *one second of arc*. Of course the transit, being so stabilized, had no "out of vertical" error, and consequently no need to "dip the star." Additionally the transit had an accurate magnetic compass (with no settling problem) and a finely divided horizontal circle from which azimuth could be read with great accuracy.

Another aspect of this land navigation is that time to take various observations is not as important as it is to the seagoing navigator. The surveyor is not riding a moving ship which may get into trouble if the navigator does not get his position promptly. There are many specialized instruments for obtaining times of transit and times at which a star passes through a given altitude, which can trade setup time for accuracy. Without vibration and roll and pitch, the surveyor can use highly specialized instruments to get accuracy. There are transit-type instruments which measure only one elevation, say 60 degrees, but do so with extreme accuracy, using double images of a star which move in opposite directions to double the accuracy with which the time of crossing 60 degrees can be measured.

The existence of a true natural horizon at sea appears to be an advantage for the maritime navigator at first glance. However the artificial horizon has been incorporated in many instruments and offers a significant improvement in accuracy by doubling the angle measured. Of course this artificial horizon is not available at sea, although in modern times the bubble octant provides some ability to take sights without a natural horizon. Note, though, that it does nothing for accuracy.

Peary, Marvin and Bartlett (the Captain of Peary's ship *S.S. Roosevelt*) all used an early artificial horizon which consisted of a pool of Mercury sheltered from the wind and from vibration. Their sights reflected the accuracy provided by this device even in the weather ambient of the polar sea. Reduction of the LAN sights taken was slightly different from those at sea, in that the I.C. correction was applied to the measured double-angle, but the refraction and semi-diameter corrections had to applied after dividing by two.

An interesting aspect of this feature is that Bartlett, a sea-going navigator not accustomed to this technique goofed and applied the latter two corrections before dividing by two, thus producing a small error in his position. Other than this the sights of all of the members of the 1909 expedition demonstrated good competence. For the demands of that polar expedition the surveyors were clearly as good, perhaps even slightly better, than maritime navigators.

A Navigation Problem

by Roger H. Jones

27. Answer

Finding direction with a watch and the sun is easy whenever the height of the sun at local apparent noon (LAN) is less than 45 degrees above the horizon. The height of the sun at LAN can, of course, be checked with a sextant, but there is another emergency method at hand. Use a vertical stick. If the shadow length at LAN is longer than the length of the stick, the height of the sun is less than 45 degrees.

The reason for the concern with a height of less than 45 degrees is that the sun always moves along its arc across the sky at a rate of 15 degrees per hour, but only when the noon sun is less than 45 degrees high does the sun's bearing move along the horizon at a near constant rate of 15 degrees per hour.

In the preceding problems, the navigator has obtained the direction of the sun when it rises and sets and its due east and west bearings after rising and before setting. He obtains its due north and south bearings at LAN. At intermediate times throughout the day he can obtain additional useful bearings by simply applying his knowledge that the sun will move along the horizon at 15 degrees per hour. One hour after the bearing at rising or after LAN, the sun will have moved 15 degrees along the horizon. For example, one hour after LAN the sun will bear 195 degrees. Three and a half hours after LAN it will bear 232.5 degrees. If local apparent noon occurs at 1240 according to the watch used, four hours before that at 0840 the sun will bear 120 degrees.

Problem No. 28

Beginning with Problem No. 22 in Issue 20 (Spring 1988) we have presented a series of emergency navigation problems. Readers who have recently joined us may be interested to know that prior to that we completed a circumnavigation over a two-year period with more conventional celestial problems presented in each issue and featuring geographic locations as diverse as the Chesapeake and the Australian coast. ^J ^JIn this issue we will continue to explore the useful emergency techniques. The daytime tricks have preoccupied these pages. It is time to explore a few of the nighttime ones. Before we leave solar time entirely, it is useful to contemplate the moon and the stars. Can the moon be used like the sun to obtain bearings by a method the same as the solar time method, and if so, what restrictions apply? (The stars can most certainly be used. The next issue's "Answer" will comment on the stars as well as present the answer regarding the moon.)

NAVIGATION PERSONALITIES

Captain (later Vice Admiral) William Bligh R.N.

by T. D. Davies

It will undoubtedly come as a surprise to some that the "infamous" Captain Bligh can be considered a personality in navigation. Romanticized (as a villain) by books and television the real personality and achievements of William Bligh are almost unknown to the average citizen today —certainly in the United States. The real Bligh was a competent officer of the Royal Navy, of good reputation and accomplishments. His career, both before and after the famous mutiny, was about normal for an officer of his time. He was promoted Vice Admiral of the Blue on the same promotion list as Horatio Nelson.

The final expedition of Captain James Cook included William Bligh as sailing master of H.M.S. Resolution. He was largely responsible for the surveying work which covered five oceans in what was then the longest sailing voyage ever made. His cartography was considered excellent; some samples still exist to prove it. After James Cook he was considered one of the most skillful practitioners of the art of navigation. In the Bounty he performed the remarkable navigational feat of making an accurate first landfall on the southern tip of Tasmania after sailing 7000 miles from the Cape of Good Hope.

However the ultimate test and demonstration of Bligh's navigational ability commenced when he was put adrift off Tofoa on April 28th, 1789. With 19 men and meager provisions he commenced a voyage of 3618 miles through mostly uncharted waters in a 23 foot boat. Fortunately this craft had excellent sea-keeping characteristics, making an average of 4 knots under sail.

For navigation Bligh had a sextant and a quadrant for sights. For time they had only a pocket watch and were unable to get longitude with any accuracy. As a result they had to make estimates of distance made good on what was essentially latitude sailing. They did have an Almanac and some other tables so that noon latitude sights were feasible. Of course the boat was equipped with a boat compass. For charts Bligh had only the memory of Cook's survey.

On May 29, 1789, having passed through the Great Barrier Reef, they made their first landing at Restoration Island off the northern coast of Australia, a distance of 2488 miles. From June 3rd to June 14th they sailed on to the Island of Timor where their long voyage finally ended. The Dutch governor provide much needed food and shelter for a month-long recuperation. After some additional travail Bligh returned to England on March 14, 1790, where he was somewhat recompensed for the hardship by writing a very successful book on the entire voyage.

Maintaining an average speed of 4 knots on this voyage would be an accomplishment for a modern sailor, and doing without charts or timepiece almost a miracle. William Bligh certainly proved himself to be a remarkable navigator in every sense of the word.

MARITIME INFORMATION NOTES

Compiled by Ernest Brown

We cite here the commendation of the Secretary of the Navy presented to member Richard E. Kabrick with a Navy Commendation Medal.

Citation:

For meritorious achievement while serving as Instructor for the Division Officer Course, Surface Warfare Officers School Command, Newport, Rhode Island from January 1988 to December 1988. Chief Petty Officer Kabrick was identified by eight graduating classes as the Ship Control instructor who contributed most to the learning experience and professional growth of the class. His improvements to curriculum included implementing a variation of the Franklin method for determining gyro error. His understanding of the science of navigation has enabled development of a new celestial demonstrator that illustrates celestial concepts with outstanding clarity. Chief Petty Officer Kabrick's exceptional professionalism, initiative and loyal devotion to duty reflected great credit upon himself and were in keeping with the highest traditions of the United States Naval Service.

For the Secretary of the Navy,
J. S. Disher
Vice Admiral, U.S. Navy

NAVIGATION COURSES

Bill Land advises he is opening a new session at East Norriton Middle School in Norristown, PA, on September 13th, from 1930 to 2130.

BOOK REVIEW

by Roger H. Jones

The Practical Pilot: Coastal Navigation by Eye, Intuition and Common Sense

by Leonard Eyge

International Marine Publishing Co., 21 Elm Street, Camden, Maine 04843 (1989), 244 pages; $19.95

Leonard Eyges is well known to us as a Foundation member and correspondent on diverse navigational matters. A sailor for more than forty years, he has also been a teacher and researcher in physics. In recent years, he has devoted his time to writing and conceptualizing new approaches to the art and half-science of piloting. His contributions in a field that many would have believed to be already exhaustively explored are nevertheless fresh and eminently useful. *The Practical Pilot* is a compendium of his insights, and it is well titled. Indeed, it is the practical coastal pilot whose practice and convenience he addresses. Don't sail by him too quickly. He offers much.

His mental image of the single-handed skipper beset by all sorts of problems is clear and seasoned by his own vast experience. His fresh approach is to place buoys and navaids in their proper, often limited role and to elevate natural features of the land to a much, much higher rank of usefulness. No broken buoy mooring chain, no Notice to Mariners, no darkened light gives him pause.

Eyges has long been an advocate of "small angle navigation." He has highly refined the art of using small horizontal angles to render small angle circles of position. The transit line based upon natural land features acquires new flexibility and practicality in his hands, and the measurement of those small angles may, indeed, be accomplished with nothing more than the hand.

There are 28 chapters. They deal with all aspects of piloting— from chart use to compass checks and from time and tide to speed and distance. However, chapters 9 through 23 are what commanded this reviewer's attention most. It is here that Eyges deals with "all the angles," lines and curves and circles of position, the transit line, and fixes that many readers will not have encountered in standard piloting texts. He writes well and succinctly. His illustrations are many and clear. It is a well thought, well taught work!

The Atlantic Crossing Guide, Second Edition (1988)

Royal Cruising Club Pilotage Foundation
Edited by Philip Allen
International Marine Publishing Co., 21 Elm Street,Camden, Maine 04843; 278 pages; $29.95

In Issue No. Eighteen (Fall 1987), we reviewed Jimmy Cornell's new *World Cruising Routes*, comparing it to the older classic, *Ocean Passages for the World*. In *The Atlantic Crossing Guide*, the focus is once again upon the subject of voyage and navigation planning, and a new comparison is in order.

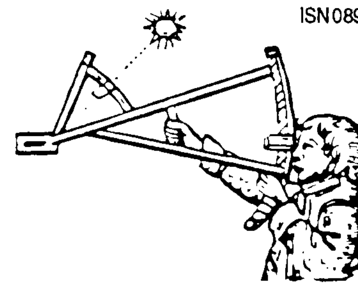
The Atlantic Crossing Guide was first published in Great Britain in 1983 by Adlard Coles. It was an instant success, and was republished with amendments in 1984 and 1985. Now the Second Edition has appeared, a sure sign that this work is finding its own place in the minds and hearts of voyagers.

Like *Cruising Routes and Ocean Passages, The Atlantic Crossing Guide* is an enormously useful compendium of information on sailing routes, in this case those that encompass the eastward and westward crossings of the North Atlantic in their respective latitudes, the intermediate passages from the U.S. to the Virgins and Bermuda and thence to the island groups in the eastern Atlantic (Azores, Madeira, Canaries, Cape Verde Islands), landfalls on the Canadian and American coast, and landfalls on the European coasts. In each case, the pertinent Admiralty and U.S. charts and Sailing Directions are listed, as are passage times and distances. The routes are well described in easy narrative covering winds and weather, special considerations, currents, ports, clearance formalities, and such nice-to-know details as those that pertain to cruising licenses and sewage disposal.

The many port charts are clear and of large scale. There are also finely detailed photographs of approaches, berthing areas and anchorages, and landmarks. Finally, there are up-to-date ratings (from poor to good) respecting anchorages, marinas, slipways, yacht services, shipwright and engineering services and facilities, and many other facilities available in the various ports. The port and facility information is particularly useful, and is more detailed than in Cornell's or other similar route and port guides.

Unlike *Cruising Routes, The Atlantic Crossing Guide* also contains ten special chapters that deal with navigation, the vessel and her gear, provisioning, special equipment, the mechanics of cruising (including paperwork, money and insurance), and safety in ocean cruising. The space conserved by addressing only the Atlantic routes (as opposed to world-wide routes) is put to very good use in these ten other chapters. In all, it is a nicely self-contained work that, for its geographic area, anticipates and answers all the questions in a well organized format. Like a beacon at the end of a fog-shrouded breakwater, this single volume will activate the homing instinct of almost any blue water voyager who picks it up. It is likely he'll not leave the bookstore without a copy tucked under his arm.

THE NAVIGATOR'S NEWSLETTER



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FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

ISSUE TWENTY-SEVEN, WINTER 1990

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

by T. D. Davies

Peary Report Completed

Activity this quarter has demanded so much time that this newsletter is late getting started. Normally we would have tried to get it prepared early to compensate for the normal Christmas season mail delay. In any event The final report on the Peary project has been released, at a press conference assembled by the National Geographic Society in their auditorium in Washington and attended by all of the directors of the Foundation. The report is a 240 page volume representing about a year's work of the 4 directors in the Washington area, plus substantial time of the others spent in reviewing and editing. I want to express my thanks for all of these good efforts. I believe the final product is worth while. Potential demand seemed great enough, so we undertook to have it printed. It is available to interested members at a 20% discount price of $ 12.00 (see order form, p. 19).

The conclusion of the study is that Robert E. Peary did in fact get to the North Pole in 1909. We base this on a detailed analysis of his navigation, including how it was affected by ice movement, his sledging speeds (questioned by many of his critics), the match between his soundings and the ocean bottom as we now know it, and on a photogrammetric analysis of the photographs he took at the Pole. These last two items represent the first detailed attempts at dealing with those particular data. Our conclusion was not based on any one aspect of the trip; even the new analyses do not constitute "positive proof." However we found no anomalies in any of these areas, which would suggest any sort of fraud, and there was an internal consistency in all of the factual material which could only be explained by reality.

Generally the critics of the last 80 years have based their case on questioning his navigation and distances, but then dwelt heavily on a series of stories of Peary's subsequent behavior in a manner which resembled psychoanalysis. This behavior included idiosyncracies of record-keeping, moodiness, reticence and apocryphal stories from ghost-written books. His navigational sights were dismissed because "everyone agreed that they could have been faked." We examined most of these stories and found that there were pedestrian and reasonable explanations for them, if you were not trying to read them as evidence of fakery. They were clearly "makeweight" to bolster the weak case of the anti-Peary writers.

One particularly strident critic of Peary always describes himself as a "scientist", and insists that whatever he says is "science." We came to the conclusion that the case really rests on practical navigational knowledge. The "scientist" is the one who mistook chronometer serial numbers for compass headings in the first round, last year.

Our work was far too detailed to go into here, but I am sure you will find it worth reading. I am also sure that you will hear more about it in the future. The commitment and emotion of some of the people who do not believe Peary made it, is such that I do not expect the logic of this report to end the arguments. The debate has long gone beyond logic.

Tandemeer

As you will note in the Reader's Forum, interest is reviving in our at-sea program in Tandemeer. We expect to run one or more trips again in 1990, probably starting in late spring or early summer. Interested members should let us know as early as possible so we can firm up a mutually satisfactory date.

A Reminder On Checks

I would like to remind our Canadian members that checks should be written on banks with U.S. affiliates if at all possible. We still have a few come in that are not on such banks, and it costs us $ 12.00 each for the international transfer of funds.

Navigator's Almanac

The Navigator's Almanac for 1990 will be ready shortly and will be available at the member price of $5.00. (See order form on page 19).

READERS FORUM

Anthony L. Kelley of Hicksville, NY writes:

The success of the new Nautical Almanac Concise Table for Sight Reduction seems assured. Congratulations!

Data Processing has developed a logical thought process called "Structured Programming." This process enables someone other than the originator to understand the logic presented by the program author. Other uses include rules presented in the "structure" format. The simplest use is the "IF THEN ELSE" thought process. The IF tests conditions with ANDs and ORs; whentrue the actions after the THEN are executed. The ELSE actions are performed for not true conditions. Describing the actions before the conditions are tested is avoided. Were that process available to Admiral Ageton, he would have written rules for H.O.211 as follows: IF K is the same name AND greater than Latitude, THEN Z is less than 90. The understood: ELSE Z is greater than 90, is so obvious that it is not necessarily written.

In the new Nautical Almanac, the rules on pages 284 and 285 would be easier to use and less error prone when written;

Step 2. IF 90 < LHA < 270 THEN B is minus.
Step 3. IF the name of Dec is contrary to Latitude (N vs S) THEN Dec is minus.
Step 5. IF F < 90 and F' > 29' OR F > 30 and F' < 30 THEN corr1 is minus.
Step 6. IF A' < 30' THEN corr2 is minus.
Step 7. IF F is minus THEN H is minus.
Step 8. IF F > 90 THEN Z is minus.

The second rule in Step 8 does use IF THEN ELSE as follows: IF F is minus THEN replace Z by 180 - Z. The value of Zn from Step 8, comes from another modern logic form—the Truth Table.

For N Latitude,
IF LHA > 180 Zn = Z
IF LHA < 180 Zn = 360 - Z

For S Latitude,
IF LHA > 180 Zn = 180 - Z
IF LHA < 180 Zn = 180 + Z

When will the Nautical Almanac rules be rewritten to use the much easier form? Large tables have few rules; small tables use lots of rules — let's simplify them.

Allan E. Bayless, of Los Angeles, CA writes:

It seems Admiral Davies is off to Uruguay and is, in any case, still deeply embroiled ith the Peary study and Terry Carraway is off for Europe for a month, so he sent your letter to me for reply, possibly because of my long-time involvement with USPS, CPSS' sister organization.

Actually, I think the page you wrote for "The Wheelhouse" is very complete and might well serve the purpose you envision, a summary of the purposes and activities of The Navigation Foundation for "The Port Hole." As a matter of fact, I would not have known had you not mentioned it that the dues are not deductible in Canada. I certainly can't think of anything substantive to add.

I greatly enjoyed reading the copy of "Port Hole" which I hadn't seen for a number of years; during my term of office as Director of Education for USPS, I also enjoyed the association it made possible with the Canadian organization.

I suspect your organization is a bit more amenable to change. When I was Director, the Chief Commander and I made a concerted attempt to change the name of USPS to "United Sail and Power Squadrons," with a notable lack of success. Also, it took several more years to see the adoption of the CPS-style shoulder insigne for white uniforms.

In any case, as you have probably guessed from my involvement with "The Compact Table" (of which a second edition is forthcoming which includes a method to accurately reduce sights in the formerly "forbidden zone" and a graph which will predict which sights fall into this category before the table is opened), I hardly think any navigator truly proficient without knowledge of celestial navigation in view of the less than completely reliable nature of the electronic substitutes. Further, celestial navigation is an essential part of our maritime heritage. The importance of this fact will be very evident when the Foundation's study of the Peary expedition to the Pole appears.

A. E. Saunders, R.K.N. of Vineland, Ontario writes:

I have for many years been interested in the Lunar Distance method of not only establishing an LOP but also in telling time.

Please advise me as to how I may obtain Lunar Distance section of the 1909 Almanac. I would also be interested in knowing of any books or periodicals that may contain formulae that I could program into my IBM-PC.

Ed. Note: Lunar Distance data will be sent.

Charles L. Hobson of Frankfort, Kentucky writes:

As you are no doubt aware, my friend and neighbor, Lt. Colonel Bill Mollet, U.S.A.F. Ret., has written an article entitled "Analysis of Admiral Peary's Trip to the North Pole" which was published in Vol. 36, No. 2, Summer 1989 issue of "Navigation; Journal of the Institute of Navigation."

Your current report on the Peary project was of great interest to me. While it is entirely appropriate that the report will be the product of the whole Board, it is devoutly hoped that appropriate recognition to Lt. Colonel Mollet will be forthcoming for whatever contribution his article and analysis has made to the report that your Board will make to the National Geographic Society.

It is difficult for me as a Phi Beta Kappa graduate of Washington and Lee University in 1941 to subscribe to the theory that Peary falsified his records. This, of course, is a subjective opinion based upon my college background.

As a plank owner and top watch stander under way on the New Lexington (CV- 16) Commander Stafford's book "The Big E" is one of the finest accounts of the carrier war in the Pacific that I have read. The "Blue Ghost" operated with the Enterprise on several occasions. I learned from Bill Mollet that Commander Stafford is a grandson of Admiral Peary. I can appreciate the interest of Commander Stafford in clearing his grandfather's name.

Back to Admiral Bligh for a moment, I presume that Bligh Reef, upon which the Exxon Valdez grounded in Prince William Sound, was named for William Bligh just as Cook Inlet at Anchorage, Alaska, is named for Captain James Cook under whom William Bligh served as sailing master of H.M.S. Resolution.

Can you confirm that Bligh Reef in Prince William Sound was in fact charted by William Bligh and hence, for that reason, bears his name?

Ed. Note: We will check and advise in next issue.

Charles L. Hobson of Frankfort, Kentucky also writes:

Navigator's Newsletter Twenty-Six carried an overdue minute biography of William Bligh, Vice Admiral of the Blue. This addendum may be of interest:

In the heart of London on the bank of the Thames in a little churchyard at the foot of Lambeth Bridge is the grave of Bligh. The inscription on the side of the monument facing the river is:

SACRED
TO THE MEMORY OF WILLIAM BLIGH ESQUIRE F R S
VICE ADMIRAL OF THE BLUE
THE CELEBRATED NAVIGATOR
WHO FIRST TRANSPLANTED THE BREADFRUIT TREE
FROM OTAHEITE TO THE WEST INDES
BRAVELY FOUGHT THE BATTLES OF HIS COUNTRY
AND DIED BELOVED RESPECTED AND LAMENTED
ON THE 7TH DAY OF DECEMBER 1817.

These lines would indicate that our British cousins regard Bligh in a vastly different light from the image we have thanks to the dramatic abilities of Charles Laughton and Clark Gable in the well known movie "Mutiny on the Bounty" popular some fifty years ago.

Donald C. Hilton of Franklin, NC writes:

Would you please send to me the same information regarding Lunar Distances that you recently sent to Mr. Robt. Young, namely—expanation pages and some pages from Lunar Distance section of the 1909 Almanac. Thank you.

Ed. Note: Lunar distances are popular, we will send data.

William O. Land of Norristown, PA writes:

I have just received my 1990 Nautical Almanac and am pleased to see your Concise Sight Reduction Tables included. If you recall, I sent you a work- form that I prepared for these tables for the complete solution of a problem and you published it in the "Navigator's Newsletter" Issue 24, Spring 1989.

In my celestial navigation classes (H.O.299) I also supply my students with this Concise work-form and ask them to use it to do the same problems. It was suggested that this Concise work-form could easily be printed on the blank page of the N.A. following the last page of the Concise section. This would be page 319.

If the full size 8 1/2" x 14" work-form enclosed is reduced x0.70 it becomes approxiateely 6" x 9 1/2" which fits neatly onto page 319, and is very legible. I have one pasted in my N.A. and most of my students do too. I'm enclosing several copies of each size for you, and hope you consider having t included in the next issue of the N.A. I believe the prime reason for the inclusion of the Concise Tables in the N.A. is to give the navigator complete information to obtain a fix with the use of only one book. I believe that adding the blank work-form to the N.A. will be of great help to the navigator, especially

STAR SIGHT REDUCTION WORK FORM. For use with the Concise Sight Reduction Tables, 1989 Nautical Almanac pages 284 to 317. Given: Lines 1, 2, 3, 11, 15, 36, 37, 40. Solve for Azimuth and Intercept Lines 34 and 45. Refer to Steps 1 thru 8, pages 284 and 285.

Step	Item	Line	Value					Instruction
	STAR	1						
	G.M.T. Date	2						
	G.M.T.	3	h m s					
Step 1	G.H.A. ♈ (h)	4	° . '					Enter N.A. with Lines 2 and 3(h).
Step 1	G.H.A. ♈ (m)	5	° . '					Enter N.A. with Line 3 (m).
Step 1	S.H.A. ☆	6	° . '					Enter N.A. with Lines 1 and 2.
Step 1	G.H.A. ☆	7	° . '					Add Lines 4 + 5 + 6.
Step 1	Correction	8	° .					Need ± 360°?
Step 1	Correction	9	° . '					Need ± 60'?
Step 1	G.H.A. ☆	10	° . '					Add Lines 7 + 8 + 9.
Step 1	Assumed Long.	11	° . '					(W = -)(E = +).
Step 1	L.H.A. ☆	12	° 00.0'					Add Lines 10 ± 11.
Step 1	Correction	13	°					Need ± 360°?
Step 1	L.H.A. ☆	14	° 00.0'					Add Lines 12 + 13.
	Assumed Lat.	15	° 00.0'					Whole nearest integral °
Step 2	1st Entry	16	Enter Sight Reduction Table with Lat.(Line 15) and L.H.A. (Line 14).					
Step 2	A	17	° '	A°	°			A° nearest whole °
Step 2	B (see note)	18	° '	A'	0° '			A' Same as A minutes in Line 17.
Step 3	Dec. ☆(see note)	19	° '	Z_1	. °			Z_1 Same sign as B (Line 18).
Step 3	F (Add 18±19)	20	° '	F°	°			F° = Nearest whole ° of F.
Step 3	(See #20 note)	21		F'	0° '			F' = Same minutes as F (Line 20).
Step 4	2nd Entry	22	Enter Sight Reduction Table with A° (Line 17) and F° (Line 20).					
Step 4	H	23	° '	P	° '	P°	°	P°= Nearest Whole ° of P.
Step 4		24		Z_2	. °	Z_2°	°	Z_2°= Nearest Whole ° of Z_2.
Step 5	1st Entry	25	Aux. Table N.A. Page 316 enter with F' (Line 21) and P° (Line 23).					
Step 5	$Correction_1$	26	'					See note below for ± information.
Step 5		27	° '					Add Lines 23 ± 26.
6	2nd Entry	28	Aux. Table N.A. Page 316 enter with A' (Line 18) and Z_2° (Line 24).					
6	$Correction_2$	29	'					Correction is (-) if A' (Line 18) < 30'
7	Hc	30	° '					Add Lines 27 ± 29.
Step 8	Z_1	31	. °					From Line 19.
Step 8	Z_2 (See note)	32	. °					From Line 24.
Step 8	Z	33	. °					Add Lines 31 ± 32.
Step 8	Zn	34	. °	Zn	°			Same as H.O.229 method. (See note).
Sextant Correction	Sextant Corr'n.	35	+ | -					
Sextant Correction	Dip (')	36	xxx | . '					Feet or Meters?
Sextant Correction	I.C.	37	. ' | . '					(On = -)(Off = +).
Sextant Correction	Totals	38	. ' | . '					Add Lines 36 ± 37.
Sextant Correction	Difference	39	. '					Don't forget the + or - sign.
Sextant Correction	Hs	40	° . '					Sextant reading Hs.
Sextant Correction	Ha	41	° . '					App. Alt. Add Lines 39 ± 40.
Sextant Correction	☆ Ha Corr'n.	42	. '					From App. Alt. ☆ Table in N.A.
Sextant Correction	Ho	43	° . '					Add Lines 41 ± 42.
	Hc	44	° . '					From Line 30
	(a) Intercept	45	. '					A or T? Ho Larger = T

NOTE Line 18. B is (-) if LHA (Line 14) is greater than 90° and less than 270°.
Line 19. Dec. is (+) if Lat.(Line 15) and Dec. (Line 19) are SAME name. CONTR = (-).
Line 20. Add Lines 18 ± 19. Do NOT include Line 17 in addition. If F > 90° it is (-).
Line 26. Correction is (-) if F° is less than 90° and F' is greater than 29'. Lines 20 &21. And is (-) if F° is greater than 90° and F' is less than 30'. All else = (+).
Line 32. Z_2 (Line 32) is (-) if F (Line 20) > 90°. If F is (-), Z_2 = 180° - Z_2.
Line 34. N.Lat. LHA greater than 180°..Zn=Z. LHA less than 180°..Zn=360°-Z. ‖ S.Lat. LHA greater than 180°..Zn=180°-Z. LHA less than 180°.....Zn=180°+Z.

Workform by W.O. Land 1521 W. Main St.(E-3) Norristown, Pa. 19403 the less experienced ones. I can vouch for the fact that this work-form is a big help to my students in using the Concise Tables, and it gives them confidence and eliminates most errors. If you would like to discuss this with me, please let me know.

Heyward Canney of Bowie, Md. writes:

Issue 26 jogged my memory that I'd been mulling over doing the Tandemeer thing. I talked on the phone with Adm Davies about it and seemed to remember that several cruises are attempted in good season in a 55-ft ketch sleeping I think about 8: about 10 days per cruise for about $750 and each hand aboard stands watch, etc. That telecon was last summer, and I've forgotten the particulars. Do you have an info sheet on it? How far in advance of a cruise does an applicant have to have his money in?

Ed. Note: no sheet is available now, but we will issue one shortly. Any other interest? Let us hear if there is.

Lloyd Smith of Sarasota, Florida writes:

Can you tell me what "CORR^N" (with a small upper N) means? I know it means correction but what does the "n" signify. It is on page A2 after"App Alt" for stars and planets and after height of eye in two columns of Dip. It is also on the 2 Altitude Correction cases for the Moon. It appears at the top of each column under the degrees values. Also on the dip table in two spots. I presume it has a significance but I don't know what it is.

Editor's note: Of course it simply means the column of corrections in each case, but the utilization of the upper "n" probably comes from a traditional abbreviation of some sort, used in almanacs. Such usages frequently go back to early latin writing, which was filled with abbreviations, many specific only to a particular writer. The endings of latin words that were repeated many times soon became a small mark over the last letter. The "orum" on many latin words was often omitted but indicated by a small horizontal mark over the last letter. Other examples are the ampersand sign, the "til" and the degree sign (probably from the word "grado").

NAVIGATION BASICS REVIEW

Checking Steering Compass Accuracy Using Celestial Observations

By John M. Luykx

It is normal practice, prior to an extended voyage, to have a vessel's magnetic steering compass adjusted by a reputable compass adjustor and to provide a Compass Deviation Table (Figure 1) to the owner of the vessel prior to departure.

It is then the responsibility of the vessel's navigator periodically during the voyage (usually, twice daily) to compute the deviation of the magnetic steering compass by observation of a celestial body and compare it with the value of deviation indicated in the Compass Deviation Table. If these two values agree within one or two degrees, the compass is deemed to be operating satisfactorily. If, however, these two values do not substantially agree, the navigator should consider the three possibilities that, either a) an error was made in the observation or calculations, b) a metallic object has inadvertently been placed in the vicinity of the compass or c) the magnetic "signature" of the vessel has changed since the compass was adjusted and that a readjustment of the compass may be necessary.

Simply stated, the basic procedure employed to compute the compass deviation by celestial observation is to compare the magnetic azimuth (true azimuth corrected for variation) of a celestial body computed for the date, time of day and location (LAT/LON) of the vessel with the azimuth of the celestial body observed either directly at the compass or by pelorus (Figure 2). The difference between the computed magnetic azimuth and the observed compass azimuth is the deviation. Deviation is west if the observed compass azimuth is greater than the computed magnetic azimuth and east if it is less.

To obtain the compass deviation by observation:

Step One: Observe and record the time of observation as well as the azimuth of the celestial body measured by the compass directly or by pelorus.

Step Two: Compute the true azimuth of the celestial body for the date, the time of observation and the DR position of the vessel using any sight reduction method. (Refer to III.C. below describing some of the methods available.)

Step Three: Apply the magnetic variation to the computed true azimuth to obtain the computed magnetic azimuth of the celestial body.

Step Four: Compare the computed magnetic azimuth of the celestial body (Step Three) with the observed compass azimuth (Step One). The difference between the two is the compass deviation,labelled west if the compass azimuth is greater than the magnetic azimuth and east if it isless.

Step Five: Compare the value of the compass deviation (Step Four) with the compass deviation tabulated in the compass deviation table. If they are in reasonable agreement (within one or two degrees), the compass is O.K. If not the compass may have to be readjusted.

Any celestial body may be used to determine the deviation of the compass. However, the sun is the most convenient body for this purpose. For example, using the sun permits the thin shadow cast by the shadow pin on most spherical compasses to indicate the reciprocal of the compass azimuth on the compass card directly. 180 is added or subtracted from this value to obtain the observed compass azimuth. For compasses shielded from the sun, a pelorus is used. The pelorus aligned with

Magnetic Heading	Deviation	C	Magnetic Heading	Deviation	C
000°	2°W	002°	180°	3°E	177°
015°	1°W	016°	195°	2°E	193°
030°	0°	030°	210°	1°E	209°
045°	1°E	044°	225°	0°	225°
060°	2°E	058°	240°	1°W	241°
075°	3°E	072°	255°	2°W	257°
090°	4°E	086°	270°	3°W	273°
105°	4°E	101°	285°	3°W	288°
120°	4°E	116°	300°	3°W	303°
135°	4°E	131°	315°	3°W	318°
150°	4°E	146°	330°	3°W	333°
165°	3°E	162°	345°	2°W	347°

Note:

CONVERTING TRUE TO COMPASS VALUES		CORRECTING COMPASS TO TRUE VALUES	
T		C	
V	W(+)	D	W(-)
M	E(-)	M	E(+)
D		V	
C		T	

Figure 1
Compass Deviation Table

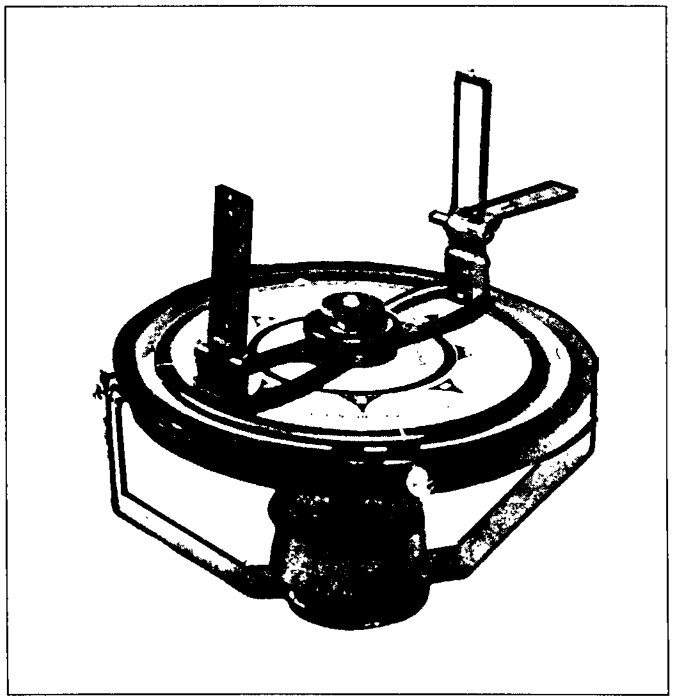


Figure 2
Pelorus

TABLE 27

Amplitudes

Latitude	Declination								
	12°0	12°5	13°0	13°5	14°0	14°5	15°0	15°5	16°0
°	°	°	°	°	°	°	°	°	°
0	12. 0	12. 5	[illegible]	13. 5	14. 0	14. 5	15. 0	15. 5	16. 0
10	12. 2	12. 7	[illegible]	13. 7	14. 2	14. 7	15. 2	15. 7	16. 3
15	12. 4	12. 9	[illegible]	14. 0	14. 5	15. 0	15. 5	16. 1	16. 6
20	12. 8	13. 3	13. 9	14. 4	14. 9	15. 5	16. 0	16. 5	17. 1
25	13. 3	13. 8	14. 4	14. 9	15. 5	16. 0	16. 6	17. 1	17. 7
30	13. 9	14. 5	15. 1	15. 6	16. 2	16. 8	17. 4	18. 0	18. 6
32	14. 2	14. 8	15. 4	16. 0	16. 6	17. 2	17. 8	18. 4	19. 0
34	[illegible]	15. 1	15. 7	16. 4	17. 0	17. 6	18. 2	18. 8	19. 4
36	[illegible]	15. 5	16. 1	16. 8	17. 4	18. 0	18. 7	19. 3	19. 9
38	[illegible]	15. 9	16. 6	17. 2	17. 9	18. 5	19. 2	19. 8	20. 5
40	15. 7	16. 4	17. 1	17. 7	18. 4	19. 1	19. 7	20. 4	21. 1
41	16. 0	16. 7	17. 3	18. 0	18. 7	19. 4	20. 1	20. 8	21. 4
42	16. 2	16. 9	17. 6	18. 3	19. 0	19. 7	20. 4	21. 1	21. 8
43	16. 5	17. 2	17. 9	18. 6	19. 3	20. 0	20. 7	21. 4	22. 1
44	16. 8	17. 5	18. 2	18. 9	19. 7	20. 4	21. 1	21. 8	22. 5

Figure 3
Amplitude Table

DEC.

LAT 35°

LHA	11° Hc	d	Z	12° Hc	d	Z	13° Hc	d	Z	14° Hc	d	Z	LHA
	° ′	′	°	° ′	′	°	° ′	′	°	° ′	′	°	
0	66 00	+60	180	67 00	+60	180	68 00	+60	180	69 00	+60	180	360
1	65 59	60	178	66 59	60	178	67 59	60	[illegible]	68 59	60	177	359
2	65 56	60	175	66 56	60	175	67 56	59	[illegible]	68 55	60	175	358
3	65 51	59	173	66 50	60	173	67 50	60	[illegible]	68 50	59	172	357
4	65 44	59	170	66 43	59	170	67 42	60	[illegible]	68 42	59	169	356
5	65 34	+59	168	66 33	+59	168	67 32	+59	[illegible]	68 31	+59	167	355
6	65 23	59	166	66 22	58	165	67 20	59	[illegible]	68 19	58	164	354
7	65 10	58	163	66 08	58	163	67 06	58	[illegible]	68 04	58	162	353
8	64 55	58	161	65 53	58	161	66 51	57	[illegible]	67 48	57	159	352
9	64 39	57	159	65 36	57	158	66 33	56	[illegible]	67 29	57	157	351
55	34 48	+34	102	35 22	+34	101	35 56	[illegible]	[illegible]	36 29	+33	99	305
56	34 00	34	101	34 34	34	100	35 08	[illegible]	[illegible]	[illegible]	32	98	304
57	33 11	34	100	33 45	34	99	34 19	33	[illegible]	34 52	33	97	303
58	32 23	34	100	32 57	33	99	33 30	33	[illegible]	34 03	33	97	302
59	31 34	34	99	32 08	34	98	32 42	32	[illegible]	33 14	33	96	301
60	30 46	+33	98	31 19	+34	97	31 53	+32	96	32 25	+33	95	300
61	29 57	34	98	30 31	33	[illegible]	31 04	32	96	31 36	33	95	299
62	[illegible]	34	97	29 42	33	[illegible]	30 15	33	95	[illegible]	32	94	298
63	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	32	95	[illegible]	33	94	297
64	[illegible]	33	96	28 04	33	[illegible]	28 37	32	94	[illegible]	32	93	296
65	26 42	+33	95	27 15	+33	94	27 48	+32	93	28 20	+32	92	295
66	25 53	33	95	26 26	33	94	26 59	32	93	27 31	32	92	294
67	25 04	33	94	25 37	33	93	26 10	32	92	26 42	32	91	293
68	24 15	33	93	24 48	33	93	25 21	32	92	25 53	32	91	292
69	23 26	33	93	23 59	32	92	24 31	33	91	25 04	32	90	291
	11°			12°			13°			14°			

Figure 4
H.O. 249

the fore and aft axis of the vessel measures the relative bearing (the angle, 000 to 360 measured clockwise from the bow of the vessel) to the sun (as well as other celestial and terrestrial objects) which when added to the vessel's heading at the time of observation provides the compass azimuth of the sun, i.e. the vessel heading by compass *plus* the relative bearing to the sun by pelorus *equals* the *compass azimuth* of the sun.

A compass azimuth of a celestial body is best observed when the celestial body is at low altitude. In the case of the sun, this occurs at either sunrise or sunset, or early in the morning and later in the afternoon when the rate of change of azimuth is small. For observations at sunrise and sunset when the sun is on the true horizon (sun center located 30' above the visible horizon) the Amplitude Table (Table 27, Vol. II Bowditch) is recommended (Figure 3). For values of sun declination at the time of observations (found in the Nautical Almanac) and observer latitude (obtained from the chart) the amplitude (A) and thus the sun's true azimuth to the nearest whole degree are obtained by inspection from the table or to the nearest tenth of a degree by interpolation.

The sun's amplitude (A) is the angular distance at either sunrise or sunset between the East Point of the Horizon (090 .0 at sunrise) or the West Point of the horizon (270 .0 T at sunset) and the sun itself when it is on the true horizon. For example, in spring and summer the sun rises north of the East Point of the horizon (090 .0T) and sets north of the West Point of the horizon (270 .0T). In autumn and winter the sun rises and sets south of these two points.

Depending on the values of the observer's latitude and the sun's declination:

The sun's true azimuth at sunrise = :
090 .0T - A (Spring/Summer)
090 .0T + A (Autumn/Winter)
The sun's true azimuth at sunset = :
270 .0T + A (Spring/Summer)
270 .0T - A(Autumn/Winter)

At other times when the celestial body is well above the horizon, one of the many following sight reduction methods may be used to obtain the true azimuth:

H.O. 249
H.O. 229
H.O. 214
H.O. 211
Mathematical Computation
Azimuth Diagram
Star Finder
Mechanical Azimuth Computer

Sample Solutions

Amplitute

Problem: While underway in LAT 36 N, LON 72 W from Chesapeake Bay Entrance to Bermuda on 18 August 1989 an azimuth observation of the sun was obtained at sunrise by pelorus and the following data was recorded:

Vessel Heading:	128
Pelorus Reading:	315
Magnetic Variation:	12 W (from the chart)

Find the deviation of the compass.

Solution:

1. Enter amplitude table (Table 27, Bowditch) with LAT= 36 .0N and Sun Declination = 13 .0N (Nautical Almanac). Amplitude (A) by inspection = 16
2. The sun's computed true azimuth = 090 .0T - 16 = 074 T
3. The sun's computed magnetic azimuth = 074 + 12 W = 086
4. The observed compass azimuth = The vessel Heading, 128 plus the Pelorus Reading, 315 = 443 minus 360 = 083
5. Comparing the *observed compass azimuth*, 083 , with the *computed magnetic azimuth* 086 results in deviation 3 E which agrees favorably with the Compass Deviation Table data: Deviation, 4 E(Figure 1). The compass is operating satisfactorily.

Sun's True Azimuth by Sight Reduction (Reference H.O. 249)

Problem: Later on the same day at time 21-00-00 GMT in LAT 35 N, LON 71 W an azimuth of the sun was obtained by pelorus and the following data was recorded:

Vessel Heading:	117
Pelorus Reading:	155
Magnetic Variation:	13 W

Find the deviation of the compass.

H.O. 249 Solution

1. GMT:	21-00-00
GHA:	134 04'
- DR LON:	71 00'
=LHA:	63 04'
DEC: 12 54'	

2. Enter H.O. 249, Vol II, Page 210 with the nearest whole degree values of LAT, (35 N), LHA, (63) and DEC (13 N).
3. From H.O. 249, Vol. II, Page 210, azimuth angle (Z)= 95 . (Figure 4) In northern latitudes when LHA is less than 180 , true azimuth = 360 - Z. *The computed true azimuth of the sun = 360 -95 =265 T*
4. The computed magnetic azimuth of the sun = 265 plus 13 W = 278
5. The *observed compass azimuth* = the vessel heading, 117 plus the pelorus reading 155 = the compass azimuth 272
6. Comparing the observed compass azimuth, 272 with the computed magnetic azimuth, 278 results in deviation 6 E which agrees favorably with the Compass Deviation Table data: Deviation, 4 E(Figure 1). The compass is operating satisfactorily.

Mathematical Solution

tan Z = sin LHA / cos LAT . tan Dec - sin LAT . cos LHA
= .89101 / (.189117 - .260400)= 12.499614
Z = 94.6

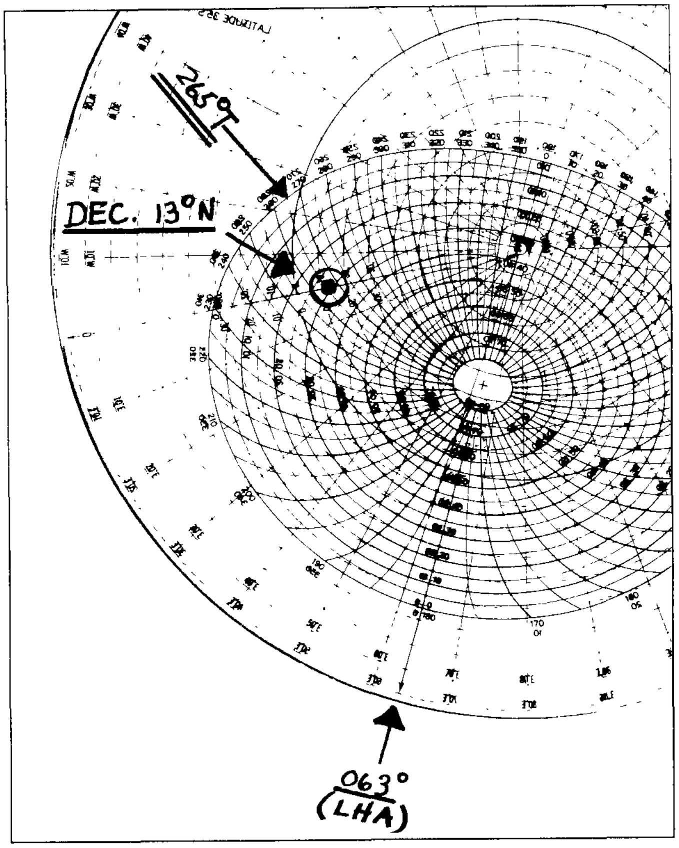


Figure 5
Star Finder (2102D)
Excerpt

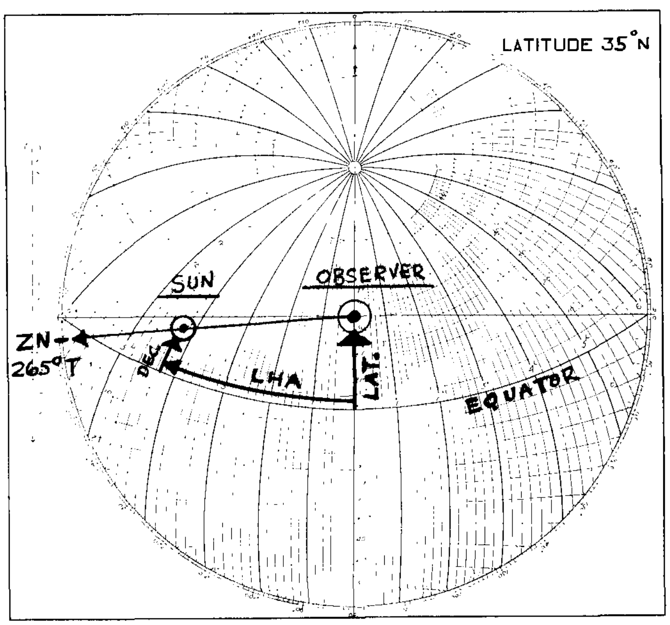


Figure 6
Stereographic Projection
Plane of the Horizon
(Latitude 35 N)

Since the vessel is in N Latitude and the LHA is lessthan180 ;
ZN = 360-Z = 360.0T - 94.6
ZN = 265.4T = 265 T

Star Finder 2102D Solution (Figure 5)

1. Using values of LHA 63 , LAT 35 N and Dec 13 N, place the blue 35 N template upon the north latitude face of the red meridian - declination template.
2. Align the blue template arrow on the meridian marked63 E on the red template. (This is equivalent to setting the value LHA 63 on the red template.)
3. Read ZN 265 T at a point 13 N on the red template declination scale.

Solution by Stereographic Projection (Figure 6)

1. Using the same values of LHA 63 , LAT35 N and Dec 13 N, mark the GP of the sun (LHA 63 , DEC 13 N) on the 35 N diagram.
2. Draw a line from the observer zenith (center of projection) through the GP of the Sun so that it intersects the circumference of the diagram. Read ZN-265 T at this point of intersection.

HISTORY OF NAVIGATION

The Artificial Horizon Sextant

By John M. Luykx

(Note: This article is a continuation of the article entitled The Artificial Horizon Sextant published in the previous issue (No. 26) of the Navigator's Newsletter.)

During the period between the end of World War I (1918) and the end of World War II (1945), the history of the artificial horizon sextant followed several separate and distinct paths. These were:

1. The development of the artificial horizon element.
2. The development of averaging devices for use in aircraft sextants.
3. The development of the artificial horizon assembly for use with the marine sextant at sea.
4. The develoment of a compact light weight octant for use primarily in aircraft navigation.
5. The development of a gyro-stabilized artificial horizon for use with sextants for both marine and air navigation.

Although for centuries many methods have been tried in efforts to determine the most effective type of artificial horizon element for use with sextants (examples are: pendulum devices, liquid leveling systems and gyroscopic devices) the basic spirit level was eventually found to be the most effective. It was simple, efficient, light weight, practical and inexpensive and was employed as the best artificial horizon system for use with the early balloon sextants as well as the more sophisticated aircraft sextants and octants of the 1920s and 1930s and during World War II. The air bubble in the spirit level was reflected into the field of view of the sextant optical system by a 45 inclined mirror and the observer aligned the celestial body with the center of the bubble when making an observation. Some artificial horizon sextants employed two spirit levels: a longitudinal level as a reference for measuring altitude and a transverse level to indicate when the sextant was vertical and not "canted". A later development was the circular spirit level, the bubble of which when reflected into the field of view of the instrument looked like a round "doughnut". During observation the observer aligned the celestial body with the center of the doughnut. "Canting" of the sextant was indicated when the bubble moved to the right or to the left in the field of view. A bubble assembly was considered "collimated to infinity" if the bubble appeared to remain aligned with a distant object as the sextant was tilted slowly upward and downward. During the period in question (1918 to 1945) three basic circular bubble systems were employed in artificial horizon sextants: These were

1. The single index reflecting glass with either celestial body or bubble reflected into the instrument line of sight. (Figures 1 and 2)
2. The double reflecting set of mirrors or prisms with the bubble reflected into the line of sight. (Figure 3)
3. The double reflecting set of mirrors or prisms with the bubble positioned in the line of sight. (Figure 4)

The Averager

Because the artificial horizon element (either a pendulum, a liquid leveling system or a gyro device) is subject to acceleration forces caused by ship motion at sea or aircraft motion caused by air turbulence or high speed maneuvers, a long series of observations was generally found necessary to reduce random errors and to obtain accuracy. The recorded observations (usually 10 to 15) were "averaged" to obtain the mean time and mean altitude of the series. These mean values were then reduced to obtain the line of position.

The first mechanical averagers were developed for use with aircraft sextants and appeared around 1935 in sextants of both British and U.S. manufacture. These were "6-shot" mechanical averagers employed with the R.A.E. Mark IX sextant, the U.S. Pioneer A-7 sextant and the Bausch and Lomb A-8A sextants.

Disc type median marking averagers were developed a year or so later for the Link A-12 sextant in 1939 and also used in the A-10 and A-10A sextants manufactured by Fairchild and Agfa-Ansco in 1942 and 1943. When using this type of averager the observer would activate a spring-loaded marking lead which would mark a rotating disc as a series of observations is taken. The median (middle) point of the marks on the disc would indicate the median value of altitude for the series: The median time for the series was the mid-time between the start and stop times of the series.

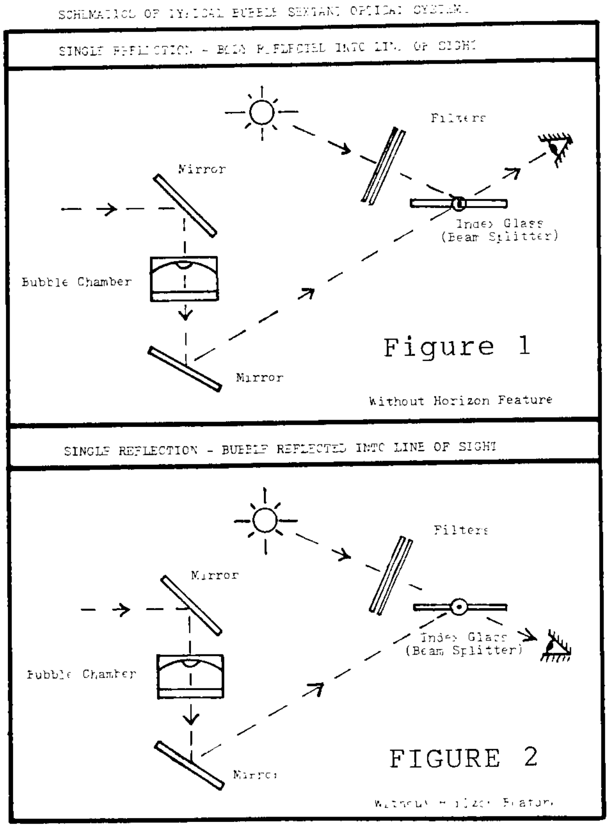
Chronometric averagers were mechanical escapement and clockwork mechanisms employed with the British R.A.E. Mark IX A and B Series of aircraft sextants commencing in 1940 and 1941 and later (1942) incorporated in the U.S. A-14 (USN Mark 5) aircraft sextant manufactured by the Bendix Aircraft Corporation. 60 observational increments of altitude were recorded by the averager at 2-second intervals over a 2-minute period and the mean observed altitude was computed for the 2-minute observation period. The mean time of the observation was computed by subtracting one minute from the time recorded at the end of the 2-minute observation. (Figure 5).

The most sophisticated mechanical averaging device was the Ball and Disc (or Roller) Integrator Averager. It was first employed prior to World War II (1938) in the German SOLD artificial horizon sextant manufactured by Plath of Hamburg. It was a variable time averager and ran from 40 to 180 (or 200) seconds in the SOLD sextant, from about 20 to 120 seconds in the Ball and Disc Averager of the Bendix A-15 sextant (1945) and 1 minute for the Hughes Super Integrating sextant of 1946. The mean altitude for the period of observation was computed by the averager and the mean time of the observation was equal to the time recorded at the end of the observation minus one-half the duration of the observations. This type of averager was also incorporated after the war in hand-held and periscopic aircraft sextants manufactured by the Kollsman Instrument Corporation. (Figure 6).

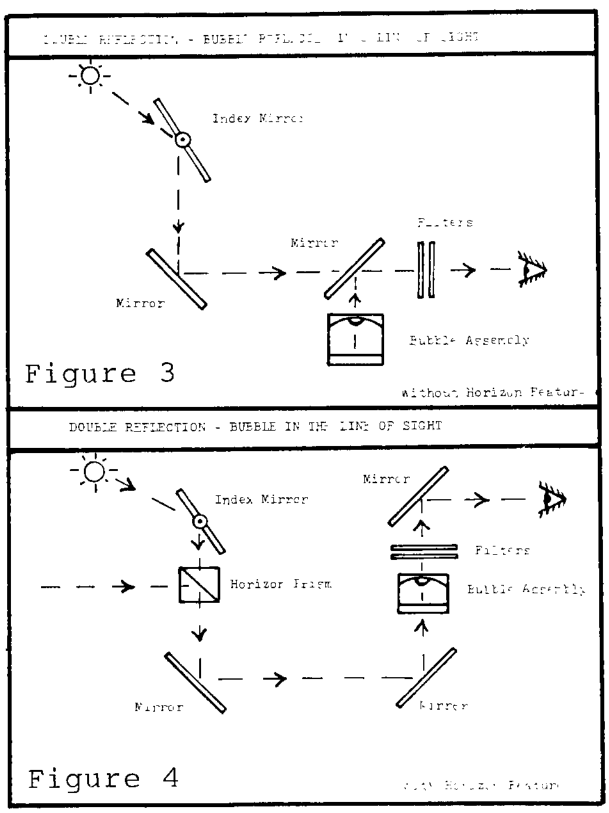
Following World War I, there was a continued interest by mariners in the development of an instrument for use primarily at sea which was not solely dependent on the visual horizon as a reference for measuring altitude. Sextants designed by R.W. Willson (U.S. 1917) (Figure 7), R.E. Byrd (U.S. 1917) (Figure 8), G. Coutinho (Port. 1920) (Figure 9), C. Plath (Coutinho design, Ger. 1925), Coldewey (Ger. 1926), H. Hughes "Gothic" sextant (Brit. 1931), Heath and Co. (Brit. 1934), Tamaya (Coutinho design, Jap. 1938) are all examples of progress in this direction. The Willson, Hughes and Heath sextants employed a circular spirit level. The Byrd sextant employed a single longitudinal spirit level located forward of the horizon mirror while the Coutinho and Coldewey sextants employed both longitudinal and transverse spirit levels also located forward to the horizon mirror. The bubble assemblies for these instruments (except for the Willson sextants) were all collimated to infinity.

The most successful of these sextants were a) the Coutinho sextant later made famous by C.Plath in the 1920s and 1930s (under license from Captain Coutinho) by their "System Gago Coutinho" sextants one of which was used for the aerial navigation of the Dirigible GRAF ZEPPELIN in 1929 during its round the world voyage. (Figure 10) The H. Hughes "Gothic" sextant with Booth bubble attachment became well known throughout the world in the 1930s especially among merchant mariners as the best of its type for use at sea. (Figure 11)

Although the characteristics of the aircraft sextant



Figures 1 and 2
Single Reflecting Index Glass Optical System



Figures 3 and 4
Double Reflecting Index Mirror Optical System

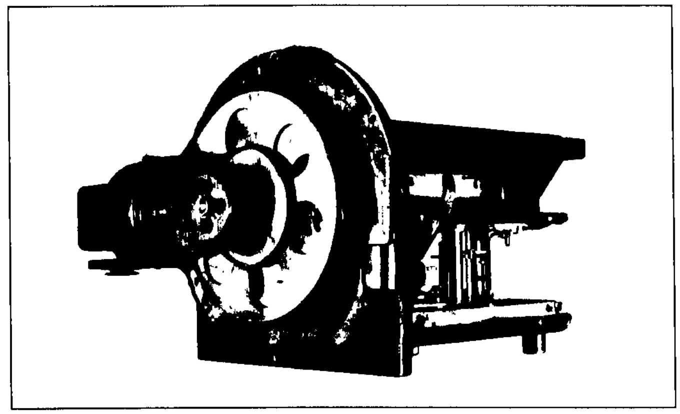


Figure 5
Chronometric Averager

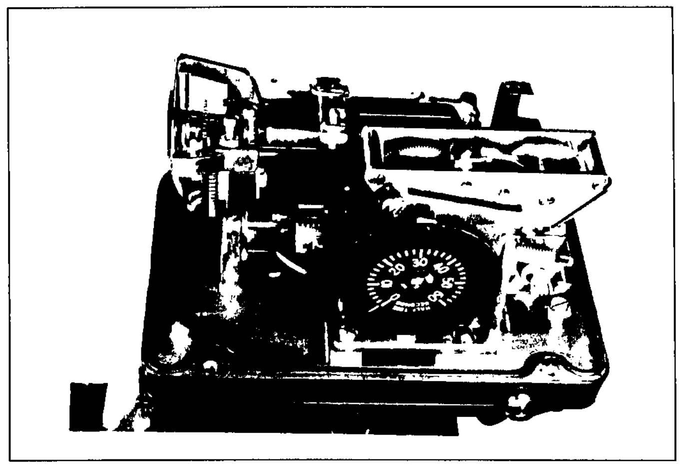


Figure 6
Ball & Disc Integrator Averager

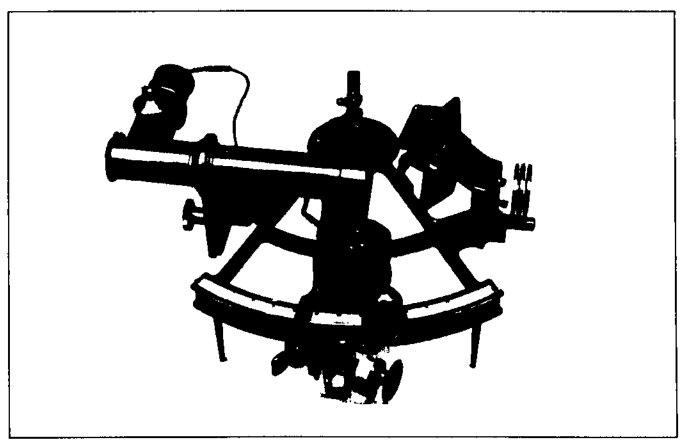


Figure 7
Willson Sextant 1917

Credits for Illustrations: Figs. 1-6, author; Fig. 7-8, courtesy The Smithsonian Institutes, Washington, DC; Fig. 9, courtesy The Naval Museum, Belem, Portugal; Fig. 10, courtesy The Whaling Museum, New Bedford, MA; Fig. 11, H. Hughes Catalogue; Fig. 12-14, courtesy The Smithsonian Institutes, Washington, DC; Fig. 15-18, author; Fig. 19, courtesy The Smithsonian Institutes, Washington, DC; Fig. 20-21, author; Fig. 22, U.S. Air Force photo.

were originally developed by European designers especially in Germany, France and Britain, the major developments in the history of this type instrument occurred in Britain and the United States.

In Britain, in 1920, the well known L. B. Booth artificial bubble horizon was initially incorporated in the first of a long line of famous Royal Aircraft Establishment (R.A.E.) sextants culminating in the Mark IX series used by all the Allied Air Forces in World War II. Well known instruments of this line designed by the Hughes firm of London included the Mark II of 1920 (Figure 12), the Mark III of 1922, the Mark V of 1925 (Figure 13), Mark VIII of 1935, the Mark IX of 1937 and the Mark IX A and B series of World War II fame. (Figure 14) The R.A.E. sextants employed the double mirror reflecting principle with the bubble reflected in the line of sight.

In the U.S. the first small hand-held aircraft octant was designed by H. Beij. It was manufactured by Bausch and Lomb and was known as the BUSTD Mod.A. Modifications to this model were incorporated in 1929 (BUSTD Mod.B), in 1930 (BUSTD Mod.C) and finally in 1935 (BUSTD Mod.D) also known as the A-8 and A-8A octant (Figure 15). The Bureau of Standards Models A-D sextants employed the single index glass optical system where the observer either looked up directly at the celestial body with the bubble reflected into the line of sight (night observations) or looked downward at the bubble with the body reflected into the line of sight (day observations).

In 1931, the Pioneer Instrument Company introduced a small, light compact instrument which became the first to be accepted for general U.S. Air Corps procurement. It was designated as the A-5 (USN Mark III). This instrument was the forerunner of the series manufactured by the Bendix Aviation Corporation that included the MK IV of 1939, the A-14 (USN MarkV) (the famous "Bendix Mixmaster" of World War II fame) (Figure 16) and the A-15 with disc type averager of 1945. (Figure 17) The Pioneer Bendix instruments employed the double prism optical system with the bubble located in the optical path.

Other notable U.S. instruments were the A-10 (Figure 18) and A-10A designed by Captain T. L. Thurlow of the U.S. Air Corps and later manufactured by Fairchild and Agfa- Ansco in 1942 and 1943 for use primarily by the U.S. Army Air Corps. The A-12 by Link Aviation devices (Figure 19) of 1940 and the Bausch and Lomb AN-5854-1 of 1944 are other instruments which saw service in World War II.

In Germany, although the Plath "System Gago Coutinho" sextant enjoyed much popularity for both marine and air navigation, as an artificial horizon sextant, it had two disadvantages, particularly for air navigation: a) the artificial horizon assembly consisted of two spirit levels, one longitudinal and the other transverse which are more difficult to use in a heavy seaway or in heavy air turbulence compared to the circular spirit level and b) it did not have an averager. As a result, in 1938, Plath developed the SOLD sextant, a sextant based on the British R.A.E. MK VIII and U.S. BUSTD Mod.D optical design which employed a unique roller integrator averager. (Figure 20) Although the SOLD sextant was designed primarily for air navigation, it could also be used for marine navigation. For marine navigation, a "stiffer" circular spirit level was used. In 1943, 1944 and 1945, Plath modified this sextant to incorporate an air driven gyro-stabilized artificial horizon element similar to the Fleuriais design of 1886. (See Navigator's Newsletter, Issue 26, Page 8.) The SOLD gyro sextant (Figure 21) was used successfully aboard submarines during the last two years of the war and was the only successful gyro-stabilized artificial horizon sextant employed by any of the belligerents during World War II.

Comparatively little information is available about the history of the artificial horizon sextant in Japan during the period of 1920 to 1945. It is known, however, from instruments in the Smithsonian Air and Space Museum collection (and other collections) that the Japanese used aircraft sextants based on the U.S. BUSTD Mod. B and C design. The well known firm Tamaya also manufactured marine sextants based on the Gago Colutinho design of 1920. The author has two of these Tamaya instruments in his collection, one of which incorporates a unique 6-shot mechanical averager similar to that of the U.S. BUSTD Mod.D (A-8A) of 1935. The serial number of this unusual instrument is 1.

In 1917 the French firm of Le Prieur manufactured an air driven gyro stabilized artificial horizon sextant based on the Fleuriais pattern designed by Bonneau & Derrien, but it doesn't appear to have been successful. A reflecting mirror was attached horizontally on the top of the gyro rotor and the observer observed the double angle between the celestial bodyand its image as reflected in the mirror. In 1922 the U.S. Air Corps developed an experimental gyro stabilized artificial horizon sextant designated the A-1. It was apparently unsuccessful. In 1936 the Sperry Gyroscope Company designed aprototype air-driven artificial horizon sextant which, however, failed acceptance tests in 1940 conducted at the Naval Aircraft Factory in Philadephia. (Figure 22) In 1937 the Pioneer Instrument Company developed a gyro-octant which was electrically driven. This sextant also was found to be unsatisfatory during tests conducted at Philadelphia in 1939. Both the Sperry and the Pioneer gyro-octants employed the optical system of the BUSTD Mod.D aircraft sextants. The two instruments weighed 8 to 9 pounds and both did not incorporatean averager in the design. In 1943 the firm C. Plath developed a gyro-stabilized artificial horizon sextant for the German Navy for use in submarines. It was based directly on the Fleuriais design described in the previous issue of the Navigator's Newsletter (No. 26). It was designated the SOLD KS-3D sextant based on the 1938 version of the SOLD bubble octant. (Figure 21) It was

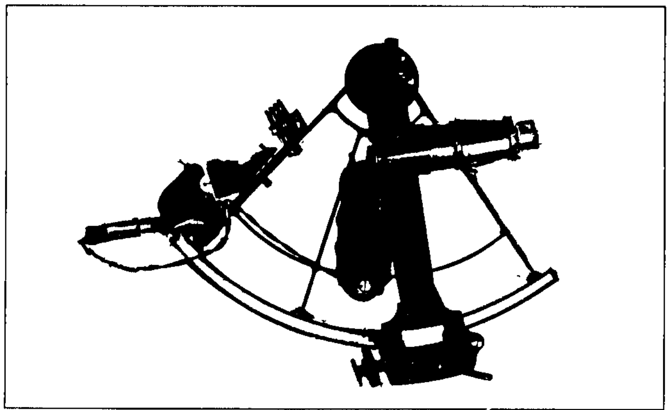


Figure 8
R. E. Byrd Sextant 1917

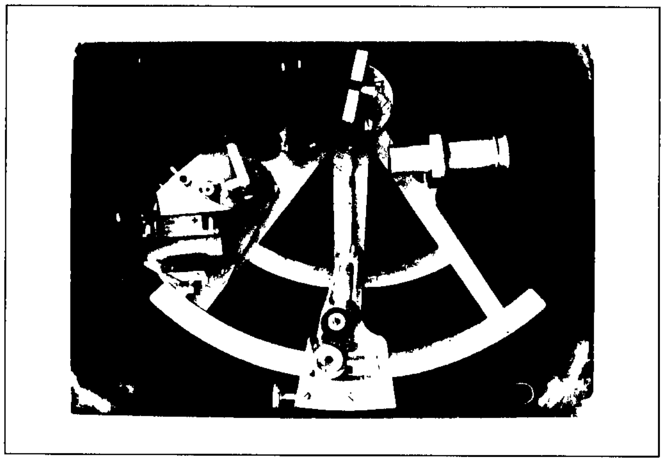


Figure 9
Coutinho Sextant 1920

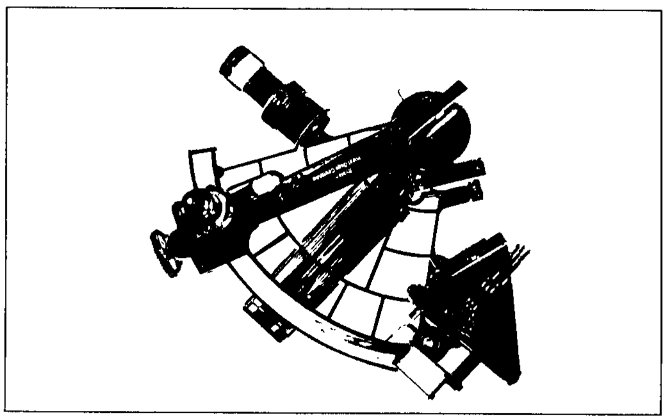


Figure 10
Plath System Gago
Coutinho Sextant 1926

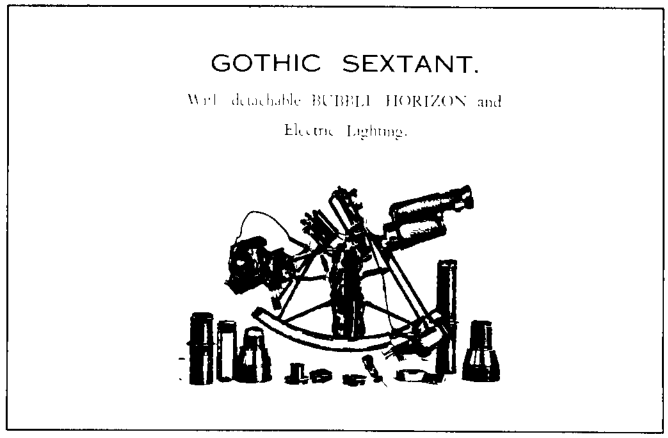


Figure 11
Hughes Gothic Sextant 1931

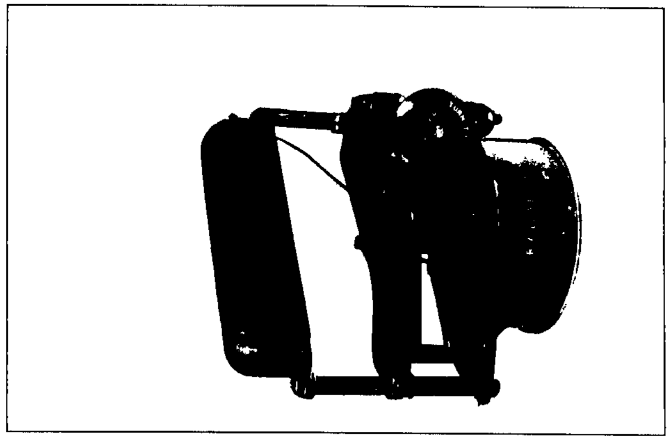


Figure 12
R.A.E. MK II Sextant 1920

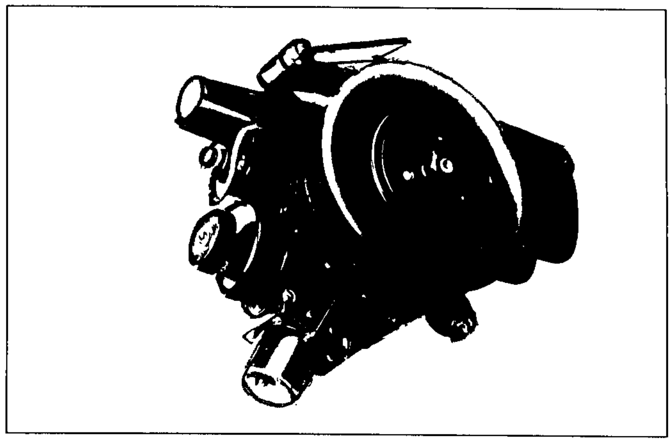


Figure 13
R.A.E. MK V Octant 1925

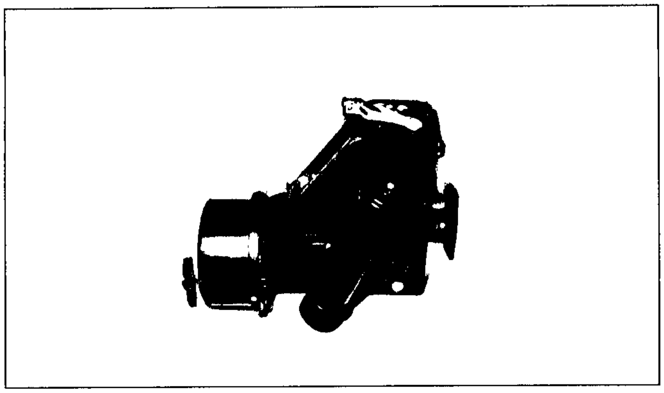


Figure 14
R.A.E. MK IXA 1941

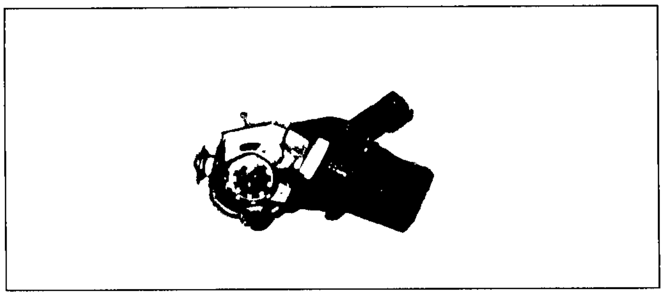


Figure 15
BUSTD MOD D Sextant A8A 1935

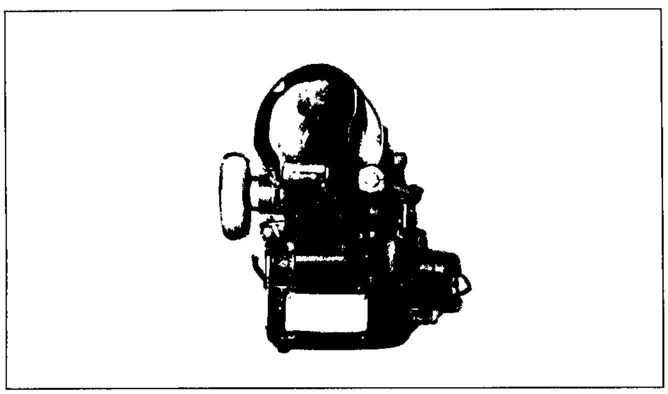


Figure 16
Bendix A-14 Sextant 1942

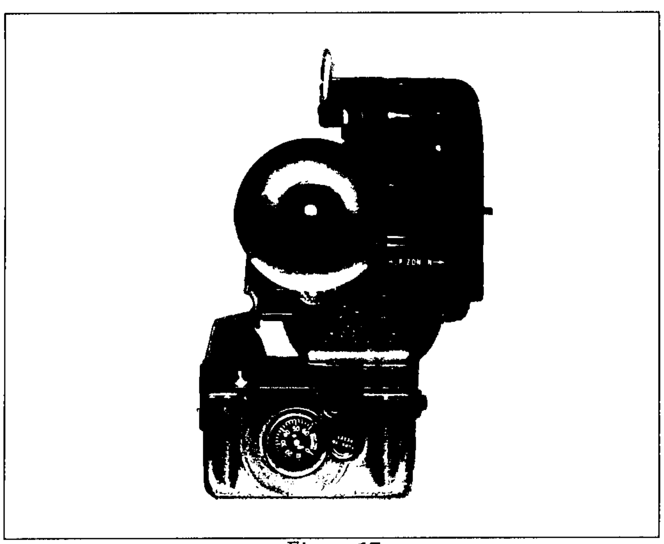


Figure 17
Bendix A-15 Sextant 1945

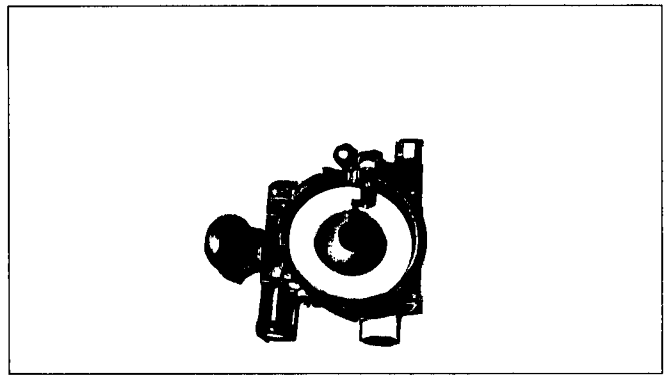


Figure 18
Fairchild A-10 Sextant 1942

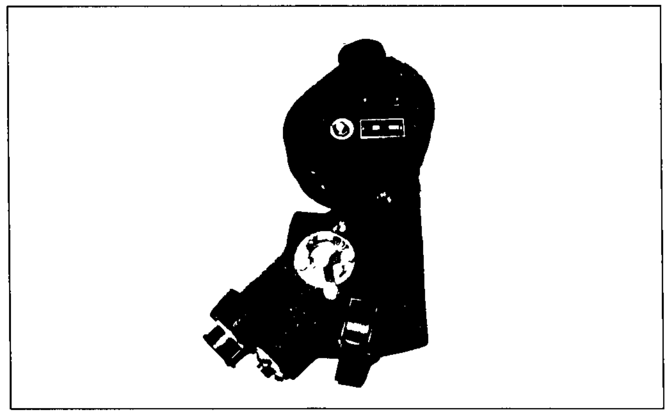


Figure 19
Link A-12 Sextant 1940

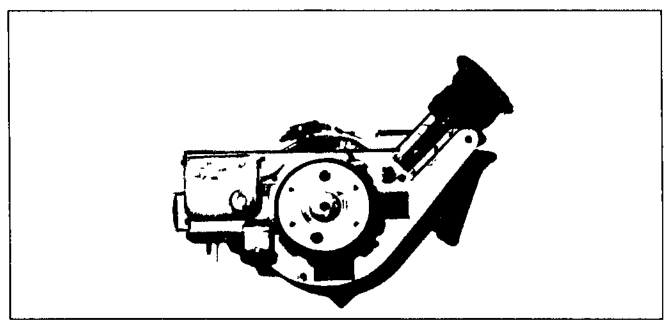


Figure 20
SOLD Bubble Sextant 1938

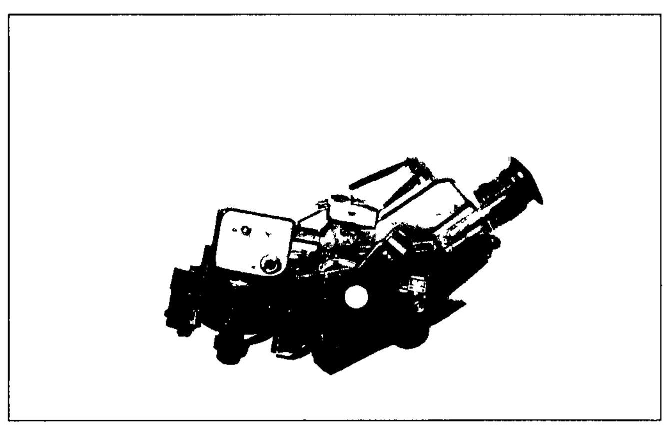


Figure 21
SOLD Gyro Sextant 1944

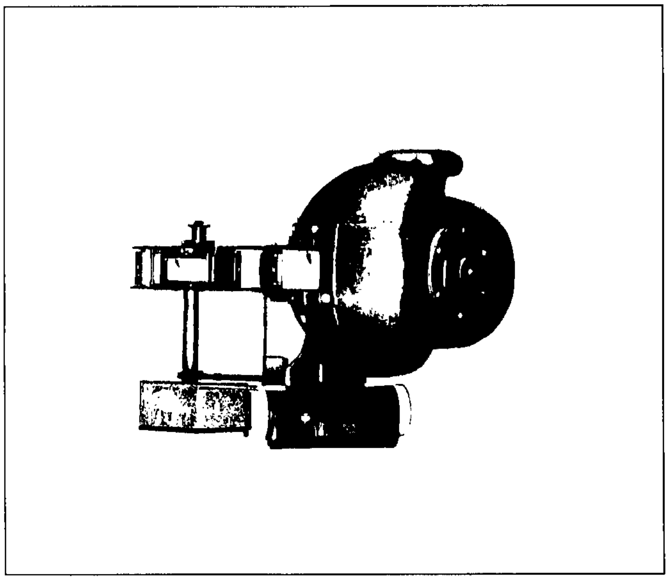


Figure 22
Sperry Gyro Sextant 1936

the Navigator's Newsletter (No. 26). It was designated the SOLD KS-3D sextantbased on the 1938 version of the SOLD bubble octant. (Figure 21) It was heavy and cumbersome to use although it included an averager which would run for either 40 seconds, 2 minutes or 3minutes. It was apparently successfully employed on submarines. It is known that in 1940 and 1944, both Siemens and Anschutz also developed an air-driven gyro-sextant for marine and air use but little is known of these instruments.

In the next issue of the Navigator's Newsletter, post-World War II developments of the artificial horizon sextant will be discussed. Also included will be a description of some techniques and "wrinkles" with regard to the use of the artificial horizon (bubble) sextant in marine navigation.

NAVIGATION NOTES

A Graphic Solution to the Noonday Fix Problem

by N. E. Andross

This graphic solution to the noonday fix problem is accurate, rapid and requires no sight reduction computations. The only limitation is that the track should be predominantly East or West.

Brief outline of the solution:

1. Using D.R. data, an approximate GMT for LAN (Local Apparent Noon) is determined.
2. Using this data, enter the nautical almanac (Arc/Time Converstion Table) and compute a more accurate ETT (Estimated Time of Transit).
3. Take a series of eleven sextant sights two minutes apart beginning ten minutes prior to ETT and ending ten minutes after ETT.
4. Plot these observations on graph paper and plot a smooth curve of increasing, then decreasing H .
5. Determine maximum H ; apply usual sight corrrections (I.C., DIP, LIMB, etc.) to determine HO.
6. Compute latitude by properly combining Zenith distance (co-altitude) and declination.*
7. The time of meridional transit (maximum H) is converted to Arc (again using table in almanac), thus giving longitude.

* See Ocean Navigator, issue #18, for an excellent explanation of this procedure, depending on declination and North or South latitude.

SAMPLE PROBLEM:

We have departed Port San Luis, California for a passage to Hilo, Hawaii. Unfortunately, it was overcast during our first day out. Also, our LORAN C receiver failed, so we are forced to rely on Celestial Navigation as our primary means of navigation fixes. On the second day, the overcast clears and we want to take an accurate noon day fix using the following data:

Date: 10 May 1988 DR Lat. 34 - 40'N
Time:LAN at 125 W DR Long. 125 - 25' W
Procedure:

1988 MAY 9, 10, 11 (MON., TUES., WED.)

GMT (UT) d h	SUN GHA ° ′	SUN Dec. ° ′	MOON GHA ° ′	MOON v ′	MOON Dec. ° ′	MOON d ′	MOON HP ′
9 MONDAY 00	180 53.8	N17 21.6	265 50.4	9.1	S18 11.0	13.5	59.2
01	195 53.8	22.2	280 18.5	9.1	17 57.5	13.6	59.2
02	210 53.8	22.9	294 46.6	9.2	17 43.9	13.7	59.2
03	225 53.9	. . 23.6	309 14.8	9.4	17 30.2	13.8	59.3
04	240 53.9	24.2	323 43.2	9.3	17 16.4	13.9	59.3
05	255 53.9	24.9	338 11.5	9.5	17 02.5	14.0	59.3
06	270 54.0	N17 25.6	352 40.0	9.5	S16 48.5	14.1	59.3
07	285 54.0	26.2	7 08.5	9.7	16 34.4	14.2	59.3
08	300 54.0	26.9	21 37.2	9.6	16 20.2	14.2	59.3
09	315 54.0	. . 27.5	36 05.8	9.8	16 06.0	14.4	59.3
10	330 54.1	28.2	50 34.6	9.9	15 51.6	14.5	59.3
11	345 54.1	28.9	65 03.5	9.9	15 37.1	14.5	59.3
12	0 54.1	N17 29.5	79 32.4	9.9	S15 22.6	14.7	59.3
13	15 54.1	30.2	94 01.3	10.1	15 07.9	14.7	59.3
14	30 54.2	30.9	108 30.4	10.1	14 53.2	14.8	59.3
15	45 54.2	. . 31.5	122 59.5	10.2	14 38.4	14.9	59.3
16	60 54.2	32.2	137 28.7	10.3	14 23.5	14.9	59.3
17	75 54.3	32.8	151 58.0	10.3	14 08.6	15.1	59.3
18	90 54.3	N17 33.5	166 27.3	10.4	S13 53.5	15.1	59.3
19	105 54.3	34.1	180 56.7	10.4	13 38.4	15.2	59.3
20	120 54.3	34.8	195 26.1	10.6	13 23.2	15.3	59.4
21	135 54.4	. . 35.5	209 55.7	10.5	13 07.9	15.3	59.4
22	150 54.4	36.1	224 25.2	10.7	12 52.6	15.4	59.4
23	165 54.4	36.8	238 54.9	10.7	12 37.2	15.5	59.4
10 TUESDAY 00	180 54.4	N17 37.4	253 24.6	10.7	S12 21.7	15.6	59.4
01	195 54.4	38.1	267 54.3	10.9	12 06.1	15.6	59.4
02	210 54.5	38.7	282 24.2	10.8	11 50.5	15.7	59.4
03	225 54.5	. . 39.4	296 54.0	11.0	11 34.8	15.7	59.4
04	240 54.5	40.0	311 24.0	11.0	11 19.1	15.8	59.4
05	255 54.5	40.7	325 54.0	11.0	11 03.3	15.9	59.4
06	270 54.6	N17 41.3	340 24.0	11.1	S10 47.4	15.9	59.4
07	285 54.6	42.0	354 54.1	11.2	10 31.5	16.0	59.4
08	300 54.6	42.6	9 24.3	11.2	10 15.5	16.0	59.4
09	315 54.6	. . 43.3	23 54.5	11.2	9 59.5	16.1	59.4
10	330 54.6	43.9	38 24.7	11.3	9 43.4	16.1	59.4
11	345 54.7	44.6	52 55.0	11.3	9 27.3	16.2	59.4
12	0 54.7	N17 45.2	67 25.3	11.4	S 9 11.1	16.3	59.4
13	15 54.7	45.9	81 55.7	11.5	8 54.8	16.3	59.4
14	30 54.7	46.5	96 26.2	11.4	8 38.5	16.3	59.4
15	45 54.7	. . 47.2	110 56.6	11.6	8 22.2	16.4	59.4
16	60 54.8	47.8	125 27.2	11.5	8 05.8	16.4	59.4
17	75 54.8	48.5	139 57.7	11.6	7 49.4	16.5	59.4
18	90 54.8	N17 49.1	154 28.3	11.6	S 7 32.9	16.5	59.4
19	105 54.8	49.8	168 58.9	11.7	7 16.4	16.5	59.4
20	120 54.8	50.4	183 29.6	11.7	6 59.9	16.6	59.4
21	[illegible]	. . 51.0	198 00.3	11.8	6 43.3	16.6	59.4
22	150 54.9	51.[illegible]	212 31.1	11.7	6 26.7	16.6	59.4
23	165 54.9	52.3	227 01.8	11.8	6 10.1	16.7	59.4
11 WEDNESDAY 00	180 54.9	N17 53.0	241 32.6	11.9	S 5 53.4	16.7	59.4
01	195 54.9	53.6	256 03.5	11.8	5 36.7	16.7	59.4
02	210 54.9	54.3	270 34.3	11.9	5 20.0	16.8	59.4
03	225 55.0	. . 54.9	285 05.2	11.9	5 03.2	16.8	59.4
04	240 55.0	55.5	299 36.1	12.0	4 46.4	16.8	59.4
05	255 55.0	56.2	314 07.1	11.9	4 29.6	16.8	59.4
06	270 55.0	N17 56.8	328 38.0	12.0	S 4 12.8	16.9	59.4
07	285 55.0	57.5	343 09.0	12.0	3 55.9	16.9	59.4
08	300 55.0	58.1	357 40.0	12.1	3 39.0	16.9	59.4
09	315 55.1	. . 58.7	12 11.1	12.0	3 22.1	16.9	59.4
10	330 55.1	17 59.4	26 42.1	12.1	3 05.2	16.9	59.4
11	345 55.1	18 00.0	41 13.2	12.1	2 48.3	16.9	59.4
12	0 55.1	N18 00.6	55 44.3	12.0	S 2 31.4	17.0	59.4
13	15 55.1	01.3	70 15.3	12.2	2 14.4	16.9	59.4
14	30 55.1	01.9	84 46.[illegible]	12.1	1 57.5	17.0	59.4
15	45 55.1	. . 02.5	99 17.6	12.1	1 40.5	17.0	59.4
16	60 55.2	03.2	113 48.7	12.1	1 23.5	17.0	59.4
17	75 55.2	03.8	128 19.8	12.2	1 06.5	17.0	59.4
18	90 55.2	N18 04.4	142 51.0	12.1	S 0 49.5	16.9	59.4
19	105 55.2	05.[illegible]	157 22.1	12.2	0 32.6	17.0	59.4
20	120 55.2	05.7	171 53.3	12.2	S 0 15.6	17.0	59.4
21	135 55.2	. . 06.3	186 24.5	12.[illegible]	N 0 01.4	17.0	59.4
22	150 55.2	07.0	200 55.6	12.2	0 18.4	17.0	59.4
23	165 55.2	07.6	215 26.8	12.1	0 35.4	17.0	59.4
	S.D. 15.9	d 0.6	S.D. 16.2		16.2		16.2

Lat. °	Twilight Naut. h m	Twilight Civil h m	Sunrise h m	Moonrise 9 h m	Moonrise 10 h m	Moonrise 11 h m	Moonrise 12 h m
N 72	▭	▭	▭	05 14	03 49	03 05	02 28
N 70	////	////	01 30	04 22	03 31	02 58	02 29
68	////	////	02 13	03 49	03 16	02 52	02 31
66	////	00 38	02 41	03 25	03 04	02 47	02 32
64	////	01 39	03 03	03 06	02 53	02 43	02 33
62	////	02 11	03 20	02 50	02 45	02 39	02 34
60	00 34	02 35	03 34	02 37	02 37	02 36	02 35
N 58	01 28	02 53	03 46	02 26	02 30	02 33	02 36
56	01 58	03 09	03 57	02 15	02 24	02 31	02 37
54	02 20	03 22	04 06	02 07	02 19	02 28	02 37
52	02 38	03 33	04 14	01 59	02 14	02 26	02 38
50	02 53	03 43	04 21	01 51	02 09	02 24	02 38
45	03 21	04 03	04 37	01 36	02 00	02 20	02 40
N 40	03 42	04 19	04 50	01 23	01 52	02 17	02 41
35	03 59	04 33	05 00	01 12	01 45	02 14	02 41
30	04 13	04 44	05 10	01 03	01 38	02 11	02 42
20	04 35	05 03	05 26	00 46	01 28	02 06	02 44
N 10	04 52	05 18	05 40	00 32	01 18	02 02	02 45
0	05 06	05 31	05 53	00 18	01 09	01 58	02 46
S 10	05 18	05 44	06 06	00 04	01 00	01 54	02 47
20	05 30	05 56	06 19	24 51	00 51	01 50	02 49
30	05 41	06 10	06 35	24 40	00 40	01 45	02 50
35	05 46	06 17	06 44	24 33	00 33	01 43	02 51
40	05 52	06 25	06 54	24 26	00 26	01 40	02 52
45	05 59	06 34	07 06	24 18	00 18	01 36	02 53
S 50	06 06	06 45	07 20	24 07	00 07	01 32	02 55
52	06 09	06 50	07 27	24 02	00 02	01 30	02 55
54	06 12	06 55	07 34	23 57	25 27	01 27	02 56
56	06 15	07 01	07 42	23 51	25 25	01 25	02 57
58	06 19	07 07	07 52	23 44	25 22	01 22	02 58
S 60	06 23	07 14	08 02	23 37	25 19	01 19	02 59

Lat. °	Sunset h m	Twilight Civil h m	Twilight Naut. h m	Moonset 9 h m	Moonset 10 h m	Moonset 11 h m	Moonset 12 h m
N 72	▭	▭	▭	08 13	11 25	13 54	16 18
N 70	22 30	////	////	09 03	11 41	13 57	16 10
68	21 44	////	////	09 34	11 54	14 00	16 03
66	21 15	23 32	////	09 57	12 04	14 02	15 58
64	20 52	22 19	////	10 15	12 12	14 04	15 54
62	20 35	21 45	////	10 29	12 19	14 05	15 50
60	20 20	21 20	23 35	10 41	12 26	14 07	15 46
N 58	20 08	21 01	22 29	10 52	12 31	14 08	15 43
56	19 58	20 46	21 57	11 01	12 36	14 09	15 41
54	19 48	20 33	21 35	11 09	12 40	14 10	15 38
52	19 40	20 21	21 17	11 16	12 44	14 10	15 36
50	19 32	20 11	21 02	11 22	12 48	14 11	15 34
45	19 17	19 50	20 33	11 36	12 55	14 13	15 30
N 40	19 04	19 34	20 11	11 47	13 01	14 14	15 27
35	18 53	19 21	19 54	11 56	13 07	14 15	15 24
30	18 43	19 09	19 40	12 05	13 11	14 16	15 21
20	18 27	18 50	19 18	12 19	13 19	14 18	15 16
N 10	18 13	18 35	19 01	12 31	13 26	14 20	15 12
0	18 00	18 22	18 47	12 43	13 33	14 21	15 09
S 10	17 47	18 09	18 34	12 54	13 39	14 22	15 05
20	17 33	17 56	18 23	13 06	13 46	14 24	15 01
30	17 18	17 43	18 12	13 20	13 54	14 25	14 56
35	17 09	17 35	18 06	13 27	13 58	14 26	14 54
40	16 59	17 27	18 00	13 36	14 03	14 27	14 51
45	16 47	17 18	17 53	13 46	14 08	14 28	14 48
S 50	16 32	17 07	17 46	13 59	14 15	14 30	14 44
52	16 25	17 02	17 43	14 04	14 18	14 30	14 42
54	16 18	16 57	17 40	14 11	14 22	14 31	14 40
56	16 10	16 51	17 37	14 16	14 25	14 32	14 37
58	16 00	16 45	17 33	14 25	14 29	14 32	14 35
S 60	15 50	16 38	17 29	14 34	14 34	14 33	14 32

Day	SUN Eqn. of Time 00h m s	SUN Eqn. of Time 12h m s	SUN Mer. Pass. h m	MOON Mer. Pass. Upper h m	MOON Mer. Pass. Lower h m	MOON Age d	MOON Phase
9	03 35	03 36	11 56	06 30	18 56	23	◑
10	03 38	03 39	11 56	07 21	19 46	24	
11	03 40	03 40	11 56	08 10	20 34	25	

Figure 1
Nautical Almanac With Date

DR Longitude(120 - 55')—GMT (20 hrs). (Round off GHA value to nearest whole minute value).
Step 3. Record declination for GMT (N. 17 - 50.4')^]Step
4. Subtract GHA value from D.R.Long.

125 - 18'
120 - 55'

GHA Diff. 4* - 23'

Step 5. Enter Arc/Time increment conversion section of Almanac (Figure 2) GHA diff. (4 - 23')
Step 6. Convert GHA diff. value to time—(17 mins., 32 sec.). This value, combined with the GMT of 20 hrs., gives us the approximate time of ETT (Estimated Time of Transit)—20 hrs., 17 minutes.
Step 7. Begin taking sextant sights 10 minutes prior to ETT, at 2 minute intervals until 10 minutes after ETT, for a total of 11 observations. Record these observations.
Step 8. Plot the following H values on graph paper (Figure 3) with time on the X, or horizontal axis; and altitude on the Y, or vertical axis. Both the horizontal and vertical scales should be greatly expanded. Thus, only

INCREMENTS AND CORRECTIONS

16m	SUN PLANETS	ARIES	MOON	v or d	Corr	v or d	Corr	v or d	Corr
s	° '	° '	° '	'	'	'	'	'	'
00	4 00·0	4 00·7	3 49·1	0·0	0·0	6·0	1·7	12·0	3·3
01	4 00·3	4 00·9	3 49·3	0·1	0·0	6·1	1·7	12·1	3·3
02	4 00·5	4 01·2	3 49·5	0·2	0·1	6·2	1·7	12·2	3·4
03	4 00·8	4 01·4	3 49·8	0·3	0·1	6·3	1·7	12·3	3·4
04	4 01·0	4 01·7	3 50·0	0·4	0·1	6·4	1·8	12·4	3·4
05	4 01·3	4 01·9	3 50·3	0·5	0·1	6·5	1·8	12·5	3·4
06	4 01·5	4 02·2	3 50·5	0·6	0·2	6·6	1·8	12·6	3·5
07	4 01·8	4 02·4	3 50·7	0·7	0·2	6·7	1·8	12·7	3·5
08	4 02·0	4 02·7	3 51·0	0·8	0·2	6·8	1·9	12·8	3·5
09	4 02·3	4 02·9	3 51·2	0·9	0·2	6·9	1·9	12·9	3·5
10	4 02·5	4 03·2	3 51·5	1·0	0·3	7·0	1·9	13·0	3·6
11	4 02·8	4 03·4	3 52·7	1·1	0·3	7·1	2·0	13·1	3·6
12	4 03·0	4 03·7	3 51·9	1·2	0·3	7·2	2·0	13·2	3·6
13	4 03·3	4 03·9	3 52·2	1·3	0·4	7·3	2·0	13·3	3·7
14	4 03·5	4 04·2	3 52·4	1·4	0·4	7·4	2·0	13·4	3·7
15	4 03·8	4 04·4	3 52·6	1·5	0·4	7·5	2·1	13·5	3·7
16	4 04·0	4 04·7	3 52·9	1·6	0·4	7·6	2·1	13·6	3·7
17	4 04·3	4 04·9	3 53·1	1·7	0·5	7·7	2·1	13·7	3·8
18	4 04·5	4 05·2	3 53·4	1·8	0·5	7·8	2·1	13·8	3·8
19	4 04·8	4 05·4	3 53·6	1·9	0·5	7·9	2·2	13·9	3·8
20	4 05·0	4 05·7	3 53·8	2·0	0·6	8·0	2·2	14·0	3·9
21	4 05·3	4 05·9	3 54·1	2·1	0·6	8·1	2·2	14·1	3·9
22	4 05·5	4 06·2	3 54·3	2·2	0·6	8·2	2·3	14·2	3·9
23	4 05·8	4 06·4	3 54·6	2·3	0·6	8·3	2·3	14·3	3·9
24	4 06·0	4 06·7	3 54·8	2·4	0·7	8·4	2·3	14·4	4·0
25	4 06·3	4 06·9	3 55·0	2·5	0·7	8·5	2·3	14·5	4·0
26	4 06·5	4 07·2	3 55·3	2·6	0·7	8·6	2·4	14·6	4·0
27	4 06·8	4 07·4	3 55·5	2·7	0·7	8·7	2·4	14·7	4·0
28	4 07·0	4 07·7	3 55·7	2·8	0·8	8·8	2·4	14·8	4·1
29	4 07·3	4 07·9	3 56·0	2·9	0·8	8·9	2·4	14·9	4·1
30	4 07·5	4 08·2	3 56·2	3·0	0·8	9·0	2·5	15·0	4·1
31	4 07·8	4 08·4	3 56·5	3·1	0·9	9·1	2·5	15·1	4·2
32	4 08·0	4 08·7	3 56·7	3·2	0·9	9·2	2·5	15·2	4·2
33	4 08·3	4 08·9	3 56·9	3·3	0·9	9·3	2·6	15·3	4·2
34	4 08·5	4 09·2	3 57·2	3·4	0·9	9·4	2·6	15·4	4·2
35	4 08·8	4 09·4	3 57·4	3·5	1·0	9·5	2·6	15·5	4·3
36	4 09·0	4 09·7	3 57·7	3·6	1·0	9·6	2·6	15·6	4·3
37	4 09·3	4 09·9	3 57·9	3·7	1·0	9·7	2·7	15·7	4·3
38	4 09·5	4 10·2	3 58·1	3·8	1·0	9·8	2·7	15·8	4·3
39	4 09·8	4 10·4	3 58·4	3·9	1·1	9·9	2·7	15·9	4·4
40	4 10·0	4 10·7	3 58·6	4·0	1·1	10·0	2·8	16·0	4·4
41	4 10·3	4 10·9	3 58·8	4·1	1·1	10·1	2·8	16·1	4·4
42	4 10·5	4 11·2	3 59·1	4·2	1·2	10·2	2·8	16·2	4·5
43	4 10·8	4 11·4	3 59·3	4·3	1·2	10·3	2·8	16·3	4·5
44	4 11·0	4 11·7	3 59·6	4·4	1·2	10·4	2·9	16·4	4·5
45	4 11·3	4 11·9	3 59·8	4·5	1·2	10·5	2·9	16·5	4·5
46	4 11·5	4 12·2	4 00·0	4·6	1·3	10·6	2·9	16·6	4·6
47	4 11·8	4 12·4	4 00·3	4·7	1·3	10·7	2·9	16·7	4·6
48	4 12·0	4 12·7	4 00·5	4·8	1·3	10·8	3·0	16·8	4·6
49	4 12·3	4 12·9	4 00·8	4·9	1·3	10·9	3·0	16·9	4·6
50	4 12·5	4 13·2	4 01·0	5·0	1·4	11·0	3·0	17·0	4·7
51	4 12·8	4 13·4	4 01·2	5·1	1·4	11·1	3·1	17·1	4·7
52	4 13·0	4 13·7	4 01·5	5·2	1·4	11·2	3·1	17·2	4·7
53	4 13·3	4 13·9	4 01·7	5·3	1·5	11·3	3·1	17·3	4·8
54	4 13·5	4 14·2	4 02·0	5·4	1·5	11·4	3·1	17·4	4·8
55	4 13·8	4 14·4	4 02·2	5·5	1·5	11·5	3·2	17·5	4·8
56	4 14·0	4 14·7	4 02·4	5·6	1·5	11·6	3·2	17·6	4·8
57	4 14·3	4 14·9	4 02·7	5·7	1·6	11·7	3·2	17·7	4·9
58	4 14·5	4 15·2	4 02·9	5·8	1·6	11·8	3·2	17·8	4·9
59	4 14·8	4 15·4	4 03·1	5·9	1·6	11·9	3·3	17·9	4·9
60	4 15·0	4 15·7	4 03·4	6·0	1·7	12·0	3·3	18·0	5·0

17m	SUN PLANETS	ARIES	MOON	v or d	Corr
s	° '	° '	° '	'	'
00	4 15·0	4 15·7	4 03·4	0·0	0·0
01	4 15·3	4 15·9	4 03·6	0·1	0·0
02	4 15·5	4 16·2	4 03·9	0·2	0·1
03	4 15·8	4 16·5	4 04·1	0·3	0·1
04	4 16·0	4 16·7	4 04·3	0·4	0·1
05	4 16·3	4 17·0	4 04·6	0·5	0·1
06	4 16·5	4 17·2	4 04·8	0·6	0·2
07	4 16·8	4 17·5	4 05·1	0·7	0·2
08	4 17·0	4 17·7	4 05·3	0·8	0·2
09	4 17·3	4 18·0	4 05·5	0·9	0·3
10	4 17·5	4 18·2	4 05·8	1·0	0·3
11	4 17·8	4 18·5	4 06·0	1·1	0·3
12	4 18·0	4 18·7	4 06·2	1·2	0·4
13	4 18·3	4 19·0	4 06·5	1·3	0·4
14	4 18·5	4 19·2	4 06·7	1·4	0·4
15	4 18·8	4 19·5	4 07·0	1·5	0·4
16	4 19·0	4 19·7	4 07·2	1·6	0·5
17	4 19·3	4 20·0	4 07·4	1·7	0·5
18	4 19·5	4 20·2	4 07·7	1·8	0·5
19	4 19·8	4 20·5	4 07·9	1·9	0·6
20	4 20·0	4 20·7	4 06·2	2·0	0·6
21	4 20·3	4 21·0	4 08·4	2·1	0·6
22	4 20·5	4 21·2	4 08·6	2·2	0·6
23	4 20·8	4 21·5	4 08·9	2·3	0·7
24	4 21·0	4 21·7	4 09·1	2·4	0·7
25	4 21·3	4 22·0	4 09·3	2·5	0·7
26	4 21·5	4 22·2	4 09·6	2·6	0·8
27	4 21·8	4 22·5	4 09·8	2·7	0·8
28	4 22·0	4 22·7	4 10·1	2·8	0·8
29	4 22·3	4 23·0	4 10·3	2·9	0·8
30	4 22·5	4 23·2	4 10·5	3·0	0·9
31	4 22·8	4 23·5	4 10·8	3·1	0·9
32	4 23·0	4 23·7	4 11·0	3·2	0·9
33	4 23·3	4 24·0	4 11·3	3·3	1·0
34	4 23·5	4 24·2	4 11·5	3·4	1·0
35	4 23·8	4 24·5	4 11·7	3·5	1·0
36	4 24·0	4 24·7	4 12·0	3·6	1·1
37	4 24·3	4 25·0	4 12·2	3·7	1·1
38	4 24·5	4 25·2	4 12·5	3·8	1·1
39	4 24·8	4 25·5	4 12·7	3·9	1·1
40	4 25·0	4 25·7	4 12·9	4·0	1·2
41	4 25·3	4 26·0	4 13·2	4·1	1·2
42	4 25·5	4 26·2	4 13·4	4·2	1·2
43	4 25·8	4 26·5	4 13·6	4·3	1·3
44	4 26·0	4 26·7	4 13·9	4·4	1·3
45	4 26·3	4 27·0	4 14·1	4·5	1·3
46	4 26·5	4 27·2	4 14·4	4·6	1·3
47	4 26·8	4 27·5	4 14·6	4·7	1·4
48	4 27·0	4 27·7	4 14·8	4·8	1·4
49	4 27·3	4 28·0	4 15·1	4·9	1·4
50	4 27·5	4 28·2	4 15·3	5·0	1·5
51	4 27·8	4 28·5	4 15·6	5·1	1·5
52	4 28·0	4 28·7	4 15·8	5·2	1·5
53	4 28·3	4 29·0	4 16·0	5·3	1·5
54	4 28·5	4 29·2	4 16·3	5·4	1·6
55	4 28·8	4 29·5	4 16·5	5·5	1·6
56	4 29·0	4 29·7	4 16·7	5·6	1·6
57	4 29·3	4 30·0	4 17·0	5·7	1·7
58	4 29·5	4 30·2	4 17·2	5·8	1·7
59	4 29·8	4 30·5	4 17·5	5·9	1·7
60	4 30·0	4 30·7	4 17·7	6·0	1·8

Figure 2
Arc/Time Increments Section of Almanac

the maximum altitude portion of the resulting curve is plotted. Using the H values, 72 - 40' would be plotted as the origin of the Y axis. This procedure is necessary to determine the maximum altitude (thus LAN) as accurately as possible. (Suggested scales for the graph—1 1/4' of altitude per square and 40 seconds of time per square.)

H Values:

Time	Hs	Time	Hs
20-07	72-45'	20-19	73-08'
20-09	72-53'	20-21	73-04'
20-11	72-53'	20-23	73-02'
20-13	73-02'	20-25	72-54'
20-15	73-08'	20-27	72-50'
20-17	73-10		

Note: Times for the sightings do not have to be taken on the exact minute. Just remember to adjust them horizontally on the timescale for exact time of observation.
Step 9. To determine maximum H , plot a smooth, balanced curve.
Step 10. Apply all necessary corrections (I.C.,DIP,Semi-Diameter) to maximum H (730-10') to derive Ho.
Example:
IndexCorrection .... +0.7'
DIP .... -2.7'
Semi-Diameter (L.L.) .... +15.6'
(from Almanac)

Total Corr. +13.6'
J73 -10'

Ho 73 - 23.6(24')

Step 11. Compute latitude as following:
Lat. = Zenith distance + Dec.
Lat. = [90 -(73 -24')] + N.17 -55'
Lat. = (16 -36') + 17 -55' = 34 -31'N.
Step 12. The time of maximum H (Meridional Transit) 20 hrs., 17 mins., 20 secs., is converted to Arc again using arc/time tables (Figure 2) in almanac. This gives us our longitude as follows:
20 hrs. GMT = 120 -55'
17 mins. 20 secs. = +4 -20.0'

Longitude = 125 -15'W
Step 13. Thus our fix at 20-17 GMT is: 34 -31'N
125 -15'W

The values for H and other items have been rounded off to the nearest minute of arc. This is realistic when taking sextants sights from a small vessel that is pitching and rolling while clinging to the rigging and protecting the sextant.

Depending on the accuracy of the sextant observations, this technique should provide latitude accuracy within 2 to 5 N.M. and longitude within 4 to 10 N.M. of actual position, with a C.E.P. (Circular Error Probability) of 5 nautical miles.

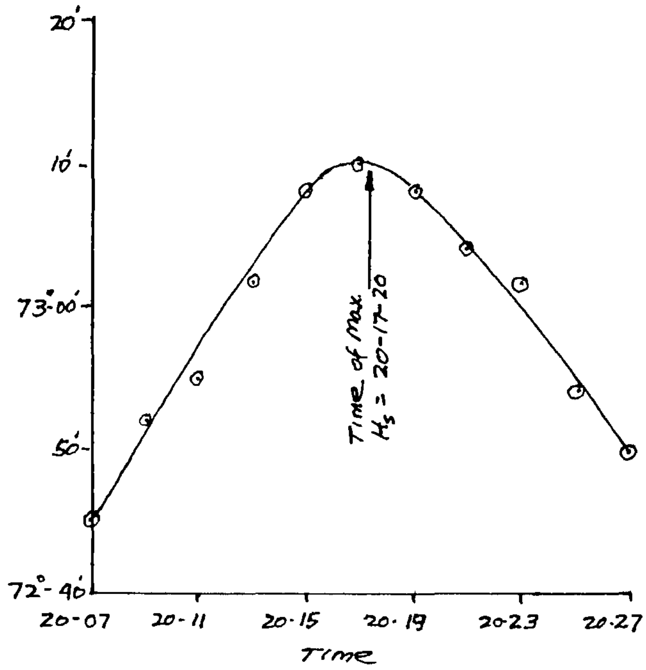


Figure 3
Plot of H_s Values

within 2 to 5 N.M. and longitude within 4 to 10 N.M. of actual position, with a C.E.P. (Circular Error Probability) of 5 nautical miles.

Editor's Note: The author (N. E. Andross) is a licensed, professional navigator with over 15,000 hours flying time. He was employed as a navigator for several airlines as well as flying large corporate aircraft and is retired from the U.S. Air Force. He is President and Senior Consultant of an avionics firm specializing in Inertial Navigation and Electronic Warfare. In addition, he teaches LORAN-C and Celestial Navigation in the California Central Coast area.

A Navigation Problem

by Roger H. Jones

28. Answer

Our problem focuses on the moon, but the stars were mentioned in stating the problem in Issue 26. Briefly, the principles of the solar time method apply equally well to the stars. (See Answer No. 27 in the preceding issue.) Use stars with a meridian height of less than 45 degrees. They will move along the horizon at 15 degrees per hour. Since there are numerous stars and only one sun, the method is not so restricted. It is not limited to circumstances where a single body (the sun) has a meridian transit height of less than 45 degrees, and thus there is a wider option for the navigator in terms of his own latitude.

The moon is another case altogether. When it is full (only one day per month), it behaves just like the sun. A full moon will cross the navigator's meridian at solar midnight. If the sun crosses the meridian at 1247 by watch time, a full moon that night will cross the meridian at 0047. At other times of the night, the full moon can be used just as the sun to determine direction, but like the sun its movement along the horizon will be a nearly constant 15 degrees per hour only if its height at meridian transit is less than 45 degrees.

Note that a one day error in the phase of the moon creates a bearing error of 12 degrees since the moon moves 12 degrees per day relative to the sun. This leads to all sorts of lunar reasoning, some of it being quite complex. The lesson is simple: the method may be useful with a full moon. Your better bet will be the stars and the sun.

Problem No. 29

With this Problem No. 29, we will offer one last comment on the stars and the central role they play in emergency navigation at night. The possibilities with the stars are so numerous that we could not do justice to them all in the next ten issues of the Newsletter. We'll conclude with the obvious and the not so obvious. Latitude as determined by reference to a star in the navigator's zenith is fundamental. The declination of a zenith star is the navigator's latitude. The latitude of a destination island is the same as the declination of a star that passes directly over that island. This is the heart of the ancient star methods employed by the Pacific sailing canoe voyagers over a millennium of time. How does the navigator determine his zenith? He looks straight up along the vertical line of his mast (when it is vertical), or he lies on his back with a plumb bob. With practice, he can get within one degree of accuracy. That is often sufficient for a landfall on an East-West lying parallel of latitude.

What about latitude from the stars that appear low above the horizon? This may be less obvious. What technique would be used, and what practical considerations both limit the number of stars available and also make them more readily identifiable?

NAVIGATION PERSONALITIES

William Chauvenet

by Thomas D. Davies

William Chauvenet (1820-1870) is a name that is probably not too familiar to some of our members, yet his was a major contribution to navigation and the U. S. Navy, memorialized by a building named for him at the Naval Academy. Many of the tables and methods set forth in his writings are still the basis of modern applications of astronomy to navigation and surveying. At the time of his death he was Vice President of the National Academy and President of the American Association for the Advancement of Science. He was also a member of the American Philosophical Society and the American Academy of Arts and Sciences.

Chauvenet was born in Pennsylvania of french forebears and graduated from Yale in 1840. His first scientific work was in magnetic observations at Girard College in Philadelphia. However in 1841 he was appointed a Professor of Mathematics in the U. S. Navy. The Corps of Professors of Mathemetics was created as a result of the policy of the navy at that time, of educating Midshipmen aboard ship. Since mathematics was considered absolutely essential to the education of a naval officer that corps provide uniformed commissioned officers competent for this teaching. The corps continued for about a century, although the need vanished with the removal of Midshipman training to the new academy at old Fort Severn, in Annapolis. Nonetheless the last member of that corps (Capt. Johnson) taught at the Naval Academy during my tour as a Midshipman (1937). He retired shortly thereafter, and with that the corps terminated.

Certainly the corps was instrumental in bringing Mishipman education into the modern world, and played an important role in the founding and development of the Naval Academy and thereby the modern navy. Chauvenet was shortly (1842) appointed in charge of the rudimentary shore-based education at the U. S. Naval Asylum in Philadelphia, some of the buildings of which are still to be seen. He immediately commenced planning and working for the establishment of a real naval school. He recognized that the way to do this was to develop an effective course of training, i.e. to show how a naval officer should be educated, and from that develop the facility and other requirements to be presented to Congress.

It was an uphill battle against the strong traditionalism inherent in the navy, and it was not until 1851 that a four year course at the Naval Academy was adopted, even though it had been officially established in 1845. This shore course was to be completed before sea service, a complete break with the British tradition of entering new cadets at grammar school age. Chauvenet himself was professor of mathematics, astronomy, navigation and surveying. He taught these subject for a term of 16 years. With the advent of the Civil War the Naval Academy was moved to Newport and in 1859 Chauvenet left to teach at Washington University at St. Louis. He became Chancellor of the University in 1862, retiring because of bad health in 1864. He died in 1870.

His works include a treatise on trigonometry then considered to be the most complete in the english language. In the field of navigation, he published a manual of Spherical and Practical Astronomy which embraced all of the topics involved in the work of an observatory or in astronomical work on land or sea. Many of the mathematical treatments are original, such as formulae for calculation of eclipses, occultations of planets and an improved method of lunar distances. Some of his works are still used today for reference.

MARITIME INFORMATION NOTES

Compiled by Ernest Brown

Areas To Be Avoided In the Indian Ocean

The Government of the Seychelles has proposed the establishment of Areas to be Avoided around the Seychelles Bank, the Aldabra Group, and Assumption Island. These proposals have been adopted by the Maritime Safety Committee of the International Maritime Organization (IMO) and, subject to final approval by IMO, will be implemented at 0001 GMT on 5 October 1989.

The areas have been established as environmental protection measures. Vessels greater than 500 gross tons carrying oil or hazardous materials should avoid entering the Aldabra Group and Assumption Island area and vessels greater than 200 gross tons should avoid entering the Seychelles Bank area.

The Seychelles Bank Area, including the waters between the Areas to be Avoided, which will form the North and South approach routes to Port Victoria, Mahe Island, has not been surveyed to full modern standards. Uncharted dangers may exist, and vessels should therefore navigate with caution in these areas.

The recommended approach routes to Mahe Island, as depicted in chart 61036 (7th ed), which were established by the Department of Transport, Republic of Seychelles, are used regularly by local vessels and remain unaltered by the establishment of the Areas to be Avoided.

Exercise caution while transiting Old Bahama Channel

1. Effective 010001Z Sep 89, seven (7) traffic separation schemes, approved by the International Maritime Organization, will be implemented offthe east, west and north coasts of Cuba.

2. In conjunction with this implementation, the government of Cuba has unilaterally established a mandatory ship reporting system within the Old Bahama Channel to govern vessel movement within the area, while it is the U.S. position that the mandatory provisions of the ship reporting system are inconsistent with international law, vessels should exercise caution while transiting the Old Bahama Cannel.

DMA Prices for Nautical Products, Effective 1 October 1989

CHARTS	PRICE CATEGORY	PRICE
Coastal Charts - Harbor and Approach Charts	A	$12.25
Coastal Charts - Harbor and Approach Charts (Foreign Reproduction)	B	$13.00
LORAN Plotting charts - LORAN Reliability Diagrams	C	$9.75
World General Nautical Charts - World International Chart Series - OMEGA Plotting Charts - Display Plotting Charts (Border Strips)-Ice Surveillance Products - Geophysical Data Charts	D	$7.00
Great Circle Sailing and Polar Charts	E	$6.00
Pilot Charts - Radar Plotting Sheets & Maneuvering Boards - Great Circle Tracking Charts - Display Plotting Charts	F	$5.50
Reference Charts (Symbols, Abbreviations, Ensigns, Flags) - Chart Corrrection Template - Compass Roses - Whale Chart - LORAN Coverage Diagram - Plotting Diagrams - Antarctica Plotting Charts - North Polar Basin Chart - North Atlantic (Training Chart) - Plotting Chart, Southeast Coast of North America - Plotting Chart, Pacific Yacht Races - Special Bathymetric Chart of the Mediterranean	G	$2.75
Universal Plotting Sheet (pad of 50)	H	$1.00
PUBLICATIONS		
Gazetteer of Undersea Features	I	$26.00
Sailing Directions - American Practical Navigator Vols.	J	$16.25
List of Lights - Radio Navigational Aids - Notice to Mariners Summary of Corrections	K	$14.00
DoD Glossary of Mapping, Charting, and Geodetic Terms	L	$12.00
Radar Navigation Manual	M	$9.75
LORAN Rate and Correction Tables - Sight Reduction Tables - International Code of Signals - Tables of Distances Between Ports - Maneuvering Board Manual Handbook of Magnetic Compass Adjustments - World Port Index	N	$8.75
OMEGA Lattice Tables - OMEGA Propagation Correction Tables	O	$7.00
Atlas of Pilot Charts	P	$5.50
Catalog Volumes	Q	$2.75
Chart Publication Correction Record Card (per 100)	R	$1.50

BOOK REVIEW

by Roger H. Jones

In this issue of the Newsletter, we continue the practice of reviewing a very recent book. In the next issue, we will introduce a new element, the review of a video tape dealing with navigational topics. In succeeding issues, the review will be of either a book or a video tape, with the emphasis on what is new and what makes the best reading or viewing.

Basic and Intermediate Celestial Navigation

by Wm. Bruce Paulk

Hearst Marine Books, 105 Madison Avenue, New York, New York 10016 (1989), 214 pages; $16.95

Elbert S. Maloney has written the introduction to Bruce Paulk's new book, which in itself is something of a tribute. Many readers of the Newsletter may recall that Maloney is the most recent author responsible for the updating of the classic, *Dutton's Navigation and Piloting*, the 1985 edition of which was reviewed in Issue No. 10

(Fall, 1985). Maloney aptly states: "This book serves both as an excellent guide to learning the latest method, and as an interesting description of life in a small sailboat." The "latest method" to which he refers is the method of sight reduction using the concise tables devised by Admiral Thomas D. Davies (President of the Foundation), which now appear in the white pages at the back of the Almanac, and which were the subject of a review in Issue No. 7 (Winter, 1984).

A physicist by education and a sailor and teacher of celestial navigation by avocation and long experience, Bruce Paulk has, in reality, presented two books in one volume. Book One, dealing with basic celestial navigation, consists of thirteen chapters, and Book Two presents an additional five chapters dealing with theory. Whereas Book One focuses on sight reduction by the tabular method of the new concise tables, Book Two focuses on use of scientific calculators and the classic spherical trigonometry equations. The overall result is a modest volume that will please both the practical navigator, whose background may not include higher mathematics, and his counterpart who is well versed in the equations and their use. It is one of the very few books that has this dual appeal, and is one of the very best in that select group.

The spice that is tasted in Book One and Book Two is that the material is based upon an actual voyage taken by Paulk from the coast of California to Hawaii in the summer of 1986 aboard the thirty-five foot sailing vessel, Zoe. Life abroad is served up in an enticing recipe that includes the full panoply of celestial navigation and the seamanship involved in approaching a strange coast at night, checking compass deviation at sea, and performing the many other skills that complement celestial practice.

Paulk is thorough. He starts with all the tools of the trade, including the sextant and its adjustment. From the sun sight and the plotting sheet, he proceeds to the running fix, the noon sight, latitude by Polaris, the star fix, moon and planet sights, and many other key subjects. Along the way, he presents some particularly useful tricks of the trade, including the method of timing a sight so that the line of position will exactly parallel the course line. (This method was also the subject of the navigation problem presented in Issue No. 13 of the Newsletter.) His initial thirteen chapters conclude with much that is useful on finding the wind, identifying unknown stars and planets, averaging sights, and plotting errors.

In chapters fourteen through eighteen, the same building block approach is used. The theory underlying the circle of equal altitude and the intercept is succinctly presented, with clear illustrations. Then the mathematical fun begins. For the initiated, it is not tedious, and it may even be absorbing. Virtually all the classic equations are there with clear illustration of their use. Some of the procedures from days gone by are also included, such as the time sight, longitude by the prime vertical sight, and even the equations for dip and refraction. Book Two will be a prized compendium for many because of its thorough yet succinct pulling together of concepts and equations that today tend to be scattered far and wide throughout the dusty pages of thick treatises from the 19th and early 20th Centuries. This reviewer is not of a mathematical background, but he can recognize a jewel which will be appreciated by those who are of such lineage.

Paulk is worth reading. He has aimed at two targets, and has hit them both. A basic purpose of the Foundation for the Promotion of the Art of Navigation is the preservation of the celestial art in this day of electronic "silver platters" that serve up so much so easily. Paulk makes a meaningful contribution to that purpose.

FOR YOUR INFORMATION

The Government Printing Office has raised the price of *The Nautical Almanac* to $16.00

Address all correspondence to:
The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850
Telephone 301-622-6448

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The 1990 Navigator's Almanac

Please send me ____ cop(y/ies) of the Navigator's Almanac at the member's price of $5.00 (postpaid).

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ORDER FORM

Robert E. Peary At The North Pole

Please send me ____ cop(y/ies) of the Navigation Foundation's report, *Robert E. Peary at the North Pole*, at the member's price $12.00 (postpaid). Non-members, $15.00

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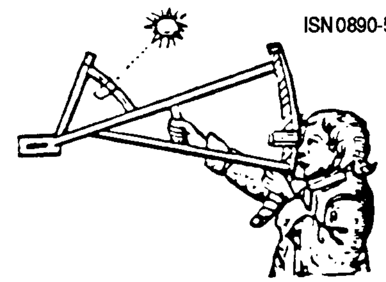
THE NAVIGATOR'S NEWSLETTER



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FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

ISSUE TWENTY-EIGHT, SPRING 1990

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

by T. D. Davies

The Peary Report Continued

Since releasing the report on 11 December 1989 we have spent most of our time answering mail. However some of this involved shipping many copies of the report out. So far comments on the report have been overwhelmingly favorable with some few questions about details. Several members of the Board of Directors have given talks on the subject, with some coming up in the future. In doing the original searching for north pole pictures we used a computerized indexing system. After we had time to draw our breath we decided to do a more thorough manual search. The results were gratifying. We have now located two Peary North Pole pictures (with negatives) which permit us to measure the altitude of the sun directly, without the use of shadows or photogrammetry (the sun is in the picture). The results agree very closely with the altitude stated in the report, thus confirming the accuracy of our application of the method.

Mr. William Hyzer of Janesville, Wisconsin, (a certificated photogrammetrist) has presented a paper to a recent meeting of the American Academy of Forensic Sciences, in which he measured the sun altitude in these two new pictures. His measured values were 6-41 for one and 6-49 for the other. The report gives 6-50 as the average of six pictures taken at the time of the two new ones. Mr. Hyzer is also doing another paper for an upcoming meeting of the American Society of Photogrammetry and Remote Sensing, in which he will make his own measurements of all of the photographs used in the report.

In the light of these developments we have decided to issue a Supplemental Report. This will be about 5 to 10 pages and will be mailed to all holders of the report and bound into new issues of it. It will address the new pictures and Mr. Hyzer's review and we expect to release it about 16 April.

Navigator's Almanac

After a long delay the Navigator's Almanac is ready and existing and future orders will be filled promptly. We must apologize for the delay.

Video Tape Review

In this issue we are offering a review by Roger Jones of a Video Tape in place of our normal book review. This is an experiment and we will be interested to hear member's comments. We expect to continue with book reviews but intersperse Video Tape reviews when there is something we believe will interest our members.

Reminder

Back issues of the *Navigator's Nersletter* can be purchased for $2.00. Write to The Navigation Foundation, Box 1126, Rockville, MD 20850.

READERS FORUM

Frederick D. Coleman of Mexico City, writes:

Several Thoughts: First, I find I am missing The Foundation's Newsletter number 23, which is somewhat akin to missing, perhaps, Job or Genesis. Since I can't seem to find the price of a single issue, I am enclosing a check for five dollars. If it is not enough please bill me for the difference. If it is too much keep the balance for the Foundation's work.

While on that subject, I notice on the Newsletter's stamp that it is a non-profit organization. Is it also a tax-exempt organization to which we could make tax deductible, charitable contributions to aid and expand our organization in its works and studies?

Second, has the Foundation given any thought to a series of navigation courses, perhaps using the programmed learning method and ranging from beginners Coastal Piloting through Celestial and offshore work. This could greatly help us rusty old, landlocked navigators and might well expand the Foundation's membership base by attracting new members, particularly if they would receive a certificate for each course completed, bearing the Foundation's certification and acceptable to organizations such as the American Sailing Association, insurers, and chartering companies. Finally, I need a current list of publications and materials with their prices offered for sale by the Foundation.

Thanks for your excellent, educational, well written work, and keep up the good work.

[Ed. Note: The Navigation Foundation is indeed a tax exempt organization (approved by IRS) which can receive tax exempt donations to help it in its work. The idea of teaching navigation has been considered but does not seem practical so we have limited our efforts to publicizing navigation course run by our members. Certificating navigators would be far to involved for our present resources.]

Walter H. Johnson of Annapolis, MD writes:

The best body for night navigation is, of course, Polaris. It can be considered as a compass with no deviation or variation greater than +/- about 1 degree. However, it cannot be seen from below the equator and would be difficult at any point below 10 degrees north. The moon as well as the stars can be used as reference bodies. A compass card can be mounted with reference to the keel of the boat with an arrow marked with the aziumuth of the moon when the time and position are known. The card then must be re-adjusted at intervals to keep the arrow directed toward the body selected. By this method it should be possible to steer within about +/-5 degrees of the desired course. In any event, the use of either the moon or a star is certainly better than no reference! I think that an altitude of 45 degrees is a bit high; altitudes below 30 degrees would be desirable. When the altitude is over 60 degrees, the error in determining the bearing becomes large. At 80 degrees the error approaches 90 degrees!

HO 2102-D can be a valuable tool for selecting the star to be used. The enclosed sample tables were prepared using a computer. The errors in the altitudes are with +/-0.1'; the errors in the azimuth are within +/--.1 degree.

Harry H. Dresser, Jr. of Bethel, Maine writes:

I am enclosing a brief piece I've written on the growing usefulness of personal computers in even the most traditional navigational settings. Along with that piece is a TurboPascal unit which I have written with the coding for trigonometric functions which are commonly used in navigation algorithms. As you and some of your readers probably know, a unit in TurboPascal which resides on a disk in the active drive can be referenced in the declaration portion of a program making all of its procedures and functions available within the program without further declaration. For example, I have named this unit NavTrig. Having it available on the active floppy or hard disk makes all of its functions available simply by typing Uses NavTrig; in the declaration portion of my program. Many programmers have become frustrated with the availability of only the sine and inverse tangent functions in most popular computer languages. A unit such as the one I've provided quickly and easily overcomes that limitation and makes programming complex equations as simple as entering them as they're written. I hope that navigation programmers within the readerhsip will find this unit useful and will feel free to use it.

[Ed. Note: Member Dresser's piece is published under Navigation Notes.]

Rupert Summerson of New South Wales, Australia writes:

I was the navigator for Icewalk, the International North Pole expedition, sponsored by Amway Japan Limited, which successfully reached the North Pole on 14 May last year. One of the facets of our expedition was the fact that it was the 80th anniversary of Peary's final attempt on the North Pole. Our point of departure was Cape Columbia and it so happened that Darryl Roberts, our team member from the USA, was black. I am a Fellow of the Royal Geographical Society and a Member of the Royal Institute of Navigation and I have a special interest in astro-navigation in the Polar Regions.

It is obviously absolutely essential for the book of our expedition to be historically accurate, particularly when it comes to the question as to whether or not Peary actually reached the North Pole. In 1986 when we started the planning for our expedition it seemed that the balance of evidence was in Peary's favour - at least history had judged him the winner. In 1988 with the publication of the centenary issue of the National Geographic magazine, Wally Herbert's article indicated the balance of evidence had shifted against Peary and this was reinforced with the publication of his book, The Noose of Laurels, in 1989. I was electrified to read an article in our daily newspaper in December which said that the National Geographic Society had commissioned the Navigation Foundation to report on Peary's claim to the North Pole. I wrote to the National Geographic Society immediately asking for a copy of your report. I have just received a reply from them in which they said that I could obtain a copy direct from you for $15.00. I am therefore enclosing a bank cheque for US$15.00.

I would very much look forward to reading this report. As a professional navigator I am very interested in the solution of the problem of whether or not Peary did in fact reach the North Pole. I have stood at the base of Peary's marker pole at Cape Columbia twice and I have walked to the North Pole, 80 years after he did - or did he? I would like to know, and would like the opportunity to examine the evidence. We must also make the correct judgment in the book of the expedition.

I would also be very interested to learn something about the Navigation Foundation and what you do.
I am looking forward very much to hearing from you.

Luis Marden of McLean, Virginia, writes:
With regard to the enquiry concerning Bligh Reef in the current Newsletter, I have put together some references. William Bligh did indeed do the first survey of that part of Prince William Sound in 1778, as described in the appended xerocopies from the Hakluyt Society's edition of Cook's Voyages. Bligh was then sailing master of the "Resolution", under Cook's command, on the third and final voyage. However, Cook did not give Bligh Island its name; this was done by George Vancouver when he did the first detailed survey of that whole coast some time later. See the xerocopy from the Hakluyt Society's four-volume account of that voyage.

There is no mention of Bligh Reef in Cook or Vancouver; this may have been named by the Canadian Hydrographic office when it made Bligh Island official in 1862. A look at the modern chart of the area will show Bligh Reef's relation to Bligh Island. A modern evaluation of Bligh's most celebrated feat of navigation—conducting the overloaded open boat from Tonga to Timor 3,618 miles in 41 days—is in the companion volume to the facsimile edition of the journal Bligh kept on that passage, published by the National Library of Australia, which owns the original. The Geographic Library has a copy.

While looking up these things I came across my copy of an address on Cook as a navigator given before the Royal Society by Professor J. C. Beaglehole, editor of the Hakluyt definitive edition of Cook's voyages. I have xerocopied that also, as much for the eloquent language as for the content. The scholarship of Dr. Beaglehole was towering, but he showed that scholarship does not have to be dull—particularly in the introductory essay to the Voyages, a magnificent and instructive piece of writing. Whatever else Bligh may have been—and he certainly was not the monster depicted in simplistic films—as a navigator and hydrographer he was a worthy successor to his illustrious mentor.

George A. Richardson, of Ann Arbor, Michigan writes:
I am a close friend of Allan E. Bayless and I have been on the National United States Power Squadrons Navigation Committee for about 20 years. I have also supported "The Foundation for the Promotion of the Art of Navigation" since its inception. I find the contents of the quarterly publications very stimulating. Allan was kind enough to mail me a copy of the Foundation's report "Robert E. Peary at the North Pole". I want to commend you and the members of your committee on a job "Well Done"!

I received the report in the noon mail and sat down to glance over it. Once started, I could not put it down until about 11:00 at night, after I had had time to read it cover to cover. You certainly conducted a painstaking and exhaustive study of all documents available on the subject. At least in my mind, you left little to be challenged on the authenticity of Peary's expedition to the pole. I found your portrayal of Peary's life and his work realistic and exciting.

As a Navigator as well as a Professional Compass Adjuster for many years, the report was also very educational. I found that I was learning much about polar navigation. Particularly, I was impressed with the manner in which Peary used "homing" and "compass bearings" to direct his track to the pole. The methods you used to validate his reports were most interesting.
Already I have had invitations from the Detroit Navigators Club, the International Shipmasters' Association and several Power Squadrons to give a program on the report. I plan to make some overhead transparencies to use in order to portray the homing (from meridian transit sights and compass bearings) because I found that to be the clinching argument in the report.

I believe you probably know from Allan that USPS has replaced the Ageton Method of sight reduction with the Nautical Almanac Method, which you were so instrumental in developing. Since I wrote much of the explanatory text on the NA Method in the forthcoming edition of our Navigation Student Manual, I am very familiar with the method. I am pleased to report that the USPS reaction to this sight reduction method has been exceedingly favorable. That's something for a new sight reduction method to receive such immediate acceptance.

Again, let me tell you how much I enjoyed all the work you have done on the Peary Report. You have every reason to be very proud of what you and your committee have accomplished.

Bruce Stark of Eugene, Oregon writes:
Although Mr. Young is the one who asked about lunar distances, this letter is to you.

I've been observing lunars for thirteen years, using advice and methods from eighteenth and nineteenth-century navigation manuals as well as methods of my own, and have devoted years of research, thought, and trigonometry to overcoming present-day stumbling blocks. The September '87 issue of the British *Journal of Navigation* published a paper discussing some of the results of this effort. Before it was accepted, though, the paper was cut down to the point that it raises more questions than it answers. I would like very much to send you the original version, if you think you might find time to look at it.

What got me thinking about lunars in the first place was the advice modern authorities give on getting GMT from the moon. I've written a number of people explaining why I think their advice is a danger to anyone who might have reason to use it. Those who have been kind enough to respond have ignored the arguments and examples and taken the view that it doesn't matter. They say no one is interested in getting GMT from the moon anyway. I've been baffled by this same attitude when I try to get a set of tables published. Sooner or later, it seems to me, some adventurous soul will want to do what Joshua Slocum did—circumnavigate with only dead reckoning and the moon for longitude. There is also a chance the electromagnetic side effects of lightning could derange electronics and watches in the middle of an ordinary voyage.

In either case—unless advice now in print is better than I think it is—a boat could be wrecked some thick night when the navigator believes he has four or five hundred miles of sea room. But the main reason I want to get the tables published is that lunars are a wonderful game of skill for anyone who enjoys using a sextant. They can be observed from a backyard, suburban sidewalk, or the top of a building. There is no need to bother with an artificial horizon. Altitudes are wanted only within a couple minutes of the truth and can be gotten from a programmed electronic calculator, or by other means, using the approximate position estimated from a map. Just about any time the moon is visible and a sextant at hand you can pop out the door and get a set of distances.

Since a person is competing against himself, the observation is as enjoyable for someone like me who wears trifocals as it is for the fellow with perfect vision and rock-steady hands. I've learned to measure much more accurately than I can see, even though the difficulty of the calculation has kept me from observing often. If the tables were available I'd probably be using the sextant three or four times a week, for pleasure.

Congratulations on the Peary Project. That was an impressive job. I'd also like to mention that the *Land Navigators* article in the last *Newsletter* touches my area of interest, and was much appreciated.

[Ed. Note: We will be glad to review the piece.]

William O. Land of Norristown, PA writes:

Quite often students in my Celestial Navigation classes (H.O. 229) have asked me why I don't put the complete course on Video tape and market it.

I have contacted several Video companies about this, but they always beg off, explaining that they do only T.V. commercials or "in house" training films for corporations. Would you or any of the members of the Navigation Foundation know of a company that could make, edit and market this navigation course?

I would appreciate any help you could give me on this.

NAVIGATION BASICS REVIEW

Checking The Accuracy Of Navigation Equipment and Procedures

By John M. Luykx

In the early spring prior to the advent of the yachting/boating season, the owner/navigator should consider the check for accuracy and proper operation of all his navigation equipment as an integral phase in the voyage planning and fitting out process. Most navigation equipment and instruments operate with a certain amount of error. The purpose of the pre-season equipment operation accuracy check is to determine instrument errors, correct the errors where possible, and determine the corrections to be applied for those errors which are residual or cannot be corrected.

The following is a suggested basic outline in conducting an accuracy check of navigation equipment, instruments and procedures:

1. The Chronometer

The chronometer should be checked/overhauled as necessary by an expert and its rate reduced to a minimum. The amount of its daily/weekly/monthly rate should then be computed and recorded by the owner/navigator. The ability of the instrument to maintain its rate over a long period of time will indicate its value in predicting error during periods when time signals are not available. (See *Navigator's Newsletter,* Issue No. 19, Winter, 1988) The rate computations should be maintained in a chronometer record book. Navigation timepieces such as watches, stop watches and clocks should also be checked and their rates recorded.

2. The Steering Compass

The steering compass should be aligned and adjusted by a qualified compass adjuster and a deviation table computed. The purpose of the compass checks conducted regularly each day during a voyage is to compare the tabulated deviation with the deviation computed by observation. If significant differences occur between the two during a voyage, the compass may require readjustment. (See *Navigator's Newsletter,* Issue 27, Winter 1990.)

3. The Hand-Bearing Compass

The hand-bearing compass may be checked ashore by measuring the compass azimuth of the sun just prior to sunset (when it is low in the sky) from a position known to be free of magnetic influence. The variation for the area is then algebraically subtracted from the compass azimuth to obtain the observed true azimuth which is then compared with the computed true azimuth. The difference is the instrument error of the hand-bearing compass. Several observations should be made and the mean value of hand-bearing compass index correction computed.

To use the hand-bearing compass effectively at sea, aboard a boat or yacht, a position on board the vessel should be found which would have minimum magnetic influence on the hand-bearing compass. This is accomplished with the vessel at anchor using a distant target some miles away. The bearing to the object by hand-bearing compass is compared with the charted magnetic bearing to the target. The hand-bearing compass is then moved from position to position on board the vessel until the difference between the charted magnetic bearing to the target and the observed hand-bearing compass reading is minimum.

4. Boat Engine Trials

Boat engine trials are conducted for both power boats and for sailboats with auxiliary engines and consist of a number of individual tests of engine operation. The tests suggested are:

1) test of engine tachometer accuracy;
2) tests of speedometer and log accuracy;
3) tests of fuel consumption for various values of shaft rpm and conditions of loading;
4) tests of boat speed versus rpm for various values of shaft rpm and conditions of loading using a measured course.

For various conditions of loading, the results of these tests will provide data to establish:

1) Boat speed through the water for various values of actual and indicated shaft rpm;
2) Maximum cruising range (and cruising time) for various values of shaft rpm;
3) Most economical cruising speed;
4) The rate of fuel consumption for various values of shaft rpm.

The check of underwater log accuracy, whether the log is the taffrail, mechanical or electronic type, is of particular importance to celestial navigation. Often the only means of determining distance made good between celestial observations for the purpose of computing a running fix is from the record of log readings. Some navigators regularly compare and keep a record of distance made good by log with distance made good by observation.

5. The Echo Sounder (Fathometer)

The purpose of the echo-sounder test is to determine if the water depth information provided by the equipment is correct. The test is conducted so that soundings by echo sounder (particularly in shallow water) are compared with soundings obtained by sounding lead, wire or other standard. The state of the tide and the distance of the transducer below the vessel's water line are factors to be considered in determining the error of the echo sounder, particularly in shallow water areas.

In deep water soundings by echo sounder can be compared with the charted depth determined from an accurate (LORAN C or GPS) fix.

Corrections to be applied to echo-sounder readings at various depths should be recorded in the navigation log and kept near the equipment.

6. The Radio-Direction Finder (RDF)

The purpose of the radio-direction finder calibration test is to determine whether error exists between relative bearings obtained by RDF and relative bearings obtained visually by pelorus.

Special radio direction finder calibration stations are used in conducting the tests. While steaming on various courses (at regular intervals from 000° to 360°) within visual range of a calibration station, relative bearings to the station obtained by RDF are compared with visual relative bearings obtained using a pelorus. An RDF bearing corrrection table, similar to a compass deviation table is then computed showing the corrections to be applied to RDF relative bearings to obtain the corrected relative bearing to a radio beacon.

7. The Radar

The purpose of the radar check is to determine whether relative/true bearings and ranges to objects at sea measured by the radar are correct.

Errors in either bearing or range measurement are determined, for a vessel at anchor, by comparing the range and bearing to well-defined objects as shown on the radar scope with the range and bearing to these objects obtained from the nautical chart. Tests are conducted covering all the radar's range scales with the vessel's at anchor position precisely determined and within radar range of a number of well-defined objects "visible" to the radar and also plotted on the chart.

A table of range and bearing corrections is kept in the vicinity of the radar scope so that observed values may be easily and rapidly corrected to obtain true values.

8. The LORAN C Receiver

LORAN C provides a fix of the vessel's position at the intersection of at least two time difference (TD) curves. The TD fix is converted, in most modern LORAN C receivers, into a LAT/LON coordinate fix of the vessel's position.

To check the accuracy of the LORAN C receiver, the vessel is positioned at an accurate location using a large scale chart with TD grid overlay. The TD and LAT/LON coordinates measured by the receiver are then compared to the charted values. The differences between the two are then tabulated with sign reversed as corrections to be applied to observed values.

Where possible these corrections should also be applied to the receiver. For example, some modern LORAN C receivers include a provision for adjusting the LAT/LON coordinates manually to incorporate corrections so that receiver readings will match charted readings.

Other computed outputs of the LORAN C receiver including 1) course and distance to next waypoint 2) cross-track error 3) time to go to next waypoint should also be compared with data based on charted values. Corrections for errors in these computations should also be recorded and applied to observed values.

9. Electronic Navigation Equipment

Basically, the outputs of electronic navigation systems such as OMEGA, SATNAV and GPS provide a fix of the vessel's position in LAT/LON coordinates.

To check the accuracy of these equipments the charted LAT/LON coordinates of an accurately positioned vessel are compared with those computed by the equipment. The difference between the two is observation error which may either be tabulated as a correction or applied to the equipment as a correction. Special procedures for determining and applying corrections are available from individual equipment manufacturers.

10. Wind Drift Trial

The purpose of the wind drift trial is to determine, by observation, the effect of the wind on a power driven vessel in the water. The force applied to the vessel's above water hull and superstructure by the wind causes the vessel to "drift" through the water in the direction of the wind flow at a rate which is dependent upon:

1) the wind velocity
2) the ratio of the vessel's above water vertical hull area compared to its underwater vertical hull area.

For any specific hull design, the rate of "drift" through the water, caused by the wind, is best determined by actual observation. For all practical purposes, the rate of vessel drift varies directly as the wind velocity; i.e., if the wind velocity is doubled, the rate of vessel "drift" through the water is also doubled.

The angular difference between the course steered by a vessel and the course made good caused by the wind is called "leeway". The correction for leeway caused by the wind (for the speed of the vessel) can be predicted from data obtained in the wind drift trial.

The wind drift trial is basically conducted as follows:

1. The vessel is brought to a dead stop in the water and the vessel's position fixed as accurately aspossible.
2. During the trial, the vesel is allowed to drift with the wind.
3. At the end of the trial (usually in 15 to 30 minutes) the vessel's position is again accurately fixed and the set and drift of vessel motion caused by the wind (corrected for the set and drift of the current) computed. Similar tests conducted at different wind velocities will provide data to predict the leeway of the vessel at various values of engine speed and conditions of loading.

Leeway may also be determined by:

1. Trailing a weighted line astern while underway and measuring the angle between the fore/aft axis of the vessel and the trailing line. This angle is equal to leeway.
2. Steering down a well-marked channel and recording the difference between the course steered and the direction of the channel axis. The angular difference is equal to leeway.

11. Sailboat Sea Trials

The purpose of conducting a sea trial of a sailboat is to determine its speed through the water, its leeway and its angle of heel for any wind condition, sail configuration and condition of loading.

The speed of a sailboat through the water is dependent not only on the surface wind direction and velocity but also on other factors, such as the course, its water line length, its underwater shape, the shape and size of the sails and the vessel's loading condition. Of these factors, the most important are the course (relative to the wind), wind velocity and sail design.

The sea trial consists of sailing the vessel on successive courses (at 10 intervals) beginning with the wind ahead, then proceeding to wind on the beam and ending with the wind astern.

For each course (on which the boat is "steadied" for at least five minutes) and sail configuration, the following data is recorded:

1. Apparent wind direction(to compute true direction)
2. Apparent wind velocity (to compute true velocity)
3. Boat speed through the water
4. Angle of heel
5. Leeway

In summary, the basic purpose of the sailboat performance trial is to provide data concerning the following:

1. The comparative performance of various sails and sail configurations at the different points of sailing from the true wind.
2. The speed through the water of the boat, the angle of heel and the "leeway" at the various points of sailing for given values of true wind velocity.
3. The maximum speed that can be made to windward for given values of true wind velocity and points of sailing.
4. The course relative to the true wind which gives the maximum boat speed through the water for a given sail configuration.
5. The nearest course to the true wind at which the boat can maintain steerageway for a given sail configuration.

A polar diagram computed from the data acquired during the sea trials should be drawn up and made readily available for use by the owner/navigator. The polar diagram is, in effect, a graphic representation of a boat's capabilities under various conditions and various points of sailing.

12. Meteorological Sensors

Tests of instruments such as barometers, thermometers, anemometers, hygrometers, etc are best conducted ashore at repair facilities specializing at such work. Basically, the instruments are checkedfor overall operation, then adjusted to match standard instruments. Corrections for residual errors are computed and tabulated in a correction certificate issued with the overhaul record.

The above discussion, although very basic and general in scope, will hopefully provide the yacht/boat owner or navigator with a guide to some of the procedures which may be used during the voyage planning or fitting out phase in checking navigation equipment and instruments for proper operation and accuracy. Although some equipments and instruments (sextants, stadimeters, range finders, etc.) have been omitted from the discussion due to space limitations, and some of the test trial procedures presented with too little detail or explanation (i.e. turning and acceleration, deceleration trials), the author will feel satisfied if this short discussion encourages readers of the newsletter to more thoroughly plan the navigation aspects of preparing a small vessel for sea after a long winter layoff.

HISTORY OF NAVIGATION

The Artificial Horizon Sextant (conclusion)

By John M. Luykx

(Note: This brief article concludes the series of three articles on the artificial horizon sextant.)

The end of World War II brought about a nearly complete termination of the manufacture of military hardware. Research and development continued, however, and the period 1945-1960 saw the introduction of new developments and improved concepts in the design of artificial horizon sextants for both air and marine use. With the exception of the well-known C. Plath marine sextant bubble attachment which first appeared in the mid-1950s, most of these developments occured in Britain and the United States.

Following the end of World War II, in 1946, The Marine Super Integrating Bubble Sextant was introduced by Henry Hughes of London. It was a hand-held instrument based on the wartime R.A.E. MK IXA and B series of aircraft sextants but included in lieu of the 1 to 2 minute chronometric averager a 1 minute ball and disc integrator averager. (Figure 1) It employed the double mirror reflecting optical system with the bubble reflected into the line of sight. Although advertised as a marine sextant, the instrument could also be used in aircraft navigation. It is believed that very few of these were manufactured. The author knows of the existence of two: one in his own personal collection and the other in a private collection in Sydney, Australia.

In 1955 the firm of C. Plath of Hamburg introduced a spherical bubble attachment which was designed for use with their famous line of marine sextants reintroduced a few years earlier. The attachment consists of a bubble assembly based on the World War II SOLD bubble assembly (See the Navigator's Newsletter, Issue 27, Winter 1990) which, when in use, is installed on the sextant in lieu of the sextant telescope. (Figure 2) The Plath bubble attachment requires an external 3-volt electrical supply which is provided by two AA batteries in the sextant handle. This bubble attachment which does not incorporate an averager has been modified once since it was first introduced in the 1950s. (Figure 3) Bubble attachments of basically the same design are currently available from both C.Plath of Hamburg and, since 1970, from Cassens and Plath of Bremerhaven.

In 1965, Weems System of Navigation of Annapolis, Maryland designed a gas/air driven gyro artificial horizon (based on and similar to the Fleuriais design of 1886). (See the Navigator's Newsletter, Issue 26, Fall 1989) It was mounted on a newly designed marine sextant for use by the U.S. Navy. (Figure 4) The sextant was to be a replacement for the Mark II sextant which had been the standard Navy sextant since early in World War II. The new sextant, although of unique design, did not include an averager but incorporated improved optical features such as larger mirrors and a 6x30 Bausch and Lomb monocular. It, however, was not accepted by the Navy although a similar design, the Mark III, without gyro artificial horizon was eventually accepted some years later.

A few years after World War II, Kollsman Instrument Corporation developed an artificial horizon periscope sextant for use with high speed aircraft. (Figure 5) The sextant incorporated a unique oil dampened pendulous mirror in lieu of a bubble system as the artificial horizon element. It also incorporated a 1-minute ball and disc type integrator averager. Higher aircraft speeds and cruising altitudes, the pressurization of the cabin and the drag caused by the World War II observation or astrodome necessitated the design of a periscopic type of sextant for use by both commercial and military aircraft of more modern design. The mounting arrangement through the overhead or ceiling of the navigator's compartment permitted the tilting of the sextant 15 in any direction through a simple gimbal arrangement. A later modification of the Kollsman periscope sextant incorporated a bubble artificial horizon as a replacement for the pendulous mirror system. Some 10 years later, in 1957, Kollsman introduced hand-held designs of their periscopic sextants which also incorporated both the pendulous mirror (MA-1) and bubble artificial horizons (MA-2) as well as the 1-minute ball and disc integrator averager. (Figure 6) All Kollsman instruments were characterized by fine workmanship and optical design.

At about the same time as the introduction of the Kollsman Periscope sextant, Kelvin Hughes of England (successors to Henry Hughes and Son) introduced the Mark 2 series periscope sextant. (Figure 7) It was based on the design of the R.A.E. Mark IX A and B hand-held sextants of World War II fame. (See the *Navigator's Newsletter*, Issue 27, Winter 1990) and incorporated a 1 or 2 minute chronometric averager and a spherical bubble artificial horizon system. The mounting, as with the Kollsman sextant, provided a gimbal arrangement which permitted tilting the sextant when taking observations. In the early 1950s Smith's Industries, a successor to Kelvin Hughes, offered their KSH02 series of periscopic sextants. The artificial horizon element was of the bubble type and the 2- minute averager incorporated a ball and disc type averager. (Figure 8)

Although the first practical periscopic sextant design, the Opitz-Plath instrument (Figure 9) dates from the pre-

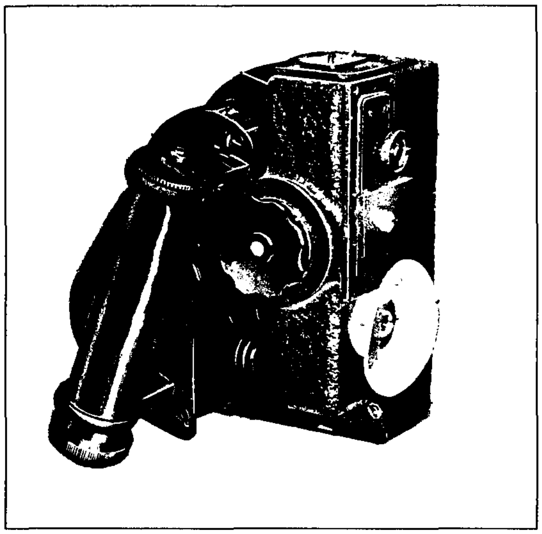

Figure 1
Hughes Marine Super Integrating Bubble Sextant (1946)

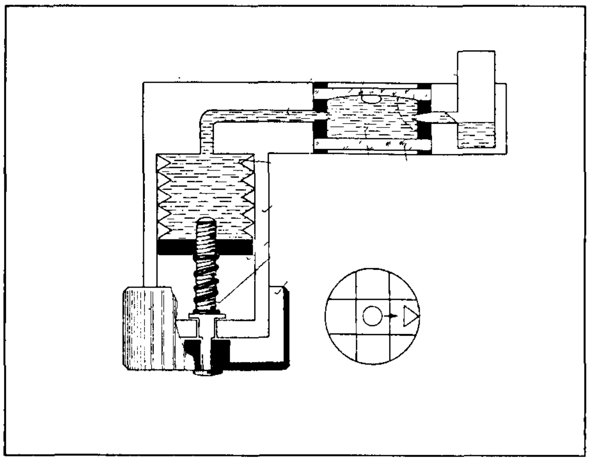

Figure 2
Plath Bubble Assembly Schematic (1955)

war period in 1930 (it employed the "System Gago Coutinho" artificial horizon system without a averager), it was not until at least 20 years later that periscope sextants, incorporating averagers, were adopted for general use. Today, because of highly developed accurate global electronic all-weather navigation systems, celestial navigation is now little used for the navigation of aircraft and the periscope sextant has been relegated to a secondary or back-up role in aircraft navigation.

At the present time artificial horizon (bubble) attachments for marine use are manufactured by the following firms:

a. C. Plath of Hamburg, Germany
b. Cassens and Plath of Bremerhaven, Germany
c. InfoCenter of Forestville, Maryland

The bubble artificial horizon attachments manufactured by C. Plath and Cassens and Plath are similar in design and are intended for use only with marine sextants of their own manufacture. They both incorporate a spherical bubble assembly in conjunction with a double

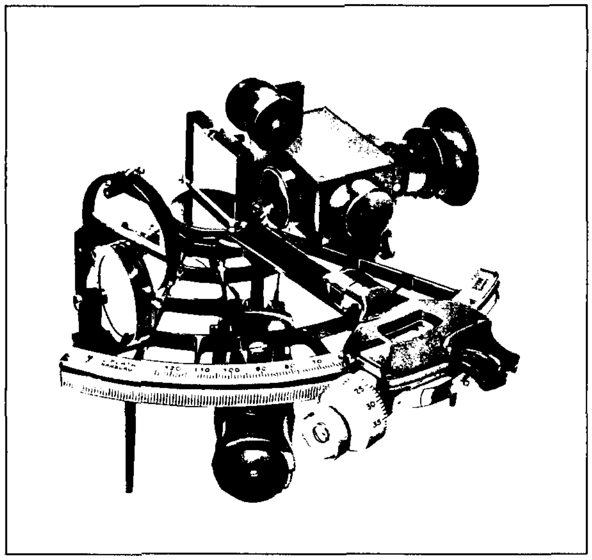

Figure 3
Plath Bubble Attachment (Early Design) (1955)

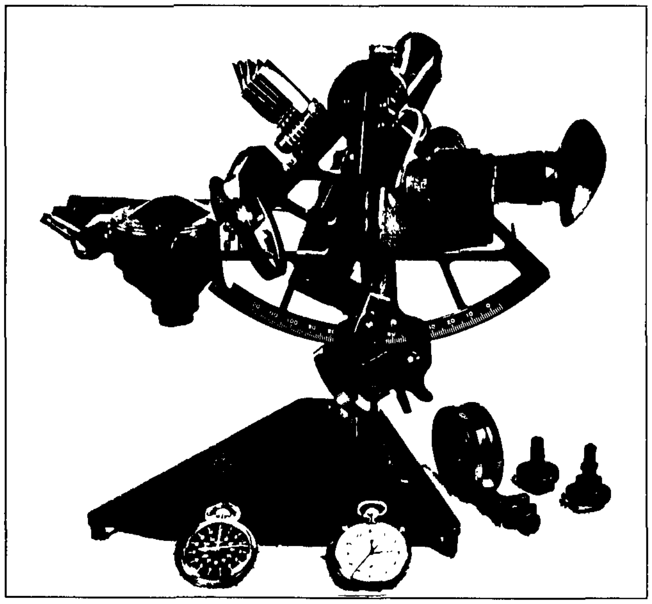

Figure 4
WSN Gas Driven Gyro Artificial Horizon Sextant (1965)

reflecting mirror optical system with the bubble reflected into the optical path. In addition a ligting system is provided to illuminate the bubble for both daylight and nightime observations. The power for the lighting system is provided by 2 AA batteries in the sextant handle. An early (1955) C. Plath bubble artificial horizon system is shown in Figures 2 and 3.

Bubble attachments available from InfoCenter, Inc. include both spherical and longitudinal bubble type assemblies. Both types are designed for use with any modern sextant including the Plath, Tamaya, Freiberger and ASTRA III sextants and the Davis and Ebbco plastic sextants. (Figure 10) Some of these bubble attachments have also been modified for use with the Hughes Mate sextant, the Hughes (1/2 size) flying boat sextant, the

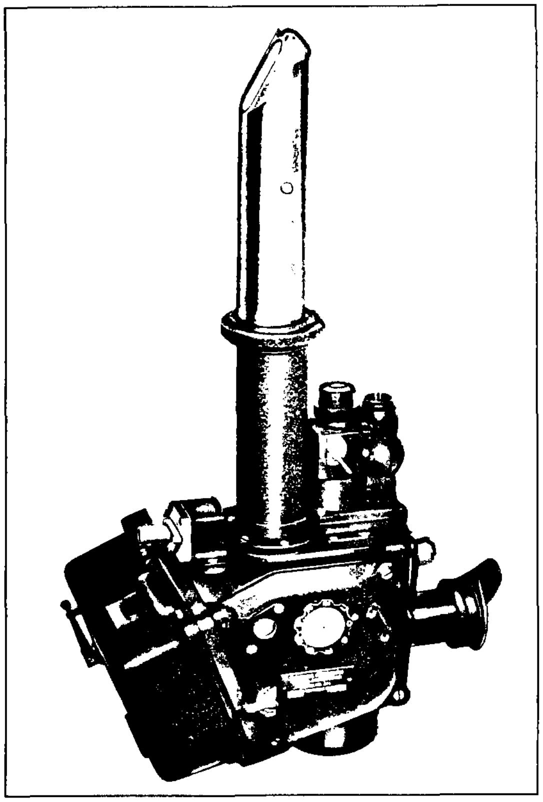

Figure 5
Kollsman Pendulous Mirror Periscopic Sextant (1948)

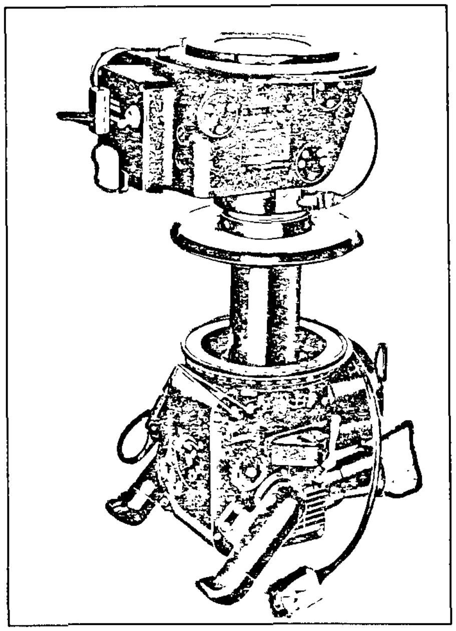

Figure 7
KH Mark 2 Periscopic Aircraft Sextant (1948)

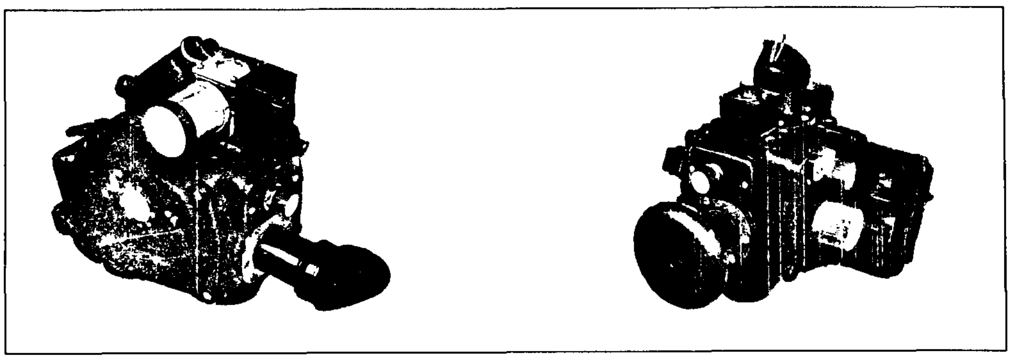

Figure 6
Kollsman Hand-Held Aircraft Sextants (1957)

Heath MC1 sextant and the Bendix USN Mark II sextant. The InfoCenter bubble attachments are available with individual lighting systems for night use.

Sextants designed particularly for celestial navigation in aircraft are no longer manufactured although World War II surplus instruments are still to be found, available primarily from collectors and second-hand instrument dealers.

Often when the visible horizon has become obscured by haze or fog or a period of darkness, it has been found useful to employ either an artificial horizon sextant or an artificial horizon (bubble) attachment with the marine sextant when making celestial observations at sea.

The problem, however, of accurately observing a celestial body at sea with an artificial horizon sextant is basically that the motion of the boat causes acceleration forces to be applied to the bubble causing it to oscillate in the field of view. Practice in making observations at sea will develop skill in reducing observational errors. The following factors should be considered when making observations at sea:

1. Acceleration forces are minimum during the midpoint of a roll.

2. The sextant should be held so that when oscillating in the field of view, the amplitude of oscillation of the bubble above the center of the field should equal the amplitude below the center of the field; i.e., the sextant should be held so that the bubble oscillates about the center of the field of view.

3. Individual observations rather than averaged obser-

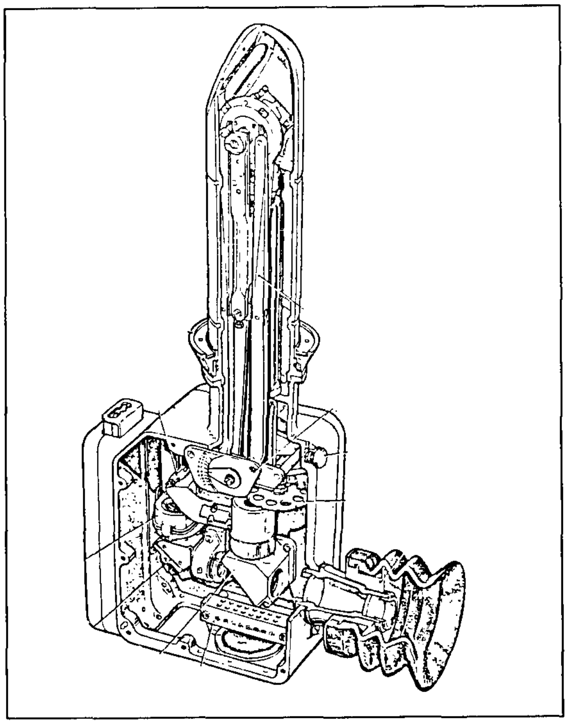

Figure 8
Smiths KSH 02 Series Periscopic Aircraft Sextant (1951)

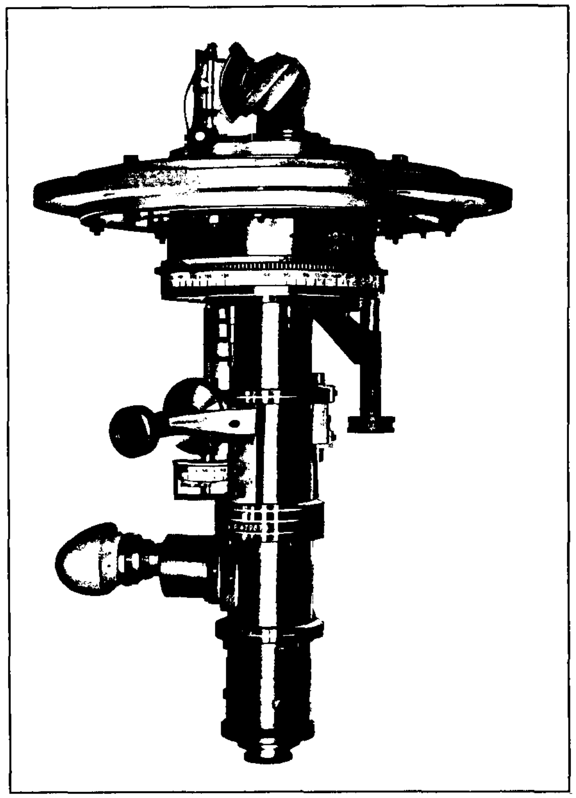

Figure 9
Opitz-Plath Periscopic Aircraft Sextant (1930)

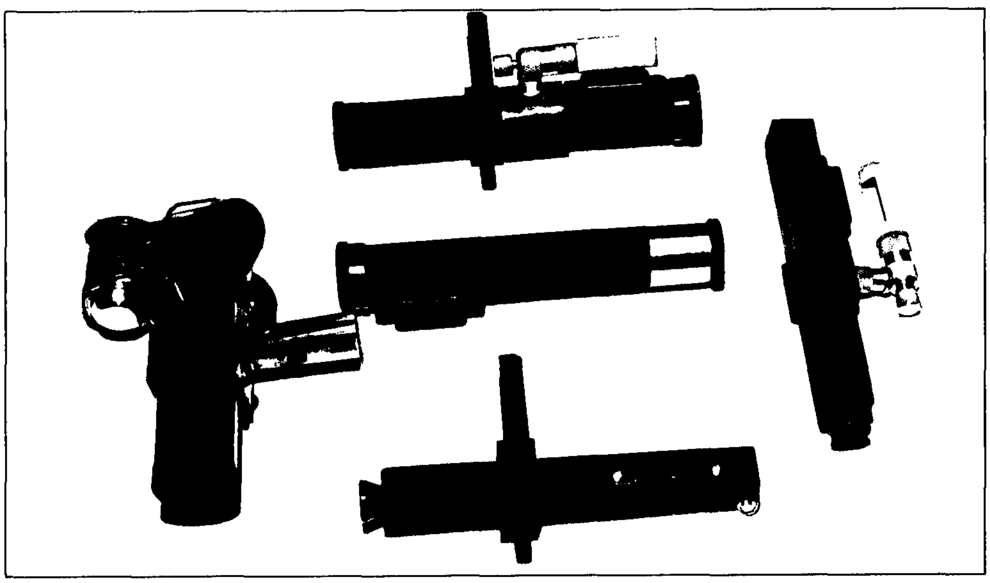

Figure 10
Infocenter, Inc. Bubble Attachments (1990)

vations should be recorded. For example, if a sextant with averager is used at sea, the tendency will be to include both good and bad observations during the 1 or 2-minute period of observation. However, if only individual observations are recorded, the tendency will be to record only observations considered good by the observer.

4. A long series of observations (10 to 15) should be taken and the mean time and altitude for the series computed for sight reduction. Compared to the probable error of individual observations the probable error of the mean of a long series is reduced by a factor of 2 to 3.

5. Whenever the opportunity exists, altitude observations by bubble sextant or bubble attachment should be compared with correct values. Using this procedure the

observer will gain experience in judging the value and estimating the accuracy of observations.

6. The observer may wish to consider the use of a "stiffer" bubble assembly; i.e., one where the bubble is formed by the upper lens of the assembly which is ground to a reduced radius of curvature. The C. Plath SOLD sextant used by the German Navy during World War II was provided with a so-called "stiffer" bubble for marine navigation.

7. As in everything else, extensive practice is required to gain skill in the use of an artificial horizon sextant or attachment for marine navigation. The development of observational skill in using the artificial horizon sextant is analagous to the development of skill in shooting a pistol accurately. For example, some neophyte shooters can't hit the "broad side of a barn" with the pistol while other who are skilled can keep 10 shots within a 5" circle at 50 yards.

Credits for Illustrations: Fig. 1, author; Fig. 2-3, Plath, Hamburg; Fig. 4, Weems System of Navigation, Annapolis; Fig. 5, Plath, Hamburg; Fig. 6-8, author; Fig. 9, Plath, Hamburg; Fig.

NAVIGATION NOTES

Navigation Programming

By Harry H. Dresser, Jr.

Many strategic yacht racing, pilotage, and navigation problems are easily expressed in mathematical terms. Handheld calculators have made the algorithms for solving those problems ever more accessible to mariners. Using published keystroke sequences or recorded programs, nearly anyone can resolve countless mathematical problems which once required lots of time in various tables. Today, computers are moving aboard boats and taking with them software which makes solution of these many problems easier still. For the computer using mariner the development of this user-friendly software is a blessing. For the programmer of navigational software there are a couple of foibles of today's popular computer languages which make programming trigonometric algorithms complex. Happily, the modularity of the recent versions of some languages is making the programming of trigonometric problems much more manageable.

To begin with, navigators are accustomed to working in degrees, minutes and tenths of minutes. This is a curious combination of decimal and sexigesimal bases which most people find confusing and which computer languages are certainly not ready to accept without interpretation. The peculiarity of the notation lies in the decimal minutes, which apparently arose from the convenience of interpolation of fractional parts of a minute in tenths rather than seconds on the micrometer drum of the sextant.

Converting degrees, minutes, second format entries to decimal degrees allows one to use ordinary arithmetic on the decimal degrees. However, this is not the end of format difficulty. A math programmer quickly discovers th t some common computer languages provide the sine, cosine and tangent functions all right, but that these built-in functions expect input parameters in radians. The conversion from decimal degrees to radians isn't particularly difficult, but it requires that parameters sent to a function be converted to radians and that the values coming out of the function be reconverted to an appropriate format. Generally, arctangent is provided as the only built-in function for converting functions back to angular measure. We all remember our trig analogies and recognize that we can convert other functions to the tangent function for converson, but this makes the programming process just that much more cumbersome. The Pascal language has always made the creation of modular programs easy and desirable, but Turbo Pascal 4.0 by Borland, makes reusable functions and procedures particularly easy to create and powerful to use. In Turbo Pascal 4.0, the programmer can produce units which define commonly used functions and procedures, compile those units to disk and make those functions and procedures available in an independent program by simply including a uses statement in the program heading. This is not the familiar includes compiler directive, but a much more invisible link between the using program and the compiled unit.

For example, I have written the unit shown below which defines many functions and procedures useful to a navigation programmer. I've named that unit NavTrig. Whenever I write a navigation program, I simply write "Uses NavTrig;" in the declaration section of my new program. That makes all the functions and procedures of the NavTrig unit accessible to my program without further declaration. The incorporation of this unit greatly diminishes the effort required to write navigational programs.

Following is the source code for the NavTrig unit; it has been documented internally to make it useful to you:

```
Unit NavTrig;
Interface
Const Max = 12;
Type PlaceArray = array[1..Max]of real; {Do not
redeclare this type in main program} {It can be
used in main program on this declaration.}
Function Sine(number:real):real;
Function Cosine(number:real):real;Function
Tangent(number:real):real;
Function ArcSine(number:real):real;
Function ArcCosine(number:real):real;
Function ArcTangent(number:real):real;
Function ConvertToDecDegrees(DMS:real):real;
Function ConvToDMS(DD:real):real;
```

```
Function FindLat2(Lat1,distance,course:real):
real;
Function FindLo1(Lat1,Lo1,distance,course:real):
real;
Function Distance(Lat1,Lo1,Lat2,Lo2:real):real;
Function ConvpToDLo(p,Lat:real):real;
Function ConvDLoTop(DLo,Lat:real):real;
Function FindCourse(p,l:real):real;
Procedure
Findpl(BoatLat,BoatLo,WeathrLat,WeathrLo:
PlaceArray;VARparray, larray:PlaceArray);

Implementation
(All trig functions require actual parameters in
decimal degree format.)

Function Sine (number:real):real;
  Begin
     number:=number*(pi/180);
     sine:=sin (number)
  End
Function Cosine (number:real):real;
  Begin
     number:=number*(pi/180);
     cosine:-cos(number)
  End;
FunctionTangent (number:real):real;
  Begin
     number:=*(pi/180);
     tangent:=sin(number)cos(number)
  End;
Function ArcSine (number:real):real;
  {Output in decimal degrees}
  VAR sine2,p:real;
  Begin
     sine2:=sqr(number);
     p:=sqrt(1-sine2);
     ArcSine:=ArcTangent(number/p)
  End;
Function ArcCosine (number:real):real;
  {Output in decimal degrees}
  VAR cosine2,l:real;
  Begin
     cosine2:=sqr(number);
     l:=sqrt(1-cosine2);
  ArcCosine:=ArcTangent(l/number)
  End;
Function Arctangent (number:real):real;
  {Output in decimal degrees}
  Begin
     Arctangent:=(arctan(number)*(180/pi))
  End;
Function ConvertToDecDegrees(DMS:real):real;
  {Input in degrees.minutes format; output in
  decimal degrees.}
  Var whole,Fraction:real;
  Begin
     Fraction:= (frac(DMS)*100/60;
     whole:=int(DMS);
     ConvertToDecDegrees:-whole + Fraction
  End;
Function ConvToDMS(DD:real):real;
  {Input in decimal degrees format; output in
  degrees.minutes format}
  VAR Whole,Fraction:real;
  Begin
     Fraction:=(frac(DD)*60)/100;
     Whole:=int(DD);
     ConvToDMS:=Whole + Fraction
  End;
Function
FindLat2(Lat1,distance,course:real):real;
  {Lat1 must be provided in decimal degree for
  mat.}
  {Output (FindLat2) is expressed in decimal de
  gree format}
  VAR Lint,Lfrac,l,Lat2:real;
  Begin
     l:=distance*cosine(course);{change in lati
     tude}
     Lint:=int(l/60);{finds whole degrees of
     change}
     Lfrac:=(l-(lint*60))/100; {}
     l:=ConvertToDecDegrees(Lint + Lfrac);
     FindLat2:=Lat1 + l;
  End;
Function FindLo2(lat1,Lo1,distance,course:real):
real;
  {Lat1 and Lo1 must be provided in decimal de-
gree  format.}
  {Output (FindLo2) is expressed indecimal de-
gree  format.} VARp,LLo.Dint,Dfrac:real;
  Begin
     p:=(distance*sine(course));
     DLo:=-1*([/cosine(lat1));
     Dint:=int(DLo/60);
     Dfrac:=(D:o-(Dint*60))/100;
     DLo:=ConvertToDecDegrees(Dint + Dfrac);
     FindLo2:=Lo1 + DLo;
  End;
Function Distance(Lat1,Lat2,Lo2:real):real;
  {latitudes and longitudes are provided in
  decimal degrees}
  VAR p,DLo,L,Lint,Dint,Dist:real;
     dummy:char;
  Begin
     L:= abs(Lat1 - Lat2);
     Lint:= int(L);
     L:= Lint*60 + (L-Lint);
     DLo:= abs(Lo1 - Lo2);
     Dint:= int(DLo);
     DLo:= Dint*60 + (DLo-Dint);
     if(lint <1)and(Dint<1)then
       Distance:= 60*(sqrt(sqr(L)+sqr(ConvDLoTop
            (DLo,Lat1))))
     else
       Distance:= sqrt(sqr(L)+sqr(ConvDLoTop
            (DLo,Lat1)));
  End;
Procedure Findpl(BoatLat,BoatLo,WeathrLat,
  WeathrLo,PlaceArray;VARparray,larray: PlaceAr
  ray);
  {Latitudes and longitudes must be provided in
  decimal degree format.}
```

```
  {p is departure; l is difference in latitude.}
  VAR L,Lint,DLo,Dint,p:real;
     counter:integer;
  Begin
     For counter:= 1 to Max do
     Begin
       L:= abs(BoatLat[counter]-
        WeatjrLat[counter];
       Lint:- int(L);
       larray[counter]:=Lint*60 + (L-Lint);
       DLo:= abs(BoatLo[counter]-
        WeathrLo[counter];
       Dint:= int(DLo);
       parray[counter]:= Dint*60 + (DLo - Dint)
     End
  End;
Function FindCourse(p,l:real):real;
  {p is departure; l is difference in latitude.}
  Begin
     FindCourse:= arctangent(p/l)
  End;
Function ConvpToDLo(p,Lat:real):real;
  {Input latitude in decimal degrees; output in
  decimal degrees}
  {DLo is difference in longitude.}
  Begin
     ConvpToDLo:= -1*(p/cosine(Lat))
  End;
Function ConvDLoTop(DLo,Lat:real):real;
  {Input in decimal degree format.}
  Begin
     ConvDLoTop:= -1*(DLo*cosine(Lat))
  End;
End.
```

Once you have written this unit to a source code file and compiled it to disk as a *.TPU file, all its procedures and functions are then accessible to any programs that you wish to write as long as you declare the unit in the declaration portion of your program. For example, a program to find great circle distance between two points would be reduced to a nearly trivial task with this unit available. Assuming the earlier entry and conversion to decimal degrees of the latitude and longitude of the start and destination, the computation can be reduced to a single line of code. Great Circle Distance: = 60* Arc Cosine(sine(lat1)* sine(Lat2) + cosine(La_t1)* cosine (lat2)* cosine(DLo);

The NavTrig unit should save navigation programmers who write in Pascal many lines of code. There is plenty of opportunity to write new, useful programs for the maritime trade and yachting worlds. Computer use aboard vessels is not yet sufficiently widespread to have spawned lots of robust programs. Just a few weeks ago, I helped the skipper of a composite unit set up a spread sheet to help with loading and trim computations for his barge. Despite the availability of computers aboard his vessel, no one had consigned this computation intensive problem to the computer's workload. I hope that as programs for maritime applications are developed some of them will find their ways into the public domain through the pages of publications like *Navigator's Newsletter*. This NavTrig unit is provided in that spirit.

A Navigation Problem

by Roger H. Jones

29. Answer

A bright star that crosses the navigator's meridian at a low altitude (generally 15 degrees or less) offers a fairly accurate means of determining latitude without a sextant, assuming the star's declination is known. The method is limited to about six or seven dependable stars by two considerations. First, the star must be a bright one, because normally only bright ones can be seen low above the horizon. Second, if the typical sailing latitudes are between 60 North and 60 South, these stars must have fairly high declinations if they are to be seen crossing the meridian at low altitudes. Stars that have these attributes include: Capella, Vega, Canopus, Achernar, Hadar, Rigil Kentarus, and Acrux.

The method is that of latitude by meridian passage of the celestial body, and the altitude is either estimated by eye, or determined more accurately through use of a simple kamal. Of course, the navigator will have to take into consideration the season and whether the star will be visible during morning or evening twilight. It should also be remembered that since these stars will appear very low, their height will change very little near the meridian passage. As a practical matter, the navigator may not need to observe the star at actual meridian passage. For example, such a star may still be 5 arc degrees short of the meridian at the end of twilight when it is too dark to discern the horizon, but since its arc is fairly flat, its height may be within 30 minutes of the maximum at meridian passage.

The method would require that the star's declination be contrary to the latitude of the navigator, assuming it is a "westbound" star during twilight, and the meridian passage will mark the upper transit of the star. However, the method can also be used with circumpolar stars moving eastward across the meridian at the bottom of their circular path around the pole. In this case, the navigator observes the lower transit. A navigator in a south latitude would observe the star to the south at its lowest (not highest) altitude, and declination and latitude must be of the same name. In either case, conventional rules and logic apply. In the case of the westbound, contrary name star, latitude equals the star's polar distance minus the star's maximum height. For the eastbound star, latitude equals star's polar distance plus the star's minimum height. Normal dip and refraction corrections must also be applied.

Problem No. 30

Foundation members who read the last issue of the *Newsletter* will know that the final report on the Peary matter was released at a press conference at the Washington, D.C. headquarters of the National Geographic society (December 11, 1989), and that the conclusion is that Peary did, in fact, reach the North Pole in early April, 1909. One of the major aspects of the research was on Peary's method of navigation, a method which his critics have long failed to understand or have dismissed as inadequate. Since many readers will not yet have seen the report, entitled *Robert E. Peary At The North Pole*, we present in this issue a problem illustrating Peary's method of navigation.

You are an Arctic (or Antarctic) explorer, traveling by surface means on a trek whose final destination is the North Pole. Satellite and modern electronic methods of position finding are not available. Your equipment includes: sextant, compass, chronometer or watch, artificial horizon, and *Almanac* , but does not include any sight reduction tables or means of verifying exact time. You are conscious of a number of special circumstances that are present in the high Arctic latitudes. You will be contending with ice drift and the need to go around many open water leads and pressure ridges; your course will include many local detours. You will not have a natural sea horizon. The nearer you get to the Pole, the closer the meridians will be in their convergence, and longitude sights will be impractical for that reason as well as for the reason that you have no means of verifying time. The time of year is March, and your trip is expected to extend into April.

Apart from the enormous logistical problems of food, equipment, clothing and means of travel, what simple means of navigation will you use on both the march to the Pole and the return trip to your land-based starting point?

NAVIGATION PERSONALITIES

Ed. note: From time to time there have been queries about the history of the Rude Star Finder. We were fortunate enough to come across this article on its development in an old Naval Institute Proceedings, by Captain Rude himself. We consider Captain Rude a significant "Navigation Personality", so we run this article in which he gives a great deal of personal information as well as the details of the development of his invention, in his own words.

The Original Star Finder

By Captain Gilbert T. Rude, USN (Ret.)
United States Coast & Geodetic Survey

Early in World War I, the writer had the pleasure of serving on the staff of Admiral Marbury Johnston, Commander of Squadron 2, Cruiser Force, Atlantic Fleet. Later in that war he served as navigator in the Naval Overseas Transportation Service. While navigator in the Naval Transport *Aeolus*, under the command of Captain H. G. S. Wallace, U.S.N., he was fortunate in getting the idea which eventually resulted, upon assignment to shore duty after the war, in the conception and in the development of the original Star Finder and Identifier.

In general, problems which lend themselves to solution by means of tabular values can also be solved by the use of some kind of graphic device, within certain limits of accuracy. Such a solution has the added advantage over tabular values in requiring less time and in addition, the results may be grasped more readily; the graphic diagram tending to transform an abstract problem into concrete form.

It is not now necessary to go into the details of the use, the manipulation, and the need of a star finder. After the lapse of 30 years since its first appearance, all navigators, both marine and air, have become familiar with its use, and I feel confident they would not want to return to the old methods of star identification.

Letters Patent on the device were issued to the writer in 1921, covering its patentable ideas. Briefly the patent covered the following: A star base with navigational stars plotted thereon, and cooperative templates (transparent), constructed for various definite degrees of latitude. The two, used in conjunction, furnished the means for the identification of any navigational star above the horizon, when the obsever was within the latitude sphere of any particular template.

No attempt could be made, of course, to patent the *projection*, since practically all such projections date from early times. A well-known projection (stereographic) was simply adapted by the inventor of the star finder to an entirely new use—star identification.

The stereographic projection dates back to ancient Greece, having been used by Hipparchus (160-125 B.C.). The azimuthal equidistant projection, used by the Hydrographic Office in modifying the original Star Finder to H. O. 2102C, was first employed by Postel in 1581 A.D. It is obvious, therefore, that the type of projection does not enter in the patentability of the device, both projections being suitable for adaptation to star identification.

The original device, The Mariner's Practical Star Finder, was patented in 1921 and soon afterwards put on the market by myself through force of circumstances. I would much rather have had some manufacturer take it from that point. Since the device was based on astronomical principles, it had no appeal, unfortunately, to instrument makers. Yet in spite of that reception. I still believed, as do all inventors, that it would be of benefit to navigators, even though the number of navigators is limited.

I then decided to put the device on the market myself and to take the chance of losing some money. I made the original drawings, had plates and prints made. A bookbinder mounted the Star Bases for me on cardboard. I assembled the devices in the evenings at home. The young are not easily discouraged!

Later, with agents in the principal seaports and without advertising directly, the device soon had a good sale. The Navy finally ordered several times in lots of 25 for issue to Battleships, later several orders in lots of 125 for issue to smaller ships, and finally wanted them in lots of 250. Since these quantities were getting beyond my individual capacity (and in addition I was due for sea duty), I suggested to the Navy that the device be purchased outright, including patent rights and plates. The Navy Department accepted the offer and for several years afterwards issued this original as the "Rude Star Finder and Identifier."

Later the Hydrographic Office made several modifications, none of which were basic nor in any way at variance with the patentable ideas of the original item. I am advised that the Hydrographic Office now issues the device as H.O.2102C, with a note to the effect that it is based on the principles of the Rude Star Finder and Identifier, with modifications by the Hydrographic Office. As the inventor of the original device I accept that procedure as perfectly proper and ethical in view of the modifications by the Hydrographic Office.

These modifications certainly do add in some measure to the ease of manipulation of the device, especially for use in airplanes. But in fairness to the original device and for the sake of the record, it might be well to enumerate the principal modifications:

1. The device is now made circular instead of square.
2. The star base is printed on white plastic instead of on chart paper, mounted on cardboard.
3. The templates are printed on clear plastic instead of on celluloid. (This is quite an improvement, but it so happens that plastics were not available in 1921 when the original was under development.)
4. The device is now housed in a circular, leatherette case instead of ina square cardboard case. (This is an improvement, but economically beyond the means of the inventor of the original device.)
5. The azimuthal equidistant projection is now used instead of the stereographic.
6. The device is much smaller than the original star finder, the diameter of the star base being 8 1/2" against 14" of the original.
7. The transparent templates are now constructed for a coverage of ten degrees of latitude instead of six in the original.
8. Because of its smaller size the scale naturally had to be decreased below that of the original.

In connection with modifications Nos. 7 and 8, the decreased scale, and also the greater coverage in latitude of the templates, certainly are sufficiently accurate for the purpose of star identification, which of course is the principal function of the device. But for star "spotting," another function, the question arises whether the values of altitude and of azimuth as scanned by inspection from this smaller scale and the greater template coverage are sufficiently accurate as to bring the star within the field of the telescope of the sextant in so-called star "spotting." Frankly, I do not know, never having made tests of the present device. I have done so, however, with the original device as described in the *Naval Institute Proceedings* of January, 1922, in an article entitled "The stereographic Projection for Star Identification." The following is quoted from that paper:

"The first columns are the graphic values from the projection and the second columns are the computed values, a comparison of which will furnish an idea of the degree of accuracy obtainable. The graphic values were taken by inspection from the writer's projections, the polar being 16 inches square, which allows of a sufficiently large scale to take out the values with a fair degree of accuracy, and at the same time is a convenient size for practical use."

	Altitudes		Azimuths	
	Graphic	Computed	Graphic	Computed
Capella	27 1/2	28 01'	52	51 45'
Aldebaran	15	15 48'	82 1/2	82 15'
Altair	35	35 45'	244	244 00'
Deneb	65	65 35'	285	285 30'
Vega	41	41 48'	287 1/2	287 15'

MARITIME INFORMATION NOTES

Forwarded by Ernest Brown

Navtex Service From Guam and Hawaii

The U.S. Coast Guard has begun broadcasting marine safety information, including weather forecast and navigation warnings, over NAVTEX from Honolulu, Hawaii (NMO) and Guam (NRV) on a trial operational basis. NAVTEX identifier for Hawaii is "0" with a broadcast schedule of 0040, 0640, 1240, and 1840 UTC. NAVTEX identifier for Guam is "V" with a broadcast schedule of 0100, 0700, 1300, and 1900 UTC. NAVTEX service radius is approximately 200 NM for Honolulu, and 300-400 NM for Guam. Refer to Pub. 117, Radio Navigational Aids, for details of other NAVTEX stations. Direct comments on service from Guam, Hawaii, or other currently operating NAVTEX stations to: Commandant (G-TTS-3), U.S. Coast Guard Headquarters, 2100 2nd St., S.W., Washington, DC 20593-0001.

Address all correspondence to:
The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850
Telephone 301-622-6448

VIDEO REVIEW

by Roger H. Jones

Modern Coastal Piloting

Bennett Marine Video, 730 Washington St., Marina del Rey, CA 90292, Catalog No. 391. 71 minutes (color), VHS

There has been a virtual explosion of video tapes on marine and navigation subjects within the last three years, although the offerings in the field of celestial navigation are still fairly few in number. *Modern Coastal Piloting* is a video tape that is available through Bennett Marine Video in the event that it is not on the shelf of the local marine book store. It is a production which, in terms of content, video quality and artistic technique, stands up well in the competition in this new field of presentation.

The setting is in Florida, and it consists of a dialogue between a power boat captain and a sailor. The artistic technique is interesting. It includes both land and on-the-water scenes, including some footage where an inset in the main picture is a close-up view of a chart, compass bearing, or other particular focus of attention. Both spoken and printed words highlight the critical features of these insets.

This is a good teaching tape. It starts with a review of the tools of navigation, including compasses, binoculars, dividers, parallel rules, protractors, charts, and plotters. At the outset there is detailed coverage of chart catalogs and how to determine what charts may be needed. There is even coverage of a topic often omitted in coastal piloting, the use of a sextant in measuring horizontal bearing angles.

The second section on Reading Charts is a natural extension of the introductory material. This is a thorough presentation with emphasis on all the critical information to be found on a chart, where to find it, the meaning of various colors and symbols, chart dates, and how to make chart measurements. Here the close_up detail is especially good. The material also includes a discussion of the larger view of latitude and longitude, the Equator, the Prime Meridian, and chart projections. This section ends with a good review summarizing all points covered, a technique repeated throughout the tape.

Follow-on sections deal with the compass, variation and deviation, bearings and fixes, the use of depth sounders in navigation, and rules of the road. There are some very good on-the-water scenes that follow the progress of a coastal trip and which clearly present the interrelationship between chart work and deck work in taking bearings and determining fixes. The meaning of sound signals is also presented in an on-the-water format to which no book can do equal justice.

The tape ends with comments on equipment and practical tips for those considering various pieces of equipment. In an hour and eleven minutes of running time, it presents a balanced and thorough discussion of coastal piloting. It gets its viewer out on the water, and it highlights techniques of navigation through moving visual examples, supplemented by dialogue and printed text. The color and sound are quite good, as is the visual quality of the tape. It is a tape which has been well planned and executed, and is worth viewing by those who want to recall or launch themselves for the first time into the fundamentals of marine coastal navigation.

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THE NAVIGATOR'S NEWSLETTER

FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

ISSUE TWENTY-NINE, SUMMER 1990

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

by T. D. Davies

The Dutton Award

On 26 May 1990 I had the pleasure of presenting the Dutton Award for 1990 to Midshipman 3rd Class Michael Kenney Lane. The ceremony was set at the Sailing Center of the U. S. Naval Academy at 1600, where a number of other awards were presented. Midshipman Lane was selected by the faculty of the Navigation Department of the Academy for outstanding work in the study of navigation. The award consisted of a bronze plaque with the Foundation logo, and a permanent plate on the Dutton Award display in the Navigation Department.

A second award was made at the Gould Academy in Bethel, Maine. The winner, picked by the faculty there, is Brenda J. Taylor. Ms. Taylor has received a plaque and her name is added to the permanent display of winners at the Gould Academy. Both winners will receive complimentary memberships in the Navigation Foundation.

Membership Contribution Level

The $25 annual contribution requested of our members was established in 1982-83 and has remained unchanged despite increased costs during the intervening seven years. Of course this is largely due to the fact that our staff is primarily volunteer and unpaid. However printing and mailing costs have gone up, and with the upcoming new mail increase we are unable to hold the line. Consequently we will raise the $25 figure to $30, effective 1 August 1990. We expect this to cover all our costs for the next several years.

Peary Report

The supplemental reports are being mailed out, however our financial status required that we ask for a small contribution to cover the additional printing and mailing. Overseas mailing is, of course, considerably more expensive and our request was necessarily larger for our more than 200 overseas report holders. As you can see in the Readers Forum the overwhelming response to the report was favorable. However the long-time critics of Peary have not been convinced and probably never will be. In our first review of the Peary controversy I was amazed at the lack of any quantifiable or technical evidence that would indicate that he did not reach the Pole. In fact the entire "fraud" case rested on a sort of amateur pyschoanalysis of various of Peary's actions. It seems that after many years of this type of thinking one becomes simply "convinced" that Peary was a fraud, and the mind rejects any facts to the contrary, concocting "explanations" of the new data no matter how they strain common sense. For example, one critic now tells reporters that one of the Pole photographs (by his analysis) does give a "line of position" through the Pole. However he says that it only shows that Peary staged the shot from a position which he estimates as 100 miles from the Pole on that LOP, in order to bolster his (Peary's) position. Of course Peary used his pictures for illustrations for his books and articles. There is no record of his having advanced them as proof that he was at the Pole. Saying that Peary anticipated our photogrammetric approach by 80 years and staged about 14 pictures involving 5 men to deal with it seems to us to fly in the face of common sense.

The Naval Institute is studying a proposal to hold a symposium on the subject, April 1991. Perhaps this may prove helpful in clearing the air.

Tandemeer

Several members have indicated interest in an ocean cruise on Tandemeer. Captain Carraway will contact those who have or now do express interest, directly, and try to develop a satisfactory date.

A New Department

From time to time we have inquiries from members who are trying to locate something of a navigational aspect, such as an old instrument, book or table which is out of print. We have several at the moment and will list them under a new heading, "Wanted" whenever we have such requests. Readers are encouraged to use this exposure to try to fulfill their need for some difficult-to-find material, and of course we are hoping that some reader will provide a response.

Reminder

Back issues of the Newsletter are available at $2 each.

READERS FORUM

Joseph R. Vincent of Newport News, VA writes:

Enclosed find a personal check for $15.00 for the report on the 1909 Peary North Polar Expedition, as described in the January 1990 *National Geographic* Magazine.

I also ask for any information you may wish to send concerning associate membership or any sort of ongoing affiliation with your endeavors.

My avocation is mathematical cartography. I posit unique navigational problems and then develop algorithms for their solution. To date, I have developed two complete studies of about ten pages each. The first deals with the highly accurate construction of an orthographic map projection centered on any chosen surface point. (All calculations can be made with a pocket scientific calculator; as you would certainly know, the most interesting equation deals with the orientation of the meridional ellipses.)

The second study calculates the arrival of sunrise in earth's polar regions following the winter darkness, given only the latitude and longitude of the location in question.

As you see, I am seeking peer review, or at least informal validation of my techniques. (N.B.: The map study was checked during its development on a standard computer graphics package. As a further enhancement, I wrote a FORTRAN computer program which alleviates the modest time constraints of hand calculation).

My previous occupation was in cadastral surveying and cartography as a member of the National Park Service for five years. From this genesis, I began independent studies in geodesy and navigation. I then spent one year each at West Virginia University and Pittsburgh Technical Institute, where I consolidated the mathematical and representational aspects of my studies. I am now employed in the manufacturing sector. I would greatly appreciate the opportunity to submit the details of my navigational work to your organization and maintain a relationship in which we may share the benefits of our endeavors.

[Ed. Note: Mr. Vincent will be welcomed as a member and we start by printing his letter here. His expertise is fundamental to navigation and we invite comments from interested members. Anyone wishing to communicate directly with Mr. Vincent can do so at 318-D 73rd St., Newport News, VA 23607.]

Walter N. Kuchmy of Chatham Twp, NY writes:

I have received your report of Peary at the North Pole, as well as the supplement.

Both reports are a study of deep dedication by your organization to clarify the conflicts that have plagued historians since 1909. I abide by your conclusions — the depth of your investigations deeply impressed me. The cost of the report would have been a bargain at twice its price.

Thank you for your telephone call to straighten me out. Some of Peary's records must have been hard to decipher. Why didn't Peary use printed forms to simplify his observations and reduce errors of omission?

I am joining your organization with the enclosed form. Please use the excess to your best advantage.

The *Navigator's Newsletter*, Issue 27, 1990 was very useful. Since I own five vintage bubble sextants, the history of the instruments was appreciated as related to them. If possible, the previous issue (26) would be welcomed if any copies are available.

Again, my apologies to both you and to Gilbert Grosvenor are in order. Please relay this to him.

Best wishes to you and your staff and to continued success. I am retired, but maintain my engineering license in NJ and the national organization.

[Ed. Note: This letter has been passed to Mr. Grosvenor. We also thank Mr. Kuchmy for a generous contribution.]

Gordon A. Taylor, D.D.S. of Kingston, Ontario writes:

The last newsletter mentioned a working cruise that I was interested in. But I have lost that newsletter. Could you please send me more info.

[Ed. Note: Captain Carraway will contact Dr. Taylor shortly.]

Rupert Summerson of Avalon Beach, Australia writes:

Thank you very much for your letter of 30 Jan 90. I should have noticed the cost of the postage on the envelope so many apologies for causing you to write. Please find enclosed a bank cheque for $41.00 for the $16 postage and $25 for one year's subscription to the Navigation Foundation. I hope you will have me! I enjoyed reading the *Navigator's Newsletter* very much and am looking forward to receiving them during the year. I am enjoying the Peary Report very much. I am over half-way through it already and finding it very interesting. I have read quite a bit about the controversy over the years, but of course having followed the same route to the North Pole last year has sharpened my interest. I do not have any major quarrel with your findings so far though I would contest the lack of importance you give to knowing your longitude. I am going to apply the photogrammetry method of determining the sun's altitude from photographs to some of my photographs to see if I come up with the right answer. But first of all I want to finish the book. I may say that I have always believed that Peary did make it to the Pole in 1909, and I have been disinclined to believe Cook's account. We know that Bartlett left him at nearly 88° N and I cannot believe that Peary would have either made a hash of his navigation or that he would not have given everything to make it. I have received a very nice letter from Admiral Davies, which I will be replying to soon. I notice that John Luykx is one of your directors; he is a friend of a friend of mine, Frank Bartlett, who also lives in Sydney.

Many apologies for the delay in getting this off to you. I have recently started a new job, the printer for my computer has been "on the blink" and to cap it all I lost the bank cheque and have had to get a new one raised.

Robert W. Severance of W. Palm Beach, FL writes:

The enclosed article, "Overdetermined Celestial Fix by Iteration," is appearing in *Navigation*, Volume 36, No. 4, Winter 1889-1990. It outlines a method for computing the best position fix with an error estimate from any number of sextant altitudes of any number of celestial bodies. "Best" is defined as producing the minimum sum of squares of altitude measurement residuals.

I will gladly send any interested reader a copy of the FORTRAN code. Although it could undoubtedly be programmed on a hand calculator, it is not yet a user-friendly method ready for routine use by the cruising yachtsman.

The example in the paper is a morning sun sight with multiple measurements taken for nearly an hour. Since then I have run multiple star sights using a bubble sextant from my back yard, with excellent results.
Could you please send me a copy of the 1909 almanac section on Lunar Distances, and any other information you may have on determining watch error by celestial observations? The only source I have is the article "Longitude Without Time" by J. W. Luce, *Navigation* Volume 24, No. 2, 1977.
[Ed. Note: The 1909 lunar distances data will be forwarded.]

Stephen D. Matthews, Ph.D. of Port Washington, NY writes:

As a member of the Foundation I'd like to suggest a workform for the NAO Tables in the Nautical Almanac and comment on workforms in general.

The use of workforms is a deliberate part of my classes in celestial navigation. To offer beginners a choice, I give out a variety of forms for each method of solution. What interests me is the unanimity of the students' choices of the forms they find most helpful. For HO-229 and for Davies Assumed Altitude their choice is always the Weems & Plath forms as found in Edward Bergin's *A Star to Steer Her By*, and that in spite of the fact that the book itself is not used in the class. For solutions by hand calculator they prefer a form I have devised which is laid out much like the Plath forms.

When we come to the NAO Tables, I supply three sets of forms; the W. O. Land form, from this newsletter, blown up to full size, the form from Davies' Concise Tables and David Burch's form. The feedback is unanimous; the Burch form and none other. Why this is the case I will address below.

It is David Burch's form that I would nominate for consideration. I assume The Foundation knows the Burch form. Its author has been honored by The Foundation and is surely well known to its members. I have enclosed a copy along with his instructions, and hope you will obtain his permission and print them in the *Newsletter*. I feel strongly that our members should see and assess it before the Almanac Office makes any choice. Consideration of workforms, in and of themselves, is a neglected part of celestial navigation. Virtually every text in celestial provides some sort of form, but I cannot remember seeing a text that gives the form itself sufficient credit as an essential pedagogical tool.

Workforms are not merely a tidy way to put numbers down on a piece of paper. Neither are they a "trot". They are not the equivalent of sitting in your Latin 2 class spouting Caesar with an interlinear translation of the Commentaries open on your lap. If you don't know how to reduce a sight, no workform will, by itself, teach you how to do it.

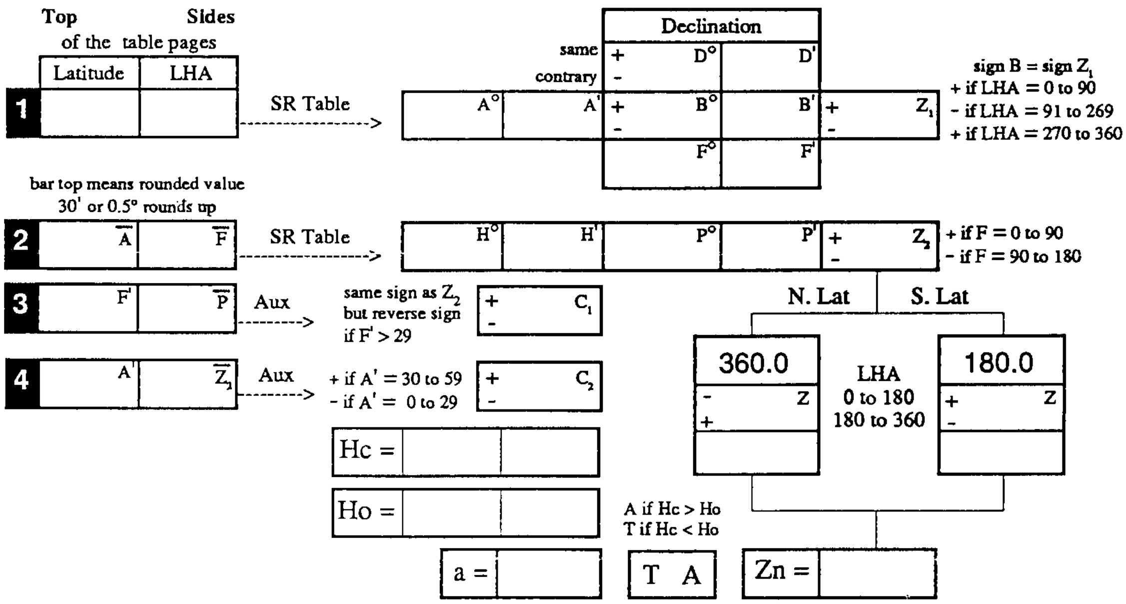
A good form provides a place to record data, and a place to manipulate that data. Good forms or, at least, the ones my classes and I prefer, offer some help and encouragement for both of those functions. In so doing they do not become a *substitute* for learning, they become a powerful *aid* to learning. The ultimate test of learning any sight reduction method is the ability to perform it, on demand, on the "back of an old envelope." The fact that when students (and I, myself) do this, the resulting calculations always bear some resemblance, in format, to the workform they're learned with, suggests to me that the workform itself has been mentally internalized as a part of the learning process.

I understand workforms to perform two functions in the learning process. Firstly, because they require that data be written down in a logical, step-by-step fashion, they organize and structure the internalization of that data. People learn best when they do something, rather than merely *absorb* something, whether by reading or learning. The logic of the sight reduction process is the work with a set of data in order to obtain a series of entering arguments which culminate in some inferences as to our position at sea. Date, time and body become entering arguments for the Almanac, Almanac data becomes entering arguments for the sight reduction tables. Tabular and sextant data becomes the "entering argument" for the plotting sheet. Such a logical progression lends itself well to concrete organization on a sheet of paper.

Secondly, the workform itself becomes a powerful mnemonic along the lines of what I call the "touch-tone phone phenomenon." When faced with a dial telephone many habitual push-button phone users, myself included, forget phone numbers that they usually have no trouble remembering. This suggests that memorizing

STARPATH

Sight Reduction Workform for use with the NAO Tables included in the *Nautical Almanac*



Short Instructions

Step 1. In row 1, record assumed Lat, LHA, and Dec (D). Mark the signs of D, B, and Z1

Step 2. In row 1, with Lat and LHA, enter the Sight Reduction (SR) Table and record A, B, and Z_1.

Step 3. Copy A' to row 4 and mark the sign of C_2.

Step 4. Round off A to the nearest whole degree and record it as A-bar in row 2.

Step 5. Add D and B to get F, and record it in row 1.

Step 6. Determine the signs of Z_2 and C_1 and mark them in rows 2 and 3.

Step 7. Round off F to the nearest whole degree and record it as F-bar in row 2.

Step 8. In row 2, with A-bar and F-bar, enter SR table and record H, P, and Z_2.

Step 9. Round off P and Z_2 to nearest whole degrees and record them as as P-bar and Z_2-bar in rows 3 and 4.

Step 10. In row 3, with F' and P-bar, enter the Auxiliary Table (Aux) and record C_1.

Step 11. In row 4, with A' and Z_2-bar, enter the Aux Table and record C_2.

Step 12. Add C_1 and C_2 to H to get Hc.

Step 13. Add Z_1 and Z_2 to get Z. Disregard the resulting sign; Z is to be treated as a positive number when later converting it to Zn.

Step 14. Record Ho below Hc, then take their difference and record it as "a" with the proper label.

Step 15. Convert Z to Zn with the traditional rules, using the spaces provided.

the numbers involves not only the numbers themselves but also our visual memory of the numbers' place on the phone's keypad. When deprived of the "keypad mnemonic" some of the learning disappears as well, especially as we try to fit our memory into a new structure as is represented by numbers organized around a dial. My advocacy of the Burch forms for the NAO Tables is based on their clarity, relative simplicity and the graphic way in which they are laid out. They are the best "keypad mnemonic" I have seen. I hope you will reprint them for all the members to see.

David F. Burch of Seattle, WA writes:

Enclosed is my renewal form and check. Also a copy of our workform for the NAO tables. I send this because I recently received a copy of a letter from a Dr. S. Matthews to you about these forms. I do not know Dr. Matthews and do not know what version of our form he sent you (he sent me the letter copy but not the form), so I am including a copy of our latest version to be sure we are talking about the same thing. He seems to have liked it. Please feel free to mention this if you see fit to. I also write to say this now (unasked) as I am leaving tomorrow to deliver the fishing vessel "Capt. Richie" from NY to Seattle and will be gone for 40 some days.

[Ed. Note: Dr. Matthews' letter is certainly convincing; the form is printed here, with thanks to David Burch *See page 4.]*

Thomas E. Dalby of Crystal River, FL writes:

Thank you for your prompt reply to my letter, and thanks for the missing back issues.

I have just finished reading the Foundation's report—*Robert E. Peary at the North Pole*—with the conclusive affirmation that he did indeed reach the Pole as he claimed. This report should be required reading for every serious student of navigation. I particularly enjoyed the confirming new evidence by bathymetric data, and the photogrammetric confirmation of latitude. I look forward to the *National Geographic* article with review of the report. Hopefully, at long last, Peary's numerous detractors will be given a final rebuttal, and the Admiral can rest easy in his grave.

The Foundation, and Admiral Davies in particular, are to be congratulated for the extensive work and conclusive analyses included in the report.

J. David Smith of West Vancouver, B.C. writes:

I am enclosing a money order for $15.00 (U.S.) for a copy of the Peary Navigation Report.

I found your analysis of the log books and sun shots very interesting, and the photogrammetric determination of the sun angles, very clever.

I was a navigator in the R.A.F. Pathfinder Force during WWII and can only be thankful that we had sextants with an elusive bubble, instead of a pan of frigid mercury, to determine the horizon. Our "cocked hats" were big enough as it was!

Now, I'm semi-retired, and play with an old Ainsworth transit, an A.M. Mk IX A bubble sextant, an AT computer and my home-made 6" reflector telescope. The interest never dies, does it? I need a simple computer program, in Basic, to control a concentrating solar collector. It need not be too accurate, as the final few degrees could be corrected by a sun-seeker control. I wish you well with your foundation and wonder what your next project will be.

[Ed. Note: Can any reader suggest a program? The Floppy Almanac, available from the U. S. Naval Observatory might be modified to work.]

Frans W. Saris of Amsterdam, The Netherlands writes:

Thank you for your letter of 11 February 1990, and for sending me the full report. I have understood your arguments and I am convinced.

I am a scientist and I also write a column in the science section of NRC HANDELSBLAD, a daily newspaper in Holland. I have used the story on Peary at the North pole as a metaphor for management of a discovery. I enclose a copy of the article for your records. Since Mr. Carraway could not cash my check I still owe you money for the report, postage and packaging. Therefore I enclose $27.00 in cash.

[Ed. Note: The cash arrived safely!]

NAVIGATION BASICS REVIEW

Arithmetic Calculations

By John M. Luykx

Most of the arithmetic calculations required in navigation practice are basically simple and straight-forward. However, the author has found from experience in teaching that some navigation calculations are invariably more difficult than others and often require special emphasis in the classroom. Arithmetic calculations involving time and angular values appear to cause the most trouble.

Accordingly, a review in this *Newsletter* of some of the more troublesome of these calculations may be worthwhile, especially for beginners.

It is frequently advisable (in order to improve accuracy) to "average" a series of sextant observations rather than rely on a single observation to obtain a line of position. Also, when checking the index error of an instrument or when conducting tests, it is often desirable to average a series of observations to obtain mean values. An example of such computations follows:

Assume that during the evening of 25 May 1990 in

Forestville, Maryland an observer located in LAT N38° 51'.8 LON W 76°55'.1 took a series of observations of the star Arcturus using a bubble sextant (w/o error) in order to check the index error of the instrument. The following data was recorded:

NO.	GMT	Hs
1	23-54-20	43°41'.1
2	23-56-16	44°03'.3
3	23-58-02	44°23'.6
4	23-59-46	44°43'.5
5	00-00-55	44°56'.7
6	00-02-15	45°11'.9
7	00-03-41	45°28'.3
8	00-05-10	45°45'.3
9	00-07-01	46°06'.6
10	00-08-45	46°26'.1
11	00-10-06	46°41'.5
	682 272	492 387.9

Find the mean time (GMT) of this series of observations.

1. The mean value of GMT

a. To obtain the mean GMT of the series of observations:

(1) Add up the total seconds: 257
(2) Add up the total minutes: 682
(3) Divide total seconds by 11: 23.4
(4) Divide total minutes by 11: 62

```
Mean GMT: = H       M        S
            23    - 62     - 23.4
          = 00    - 02     - 23 (26 May)
```

Note: If total minutes divided by 11 does not result in a whole number, apply the remainder (converted to seconds) to the mean value of seconds.

An alternate solution would be to consider each value of GMT as an angle and to total up the trigonometric function (the sine for example) of each "angle" using a calculator to obtain the sine total. The mean value of sine could then be reconverted to mean time

Sum total sine values: 4.48109971
Mean value of sine: 0.407372702
Mean GMT: 00-02-24 (26 May)

To obtain the mean altitude of the series:

1. Add up the total arc minutes: 327'.9
2. Add up the total degrees: 492°
3. Divide total arc minutes by 11: 29'.81
4. Divide total degrees by 11: 44°.73

```
                    Degrees     Minutes
Mean altitude: =    44°.73      29'.81
                      .73
                       60
                    43°.80    - 43'.80
               =    44°         73'.61
Mean altitude: =    43°         13'.6
```

An alternate method is to total up the trigonometric function (the sine for example) of each altitude in the series using a calculator and obtain the sum total. The mean value of sine could then be reconverted to obtain the mean value of altitude for the series.

Sum total of sine values: 7.8075093
Mean value of sine: .7097736
Mean altitude: 45°13'.0

Often when planning a long voyage, extensive time, speed, distance calculations will be required which in some cases may cause difficulty. The time of voyage is determined, for example, by subtracting the date and time of departure from the date and time of arrival. If these two points are separated by a long distance and if the vessel proceeds at slow speed, the voyage time may last several months following a track through many time zones. All of this adds to the complexity of the computations. The following examples will typify the problem often met with by navigators during the voyage planning process.

A yachtsman is planning a voyage from San Francisco to Sydney, Australia. He desires to arrive in Sydney on 10 December 1990 at noon local time. Based on the best estimate of the weather during the period of the voyage and on extensive records of his boat's performance, he estimates that the average boat speed during the voyage will be 4.5 knots. The track he intends to follow is 8250 nautical miles in length. When should he plan to depart San Francisco?

Solution

1. Compute Time of Voyage:

$$T = \frac{D}{S} = \frac{8250}{4.5} = 1833.3 \text{ hours}$$

```
     76
24 ) 1883.3 =  76 days 9 hours 18 min
     168
      153
      144
        9.3
```

2. Compute Time Zone Difference

Reference: Nautical Almanac
San Francisco: + 7 (Daylight Saving Time)
Sydney: -11 (Summer Time)

Note: Local Sydney time is 18 hours *fast* on San Francisco time. San Francisco is 18 hours *slow* on Sydney.

3. Compute Equivalent Date:

```
10 Dec =    40 November (30 days)
           +31
       =    71 October  (31 days)
           +30
10 Dec =   101 September (30 days)
```

4. Compute Time of Departure SanFrancisco

```
Arrival Sydney: 101 September 12-00
Voyage Time:  - 76            09-18

Departure SF:   24 September 02-42
(Sydney time)  (23 September 26-42)
```

5. Compute Time and Date of Departure (San Francisco time)

```
Arrival: Sydney time: 24 Sept: 02-42
SF slow on Sydney:             -18
```

Date & Time Departure SF: 23 Sept: 08-42

Example 2

A voyage is planned from Norfolk, Virginia to Piraeus, Greece. The track distance is 5375 miles. The vessel plans to depart Norfolk 15 February 1990 at noon. Using an average speed of 13.5 knots, what is the estimated time of arrival of the vessel at Piraeus?

Solution

1. Compute time of voyage

$$T = \frac{D}{S} = \frac{5375}{13.5} = 398.15 \text{ hours}$$

```
    16
24|398.15 = 16 days 14 hours 09 minutes
   24
   158
   144
    14.15
```

2. Compute time zone difference

Reference: Nautical Almanac

Norfolk +5
Piraeus -2

Piraeus time is 7 hours *fast* on Norfolk;
i.e., Norfolk is 7 hours *slow* on Piraeus.

3. Compute time of arrival Piraeus (Norfolk time)

```
Departure Norfolk: 15 Feb 12-00
Voyage Time       +16     14-09

Arrival Piraeus:   31 Feb 26-09
                 = 32 Feb 02-09

Arrival Piraeus  = 4 Mar 02-09
(Norfolk Time)
```

4. Compute time of arrival Piraeus (Piraeus time)

```
ETA Piraeus, Norfolk Time: 4 Mar 02-09
  Time Difference              + 7

ETA Piraeus, Local Time:   4 Mar 09-09
```

Basic arithmetic calculations in navigation, although seemingly simple and elementary, provide the navigator with many an opportunity to produce mistakes and even blunders. Small errors in addition, subtraction, multiplication and division, if left unnoticed or unchecked, offer the major cause of much of the inaccuracy which exists in navigation computations. Hopefully, the discussion presented here has clarified, to some extent, the procedures involved in averaging observations and in calculating time, speed and distance, two arithmetical procedures which seem to cause some people much difficulty.

HISTORY OF NAVIGATION

The Weems Star Altitude Curves

By John M. Luykx

The Weems Star Altitude Curves became, particularly during the period 1935 to 1950, one of the most popular of the accurate and rapid graphical methods of sight reduction. A thin book of star curve diagrams, an artificial horizon sextant and a watch set to sidereal time were the only items needed to observe and reduce a set of star observations for a fix. A fix from three observations could be obtained within one or two minutes once the observations had been made.

Although the curves were used primarily by aviators, navigators at sea also used them to advantage.

In light of the series of articles on aircraft sextants presented in previous issues of The *Navigator's Newsletter*, it is felt that a description of this popular method of sight reduction would be appropriate in this issue of the *Newsletter*.

With the development of higher aircraft speeds and longer flight distances (including ocean flights) during the period following World War I, it became increasingly evident that improvememts in air navigation equipment and practice were required to keep pace with the rapid advancement in aircraft design and operational capability. Along with the development of aircraft sextants during this period, as described in previous issues of the *Newsletter*, a concurrent interest in improving the accuracy and rapidity of sight reduction procedures also became evident, particularly among navigators of those nations in which a significant aviation industry had already evolved.

Although, originally, celestial observations taken from aircraft employed sight reduction techniques based on standard marine publications and procedures, the air navigator found the publications inconvenient, bulky and cumbersome, especially in a drafty open cockpit. As a result, a series of mechanical, chart-based and tabular sight reduction devices were developed which greatly reduced the time involved in reducing a celestial observation. These included the two well-known navigation slide rules designed by Charles L. Poor and L. C. Bygrave. Nomograms which required plotting, though not as accurate as other methods, were also employed. Expensive heavy and bulky mechanical devices though little used in aircraft were successfully employed in airships where space for navigation was not at so great a premium.

Books and charts as well as diagrams containing altitude curves, however, were found to be the most practical when employed in the air, even when used in closed quarters. The earliest of these collections of star altitude curves were designed by K. Hilding Beij of the U.S. Bureau of Standards in 1924. (Figure 1). As an example, the intersection of the altitude curves of two bodies on the diagram provided the latitude of the fix along one

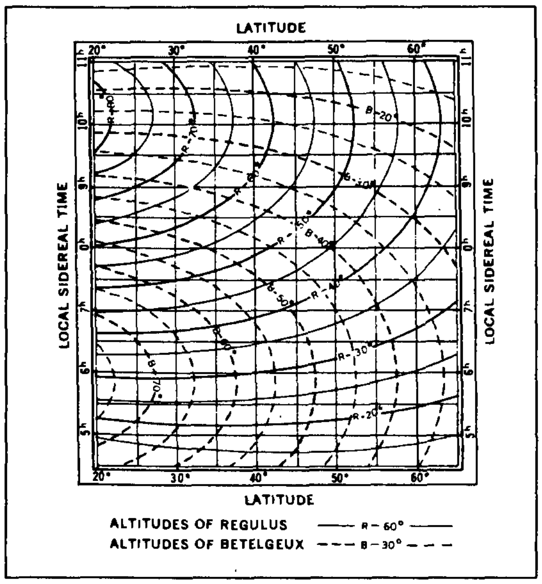


Figure 1

edge and the local sidereal time (LST) of the fix on the adjacent edge. If a watch keeping Greenwich Sidereal Time (GST) is used to time the observations, then the longitude of the fix may be determined by applying the local sidereal time (LST), determined from the fix, to the Greenwich Sidereal Time of the observation.

The Weems Star Altitude Curves

In 1928 LCDR P.V.H. Weems USN compiled a set of altitude curve diagrams and published them in a set of volumes at 10° intervals from latitude 50° S to 70° N. Curves for two sets of stars were originally provided in the first edition (1928) of the Weems Star Altitude Curves. The Second Edition of 1938 contained three star curves. In 1940 the Third Edition (for Epoch 1945) was published and this edition became the most widely used of the graphical and mechanical methods for sight reduction. For latitudes above 10° N, Polaris was included as one of the stars. In the 3rd Edition curves were plotted at 10' intervals and the altitude curves of each star were corrected for refraction and printed in a different color. A correction factor for annual variation (precessionand nutation) in altitude for each star is included at the top of each diagram. This feature extends the life of any edition of the curves over a longer period; i.e., an altitude correction may be applied which will give a correct solution for any desired date.

Each diagram is drawn on the mercator projection with a latitude scale at 5' intervals located on both the right and left edges; the same as is shown on a typical mercator chart. The upper edge of the diagram is graduated in hours and minutes (1 minute intervals) of local sidereal time (LST). The lower edge is graduated in degrees and minutes (at 10' intervals) of Local Hour Angle of Aries (LHA). A typical diagram from the Weems Star Altitude Curves (Vol. 30 to 40 N) is shown in Figure 2.

The following procedure is employed when using the Weems altitude curves to obtain a fix of the observer's position. (A watch set to Greenwich Sidereal Time is a great advantage to sight reduction with the star altitude curves because the need for a Nautical Almanac is then eliminated.)

First: Apply the DR Longitude (converted to time) to the time shown by a sidereal watch (for the projected time of observation) to obtain Local Sidereal Time (LST)

Second: Turn to the approximate volume and diagram on the Star Altitude Curves using DR Latitude and LST as references.

Third: From the appropriate diagram, identify the azimuth and altitude of the three stars to be observed.

Fourth: Record the altitude as observed by bubble sextant and the GST of each altitute observation.

Fifth: Record the latitude and LST of the point of intersection of the three altitude curves measured by the

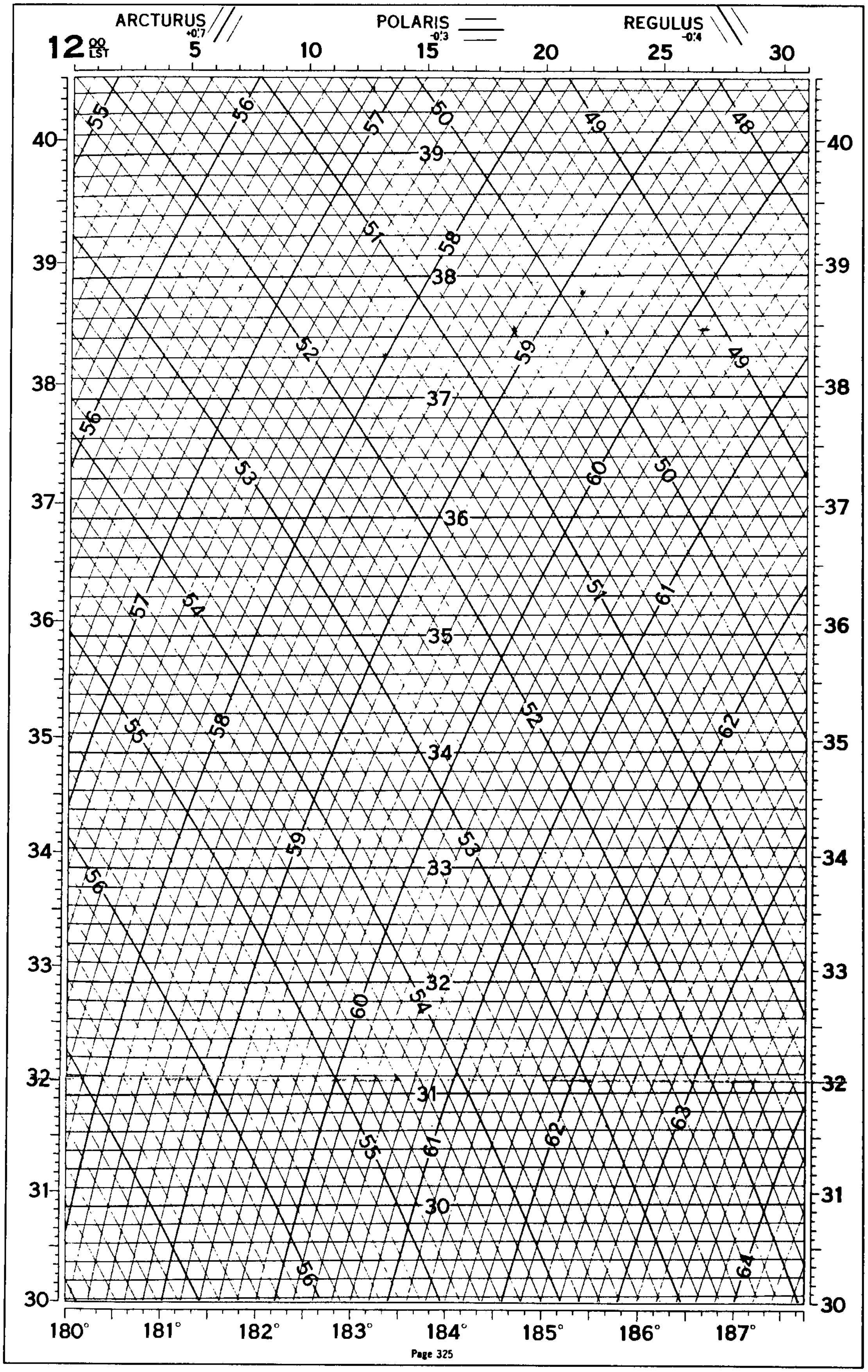

ARCTURUS +0.7
POLARIS -0.3
REGULUS -0.4
12 00 LST
5
10
15
20
25
30
40
39
38
37
36
35
34
33
32
31
30
180°
181°
182°
183°
184°
185°
186°
187°
Page 325

Figure 2

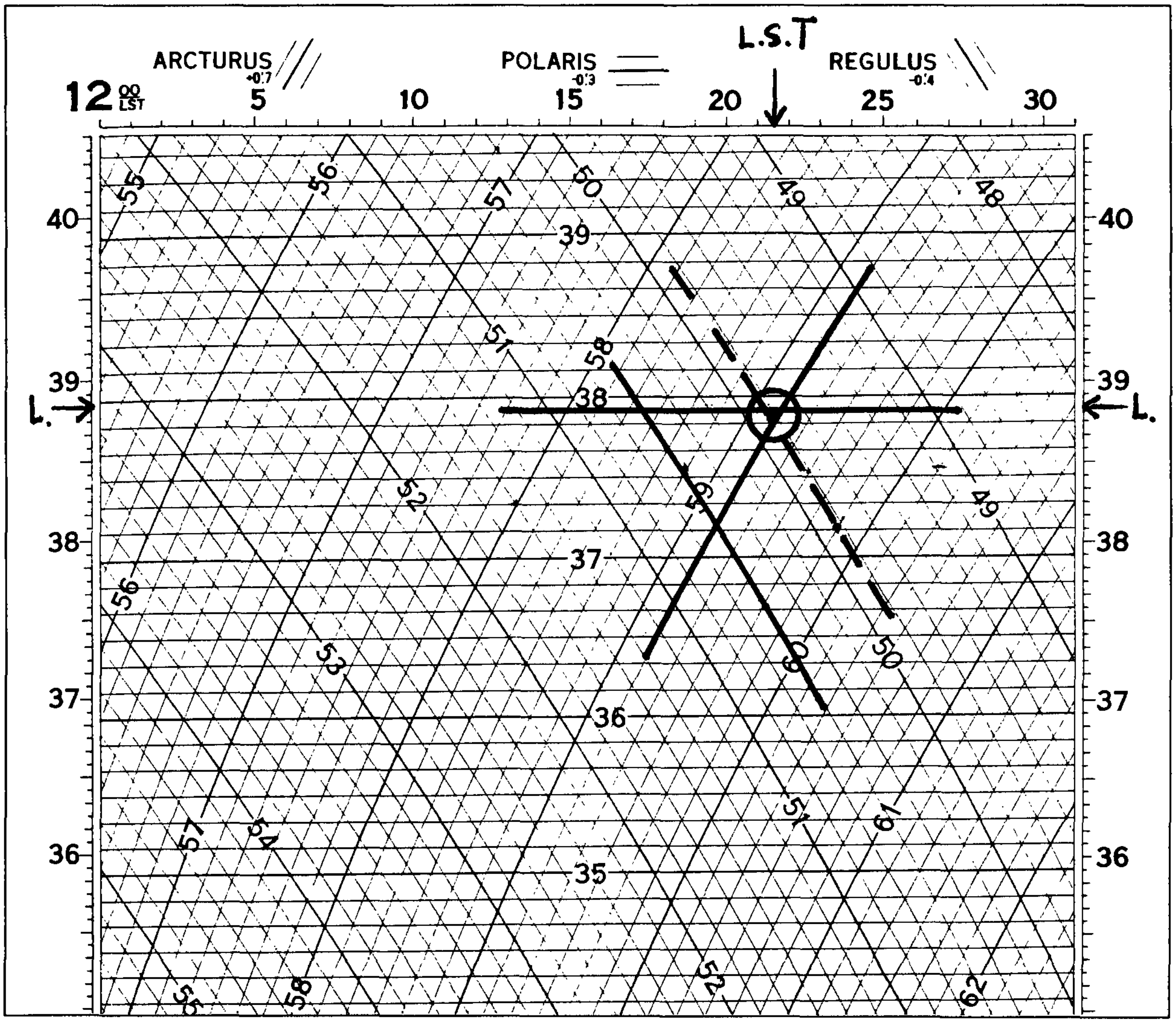


Figure 3

sextant. Note: No corrections (except sextant I.C.) are necessary to observed altitudes; they are already corrected for refraction. When using a bubble sextant, the Dip correction is 0'. If there is a time interval between observations, *advance* and/or retire the applicable LOPs using the LST scale at the top of the diagram. An LOP advanced to a *later* time is measured to the *right*; an LOP retired to an *earlier* time is measured to the *left*.

To test the accuracy of the Weems Star Altitude Curves, 3rd Edition, a set of star observations were taken in the Forestville, Maryland area on the evening of 23 May 1990 using Vol. 30 N to 40 N of the Weems Star Altitude Curves, 3rd Edition 1940, Epoch 1 January 1945. (See Figure 3)

The following data was recorded:

Weather: Clear with high clouds

Observer Position: LAT: N 38 51.8

LON: W 76 55.1

Watch: Hamilton Model 4992B, 24-hour watch set to Greenwich Sidereal Time (No Error)

Sextants: a. Hughes (RAE) MKIXA w/o averager, and

b. Bendix A-14 w/o averager.

Observations

1. BODY	GST	Hs	ALTITUDE CORRECTION FACTOR	SEXTANT
Regulus	17-25-11	50°44.3	-0.34*	MKIXA
Arcturus	17-28-57	58°36.8	+0.73*	MKIXA
Polaris	19-26-05	38°04.0	-0.33*	A-14**

2. BODY:	Regulus	Arcturus	Polaris
Hs	50°44.3	58°36.8	38°04.0
I.C.	+0.5	+0.5	+2.0
corr x 45	-15.3	+32.9	-14.9
Ho	50°30.5	59°10.2	37°51.1
			(38°49.0) NLAT

*Note: The altitude correction factors were recomputed to more accurately reflect changes in star position during the period from 1 January 1945 to May 1990.

**Note: At the time of observation, Polaris was very dim and could only be observed with the A-14 sextant.

```
3. Advance Regulus to Arcturus
   17-28-57
  -17 25 11
       3-46(Advance Regulus 3m46s to the right)
```

Latitude: 38°48.5 (From chart)
Longitude: GST: 17-28-57
-LST: 12-21-30
=LON: 5-07-27
=LON: 76 51.8 W

Fix Position
LAT: 38°48'.5 N
LON: 076°51'.8 W

The position of the fix as obtained from the Weems Star Altitude Curves, Epoch 1945, compared to the observer's actual position, indicates that this sight reduction procedure, although limited to night time use, is still, to this day, a rapid and practical sight reduction method requiring no additional equipment or publication other than the sextant and a watch set to Greenwich Sidereal Time.

As a matter of interest, the Royal Air Force late in World War II developed these curves a step further for use aboard large aircraft by incorporating them on film-strips. Images of the curves were projected by a device called the *Astrograph* on to the navigator's chart.

NAVIGATION NOTES

Measuring the Dip of the Horizon

By Thomas D. Davies

In issue eighteen of the *Newsletter* (Fall 1987) I described a device which I called the Indirect-Horizon Scope, and its use to measure actual dip of the horizon. This addressed the fact that computed refraction or refraction taken from tables, while it accounts for the refraction of the light from the star as it travels through the Earth's atmosphere, does not completely account for refraction from temperature differences between the water surface and the adjacent air layer. This difference affects the light path from the horizon which is the other component of the "match" that determines the measured altitude of the celestial body. The net effect of this is that actual "dip" may well be several minutes different from the geometrical or computed dip of the horizon.

Research in this area has demonstrated that temperature measurements of the air-water difference are impractical to make since they must extend all the way to the horizon. It has also been shown that the effect is much greater at very low heights of eye than at higher ones. For example some measurements showed that at 12 feet H.E. the effect was twice as much as at 24 feet. Consequently correction for this is much more important for the small-boat navigator. This navigator already suffers from the fact that horizon determinations are more susceptible to distortion from waves at his low H.E. In the 1985 experiments described in the earlier article the difference between calculated and measured dip was 3 minutes of arc at a H.E. of 25 feet. Certainly this error can seriously affect a line of position. Note that it is sometimes plus and sometimes minus.

The availability of a direct-horizon scope is far off and it seems that measurement of the dip is the only practical way to overcome this source of error. However an alternative exists that under usual circumstances may provide the equivalent of the scope. This is the use of a back-sight on a bright star whose altitude is 60 degrees or more.

The star should be chosen to permit reasonable horizons for both back and front sights. This will usually be the case in the early part of twilight for stars bearing roughly east or west. Each sight should be taken with great care since we are dealing here with very small differences between very large numbers. Ensuring that the altitude is measured perpendicular to the horizon may pose difficulties, particularly in the case of the back-sight. This problem will be greatly eased by the use of a Prism Level. Otherwise one must "dip the star" carefully because in the back sight case rocking the sextant will lower the star and its highest point must be picked instead of the lowest.

To determine the measured dip, the sum of the back and front altitudes must be determined, after applying index correction only. Normal refraction should not be corrected for since it will be the same for both sights and will cancel out. Index correction should be applied to both sights. This sum is now compared to 180 degrees, the difference being twice the measured dip angle. The sum will almost always be greater than 180 degrees, and one half of the difference is the dip, which should be applied to sights taken in the same time period by subtracting (except for back-sights). Usual refraction corrections based on altitudes should be applied.

While it is possible that water-air temperature difference will be vary slightly on different azimuths, this technique will usually improve the accuracy of the sights taken and can be done before or after taking the navigational stars. Daytime temperature differentials will be quite different from nighttime, and with only the sun available this technique cannot be used unless the altitude of the sun happens to be 60 degrees or greater (note that in a back-sight the upper and lower limbs of the sun are reversed).

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The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850
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A Navigation Problem

By Roger H. Jones

Solution to the Problem in Issue 28.

30.Answer

The Polar navigator equipped only with a sextant, compass, watch, almanac, and artificial horizon would employ the method which, in 1909, served Peary well, and which will serve equally well in 1990. (It should be noted that the method was also used by Roald Amundsen on his successful trek to the South Pole in 1911.)

Basically, the navigator will "home" on the Pole, using simple means to determine on successive days the direction of true north. He knows that he will not be able to stay precisely on a given meridian of longitude because of the necessity to make extended detours around pressure ridges and open water leads. He makes no attempt to use conventional longitude observations. He has no practical means of verifying the accuracy of his watch, as he has no radio capable of receiving the time "ticks", and he has no reference chronometer with a known rate. Also, the altitude of the sun when on the prime vertical would be so low and the Arctic refraction so high as to render the longitude shot virtually worthless. Finally, as he nears the Pole, the meridians converge, and although he may be still over 100 miles south of the Pole, they are now so close together as to make conventional longitude determination meaningless.

He has no natural sea horizon—only endless miles of broken ice in all directions. However, he may use an artificial horizon, a device used by surveyors and land navigators which gives the reflected image of a celestial body on the surface of a small pool of mercury or other reflecting fluid. The fluid is protected from the wind by optically ground glass panels set at a precise angle to the surface of the fluid.

Once each day the navigator observes the sun at its highest altitude as it crosses his own local meridian at local apparent noon (LAN). Facing south at this instant of time, the navigator has only to look at his own shadow to determine the reciprocal direction of true north. From this, a usable compass correction is obtained even though the north-seeking needle may be pointing in a southerly direction due to the relative location of the magnetic north pole.

The navigator notes the time of LAN by reference to his watch. If the watch maintains a fairly steady rate, and if the detours have not displaced the navigator significantly to the east or west of the local meridian he was on at the preceding day's LAN, the time of LAN on one day will be the same or nearly the same as on the preceding day. This will permit planning as to when to observe the sun, and if the sun is indistinct due to haze or low clouds, he may nevertheless get a useful shadow at the expected time of LAN.

On March 21 and 22 when the sun rises and sets the navigator may obtain true east and west. From those directions on that day, he may easily determine true north using any means to measure a 90 degree angle.

Finally, the navigator may be able to observe the sun at local apparent midnight as it crosses the meridian 180 degrees from his own local meridian. Depending on his distance south of the Pole, this will be a very low altitude observation, even lower than the altitude of the sun at LAN. Nevertheless, the technique may well prove to be useful in obtaining the direction of true north.

Distances will be determined on the basis of judgment and the latitudes obtained at local apparent noon each day. Taking into account any known information on ice drift, the party will dead reckon each day using the corrected compass. When it reaches a point which the navigator judges to be 90 degrees North, further careful sun observations will be taken to verify latitude. Of course, special precaution must be taken to account for refraction, and for differential refraction if both the upper and lower limbs of the sun are used in making the observations for latitude.

Navigation on the return trip will be by means of following the back-trail. The "homing" technique will not be valid, as all directions are due south from the Pole. The party will therefore carefully mark its trail with flags or other means on the north-bound trek, and will stay as close as possible to that trail on the return trip.

This is the method used by Peary. Readers of the *Newsletter* may wish to read the Foundation's final report, *Robert E. Peary At the North Pole*, which explains the navigation technique in detail and which analyzes many other aspects of Peary's 1909 expedition and his earlier Arctic expeditions. Those other aspects include the Peary bottom soundings, sledging speeds and distances, the Peary photographs and sun shadows, ice drift, analysis of the celestial observations, and many other topics.

Problem No. 31

In Issue 28 (Spring, 1990) there appeared an excerpt from Captain Gilbert T. Rude's description of the development of the original "star finder" which, for 70 years has borne his name. The current problem and those in the next several issues of the *Newsletter* will deal more fully with this remarkable little device and its many uses.

Most readers will know that the 2102-D Star Finder is a mainstay in identifying any of the more than 50 principal navigational stars listed in the Almanac's Index to Selected Stars. What about the lesser stars (more than 100) that are also tabulated in the Almanac? The Star Finder's base plate does not show these stars in their relative positions in the Northern and Southern skies. How may the Star Finder be used to identify a lesser star? (For purposes of this problem, a very faint star is used.)

The date is June 30, 1990. GMT is 0800. Time aboard the vessel is 0300. The DR is 34-20.0 N, 68-30.0 W. A faint star is observed at an HS of 50-00.0 on a bearing of 190. What star is this, and what procedure is used with the 2102-D Star Finder?

(Note: For purposes of the problem the time is such that it is still very dark, which would be necessary to see the faint star. This would also make the horizon indistinct, and the altitude hard to measure with precision. Nevertheless, the technique is a valid one and can be very useful with unknown stars.)

NAVIGATION PERSONALITIES

Henry of Portugal (1394-1460).

By Thomas D. Davies

As the third surviving son of the Portuguese monarch John I, Prince Henry was not in direct line for the throne and so largely avoided the politics of the royal court in Lisbon. Instead he devoted his energies first to military matters and then to navigation and the Portuguese drive to explore south on the African coast, with the eventual goal of developing a sea route to the "Indies."

His military exploits started with the capture of Ceuta (1415) across the straits from Gibraltar. His services in this expedition were rewarded with a knighthood and a Dukedom. Almost immediately after the capture of Ceuta, Henry launched his first exploration, a voyage to the Canary Islands, under one John de Trasto. By 1418 his captains had discovered Madeira, which the Portuguese proceeded to colonize and own to this day. His exploration efforts were interrupted briefly while he returned to Ceuta to repel a Moroccan attack. Thereafter he was named Governor of the Algarve, the southernmost province of Portugal which reaches out into the Atlantic at Cape St. Vincent (associated with a British naval victory in Nelson's time). It was adjacent to this cape that Henry, in 1838, established his famous "navigation school", at Sagres. His concept was to support Portuguese explorations by a centralized institution for collecting knowledge of navigation, mapmaking and exploration.

Part of the Portuguese strategy vis-a-vis their competitor, Spain, was to invoke the authority of a friendly Pope, Eugenius IV, to divide the unexplored areas between Spain and Portugal by means of a Papal "Bull." The line chosen was a parallel of latitude generally running through Cape Bojador, North of which they were wiling to let Spain explore, but all discoveries to the south were to be Portuguese. Eugenius issued such Bulls in 1436 and 1443. It seems probable that Henry was the instigator of these Bulls, since he is recorded as requesting and receiving recognition of his discoveries from the Pope.

The last of this series of Bulls was issued 1481, setting the line at 27-30 North, and may have prompted Columbus, in 1492, to record his latitude as 42 degrees (when actually about 21 degrees) in one record, since the true latitude brought his discoveries into the Portuguese area. Fortunately by that time there was a Spanish Pope, Alexander VI (Borgia), who quickly revised the orientation of the divisory line by 90 degrees, and issued a superseding Bull, which eventually (1494) became the basis of the Treaty of Tordesillas.

In 1434 one of Henry's ships rounded Cape Bojador and by 1436 they had practically reached Cape Blanco. Exploration was again interrupted by domestic politics until 1441, when Antam Goncalves brought gold dust and, more important, slaves, from the Guinea coast. This was the beginning of the Portuguese slave-raiding, which lasted until about 1456 when Henry altered his policy and forbade it. In the meantime Henry's captains continued their voyages farther down the coast reaching Senegal in 1445 and Sierra Leone in 1446.

One of the most famous captains serving under Prince Henry was a Venetian Ca da Mosta, sometimes called Cadamosta. He explored both the Senegal and the Gambia rivers for some distance up their courses and discovered the Cape Verde Islands. In 1458 Henry sent out an expedition with the sole purpose of converting the negroes of Gambia to Christianity.

Henry was designated "Protector of Portuguese Studies" at the University in Lisbon, where he founded a professorship of Theology and chairs of mathematics and medicine. To instruct his captains and pilots in mathematics he obtained the services of one Master Jacome from Majorca. He also brought in both Arab and Jewish mathematicians. His mariners were described as well taught in astronomy and geometry and were provided with excellent instruments for their work. There is no question but that his court was the center of active and useful geographic work as well as the basis for the best practical exploration of the time. Prince Henry the Navigator died in November 1460 and was buried in the church of St. Mary in Lagos, later moved to the Monastery of Batalha. There are statues of him at the church of Belem (Lisbon), Sagres and in Funchal, Madeira.

MARITIME INFORMATION NOTES

By Ernest Brown

Chart No. 1-NOS/DMAHTC New Edition of Nautical Chart Symbols Abbreviations and Terms

The 9th edition of Chart No. 1, Symbols Abbreviations and Terms, has been printed and released for distribution. This edition has been totally redesigned into a new format. The most significant change is the incorporation of symbols of the International Hydrographic Organization's Chart INT No. 1.

This new and more logical arrangement shows the explanatory text in a center column, flanked by the U.S. symbols on the left and the international equivalent on the right. Also shown in a separate column are the symbols used on foreign charts reproduced by the Defense Mapping Agency.

Chart No. 1 may be obtained from Distribution Branch, N/CG33, 6501 Lafayette Ave., Riverdale, MD 20737, (301)436-6990, and from authorized sales agents of the National Ocean Service, or Defense Mapping Agency. This new arrangement should be more useful to the practicing navigator. The previous format was no more than a style manual for cartographers.GPS Satellite System

Selective availability (SA) has been implemented on all operational global positioning system (GPS) satellites in compliance with U.S. National policy. Users with unencrypted, standard positioning service (SPS) GPS receivers should be capable of achieving the advertised 100 meter POS/NAV accuracy, provided the proper number of GPS satellites are in view and satellite geometry is correct. Precise positioning service (PPS) users will be unaffected.

BOOK REVIEW

By Roger H. Jones

Compact Sight Reduction Table

(Modified H. O. 211, Ageton's Table)
Second Edition (1989)
By Allan E. Bayless
Cornell Maritime Press, P. O. Box 456, Centreville, Maryland 21617, 32 pages; $6.00

The late Rear Admiral Arthur A. Ageton (1900-1971) described "The Secant-Cosecant Method for Determining the Altitude and Azimuth of a Heavenly Body" in the U. S. Naval Institute *Proceedings* for October of 1931. His table was published as H. O. 211, "Dead Reckoning Altitude and Azimuth Table" until discontinued in 1971. (It reappeared in 1975 as Table 35 in Bowditch.)

H. O. 211 was the most popular and durable of all of the early "short methods" of sight reduction. It could be used with the coordinates of the DR position, and it required only simple addition and subtraction.

In 1980 the First Edition of Allan Bayless' *Compact Sight Reduction Table* appeared. This was a new and simplified version of H. O. 211. The actual tabular data was reduced to 9 pages from the original 36. This was accomplished through two significant changes. First, entries for half-minutes of arc were eliminated, resulting in a still very usable precision to the nearest minute of arc (one nautical mile without interpolation). Second, the numerical duplication in the second half of the Ageton table was eliminated. The 1980 update of the Ageton table became the standard compact table that was easily slipped into a sextant case, and it was used in the teaching programs of the U. S. Power Squadrons. (It should not be confused with the even newer "Concise Table" which now appears in the back of the *Almanac* and which was first devised by Admiral Davies.)

The 1989 Second Edition of Dr. Bayless' compact table retains the two significant changes of the First Edition, and it includes an important addition devised by the late D. H. Sadler, former Superintendent of H. M. Nautical Almanac Office and a well known British authority on navigation and navigation tables. Sadler has furnished an alternative sight reduction technique which makes it possible to salvage otherwise entirely satisfactory sights that were formerly discarded because they fell in a "forbidden zone" where K is between 82 and 98 degrees. (This involved slightly less than nine percent of all possible sights.)

The Second Edition also now includes a graph devised by Elliot Laidlaw by means of which these special sights addressed by the Sadler technique can be identified and the appropriate reduction technique can be selected before the table is opened. Finally, in keeping with the new terminology, GMT is now referred to as UT (Universal Time).

E. S. Maloney, editor of *Chapman's* and *Dutton's* 13th Edition has noted that every navigator who uses a calculator for sight reduction should have the ability to use at least one backup method. He has specifically referred to the Ageton method as being well suited to this purpose. The new features of the Second Edition, if anything, make Maloney's view even more persuasive.

This reviewer has copies of the original H. O. 211 and the First and Second Editions of the *Compact Sight Reduction Table.* It is always good to see an old friend made even more user-friendly. That happy result is a bargain at only $6.00.

WANTED

The following items are on the wanted list as of now.

1) Donald J. Pegg has been seeking for some time for a first or early issue of Martelli's Table. The cover has a picture of a building with a porch and lettering "Lightning Printers" or something similar.

2) Sid M. Miller of Hamden CT, wants to purchase an english edition of Kotlarich's Star Finder (described in the 1977 Bowditch).

3) Hiroshi Nakahama of Tempaku-ku, Nagoya, Japan, asks: a) Is there a book "The Practical Navigator" by E. C. Branter, published in 1844, perhaps by a publisher named J. M. Eleater? b) Does this book still exist.? If so where can I go to see it? Is it possible to get a copy of the first page? c) Is there any connection between Branter's book and Nathaniel Bowditch's "The New American Practical Navigator." d) Is Branter's book a simplified edition or is it an entirely different book from Bowditch, or is it the same thing?

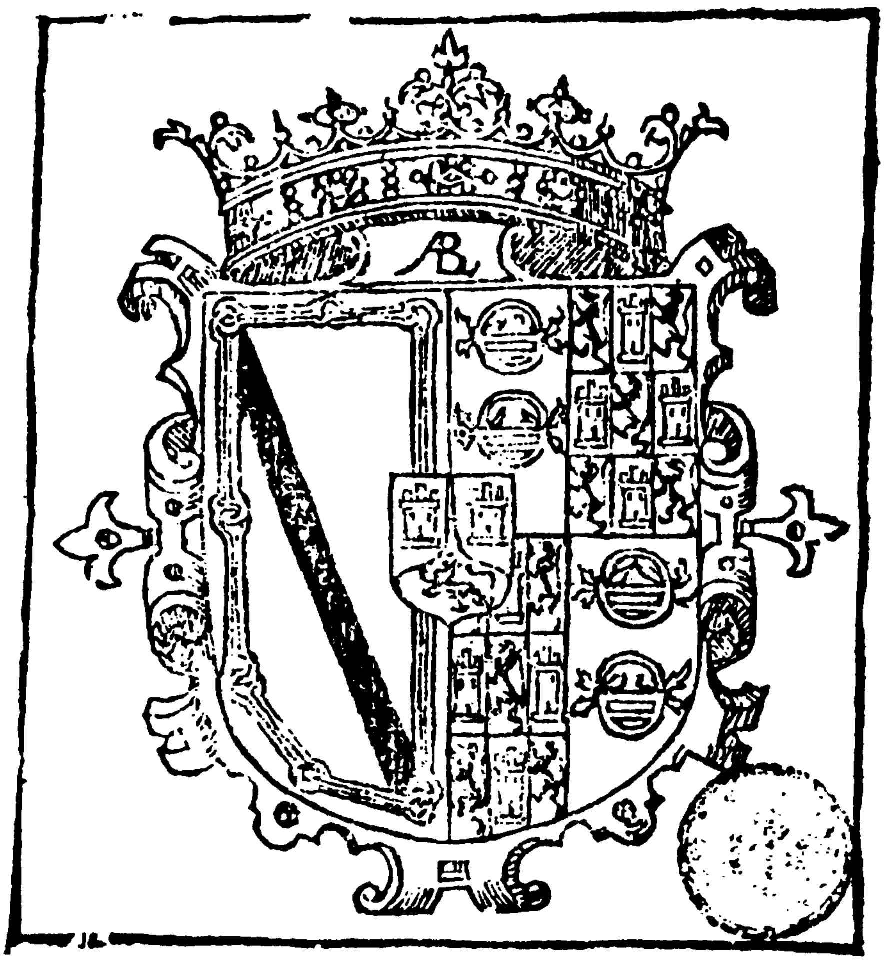
Anyone with knowledge of these items above please communicate directly with the Foundation.

INSTRVCION. NAVTHICA, PARA EL BVEN

Vſo, y regimiento de las Naos, ſu traça, y y gouierno conforme à la altura de Mexico.

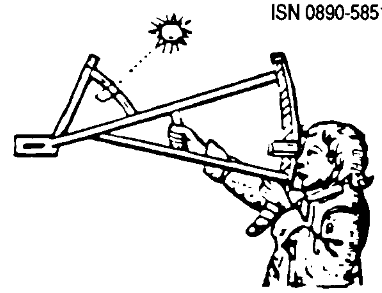
Cōpueſta por el Doctor Diego garcia de Palacio, del Cōſejo de ſu Mageſtad, y ſu Oydor enla Real audiē-cia de la dicha Ciudad.

Dirigido, al Excellētiſsimo Señor Don Aluaro Manrrique, de çuñiga, Marques de Villa manrrique, Virrey, Gouernador, y Capitan general deſtos Reynos.



Con licencia. En Mexico, En caſa de Pedro Ocharte. Año de 1587.

ISN 0890-5851



THE NAVIGATOR'S NEWSLETTER

FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

ISSUE THIRTY, FALL 1990

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

by T. D. Davies

The Supplemental Peary Report

Since the last issue of the Newsletter, readers have commented on our supplemental report. The Readers Forum has a sampling of these comments. As you can see they are almost 100 % favorable. Although we had to go to the expense of putting out a supplemental report, in a way we were lucky that the direct sun pictures were only discovered after we had completed and published our photogrammetry of Peary's pole pictures of April 6th and 7th. The direct pictures constituted a convincing check on the accuracy and quality of our work.

Not all of our critics would agree. One is now "investigating the suspicious accuracy" of our work. Another, who has criticized our statistical methods, has now written a paper purporting to show gross errors in our work which, when corrected, only places Peary within about 180 miles of the Pole. Although he received a copy of the supplemental report he ignores it. We have written a paper which shows that this distorted conclusion stems from his incorrect statistical methods, lack of knowledge of photogrammetry and unfamiliarity with the details of Peary's movements at the Pole. The standard deviations, band widths and all aspects of the report relating to the accuracy of our photogrammetry stand unchanged.

London Lecture

On 1 October I am scheduled to deliver a lecture on the Navigation Foundation and the Peary report, at the Institute of Civil Engineers, in London. This event is a bi-annual lecture established by the Permanent International Association of Navigation Congresses (PIANC), and named the "Sir William Harris' Lecture" in honor of one of their outstanding officers. The PIANC was established in 1885 with its secretariat in Brussels. It is a non-profit organization of private individuals, corporations and national governments. The term "navigation" in their title is used in its broadest sense and includes promoting the development of waterways as well as ocean navigation. It includes fisheries and sport and pleasure navigation.

While in London I expect to meet with two distinguished polar explorers, Lord Shackleton and Dr. Geoffrey Hattersley-Smith. These two gentlemen are quoted in our report and their experience provided us with invaluable knowledge. We depart on this trip on 14 September.

Cook Review

Some time after the Peary Report was published I received a communication from a gentleman who, noting that the recent death of the granddaughter of Peary's rival Dr. Frederick Cook had brought a collection of Cook's papers to the Library of Congress, asked if we would undertake to do a study of Cook's material like our Peary study. I replied that if there were indeed new material in the form of navigational data or photographs susceptible to photogrammetry we would consider undertaking such a project. After a review of the papers at the Library of Congress (including those previously acquired) I concluded that there was no data susceptible to analysis in our field of expertise. I have just answered his request to that effect.

Navigators Almanac

The 1991 edition of the compact Navigators Almanac is now available. The price to members is $5 and to non-members $8. It may be ordered direct from the Foundation.

Books

We have received several navigation books from Donald Pegg which are now lodged in our collection at the U. S. Naval observatory library. We expect several more shipments, include some rare books. In addition there are two more contributors who will meet with us shortly to discuss contributing other books.

Charts

The Defense Mapping Agency has advised us that they will no longer accept our orders for shipment direct to members, as they have in the past. Consequently all of our orders for members will be shipped only to the Foundation, and we will have to add postage onward to the member. This will be included in your billing.

Stamps

Members still are trying to be helpful by adding a stamp on our envelopes which have return mailing indicia. We appreciate this thought, but the Post Office charges us the full amount anyway, so the stamp is wasted.

Navigation Courses

George Lear will again offer his 10 weeks course in the fundamentals of celestial navigation commencing October 15, 1990 in Bethesda, Maryland.

The 12 classes will include: Fundamentals of celestial navigation, use of the sextant, and hand calculator. An on the water practice session may be scheduled in addition to the above. Call George Lear for details at (301) 986-0314.

READERS FORUM

Alva A. Hollon of Hazard, KY writes:

You may be interested to know that I visited the North Pole on April 15, 1990 together with a small group from the Lindblad and Quark Agency. It was quite a thrill. One can travel so far in the Northwest Territory, perhaps a thousand miles or more, and never see a tree; nothing but snow. It is something that one can remember. We took off by plane from Edmonton, Alberta. We stopped at Resolute Bay. Fromthere we went to Eureka and refueled there. We then went on to Lake Hazen where we stayed three days and nights in a canvas hut which was very comfortable. It had no electricity nor running water. We talked about Peary's trip to the Pole and everyone seemed to be in agreement that he really made it.

Norman G. Cubberly of Grafton, VA writes:

I compliment the Foundation on a very good report. I note that there are many though that seem to disagree out of hand. *Scientific American* magazine for one in a "Science and the Citizen" column practically rejected it out of hand. I go to sea full-time as a ship master and nay sayers abound. Just feel lucky that you are not attempting to defend Captain Lord of the Californian!

Also note that celestial navigation is alive and well. My surveillance ship not only has two Navsats and a Loran C, but soon is to have a P code 5 channel CPS. Still, my mates and I still confirm our positions daily with celestial. Of course, the modern types have to use an HP programmable with privately made up module. I at least, program my own TI 95 as I can also use it for such other things as ship stability, days between dates and payrolls.

I note that in Mr. John M. Luykx' "Navigation Basics Review" (in Issue 28) he mentioned that "2.— the steering compass should be aligned and adjusted by a qualified compass adjuster." I am by no means qualified but through force of necessity have had to adjust many compasses. Most recently I adjusted the compass of a beautiful 1932 motor sailer in Scotland which was out nearly 15 degrees on intercardinal headings when the clearview was off. This increased to nearly 30 degrees when it was on! Any compass adjustment is better than none and can be done "empirically" by most any intelligent boat owner. If you like I could donate a short article on this which would have almost no technical requirements.

Ed Note: The Scientific American *articles (there were two) are, we hope, an anomaly. I wrote a letter correcting the misquotes of the Report which they refused to print, and had a telephone conversation with the author which simply resulted in my being as badly misquoted in the next article, as the Report had been in the first one.*

Harry Dempster of San Diego, CA writes:

In response to J. David Smith's request for a simple solar position program in issue 29, I have enclosed a copy of one I developed several years ago. Feel free to publish it or distribute it to anyone interested. I would also be glad to discuss it or modify it for special applications if requested. *(See top of page 3.)*

In response to Robert W. Severance's request for watch error computations in the same issue, the following references may be useful.

"Longitude Without Time" by Donald Kerst, Navigation Vol. 22 No. 4, Winter 1975-76, pp. 283-292.

"Self-Contained Celestial Navigation with H.O. 208" by John S. Letcher, Jr., Chapters 15 and 16.

Thomas E. Dalby of Crystal River, FL writes:

I continue to be amazed at the efforts of small men to increase their stature by denigration of men of purpose and accomplishment.

Somewhere I heard that *National Geographic* is planning a TV program on Peary in December. If so, assume you will note the projected date in the next Newsletter. The 29th issue is great!

What is the Foundation's policy on reprints of articles? As a member and Past Commander of U S Power Squadrons, I find many items that are of interest to our local squadron, the District, and the national publication — *The Ensign.* I'm particularly impressed with the condensed clarity of subjects by Admiral Davies, and wonder if there is some manner in which I could seek permission

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                          SOLAR POSITION PROGRAM
INPUT:
Y = YEAR IN 1900 (2 DIGITS) i.e., 1980 = 80
M =    MONTH (JANUARY = 1)
D - DAY
U = HOUR - GMT (DECIMAL)
L - LATITUDE - + NORTH
G = LONGITUDE - + WEST

EQUATIONS:
N = INT(275 M/9) - INT((M+9)/12)*INT(7/4 + Y/4 - INT(Y/4))+INT(Y/4-1/4)-Y/4 + D + U/24 -
    202.56 + .007Y [Decimal Day of Year for 21 June 1980 Base]
X = .9856N  [Relative Solar Long.]
H = 15U + 180 + 1.785*SIN X - .455*CO5 X 2.48*SIN 2X + .066*COS 2X + .076S*IN 3X -
    .02*COS 3X - .054*SIN 4X [Greenwich Hour Angle]
H = H - 360*INT(H/360)     [Places 0'<H<360']
C = .377 + .27*SIN*X+23.26*COS X -.1*SIN 2X - .37*COS 2X + .17*COS  3X - .01*COS 4X
    [Declination]
R = H - G      [Local Hour Angle]
R = SGN SINR*ACS COSR   [Places -180'<R<180']
B = ASN(SIN L*SIN C + COS L * COS R)  [Altitude]
Z = ACS((SIN C - SIN L*SIN B)/COS L/COS B) [Azimuth]
    IF SIN R > 0 LET Z = 360-Z     [Places 0'<z<360']

[Accuracy of GHA and Declination better than .02' from 1960 to 2000]

NOTE:  INT means INTEGER
```

to submit articles for reprint by USPS?
Ed Note: Permission is granted to non-commercial publications to reprint any article from the Newsletter.

Henry John Moore II from Palo Alto, CA writes:
As a result of reading your report, it appeared to me that there may be an ongoing controversy between the Foundation and Herbert, Rawlins, or both. Your report and the one in the *National Geographic* convinced me that Herbert was "full of beans', but I am unfamiliar with Rawlins.

Your arguments that Peary, Henson, and the Eskimos reached the pole appear to me to be good ones. Like other critics, I have misgivings about your photogrammetric procedures (e.g. what rigorous criteria were used to establish the location of the horizons?) and how did you define a shadow in pictures where substantial diffuse scattering of light was obvious? Nevertheless, your arguments appear to be reasonable. What is important is the independent appraisal of Peary's location using his photographs.

In any event, 1000 holders of your report seems like a small number. Your position should receive a wider distribution but I find that your report is poorly written. It reads like a ship's log. What I would suggest is that you find a talented popular writer (not me) who would be interested in presenting your views and results in a short book that could be read by a wider audience. Although the National Geographic article was a good one, the story was not fully told.
Ed Note: We are talking to publishers about such a book; nothing firm yet.

Samuel S. Cross of Stamford, CT writes:
How thoughtful of you to send me a copy of the Supplemental Report to the NGS on Robert E. Peary at the North Pole. The indictment of Wally Herbert's analysis and position was handled superbly and with an excellent note of finality. The report also puts Dennis Rawlins to rest and should silence Russell W. Gibbons.
Congratulations!

Louis A. Valier of Honolulu, HI writes:
The Newsletter is a fine paper and it is always a pleasure to read it. Always some tidbits not seen elsewhere.

An article in the spring issue interested me, the one by Harvey H. Dresser, Jr. about Navigation Programming. My first efforts in programming were on a Hewlett Packard 75-c. It had an excellent basic which would handle degrees very easily and all the trigonometric functions and arc functions. It spoiled me. Unfortunately, HP let the good little instrument die on the vine. Not wanting to be caught with a computer which might similarly be declared obsolete, I switched to an IBM PC compatible, Zenith Laptop.

The GW Basic used by Zenith is very clumsy compared to the HP basic used previously. Radians and the lack of arc sines and cosines made programming slow and aggravating. Then I found a basic which handles degrees with all the arc functions very easily. Wish that it had been found earlier.

The reference is to True Basic by Kemeny and Kurtz. The original Basic was developed by these gentlemen at Dartmouth in 1964 and comes from the words Beginner's All-Purpose Symbolic Instruction Code. A few years ago they came out with True Basic, a modern, up-dated Basic which is far superior to other "basics". It handles trigonometric functions in degrees (or radians) with the necessary arc functions. For those who write programs using these functions I can highly recommend True Basic. It is available from True Basic, Inc., 12 Commerce Ave., West Lebanon, N.H, 03784.

Keep up the good work!

Thomas L. Scatchard of Philadelphia, PA writes:

I have given my copy, recently received, of Robert E. Peary at the North Pole, to my friend Frank Wodal, a fellow member of the Explorers Club.

Although not now a member, I was a very early member of "The Society of Photographic and Photogrammetry". Mr. Wally Herbert's cavalier treatment of this as "armchair theory" (May issue *National Geographic*) should not go unchallenged. To anyone with even a slight knowledge of Optics, it should be obvious that this is a branch of the rigorous mathematical science of Optics.

Claude Huguenin of Tripoli, Libya writes:

The report makes fascinating reading and I wish to warmly congratulate your Foundation for such a remarkable and thorough work. Bravo!

Thank you also for your explanations on the heated mercury and wooden bowl. In my desert treks in Saudi Arabia and now in Libya I first used nautical sextant and a pan of heavy gear oil which although satisfactory was a little messy. This was superseded by an ex-RAF Bubble sextant which in conjunction with TPA 1:500,000 charts gives acceptable accuracy for the vastness of the desert. I have been laboring for the past three years with an article on a sun compass which I developed on the Bagnold type but with remote control for use in today's mainly closed 4-wheel drive vehicles. I intend to submit it to the Royal Institute of Navigation in London for possible publication. Should anyone in your Foundation be interested, I would be glad to send a copy of the draft.

J. Alan Bell of Merseyside, England writes:

It was with great interest that I read Rear Admiral Davies's report, in the January 1990 copy of *National Geographic*, on the question of Comdr. Peary's final position at the Pole. As master of an inshore seismic survey vessel, with 'state of the art' navigation systems, I found it most refreshing to sit and dredge up, from the recess of the brain, equations, and formula required to understand the findings set out in the article. Because of the fine limits required in seismic surveying electronic/satellite enhanced position fixing systems are essential. 'Shooting a line' sixty or so kilometers long, and keeping the vessel five meters either side of that line, would be impossible without such aids. But even then the watch officer has to make mental calculations continuously to allow for wind, tide, weather, etc.; so even in this modern age the old navigator's skills are required to ensure that a multi-million dollar operation works!

I feel that in this 'push button' age of navigation, the old art is, in general, being ignored. Not only is this a sad condemnation of our profession but must relate to the increase in the number of marine accidents in recent years. We have had the 'radar assisted collision', the 'radio assisted collision', how long, I wonder, will it be before the term 'electronic assisted grounding' enters the marine vocabulary?

I feel that it is important that practical, basic awareness should be maintained within the modern usage of navigation equipment, and to this end I would be pleased if you could send me more details of the Foundation and its workings.

Paul V. Devlin, Jr. of Lexington, MA writes:

Thank you for forwarding the supplemental report. Please find enclosed the $3.00 check you have requested. How trusting you are! Any other outstanding controversies you might answer in your thorough, thoughtful manner? Best of luck!

Stafford Campbell of Jacksonville, FL writes:

You may have seen the enclosure from the Royal Institute's current issue of the *Journal of Navigation* containing Dag Pike's provocative view of the future role of electronic navigation. I don't know to what extent this concept might be embraced by the Board of the Foundation, but as a practicing yacht navigator and writer, I think it is dangerous. Even as yachtsmen take full advantage of the modern devices designed to ease the navigator's burden, I see celestial techniques, as the only totally passive and self-contained method, having to remain as the ultimate backup well into the future.

Coincidentally, I had just completed a piece along these lines for *SAIL* magazine well before Pike's commentary appeared at the time I was planning another Atlantic crossing under sail, a voyage I have recently completed. My navigational experiences, which I believe to be typical of many yachtsmen's, seemed to reinforce my convictions; the electronics were a great boon when they were working perfectly, but there were enough uncertainties to make celestial a necessary part of our routine almost daily. I would be most interested in comparing your and your Newsletter's readers' experiences with my own, both with respect to the reliability of the electronic displays and the methods we used for checking on them. For reference, the vessel I sailed on was fifty-seven feet overall, well-found and well-shaken down, with high-quality instrumentation: Loran, satnav, radar, depth-sounder, speedometer, and compasses. Everything tested and was operating properly when we left the dock.

Once at sea, and at various times during the three-week voyage, one or more of the electronic devices took turns "going off on their own." There was no failure or interruption to the ship's power supply, nor external accident to the equipment, and, usually, no prior indication of any aberration.

The loran readings, ostensibly showing latitude/longitude positions to the hundredth of a minute, wandered many miles out and back from the true position as we sailed through fringe waters. Finally, half-a-day west of Bermuda, it began to indicate the unreliability of its readings altogether. The satnav receiver performed well all across the Atlantic except for periods of several hours at a time when satellite contacts were unavailable and the position it indicated was the result of dead reckoning from an earlier fix. Since that position was only as good as the course and speed inputs, and the latter was frequently subject to aberrations of its own, it, too, represented a risk in placing total dependence on it for precision landfalls.

Radar, without mechanical or electronic problems, worked well, but with limited antenna height the range and the ability to distinguish low-lying reefs from sea clutter_especially with a sea running and a moderate fog we experienced approaching Bermuda—was limited. The depthsounder was of use in the inshore approaches, but even though it was of very good quality, it was of no help in the majority of the navigation offshore. The speedometer managed to pick up weed on its impeller from time to time causing errors in its input to other instruments such as the satnav, and when small, were often difficult to detect right away. Compasses also can fall prey to magnetic materials that stray into their fields—a common occurrence on a yacht in a seaway—and a constant check is essential in the absence of terrestrial references. So much for the inherent reliability of modern electronics for yachtsmen.

The routines we adopted in order to monitor the instruments were threefold: a continuously maintained, old-fashioned manual plot—to provide an early indication if we were wandering from our intended track—a daily check on the compasses by sun's azimuths, and a short- cut method for checking the position displays on the loran and satnav, which I haven't seen described elsewhere, but which worked very well for us.

The latter method, which we used at least once every day the weather made it possible, consisted in taking a celestial sight of any convenient body at any convenient moment and reducing it immediately by hand-held calculator. Standard celestial formulae were used in the reduction, but the novel part was using the reading from the electronic device as the assumed position. For this purpose, we solved only for the intercept, reasoning that if the electronic reading was good, the intercept would be very small.

In practice, if the electronics were correct, the intercept was usually less than a mile or two, and in good weather even better. If there was any indication of an error in either the celestial or electronic result, the regular celestial routine was continued until the error was pinned down. I used an HP41-CV calculator with time module and a pre-established program for the reduction. Usually I had results within a minute or two. I would be interested if any of your correspondents have had an opportunity to utilize such a check at sea, and if any have any ideas for further improvements or refinements.

The whole idea of replacing celestial by electronic devices will, I'm sure, come more and more into the forefront as GPS becomes widespread amongst civilian users, especially in the recreational market. I think the Foundation will be in a position of leadership in determining the gap between salesmanship and prudence in navigation at sea. Looking forward to your comments.
Ed Note: Members are encouraged to send comments.

Peter A. Luft of Oakland, CA writes:

I would like to commend you on the caliber and style of your editorship of *Robert E. Peary at the North Pole*, which I read in January, hot off the presses as it were. Not only have you succeeded in conveying a great deal of non-mainstream technical information clearly and concisely, you have breathed life into the episodes of Mr. Peary in an unusually natural way. I am strongly reminded of the documentaries of the first explorations of the sources of the rivers Nile, written by Mr. Alan Moorehead, i.e. The Blue Nile, and The White Nile, which also fascinated me. Of particular technical interest to me in your book was the treatment of the photogrammetric method of shadow analysis. I have an interest in this area stemming from research done in obtaining a sundial patent (#4,346,521). In fact, it was from this research that I first understood the navigator's requirement for practical and compact books on celestial events, in contrast to the unwieldy academic compilations which are all too prevalent. As a result, I tend to seek the former out over the latter. For example, I would much rather read from *The American Practical Navigator* than The Explanatory Supplement to the Astronomical Ephemeris, which I always have difficulty with. Imagine my delight, therefore, in reading the *National Geographic* article of January 1990, and learning of the existence of your volume! I can say with complete candor that my expectations were met and exceeded.

I was wondering if I might ask for your assistance in one matter. There are two books in the bibliography which are of particular interest to me. They are: *Manual of Photogrammetry* by Chester C. Slama and *Simple Photogrammetry* by John C. Williams. Unfortunately, I have been unable to locate either one. As I explained to Mr. Terry Carraway in a very cordial telephone conversation earlier this year, the American Society of Photogrammetry, the publisher of the first book, and listed in the bibliography as being located in Falls Church, Virginia, is apparently no longer located there, at least according to the telephone operator I spoke to.

Also, the publisher of the second book, Academic Press, is not listed in the standard publisher's directory, according to a local university book store. So I was wondering if you could give me some clues there; that is, how I might get a copy of the above.

The thought occurred to me that the photogrammetric technique you used would lend itself very nicely to application via computer-aided-design, in particular using a three-dimensional database structure developed for mechanical design. The advantage is that it permits graphical solutions with an accuracy of six or seven decimal places. One of the things that plagued me in building my sundials was the difficulty of checking large formulaic constructions on paper by myself, even using a modern calculator (I was doing some rather precise perspective projections of analemmas). With the CAD system, one simply builds the graphics first (a process which provides a great deal of built-in verification), then queries the database for the analytic description. It's very clean and error free. Your elegant but much simpler successor technique of direct solar image measurement may render the above suggestion moot, however. In a way I'm glad you discovered the two relevant images last. Otherwise, the world might have lost a remarkable treatment on the inter-relationship between perspective, time, the sun and the shadows it casts.

For your information I'm enclosing a couple of samples. *Ed Note: Mr. Luft. enclosed some very interesting samples of 3D figures, complete with 3D (2 color) glasses. The "American Society of Photogrammetry and Remote Sensing" is still in Falls Church, Telephone # (703) 534-6617. J. C. C. Williams book was published in 1969 and is difficult to find. Our copy was found in the library of the U. S. Geological Survey, in Washington.*

NAVIGATION BASICS REVIEW

Time and Longitude by Celestial Observation

By John M. Luykx

Although the probability is very small, the possibility always exists that while underway during a voyage, the vessel's chronometer may unexpectedly acquire an unknown, unexplainable error or may even run down and stop completely. As a result the navigator may be without an accurate time reference for perhaps a long period of time. Under ordinary circumstances, however, when at sea, away from shore, the chronometer may be reset and as a result the value of longitude may be regained by employing any one of the several methods described below.

When a chronometer has developed an unexplained error or has run down, the following procedures may be employed to restart/reset the chronometer to correct time. They are listed in the order of the accuracy by which the chronometer error is determined.

1. Radio time signal
2. Comparison and/or setting with another timepiece on board known to be accurate and correct
3. Time signal from a passing vessel by visual or electronic means
4. Chronometer time sight from a known position.

When the position of a vessel is known, the chronometer if run down * may be restarted and reset and its error determined by comparing the longitude computed by time sight with the known longitude. The difference between the two, converted to time, is equal to chronometer error. This method of computing chronometer error is especially useful when, for example, an accurate LORAN C Fix (or other electronic Fix) is obtained or when the position of the vessel is fixed using an echo sounder from reliable bathymetric information such as a well-defined sea-mount, a deep trough or a steep gradient. Whenever the time sight method is employed, the altitude of a celestial body is observed when the azimuth is preferably easterly or westerly. The sextant altitude and time by chronometer are noted and the latitude and longitude of the vessel's known position recorded for the time of observation. Longitude is then computed using the following formulae:

a. $\cos t = (\sin Ho - \sin L \times \sin d)/(\cos L \times \cos d)$

b. $LON: = GHA \pm t$

If the observed value of longitude is to the west of the actual longitude, the chronometer error is (+); if it lies to the east, the error is (-).

* Note: If a chronometer has run down and has stopped, it may be restarted and initially reset in accordance with the position of the vessel as established from the best estimate of the course made good combined with the distance made good by log since the last known position. This estimated position is compared with the vessel's intended position along the DR Track to obtain the nearest value of Zone Time (ZT) as shown on the DR Track. Applying the appropriate Zone Description (ZD) to the Zone Time provides an initial estimate of the Greenwich Mean Time (GMT) to be set on the chronometer. Once the chronometer has been initially set, its

error can then be computed as already described.

The procedure for restarting and initially resetting a stopped chronometer is best described perhaps by an example:

Assume a vessel in LAT 40°N, LON 60°W on course 090° T at speed 10 kts. The last known position was a noon running fix at 12-00. Some time during the afternoon the navigator notices that the chronometer has stopped with the hands showing 06-20. Upon discovery of chronometer failure, the navigator records that the distance made good by log since 12-00 was 43.7 miles (equivalent to approximately ZT 16-22). With this information, the navigator sets the chronometer to time 08-30-00 (ZT 16-30-00, ZD +4) and waits for the log to read 45.0 miles made good since noon before restarting it.

Once the chronometer has been initially reset, its error can be determined by the method already explained or by methods to be subsequently described.

Example of the Time Sight Solution for Chronometer Error:

A vessel is underway to Bermuda from Chesapeake Bay on 18 August 1990. The chronometer stopped during the earlymorning hours and was reset with a large unknown error.At time 09-57-30 by chronometer during morning twilight,an observation of the Star Procyon 20° off the port bowwas taken by sextant to determine the chronometer error.The sextant altitude was 16°03'.9. At the time ofobservation the ship's position was fixed by Loran C at LAT: N 35°46'.0 LON: W 72°47'.0. What was the chronometer error?

Solution:

```
A. Hs     16°03'.9
   Dip       -2'.4
   I.C.      -1'.5
   Ha     16°00'.0
   Ref       -3'.3
   Ho     15°56'.7
```

B. $\text{Cos } t = \dfrac{(\sin Ho - \sin L \times \sin d)}{(\cos L \times \cos d)}$

$= \dfrac{.22121}{.80797}$

$= .27378$

$t = 74°06'.7$

```
C.      GHA Procyon: 001°07'.5
               + t   074°06'.7
      = Computed LON: 075°14'.2
      - Actual LON:   072°47'.0
      = LON Difference +2°27'.2
```

```
Time Difference: +9 min 47 sec.
Chronometer Error: 9 min 47 sec fast
```

Equal Altitude Observation from a Known Position

This procedure involves taking equal altitude observations ** of a celestial body before and after meridian passage while the vessel is proceeding on an East/West course or hove to and stopped at a known position (i.e. vessel position established by Loran C or other electronic fix or bathymetric fix). Any celestial body can be used for this purpose. The chronometer times of the two observations of equal altitude, the first prior to meridian passage and the second following meridian passage are "averaged" to obtain the mean value of time. This mean value of time equals the chronometer time of meridian passage. The GHA of the celestial body for this time is compared with the known longitude to obtain the longitude difference which when converted to time provides the chronometer error.

** Note: To improve accuracy, a series of observations on both sides of the meridian are recommended. These are then plotted on graph paper and a series of "averaging" computations made. The mean value of these times then becomes the chronometer time of meridian passage.

Example of Equal Altitude Solution for Chronometer Error:

During the morning of 20 June 1990 enroute to Bermuda from Chesapeake Bay, the chronometer stopped and was restarted and set with a large probable error. The navigator decided to use the equal altitude method of computing chronometer error and, therefore, changed course about an hour prior to LAN to an easterly course. The course change eliminated an altitude change factor which would have been caused by the vessel proceeding on a course with a northerly or southerly component. The following data was recorded:

A. Prior to LAN at chronometer time 15-46-58 an altitude of the sun was obtained: 74°13'.3 and the vessel's position fixed by Loran C at LAT: 35°32'.5, LON: W 72°16'.6.

B. At LAN, approximately 16-31-52 by chronometer the maximum altitude of the sun was measured: 77°42'.2

C. Following LAN the navigator waited until the sun's altitude was again equal to 74°13'.3 at which time the chronometer read 17-35-19. The vessel's position was fixed by Loran C at LAT: N 35°32'.5, LON W 72°07'.4

What was the error of the chronometer?

Solution:

```
A. Longitude at LAN:        W  72°16'.6
                          + W  72°07'.4
                            2  144 24.0

                          = W  72°12'.0

B. Time of LAN:                15-46-55
                             + 17-16-56
                            =2 32-62-11
  =Chronometer Time at LAN     16-31-56


      C.T. at LAN:             16-31-56
                        GHA    67°36'.4
               Actual LON:  W 72°12'.0
               LON Diff:     - 4°35'.6
               Time Diff:   -18 min 22 sec

     Chronometer Error: 18 min 22 sec  slow
```

Lunar Altitude Observations from an unknown position

This procedure is based on the principle that the moon's average motion relative to the stars is approximately 37' (variable from 30' to 45') of arc per hour (relative to the sun about 30' of arc per hour) which provides a means for finding the approximate longitude. The procedure involves obtaining a near simultaneous series of altitude observations of themoon and several stars. If the fix when plotted on a chart shows that the moon LOP coincides with the LOPs of the stars to form one well-defined fix, then there is little if any chronometer error. If, however, the resultant fix shows that the moon LOP plots to the east or to the west of the fix, then the amount of chronometer error is equal to the difference in longitude between the star fix and the Moon LOP in minutes of arc multiplied by the difference in minutes of arc between the rate of change per minute of time of the moon's GHA and the GHA of Aries. For example:

Assume that the Nautical Almanac shows for the date and approximate time in question that the moon's GHA changes at a rate of 36'.0 per hour compared to the GHAof Aries. The rate of change of the moon's GHA relative to the GHA of Aries per minute of time is then 60/36 = -1.67 minutes of time per arc/minute.

If then as a result of a simultaneous multi-star/moon fix, the moon LOP is found to be 7'.3 minutes of longitude to the east of the multi-star fix, this would indicate that the chronometer error is fast (the moon's relative motion to the stars is eastward with the passage of time) by an amount equal to

```
7'.3 x 1.67 minutes = 12.191 minutes
                    = 12 m 11 seconds

          CE   = +12 m 11 seconds Fast
```

This example also shows that an error of 1'.0 in computing the actual longitude difference between the multi-star fix and the moon's LOP results in a 1 minute 42 second error in chronometer error computation or approximately an error of 20 to 25 minutes in longitude.

To improve the accuracy of chronometer error computation, it is recommended that a series of 5 to 10 observations of each body be taken and that mean values of time and altitude be used in sight reduction.

Example of the Lunar Altitude Solution for Chronometer Error:

During the early morning of August 18, 1990 while enroute Bermuda from Chesapeake Bay, the navigator of a vessel notices that the chronometer has stopped. Based on DR Track information and estimates of course and distance made good since the last fix, the chronometer is restarted and reset with a large probable error. The navigator assumes the vessel's position to be somewhere in the vicinity of LAT N 35°40' and LON W 72°40' and decides to employ the lunar altitude procedure while hove to at morning twilight to determine the chronometer error. The following altitude observations were made:

A.	BODY	CHRON.TIME	SEXT.ALT.
	Polaris	09-19-55	36° 37'.9
	Procyon	09-22-23	16°04'.1
	Moon (LL)	09-24-19	19°39'.9

Sextant I.C.= -1.5 H/E= 6.0'

B. The resultant fix at 09-20 from the Polaris and Procyon LOPs places the vessel at LAT: N 35°45'.7, LON: W 66°29'.8

C. From the fix position the moon's LOP is located: ZN 078°.1, Intercept 13.2 miles away

D. This azimuth and intercept places the moon's LOP 16.7 minutes of longitude to the west of the fix position.

E. From the Nautical Almanac the hourly change of GHA of Aries is found to be 15°02'.5 and for the moon the hourly rate equals 14°26'.3. This means that the motion of the moon relative to the stars equals: 15°02'.5 minus (-) 14°26'.3 or 36'.2 per hour. In effect the moon's motion relative to the stars is 1.0 minutes of longitude for each 1.66 minutes of time;(i.e. 60/36.2 minutes) in an easterly direction.

F. Since the moon's LOP lies 16'.7 minutes of longitude to the west of the star fix position, the chronometer error is equal to 16'.7 x 1.66 minutes or 27.90 minutes which equals 27 minutes 54 seconds slow.

The value of chronometer error can be continually refined by applying the computed chronometer error and re-computing the fix. The chronometer error in each subsequent step is further refined until a chronometer error is computed which results in the moon LOP passing exactly through the point of the star fix. Because this procedure is prone to error and very time consuming, it is best to use a computer. Human error in calculation and plotting is thus easily eliminated. The author used the CN-2000 System for the lunar altitude method calculations described above. The almanac program of the computer as well as its fix computation accuracy is within 0'.2.

The direction of the chronometer error; i.e. either fast or slow is determined from a) the location of the fix position relative to the approximate or estimated position and b) the location of the moon line of position relative to the position of the fix.

If the chronometer fix is to the east (or earlier) the chronometer is slow and the chronometer error is minus (-).

If the moon LOP lies to the west of the star fix, the chronometer is slow and the error is minus (-). This is explained by the fact that the moon moves from west to east among the stars rather than the other way around.

Lunar Distance Observation from an Unknown Position.

Because of the moon's relative motion (between -30' and -40' per hour eastward) among the sun, planets and stars, it is also possible, by direct angular measurement, to compute the chronometer error and the approximate longitude. The procedure is briefly as follows:

The angular distance between the moon and a star (or the sun) is measured with a sextant at the same time as a simultaneous altitude of each of the two bodies is taken. The time of each observation is recorded from a watch of known rate. The observed lunar distance is then "cleared"; i.e., corrected for refraction, semi-diameter and the moon's parallax. The Nautical Almanac is then used to compute the GMT at which the cleared lunar distance occurred. This time is the correct chronometer time of the observation. The chronometer can now be correctly set from the watch times recorded for each altitude and distance measurement obtained during the lunar distance observations.

The lunar distance computations are very extensive and too involved for an example to be presented here. However, those members who wish to obtain a detailed explanation of the lunar distance observation with an example of a solved problem may address requests to the author through the Navigation Foundation.

HISTORY OF NAVIGATION

The Bygrave Position Slide Rule

By John M. Luykx

In 1920 the Air Ministry Laboratory (A.M.L.) in London authorized Henry Hughes and Son, the well-known firm of nautical instrument makers, to manufacture a logorithmic cylindrical navigation slide rule invented by Captain L. C. Bygrave. The "Bygrave" slide rule, as it is now known, was designed to compute the altitude and azimuth of the celestial body from values of:

1. Observer's DR Position or assumed position
2. GMT of the observation
3. GHA and DEC of the celestial body

and to compute the initial Great Circle True Course and Distance in arc/minutes between two points when their LAT/LON coordinates are known.

The Bygrave Slide Rule was the favorite method of celestial sight reduction for post World War I air navigators because it was a mechanical device which was compact, handy and portable. It was only 9 inches long (closed) 2 1/2 inches in diameter and with cylindrical metal case weighed less than 2 lbs. (See Figure 1) Like the Weems Star Altitude Curves, it could conveniently be carried and worked in the close confines of an aircraft cockpit. Although the Nautical Almanac was required to provide the GHA and DEC of a celestial body, solutions accurate to 1 arc minute were possible and could often be completed (with practice) in less than 2 minutes.

The design of the Bygrave Slide Rule is based on the navigation triangle where a perpendicular from the body's Geographical Position (G.P.) is drawn to the observer's meridian forming two right angled spherical triangles with the perpendicular and the right angle in common.

From a Henry Hughes Catalog of Instruments issued prior to World War II, we read that in addition to the housing, the main parts of the slide rule consist of "...two scales which are printed on two cylinders sliding with reference to each other. The inner cylinder on which all results are read is graduated with log tangents and the spiral scale is about 24 feet long divided into minutes of arc. The outer cylinder is graduated with log cosines. Two pointers are provided; one for each scale and are attached to a sliding ring. The pointer which was to be used for each setting is clearly marked and full instructions for dealing with all possible cases are printed on the bottom of the outer cylinder..." On the back of the slide rule are given scales of dip, refraction, moon parallax and an arc to time table. The only other information needed for sight reduction is GHA and DEC data from the Nautical Almanac.

The Bygrave Slide Rule is described, or at least mentioned, in most of the standard navigation texts and was considered by Captain P.V.H. Weems "...as probably the most convenient mechanical computer for obtaining position lines from sextant observations...."

Nine steps (settings) are required to complete the sight reduction process from given values of LHA, LAT, and DEC. Each step requires rotation of either the inner or outer scale and its alignment with either one of the two pointers. At the sixth step azimuth angle (Z) is computed and at the ninth setting computed altitude (Hc) is obtained. With practice the nine steps may be accomplished very rapidly and in many cases in less than 2 minutes. Through experience with the Bygrave Slide Rule in his collection, the author has found that great attention must be given to the alignment of the scales with the pointers but that, with sufficient care, excellent accuracy; i.e., to within 1 arc/minute, can often be achieved in the computation of both azimuth and altitude.

To illustrate the order of accuracy possible with the Bygrave Slide Rule, five sample problems were solved with the rule: four sight reduction problems and one Great Circle problem. The sight reduction problems consisted of given values of LHA, DEC and LAT requiring solution for true azimuth (ZN) and computed altitude (Hc). The Great Circle problem consisted of finding the initial true Great Circle course and Great Circle distance in arc/minutes between two points whose LAT/LON coordinates are given. Table 1 gives the results of the sight reduction computations and Table 2 the results of the Great Circle Sailing computation.

The results in Tables 1 and 2 indicate the inherent accuracy of the Bygrave Slide Rule and the author can personally attest to the rapidity with which computations can be made and to the portability of the instrument and its simplicity of design.

TABLE 1
SIGHT REDUCTION

	1	2	3	4
GIVEN:				
LHA:	77°31'.2	326°41'.8	48°04'.8	297°21'.3
DEC:	N18°06'.2	S09°16'.3	S57°16'.2	N36°42'.3
LAT:	N38°51'.8	N18°31'.2	N04°17'.2	S11°13'.0
FIND:				
ZN:	276°.9T	127°.4T	204°.9T	47°.2T
HC:	20°47'.0	46°57'.0	17°16'.0	14°12'.7

SOLUTION BY TAMAYA NC-2 CALCULATOR

ZN:	276°.9T	127°.4T	204°.9T	47°.3T
(Diff.)	0°.0	0°.0	0°.0	0°.1
Hc:	20°47'.3	46°58'.0	17°17'.9	14°11'.2
(Diff.)	0'.3	1'.0	1'.9	1'.5

TABLE 2

GREAT CIRCLE SAILING

GIVEN:

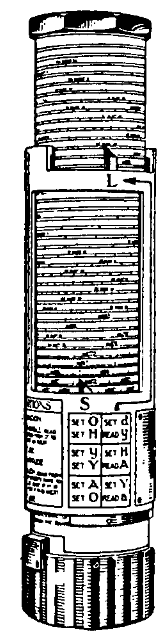
Point A:
LAT: N 38 51'.8
LON: W 76 55'.1

Point B:
LAT: N 50 15'.0
LON: W 08 20'.0

FIND:

Great Circle initial true course
Great Circle distance in arc/minutes

BYGRAVE SLIDE RULE		NC-2	(Diff.)
Course:	052°.8T	052°.8T	0°.0
Distance:	2901'.5	2902'.7	1'.2



Bygrave Slide Rule
Figure 1

NAVIGATION NOTES

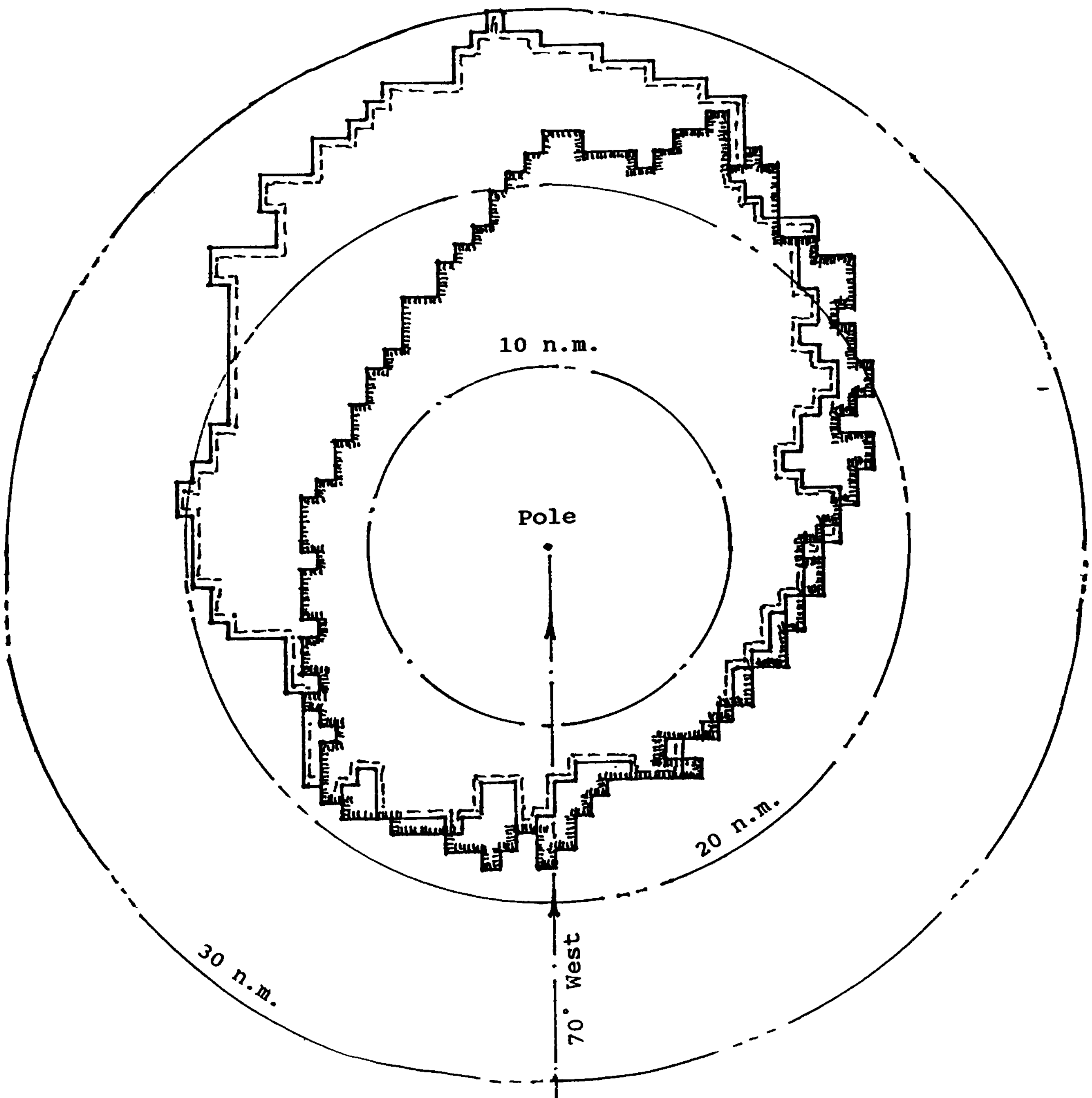
Probability and the Celestial Fix

by T. D. Davies

In an Appendix to the American Practical Navigator, which is entitled "Navigational Errors", one can find an excellent discussion of random sight errors and how they affect the LOP's and the resulting fix. If an LOP is treated as a band including plus or minus one standard deviation (one sigma), the probability of the sight being taken within that band is 68 %. The discussion goes on to cover the fact that the probable area of the location of the fix from the two lines of position is not the parallelogram intersection of the two bands, but is an ellipse.

The corners of the parallelogram represent locations near the edge of both bands that are less likely than positions near the center of one band but slightly outside the other. The special case of only two lines which are orthogonal to each other is developed to show that the error figure is a circle. A more likely case with three lines is not discussed, as it is mathematically intractable.

Recently our report on Robert E. Peary at the North



Pole has engendered a challenge from a reader concerning the same problem, as it relates to the wide bands (26 to 30 miles) derived from the Peary photographs, rather than the narrow bands (only a mile or so wide), in the case of an expertly done celestial observation.

In the report we use bands in which there was a 68 % probability that Peary was there. Our correspondent argued that use of these narrow bands was misleading in that the probability that Peary was in the intersection of two bands (we actually had three) was only 46 %. Thus there was a greater probability, 54 %, that he was outside that intersection than that he was in it. To many navigators crossing two lines of position as fix, this would come as a shock.

Of course the answer lies in the fact that there are areas of substantial probabilities very close to, but outside, the actual intersection, which should be added in to constitute the circle or ellipse of high probability of location, as described in Bowditch. Since both Bowditch and our correspondent treated only two lines or bands of position and three bands were plotted in the report we felt that the situation needed to be treated more fully.

A probability density computer model was constructed to do this. Using the data derived from the Peary photographs, which had produced three bands of position, a probability was computed for one-mile by one-mile cells throughout the polar area. This two dimensional probability density map was then used to define an area such that the probability that Peary was in it was 75 %. The result is shown in the accompanying diagram.

Although the size of the cells gives the curve a jagged look it can be seen to approximate an ellipse. The outer lighter curve is the result of the three bands in the basic report, while the darker smaller curve represents the 75 % probability area from the bands modified to include the direct sun pictures described in the supplemental report. In each case the curve is essentially circumscribed around the original polygon of the intersection, thus including the nearby areas of substantial probability outside the edges of the polygon. In any case it is clear that the probability that Peary was less than 20 miles short of the Pole is 75 %. Adding 5 miles around this curve raises the probability to 90%.

Although these curves are for wide bands and distances of 20 miles they can be scaled down to values likely to be used in celestial sights. If all of the values are divided by 10, the result looks very much like a good 3 line sight with sextant standard deviations of about 1.5 to 2.0 miles. The fix then would have a 75 % probability of being as shown, where the circles are 1, 2 and 3 miles

A Navigation Problem

By Roger H. Jones

Solution to the Problem in Issue 29

31. Answer

From the *Almanac* at GMT 0800 on June 30, 1990, the GHA Aries is 38-07.9. At longitude 68-30.0 West, the LHA Aries is (38-07.9 + 360-00.0) - 68-30 = 329-37.9. With the blue template for 35 North in place on the base, rotate the arrow to line up with 329.6 on the rim. There is no star appearing on the base at an altitude of 50 degrees on a bearing of 190. Holding the blue template steady on LHA 329.6, lift the edge and place a pencil mark at the intersection of altitude 50 with bearing 190.

Now remove the blue template and replace it with the red one, with the "North" side up. Align the arrow line (to the left of the open slot) with the pencil mark, and read the declination as 5+ South. The rim scale reading is 323. The star's approximate SHA is 360 - 323 = 37. (If in doubt as to whether the declination is North or South, simply look up any adjacent star, such as Formalhaut, and note its declination. However, the dashed circular scales also indicate that it is a South declination in this case.)

Enter the star list in the *Almanac* in the SHA column for January to June, and proceed down to "37". Then read to the right in the column for declination and read S 5. The star is Aquarii with a magnitude of 3.1. The exact values for June are SHA 37-13.8, declination S 5-36.8.

Problem No. 32

In Problem 31, the navigator was concerned with a celestial body, a faint star, whose coordinates did not appear in the form of a dot printed on the white face plate of the Star Finder. He found himself plotting the bearing and altitude of the unknown star using the blue template and LHA Aries and a penciled dot at the intersection of those two values. Then, using the red template to read declination and to determine the SHA of the star, he was able to match those values with those of a star listed in the *Almanac*.

Problem 32 is an extension of this technique. Again, there is an unknown body. This time it is a fairly bright one, but still it is not found pre-plotted on the white face plate. After obtaining declination and SHA, those values do not match the value of any listed star. The unknown body in these circumstances must be a planet.

The DR is 70-15.0 West, 34-30.2 North. The local date is September 28, 1990, and the local standard time is 19-20-40. A fairly bright body is observed in the South on an approximate bearing of 187 True. HO is 33-19.9. What is the Greenwich date and time? What is the declination and SHA of the body? What are the immediate indications that it is a planet even though it may not yet be identified? What body is it?.

Address all correspondence to:
The Navigation Foundation
P.O. Box 1126
Rockville, MD 20850
Telephone 301-622-6448

NAVIGATION PERSONALITIES

Sebastian Cabot (c.1476-1577)

by T. D. Davies

Sebastian Cabot has been called the father of English navigation because of his substantial and basic contributions to English navigation and exploration of the 16th century. His equally famous father Giovanni Caboto was an Italian born in Genoa like Columbus (later a citizen of Venice) although he is better known by his English name, John Sebastian Cabot. Sebastian Cabot accompanied his father when he removed to Bristol, England to further his idea of developing a sea route to the "Indies."

Medieval maps had sometimes shown mysterious islands to the west of Ireland, called "Brasil" and the "island of the seven cities." It was to find these islands that the merchants of Bristol sent out several ships, until the return of Columbus convinced them that they should press on immediately to the "Indies." John Cabot and his sons were empowered to make such a voyage by Henry VII, and on May 2, 1497, set out in a ship, the "Mathew", heading first North and then West. After 52 days at sea they reached what is now called Cape Breton Island. They returned to Bristol after touching on several other islands in the vicinity, which they were convinced were the northeastern coast of Asia.

In preparation for a second expedition, which this first had inspired, Cabot went recruiting to Seville and Lisbon, at which latter city he met a certain Joao Fernandes, called Llavrador. The travels of Llavrador to Greenland (thought to be Asia) inspired Cabot to set out again (1498) in that northern direction. He touched on Greenland and named it "Llavrador's land", but continued on to Baffin Land, Newfoundland and eventually down the coast as far as the 38th parallel. Having found nothing of Japan, which he had expected to encounter, he gave up and returned to England. John Cabot died shortly thereafter.

Sebastian had become well acquainted with the maritime arts from the voyages on which he accompanied his father. His first independent mention in history (1512) relates to a visit to the court of Ferdinand of Aragon. The Spanish were greatly impressed with his capabilities as a navigator and appointed him a Captain in their Navy. He was to set sail for the new world in 1516, but the death of Ferdinand stopped that. However his services were retained by Charles V and on 1518 he was named Chief Pilot (Piloto Major) of Spain, a position first held by Amerigo Vespucci.

In spite of this honor he returned to England where Cardinal Wolsey offered him command of five vessels being fitted out for a voyage of discovery. He turned this down in order to return to Spain and became the head of a three ship fleet which was sent out to discover "the Moluccas, Tarsis, Ophir, Cipango (Japan) and Cathay." In 1525 these vessels sailed to the coast of Brazil and on South to the Rio de la Plata. Sebastian Cabot's visits in Cannaneas (southern Brazil) and in the Rio de la Plata are mentioned in documents which have survived in Uruguay and Argentine archives.

Like many of his fellow explorers, upon his return to Spain (1530) he was banished to Oran, since he brought back no great riches. However by 1533 he was reinstated as the Chief Pilot of Spain. From the earliest mention of Sebastian Cabot he is noted for his ability to make navigational charts, called in those days "Cardes", and his stature in all navigational expertise was recognized when he was appointed the Chief Pilot of Spain.

In the middle of the 16th century the English recognized that they were emerging into an era where national navigation capability was a sine qua non. Cabot's reputation was such that the English decided he was a man they should have in England. After some earlier negotiations they succeeded in convincing him (probably with a bribe) to leave Charles V and come to England. By 1549 the King granted him an annual pension, and two efforts by Spain to have him returned were denied by the English.

Within a year Sebastian Cabot had organized a training ship, the bark Aucher, and a training cruise. The commander was a Bristol captain. While training navigators Cabot was also organizing in London the preparation of charts, ephemerides and instruments as well as the economic backing so necessary to venturing into unknown seas and lands. In 1551 he founded the Company of Merchant Adventurers, of which he was governor for life. By 1553 they had their first expedition ready. It sailed under Sir Hugh Willoughby for "Cathay." In trying to reach Cathay by the Northeast the expedition failed. It was scattered by a storm and most of the members frozen to death. One Richard Chancellor survived and made his way to Moscow via the White sea. Out of his negotiations a substantial Russian trade developed.

Chancellor sailed again in 1555, having formed the Muscovy Company, again for Russia. Other ships were sent to open markets in Morrocco (Barbary), and in the Canary Islands, which they Portuguese thought they had to themselves. These efforts continued and expanded and thus the sound foundation upon which Sebastian Cabot had built resulted in the long continuous expansion of English maritime exploration and economic power.

MARITIME INFORMATION NOTES

Provided by Ernest Brown

Daily Memorandum

In order to meet significant DoD budget reductions, the Defense Mapping Agency (DMA) proposes to discontinue the publication of the Atlantic and Pacific Daily Memorandum on 30 September 1990. Printed copies of HYDROLANT/HYDROPAC and NAVAREA IV/XII broadcast warnings that appear in the Daily Memorandum are made available in Section III of the weekly Notice to Mariners.

DMA's Navigation Information Network (NAVINFONET) also provides the user a summary of in force broadcast warnings. NAVINFONET is accessed through commercial telephone, satellite links and other commercial services. The data contained in NAVINFONET is free of charge. The only costs incurred by the user are those charged by the provider of the telecommunication s service.

Information about NAVINFONET can be obtained from DMA Hydrographic/Topographic Center (DMAHTC (MCN)) by telephone at (301) 227-3296 or AUTOVON 227-3296

VIDEO REVIEW

By Roger H. Jones

Magellan GPS Nav 1000

Video Operation Guide
Produced by James Marsh
Bennett Marine Video
730 Washington Street
Marina del Rey, CA 90292 (1989)
Color, 48 Minute Running Time, $29.95

In this issue we return to the "Video Review" initiated in Issue 28 of the Newsletter. The subject of the current review is a video tape that is quite recent. It is also very timely. Most readers of the *Newsletter* will have seen advertisements in the national magazines dealing with marine and nautical matters, and many will have also inspected in their local ship's store the Magellan GPS Nav 1000 depicted in those advertisements. We suspect that more than a few readers of the *Newsletter* have already obtained a Magellan for their own use, and others are no doubt contemplating purchase of the unit. The tape that is the subject of this review addresses the curiosity of the many who are intrigued by the compact size, portability, and versatility of the Magellan.

The tape is in color, with a running time of 48 minutes. It employs both clear, well conceived graphics and equally clear camera shots of the face of the Magellan unit. At the outset the graphics, as supplemented by both voice narration and on-screen text, are used to present a concise but also thorough explanation of the Global Positioning System (GPS). This system is designed to use 21 satellites, each in a fixed orbit, which provide real time information to mariners, aircraft pilots, and even land navigators operating in deserts or other remote areas. The system is very resistant to interference from weather, ground-based signals, on-board electronics, and the many other sources of interference that plague most electronic navigation systems. GPS provides a latitude and longitude fix with an accuracy often as good as 30 meters or better. It does this in either a two-dimensional mode using three satellites, or a three-dimensional mode using four satellites. In the latter mode, it solves for altitude as well as longitude and latitude.

After explaining and illustrating the GPS, the tape then systematically deals with each of the function keys on the Magellan unit. There are fourteen of these keys in addition to the numeral keys (1 - 9 and 0). Upon watching the tape, this reviewer gained the impression that this is a user-friendly device, and its versatility is extraordinary. In addition to performing a very wide range of navigation tasks, it will also alert the user when the internal battery power supply is weak, and it will even alert the user when there is poor geometry or poor satellite reception. It will also perform in a "wakeup" mode when the navigator is not on watch but has programmed it to take a fix at a window of opportunity ten minutes or more in the future.

Each of the many functions is explained with camera shots of the face of the unit and the associated keys. While the Magellan comes with a complete instruction manual, this tape would be a very good supplement to that manual because the user is talked through all of the routines.

Of course, the Magellan may also be operated on external power, and the tape covers this mode of operation as well as the battery mode. The batteries, incidentally, are six, readily available AA cells, and a set of batteries is good for about 60 fixes.

Michael Bennett has produced a number of video tapes on marine subjects, and his store is stocked with a larger variety of tapes and books than many much larger outlets. He stocks tapes from other sources as well as his own. This reviewer has found his tapes to be very informative, and this new one on the Magellan GPS Nav 1000 is one of the best thus far produced. It is not an exercise in high technology jargon. It is aimed at the general public. It does its job well, and should be a fine addition to the video library of navigators who use or may use the Magellan hand-held GPS receiver.

WANTED

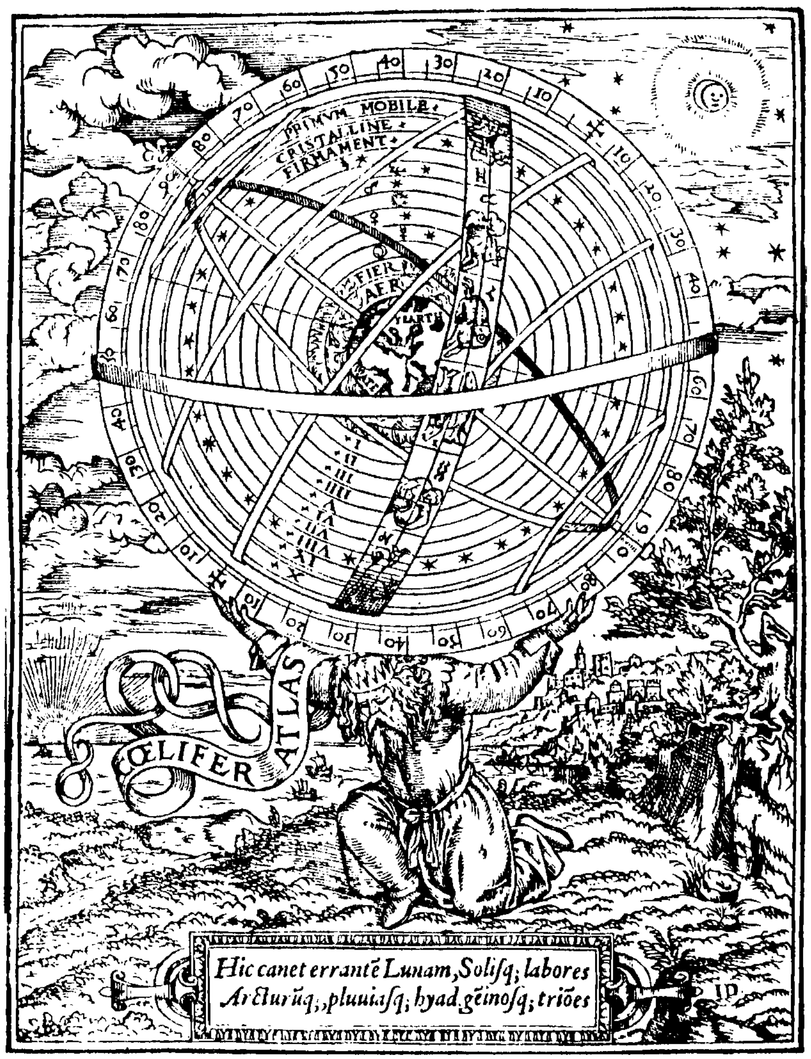
The following items are on the wanted list as of now.

1) Donald J. Pegg has been seeking for some time for a first or early issue of Martelli's Table. The cover has a picture of a building with a porch and lettering "Lightning Printers" or something similar.

2) Sid M. Miller of Hamden CT, wants to purchase an english edition of Kotlarich's Star Finder (described in the 1977 Bowditch).

3) Hiroshi Nakahama of Tempaku-ku, Nagoya, Japan, asks: a) Is there a book "The Practical Navigator" by E. C. Branter, published in 1844, perhaps by a publisher named J. M. Eleater? b) Does this book still exist.? If so where can I go to see it? Is it possible to get a copy of the first page? c) Is there any connection between Branter's book and Nathaniel Bowditch's "The New American Practical Navigator." d) Is Branter's book a simplified edition or is it an entirely different book from Bowditch, or is it the same thing?

Anyone with knowledge of these items above please communicate directly with the Foundation.



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THE NAVIGATOR'S NEWSLETTER

FOUNDATION FOR THE PROMOTION OF THE ART OF NAVIGATION

ISSUE THIRTY-ONE, WINTER 1990

This letter is published to keep members up to date on the activities of the Foundation, provide useful notes on navigation techniques, review books on the subject and maintain a readers forum for the expression of our members' opinions and their questions.

ACTIVITIES

by T. D. Davies

On 1 October I delivered the lecture on*Robert E. Peary at the North Pole* in London, at an annual meeting of the *Permanent International Association of Navigation Congresses.* This organization was founded in 1885 and has governments as well as individuals as its members. Every two years the U.K. chapter sponsors this lecture which they call the *Sir William Harris Lecture* The audience was international in character and the talk was well received. I used about 30 slides in illustration and kept the talk non-technical as appropriate for the audience.

Of note in the audience were two well-known arctic and antarctic explorers, Lord Edward Shackleton and Dr. Geoffrey Hattersley-Smith, both of whom we had cited in the full report to the National Geographic. Lord Shackleton is the son of Sir Ernest Shackleton of South Pole fame. Both spoke briefly in support of my views after the lecture. There were several questions raised by technically competent and experienced people which had to be answered during the reception which followed the lecture. Since neither individuals had seen the full report I sent each a copy upon my return to the US.

Recently I had an interesting conversation with the US co-leader of a new North Polar expedition (joint with Soviets) which is to take place in March and April of 1991. Richard Weber lives in Quebec and has organized an expedition to go to the Pole *on foot —and return without resupply.* The members are all expert skiiers and will carry (on their backs or on sledges) food for the entire round trip without resupply. Such a round trip has not been tried since Peary's 1909 trip and one of the objectives of the trip is to "shed light" on some aspects of the Peary trek. Since these aspects included speeds over the ice, finding your own trail returning and navigating by sextant, I felt some discussion would be desireable.

Since they had not seen our report I sent copies to both Weber and his navigator. In a subsequent conversation Weber indicated his belief that their speeds on skiis could equal Peary's with dogs. He was made aware that Peary's return on his own trail was based on the fact that his returning intermediate parties had "knit" the trail on their return—something that would be missing in this trip. Although their navigation will be by "sextant" they will actually use an aircraft bubble octant. Thus some aspects of Peary's navigation will not be duplicated, and some caution will have to be used in making statements to that effect. Incidentally at least 3 members of this party have been to the Pole before.

Because of the usefulness of some of the articles in back issues of the *Newsletter* I have had work started on an index. This will actually be a simple listing of the articles by title, with an indication of the issue number that contained each. I believe that this will be useful and we will have it priced and ready for the next issue. We will also sell back issues and probably offer a package with both back issues and the Index. Suggestions from members will be welcomed.

Our collection of navigation books has been further augmented by member Donald Pegg. We now have a number of unique navigation books including some very valuable old books such as an eighteenth century copy of the Practical Navigator of John Moore, a predecessor of Nathaniel Bowditch. These will be permanently lodged at the Naval Observatory as the "Navigation Foundation Collection." We will shortly compile a list of these and include in the Newsletter.

Through error our "Wanted" column was duplicated in the last issue, so we are publishing the latest version in this issue. I have been advised that, contrary to popular belief, The New American Practical Navigator was never published in a foreign language. It was, however, translated *in-toto* into Japanese in approximately twenty manuscript copies. Recent correspondence with Dr. Harold Bowditch of Peterborough, New Hampshire, brings word that all of those copies were destroyed during the World War II bombings of Tokyo. One copy of the translation was sent to the World's Fair at Philadelphia in 1876 but was never returned. Possibly, this copy may still exist. The same source indicates that the

years of issuance of the "Navigator" (after 1880) are those shown below.
1880 1882 1883 1885 1886 1887 1888 1892 1893 1894 1896 1897 1898 1899 1900 1902 1903 1904 1905 1906 1907 1909 1910 1911 1912 1914 1915 1916 1917 1918 1919 1920 1923 1924 1925 1926 1928 1929 1930 1931 1933 1934 1935 1936 1937 1938 1943 1958 1962

Navigation Course

Dr. Stephen D. Matthews, (516) 883-5632, of Port Washington, New York, Advises that he is starting a course in celestial navigation at the North Shore Yacht Club, to run on 10 Wednesday nights commencing January 9th, 8:00 to 10:00 p.m. Cost is $100. Course will cover sextant and Almanac; solutions by hand calculator and Nautical Almanac tables.

READERS FORUM

J. Alan Bell of Wirral, England writes:

Thank you for your letter of July 27th. I am sorry about the problem with the Sterling cheque. I think I have solved this matter, with the help of an American Express MoneyGram my contribution should be with you within a week. I regret the delay in my reply to your letter, but I have been working out in Nigeria for the past few months and the mail situation being what it is in that part of the world I thought it wiser to wait 'til I arrived home on leave.

Because of my late return from West Africa I was unable to attend the 'Sir William Harris' lecture, a matter I regret greatly. Please pass on my belated apology to Admiral Davies for my absence. Newsletter No. 29 has arrived and I shall be reading it in detail once I settle into my leave.

Arthur L. Horning of Great Valley, NY writes:

I wish to thank LCDR Luykx for the great deal of information which he forwarded to me regarding artificial horizons and their use. In LCDR Luykx's response, he stated that you have various types of horizons available. I would like to purchase the Davis plastic pan type artificial horizon and have enclosed a check in the amount of $25.00, $23.00 to cover the listed price and $2.00 to cover mailing costs. If additional charges are required, please inform me. Thank you.

[Ed. Note: The Foundation does not sell these items but your order has been passed to John Luykx, who does.]

Michael Belisle of Sechelt, B.C. Canada writes:

I am enclosing a cheque for the renewal of my membership in the foundation. It is at the new rate as, even though my renewal date is before Aug. 1st, I feel the money is well utilized. I've used a Canadian Postal Money Order in US funds this time and hope you are not charged a service charge on it. I have never had it happen to me in Canada with a US cheque and was unaware of it till you pointed it out.

I also have a question for you regarding a bubble sextant shown in the winter 1990 (#27) issue labeled R.A.E. MK IXA 1941. I purchased one of these last spring at a garage sale and had no trouble figuring out how to use the sextant but the windup mechanism on the front has me baffled. I would like to know what exactly it is for. Keep up the good work. I look forwrd to the upcoming issues of the newsletter.

[Ed. Note: Your question has been passed to John Luykx.]

Marshall Bishop of Kingston, NY writes:

Please forgive my late dues remittance. I found no one to do some work in our Mid Hudson Squadron so in spite of 130 members I ended up giving our class in Piloting and sending our one qualified "Navigator" candidate over to Danbury for his class at Lake Candelwood Squadron.

Here are my 1991 dues - hope it is right amount and a request for the Almanac 1991. If more is due just slip a note to me in the mail, or call!

P.S. I received the fall newsletter yesterday which reminded me of my delinquency!

Doug Black of Galesville, MD writes:

My check for $30 and application for membership in the Foundation is enclosed. I learned of your organization from several sailing friends and talked to John Luykx at the Annapolis boat show. Thank you for sending the Summer Newsletter and application form. I live on my Morgan 34 sloop at the Woodfield Fish & Oyster Co. in Galesville, MD and plan to begin an extended cruise next fall. Although I hope to purchase a GPS or LORAN, I want to prepare for potential breakdowns of the electronic gear.

The proposed cruise on Tandemeer would probably suit my needs admirably, but because of my recent retirement from the U.S. Geological Survey and pending divorce this, I suspect, would be beyond my means.

I would like your help in locating a durable sextant, learning its operation and readjustment, and gaining hands-on instruction in the fundamentals of celestial navigation. Thank you in advance.

[Editor's Note: John Luykx will contact you about a good sextant.]

Richard T. Callaghan of Calgary, Alberta, Canada writes:

Please find enclosed a money order for $20.00 U.S. This amount is to cover the $5.00 which I still owe for membership and $5.00 for 1991 edition of the Navigators Almanac. The remainder of the money will, I hope, offset some of the mailing costs to Cnada. In the fall issue of the *Navigator's Newsletter*, it was mentioned that you have a book collection at the U.S. Naval Observatory library. I would like to know if there is a listing of your holdings available to members. My own particular interests tend

towards the early development of watercraft and navigation around the world.
[Ed. Note: We will issue a list of our holdings once they are in place—probably in the next Newsletter.]

Kachadoor V. Kachadoorian of Plainsview, NY writes:

As an afterthought, have any members of the Foundation subscribed to The Great Instruments of Discovery created by the Franklin Mint and certified by the National Maritime Historical Society? This excellent series of polished brass replicas of ancient instruments are a sight to behold, Astrolabe, Universal Equinoctial and Equatorial Sundials, among others.

Should one among others have the Astrolabe, in particular, I would like to have my observation confirmed that the sighting vanes for the alidade on the reverse are in fact misaligned along the line of sight of the pinnules. Since my fascination with the Astrolabe led me to this observation, I am curious as to whether any other member has observed this critical error? This troubles me since it has been certified by the National Maritime Historical Society. Sadly, my letters have received no response.
[Ed. Note: Let us hear from any member who is familiar with these items.]

Donald J. Pegg of Ft. Pierce, FL writes:

A small package of books should arrive, via UPS, shortly. These are all small sized so I am sending them before sending the regular sized volumes. Moore's "Practical Navigation" has the title page and the page containing the dedication slightly damaged. This volume was obtained after several visits to book shops from Warsash (near Southampton) to Newcastle. The owners of most of these shops informed me that near perfect copies of Moore's work were extremely difficult to find. The small sized "Bowditch" (and useful tables) although not too scarce, are not readily available. I have located only two copies in twenty-five years. This small volume, published by the Edwin N. Appleton Publishing Co. and, the first reprint of the 1918 issues, published by the Military Publishing Co., are the only known editions published privately.

Two pocket sized books are also included because they mention the "New York Naval Militia" and include two pictures. Of the two, the second or 1918 edition, was revised by Elmer Collins of the (then) Hydrographic Office. Ernest Brown knew him and can give some information on him.

Enclosed is a copy of a print made many years ago. Perhaps it may have some information interesting to you. Will packages be receivable at your home during your absence while on your trip?
[Ed. Note: The packages have all arrived safely and in excellent condition. These donations are greatly appreciated. There is always someone at my address to receive these packages.]

Anthony L. Kelley of Hicksville, NY writes:

The following suggestions are meant to prevent confusion in the use of your Nautical Almanac Sight Reduction Tables.

There are two tables and each is used twice — the Sight Reduction Table and the Auxiliary Table. Some of my students were confused betwen the 1st and 2nd entry into each table. Could the labels in the column headings used for the 1st entries be printed in bold print? For example:

a. The Sight Reduction Table could have those capital letters that precede the slash (/) in bold print; specifially the letters: Lat, LHA, A, B, and 21.

b. The Auxiliary Table would have those capital letters that precede the slash(/) in bold print; specifically the letters: F' and P.

c. In the Nautical Almanac pages 284 and 285 instructions should be modified to reflect the bold print for the above mentioned values, but not for the values of A's degrees (A) nor of A's minutes (A') since they are not used as 1st table entries. Another suggestion concerns the corrections from the Auxiliary Table. In the directions, page 285, corr1 and corr2 are used for the results of the 1st and 2nd entries from this table. On the top of page 316 these two corrections are called only corr. Could they be more specifically identified on that page as 'corr1' on the left side and 'corr2' on the right side? Please prevent me from navigational blunders.
[Ed. Note: These suggestions will be passed on to the Naval Observatory, Almanac Office.]

J. Alan Bell of Merseyside, England writes:

I thank you for your letter explaining the aim of the Navigation Foundation, also the sample issue of *The Navigator's Newsletter.* I am in full agreement with the view expressed in your letter regarding 'the critical importance of the personal skills of the navigator'. The bridge watchkeeper of today is a highly qualified person but he seems to lack what I can only describe as a 'seaman's eye and feel' for his surroundings. His dogged reliance on electronic navigation aids disturbs me greatly. One has to explain the term *aids* to navigation and their usage in the practice of the *art* of navigation and good seamanship.

Captain Rude's article on his Star Identifier was of great interest. I was given mine, an A-N Type I, H.O. No. 2102-C, by of all people, my insurance salesman. It has been of invaluable service ever since. As for the problem of 'spotting' it is a simple matter: once the azimuth and altitude are noted, the sextant is set at the altitude and the horizon scanned around the arc of the azimuth, just above and below the horizon. The heavenly body will be spotted, in most cases, long before it becomes visible to the naked eye. In this way it is possible to confirm the position of a set, of say five stars, and then shoot them in rapid succession. With pre-computation with the use of the almanac and navigation tables, it should be possible to have the position on the chart in ten minutes of the time of sights. I still take pride in working my sights in a sight book, even though surrounded by up to date electronic equipment. The books remain a constant record of past voyages. I find the pocket navigation computer of interest, and on occasion, I have made use of it, but I do not feel that it does anything for the *art*.

Please find enclosed my donation to the Foundation. The next *Newsletter* is eagerly awaited.

John Baxter of Port Ludlow, WA writes:

Now seems a good time to repeat a tale which I posted here after my second sail to Hawaii (late summer, 1986). We were about 1100 miles ENE of the big island, when the ham nets reported a vessel with difficulty navigating, and set up a time for an informational broadcast. It turned out that a boat about 600 miles ENE of the big island had triggered his EPIRB. The Coast Guard found him (from a C-141) and learned via VHF that his SatNav and Omega had gone out, and his sextant was 'broken'. [NO ONE seemed to believe that broke meant anything except "What the h... is this thing, anyhow?] Coast Guard gave him a course for Hilo (and, one hopes, a serious talking to about use of EPIRBs when he arrived). After all, from where he was (assuming he's at least written down an occasional electronic fix), finding Hawaii is nearly a no-brain process WITHOUT a sextant (the weather was perfect for following con-trails).

More power to the Foundation, and send an info packet to Schooner "Attu'.

Claude Huguenin of Berne, Switzerland writes:

It is with immense interest that I recently read the January 1990 edition of the National Geographic summarizing your investigation into Peary's North Pole claims.

I would be very keen to obtain a copy of your full report and take the liberty of enclosing 20 U.S. dollars to cover air postage to Switzerland.

Currently Swiss Head of mission to Tripoli, Libya. I am a member of the British Royal Institute of Navigation and fascinated by land navigation in particular. I use sun compass and bubble sextant to navigate over some of the Long Range Desert Group's WWII haunts (although I must admit having recently acquired a Magellan GPS receiver, which of course takes a lot of fun out of the game!) Having used liquid artificial horizons in the past, I am puzzled by Wally Herbert's contention (Nat. Geographic, Vol. 174, No. 3, Sept. 1988, p. 410) that Peary used a sink of heated Mercury. Whereas in Rear Admiral Davies' January 1990 Article (p. 50) a wooden framed artificial horizon is illustrated. Is that compatible?

Should your Foundation be open to foreigners, I would be most interested to apply for membership.

[Ed. Note: The mercury tank of Peary's artificial horizon was a special one made of wood with cut down sides so that they would not interfere with very low altitude shots. Heated Mercury was poured into the tank from a small ceramic jug, and later returned to the jug through a plug in the bottom of the tank. Our foundation is indeed open to non-US citizens—we have many overseas members.]

NAVIGATION BASICS REVIEW

Determining Position Ashore from Celestial Observations

By John M. Luykx

As a result of operation DESERT SHIELD as well as an inquiry received during the summer from the U.S. Army regarding the use of marine sextants for land (desert) navigation, the author feels it may be of interest to members of the Foundation to present the results of accuracy tests he has conducted using marine sextants, bubble attachments, artificial horizons, aircraft bubble octants (including a pendulum octant) to determine position ashore by celestial observation. Hand-held instruments from the author's collection were employed for these accuracy tests which were conducted in the vicinity of Forestville, Maryland and Chesapeake Beach south of Annapolis, Maryland from September 1984 to the present time. Originally these observations formed the basis of a series of articles on artificial horizon sextant accuracy which was to be published at a later time. The present military situation in the near east has, however, generated a renewed interest in land navigation, especially in the deserts of the near east. Although various methods and procedures are available to determine position on land, it may be of benefit to members to describe some of the procedures and hand-held instruments which could be used for navigation ashore using celestial observations, especially in areas of great expanse and little or no habitation and where few, if any, landmarks or points of navigational reference are available.

The accuracy tests of artificial horizon sextants and octants were conducted over a period of six years starting in 1984 using five separate and distinct procedures (plus one procedure for comparison purposes) employing instruments from the author's personal collection. The procedures and instruments employed were as follows:

Procedure A.

This procedure consisted of single observations of the sun for line of position (LOP) using five marine sextants, each fitted with an artificial horizon; i.e., bubble assembly or attachment. A group of observations consisting of five series of ten observations each were taken with each sextant and the mean value of time and altitude for each series reduced for the LOP. (See Test Results, Table 1.)

Procedure B.

This procedure consisted of automatically "averaged" observations of the sun using seven representative aircraft octants with automatic averaging devices. One or two minute "averaged" observations were employed depending on the instrument. A group of five "averaged" observations were taken with each octant. (See Test Results, Table 2.)

Procedure C.

This procedure consisted of single observations of the sun using seven aircraft octants. Here again a group of observations was taken and the mean value of time and altitude for each series of the group reduced to determine the LOP. Note: For accuracy on land single observations are preferred to "averaged" observations since "averaged" observations tend to include both good and bad observations while only single observations which are considered "good" by the observer tend to be recorded. A group consisting of five series of ten observations each were taken with each sextant. (See Test Results, Table 3.)

Procedure D.

This procedure consisted of single observations of the sun using a Plath marine sextant with 6x30 monocular and both a trough type liquid artificial horizon and a reflecting mirror type artificial horizon. A group consisting of three series of ten observations each was taken with each type of artificial horizon and the mean value of time and altitude for each series reduced to determine the LOP. (See Test Results, Table 4.)

Procedure E.

This procedure consisted of single observations of the sun using three aircraft octants supported on a surveyor's plane table. As in A, C and D above, a group of obser-

Sextant	Mean Error	Standard Error	95% Error	Range of Error
Plath with Plath attachment	1´.6	2´.2	4´.2	5´.5
Plath with spherical attachment	2´.4	3´.5	6´.5	6´.5
Hughes Gothic with Booth Bubble	1´.8	2´.4	4´.6	6´.5
Tamaya Venus with spherical attachment	2´.0	2´.5	4´.8	5´.9
Hughes Yacht with spherical attachment	1´.4	1´.8	3´.5	4´.3

Table 1

Sextant	Mean Error	Standard Error	95% Error	Range of Error
Kollsman MA1	2´.2	3´.0	5´.8	7´.7
Kollsman MA2	0´.6	1´.0	2´.0	2´.9
Plath (SOLD)(Bubble)	0´.5	0´.6	1´.2	1´.2
Plath (SOLD)(Gyro)	0´.8	0´.8	1´.5	2´.2
R.A.E. MK IXB	0´.4	0´.6	1´.2	1´.2
Hughes Marine (Super)	0´.3	0´.4	0´.8	1´.0
Bendix A-14	0´.8	1´.2	2´.3	3´.0
Bendix A-15	1´.3	1´.6	3´.1	3´.5
Fairchild A-10B	0´.3	0´.4	0´.8	1´.2
Hughes Marine (Super)(Gyro)	0´.4	0´.5	1´.0	1´.4

Table 2

vations was taken and the mean value of time and altitude for the group reduced to determine the LOP. It was assumed that the use of a plane table as support for the octant during observation would improve accuracy. A group of ten observations was taken with each octant. (See Test Results, Table 5.)

Procedure F.

This procedure consisted of single observations of the sun using a Plath marine sextant and 6x30 monocular using the visible horizon as reference for altitude measurement. These observations were taken off Chesapeake Beach on the Western Shore of Chesapeake Bay, just South of Annapolis, Maryland. The mean value of time and altitude for each series in the group of observations was reduced to determine the LOP. This group of observations was taken so that a comparison could be made between the accuracy of marine sextant observations when using the visible horizon as a reference and the accuracy of observations taken ashore when using a bubble attachment or other artificial horizon as a reference for altitude measurement. A group consisting of five series of five observations each was taken in this test. (See Test Results, Table 6.)

A single observer recorded each observation using a wristwatch set to universal time (UT, GMT). All observations except those of Procedure E were taken with the observer seated in a chair supporting the instrument in his hands with his elbows tucked in against his chest. The observations taken in Procedures A, B, C, D and F were taken during the period 1984 through 1986 and reduced using a Tamaya NC- 2 navigation calculator. The observations in Procedure E were taken in November 1990 and reduced using the CN- 2000 pocket navigation computer.

Once the observations for each individual procedure were completed, the mean altitude error for each series in the group of observations was computed. The standard error (standard deviation), the 95% error and the range of error for each instrument (i.e., for each group of observations) was then determined.

The sun was used for all observations. The Ho for each observation was compared to the Hc as determined from the observer's known position. The difference between Ho and Hc in minutes of arc (i.e, the intercept a) is equal to the error of observation. When Ho is greater than Hc, the altitude error is plus (+); when Ho is less than Hc, the altitude error is minus (-).

The results of the accuracy tests shown above appear to indicate that when a group consisting of several series of ten observations each or a series of averaged observations are made ashore by a seated observer using an

Sextant	Mean Error	Standard Error	95% Error	Range of Error
Kollsman MA1	0´.9	1´.1	2´.1	2´.9
Kollsman MA2	1´.2	1´.7	3´.3	3´.9
R.A.E. MK IXBM	0´.3	0´.4	0´.8	0´.7
Hughes Marine (Super)	0´.3	0´.3	0´.6	0´.5
Bendix A-14	0´.7	0´.9	1´.7	3´.0
Bendix A-15	0´.9	1´.1	2´.1	2´.5
Fairchild A-10B	0´.7	0´.8	1´.5	1´.7

Table 3

Artificial Horizon	Series 1 Error	Series 2 Error	Series 3 Error	Mean Error
Davis (liquid)	-1´.3	-1´.2	+0´.4	-0´.7
Plath (glass)	-0´.1	-0´.7	-0´.1	-0´.3

Notes: 1. Both artificial horizons were supported on a surveyor's plane table.
2. The Plath 4 3/4 inch diameter circular glass reflecting artificial horizon was levelled using a circular level.
3. To avoid a mess, the Davis artificial horizon was filled with water rather than oil during observations. This may have reduced accuracy because the wind had a tendency to shake the plane table which in turn caused ripples on the water level surface. An additional problem was the heat of the sun which caused the water to evaporate and condense on the interior surfaces of the glass wind screens.

Table 4

Sextant	Mean Error	Standard Error	95% Error	Range of Error
Kollsman MA1	0'.0	0'.4	0'.8	1'.4
Kollsman MA2	0'.7	0'.4	0'.8	1'.4
R.A.E. MK IXA	0'.2	0'.2	0'.4	0'.6

Notes: 1. The MA1 sextant was selected for this test because it is a pendulum sextant. The artificial horizon element provided a floating illuminated cross-hair projected into the field of view. Collimation is made when the horizontal section of the reticle is aligned with either the upper or lower limb of the sun or the center of a star or planet.
2. The MA2 was selected because the artificial horizon consists of a double bubble (a design modification) in the field of view. The celestial body during observation is aligned with the common center of the double bubble which occupied a significantly smaller area than the actual bubble itself.
3. The R.A.E. MK IXA sextant was selected because of the accuracy and reliability of the gearing system and the fact that the bubble can be greatly reduced in size without reducing accuracy and freedom of movement in the field of view.

Table 5

Sextant	Mean Error	Standard Error	95% Error	Range of Error
Plath with 6x30 monocular	0'.3	0'.4	0'.8	1'.0

Note: The observer was in a standing position for these observations. They were taken off Chesapeake Beach on the West Side of Chesapeake Bay, south of Annapolis, Maryland. The height of eye was 13 feet.

Table 6

artificial horizon sextant, the order of accuracy will vary in accordance with the instrument used and whether it is hand- held or supported by a table. For example:

1. Observations using the hand-held marine sextant with bubble attachment should place the line of position within about 5 miles of the actual position 95% of the time. (See Table 1.)

2. Observations with the hand-held aircraft octant with averager engaged should place the line of position within about 3 miles of the actual position 95% of the time. (See Table 2.)

3. Observations using the hand-held octant taking single observations, should place the line of position within about 2.5 miles of the actual position 95% of the time. (See Table 3.) The mean of a series of single observations provides greater accuracy because, perhaps, only "good" observations are recorded. During "averaged" observations, however, both good and bad observations are combined and recorded by the octant's automatic averager.

4. Observations using the hand-held marine sextant employed with a liquid or glass artificial horizon should place the line of position within 1 mile of the actual position 95% of the time. *Note: This is inferred from data in Table 4 when compared with similar data in Tables 2 and 3.*

5. Observations using the aircraft octant when supported on a plane table should place the line of position within about 1 mile of the actual position 95% of the time. (See Table 5.)

6. The accuracy of the aircraft octant when used ashore and supported on a table or plane table will provide generally the same order of accuracy as the marine sextant using the visible natural sea horizon as a reference. (Compare data in Table 5 with data in Table 6.)

7. The English Hughes and R.A.E. (Royal Aircraft Establishment) aircraft octants appear to be the most accurate for use ashore. (See also descriptions of these instruments in the Navigator's Newsletter, Issue 27, Winter 1990, pp. 10-12.) (See Table 2, 3 and 5.)

8. With regard to the accuracy of the marine sextant when used with the bubble attachment for navigation ashore, there appears to be little difference between the instruments used in the test except perhaps to note that both the Tamaya Venus and the Hughes Yacht sextant are small size sextants with arc radii of 5 1/2" and 3 1/2" respectively. The other two instruments, the Plath and

the Hughes Gothic are full size brass sextants weighing well over 5 lbs each when fitted with a bubble attachment.

9. When placed on a table or other stable platform the aircraft octant is very stable and the oscillation of the bubble artificial horizon in the field of view is reduced to nil, thus significantly improving the accuracy of observation.

Improvements in the accuracy of celestial observations taken ashore can be achieved by:

1. Using two observers instead of one; the one recording time, the other recording altitude.
2. Recording time and altitude to a greater precision than one second and 0.1 arc minute respectively.
3. Employing instruments of greater precision such as prismatic astrolabes, theodolites and transits.
4. Using ephemeris data which is tabulated to a greater precision than data in the Nautical Almanac. An example is the data contained in the Astronomical Almanac.
5. The incorporation of corrections during sight reduction for precession, nutation, aberration, parallax and the irregularity of the earth's shape as is currently required in modern surveying practice.

HISTORY OF NAVIGATION

Le Grant Routtier of Pierre Garcie (1520)

By John M. Luykx

Sailing directions for northern European ports, harbors, and coastal waters were first compiled and published in book form near the end of the fifteenth century.

Although the first known printed set of sailing directions for European waters including the Mediterranean Sea was the Portolano Rizo printed in Venice in 1490, some scholars believe that sailing directions (rutters) of northern European waters were printed in France prior to this date although none are known to exist.

Rutter is the English word for sailing directions. The term was used in the sixteenth and seventeenth centuries and was derived from the French, routier (route-book); Portuguese, roteiro; Spanish, derrota; Italian, Portolano (port-book); Dutch, Leeskart (reading chart); German, Seebuch (sea-book).

The earliest rutters published for the coasts of western Europe from North Germany to Gibraltar including the coasts of England and Wales were originally published in France between 1502 and 1510 and attributed to Pierre Garcie. The earliest was entitled Le Routier de la Mer. The more comprehensive work by Garcie, Le Grant Routtier, appeared in 1520 also published in French and printed in Potiers. An english translation of Garcie's work was published later, in 1528, by Robert Copland.

Pierre Garcie's works are of special significance in the history of navigation because they are the first organized compilations of written sailing directions. For the coasts of Europe and England, Garcie described in minute detail not only the physical features of the coast but also those of the sea bottom. The characteristics of the tides and tidal currents for the coasts of Normandy, Brittany and Picardie are described in detail including a comprehensive discussion of the affect on tides of various positions and directions of the moon.

Le Grant Routtier contains data on tides, tidal currents, soundings, anchorages, directions, courses, distances, prominent land marks and winds. Garcie also included sections which described:

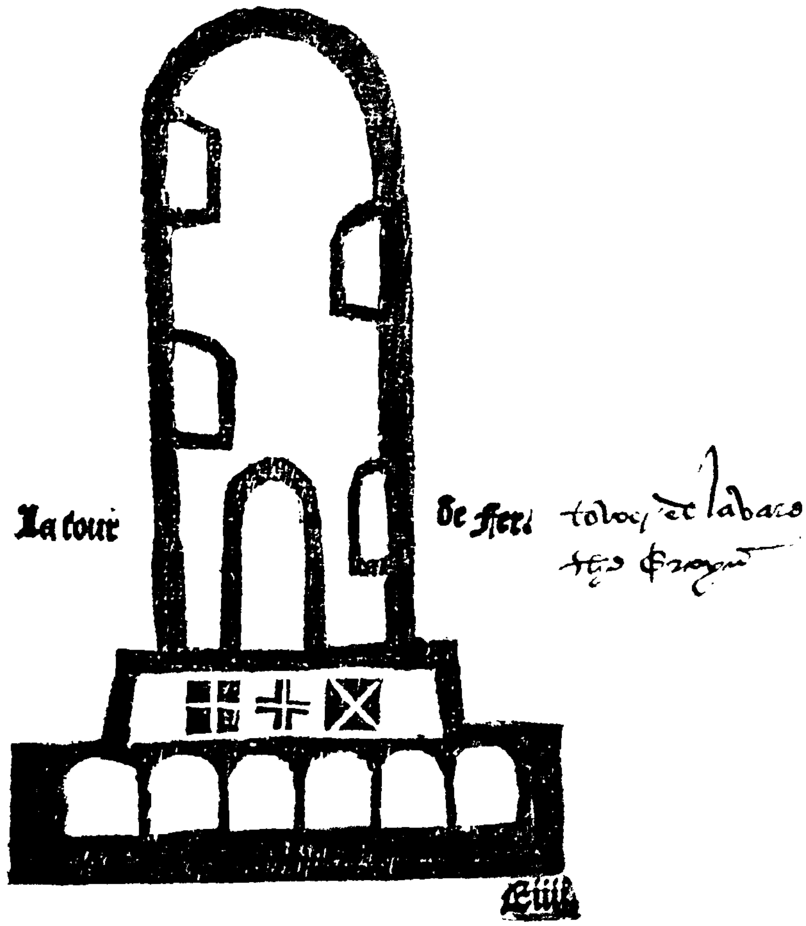
1. Rules for determining those monthly motions and phases of the moon from which tide and tidal current predictions could be made.
2. Rules for telling time at night. Instructions were provided for judging the time of midnight and dawn by the stars when neither sun nor moon was visible. Also included were rules based on the Pole star and the position of the constellation Ursa Minor (Little Bear) for indicating the time at night.
3. Rules for Traverse Sailing. When sailing homeward bound, for example, off the continental coast the seaman of the north had to sail in a direction often well off his intended course. The rules of traverse provided the mariner with a means of determining the distance off the original intended course when he maneuvered against the wind and enabled him thus to compensate for wind and tidal current when approaching his destination.
4. Rules for determining and describing wind direction and steering courses by compass. Wind directions were based on the cardinal and inter-cardinal points of the compass. Garcie employed a rule that two points of the compass (22 1/2) was equal to "half a wind" and that four points of the compass was equal to "one wind".

A rhumb of the wind (ryn de vent) was equal to one point of the compass (11 1/4) which in turn was equal to "one quarter wind" (quart de vent). Thus in traversing, Garcie gave an example, to show that sailing off course by a "quarter wind" or one rhumb would set the vessel off course 1/5 the course distance; i.e., for a track 80 leagues in length, sailing one rhumb or "one quarter wind" off course would set a vessel off the original track by 16 leagues.

The following are a few sample extracts from Le Grand Routtier which the author of this monograph has freely translated into English. These extracts indicate some of the detail to which Garcie described the coasts of Northern Europe. Three figures showing reproductions of woodcuts describing prominent landmarks in the text are also included. These examples are of interest because it was in Le Grant Routtier that diagrams, pictures and

De la mer

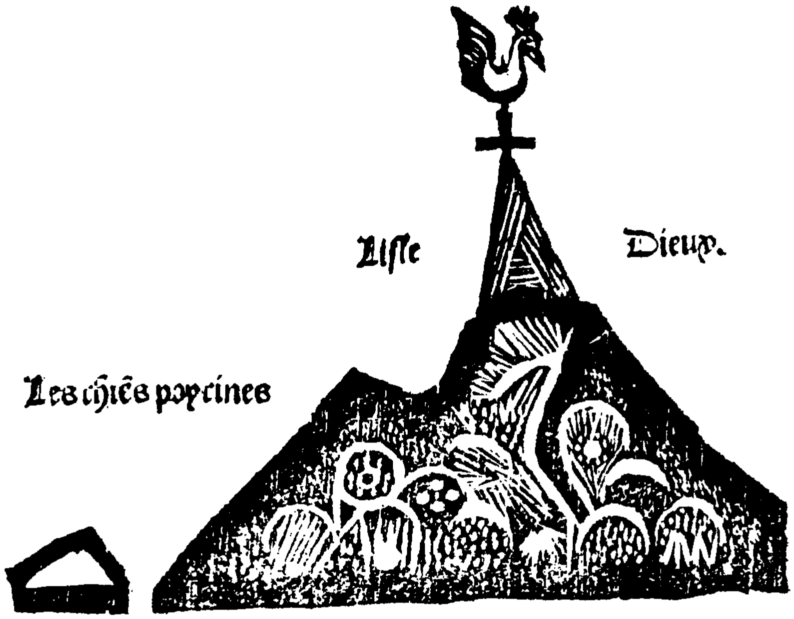
La prochainne baye de sable que voyras en su de la baye de ferron cest la baye de betances Et tu voyras devers le nort de la poincte vne isle asses grandette et est celle poincte qui faict la baye du couste devers locst. et ya vne petite isle encores plus pres de la poicte Et iras pouser devers le su suest de celle poincte.



Le Tour De Fer (page 75 of the text)
Probable site located at thte entrance to La Corunna in
Finisterra, N.W. Spain
Figure 1

Rottier et pillotage

Pour bien congnoistre Lisledieux si est. que tu voyras aussi tost ou plustost le clochier de leglise que la terre de belle veue
Lisledieux gist est et noroest et est semblable a ceste figure.



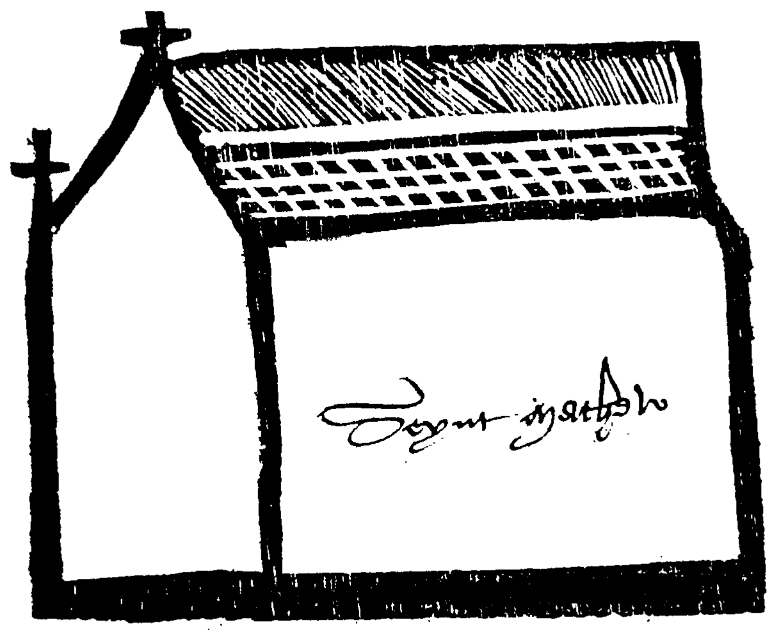
Sy tu va le bas pour querir le pillier Et veille ranger de uers noirmonstier pour toy garder des dangiers deuers noir-monstier il fault que tu aye la tour de noirmōstier la haulteur dung homme au dessus de troys gros puys de sable qui sont de uers la mer et aussi sont les plus bas et les plus haulx.
Et quant tu seras en bon chenal tu trouueras douze brasses a quatorze brasses deaue.
Et si le vent est damont et tu veulx ranger pres ne va point plus pres de six brasses si tu ne scay bien commēt car quant tu seras a six brasses si tu cours sus le nort ou sus le nort noroest

Lisle Dieux— Clochier de Leglise (page 88 of the text)
Ile d'Yeu — Spire of Sainte Sauver Church — off the Coast of La Vendee
about 15 miles south of the Bay of Bourgneuf.
Figure 2

Rattier et pillotage

Sensuyt les cours des marees et comment el
les gisent le long de la couste devers le su en
toute lescluse en flandres

Sache que en la chenal iresche vient le iusant de loest
syroest et si veulx aller a baranchier sainct crist va p
le meilleu de la sablere de sainct mahe.et qui veult en
trer en bretaigne baranchier il fault des quon sera le travers
de la terre d sainct mahe.et de sainct mahe a aller au four por
ter sainct mahe decouuret dehors d la poincte du couquet pour
les basseres.Et les esmees de sainct mahe a aller au four sont
vne grãde chappelle.Sus laquelle ya vne grosse croix a lung
des pignons.Et est semblable a ceste figure.



Dehors des isles trouueras pl v.brasses et menu perrer-

Une Grad Chapelle (page 96 of the text)
The ruined abbey of Sainte Mathieu — 10 kilometers west of Brest.
Figure 3

drawings were first used to enhance or amplify the descriptive text in a book of sailing directions.

Page 15 of the text: Tides along the Coast of Brittany: " ...at the seven islands with the moon ESE - High Tide and with the moon SSW - Low Tide." and " ...from the island of baspaoul to st. malo all along the coast to carteras with the moon South - Low Tide and with the moon West - High Tide. "

Page 102 of the text: Distances along the Coast of Britanny:

lisle dieux a belisle (Ile d'Yeu to Belle Ile)	3 veues 63 miles
belisle a groye (Belle Ile to Groix Island)	1 veue 21 miles
groye a glenan (Groix Island to Glenan Islands)	1 veue 21 miles
glenan a penmarch (Glenan Islands to Penmarch)	1 veue 21 miles
penmarch a ras (Penmarch to Point Raz)	9 lieues 18 miles

Author's note: one veue equals 21 miles
one lieue equals 3 miles
one lieue equals 1 league
one veue equals 7 lieues

The veue was reckoned as the distance a man could see along the coast.

Pages 75, 88 and 96 of the text: Diagrams of prominent landmarks (woodcuts):

Page 75: Tour de fer (Torre de Hercules) (Entrance to Ria La Coruna, NW Spain) (See Figure 1.)

Page 88: Lisle dieux (Ile d'Yeu) The broad spire of St. Sauver Church (See Figure 2.) Page 96: Chapelle sainct mahe (Ruined abbey of Saint Mathieu) (See Figure 3.)

Note: The woodcuts by Garcie which are included in Le Grant Routtier, although somewhat crude, were invaluable as additions to the text. There are fifty-nine drawings contained in the book. Those shown in Figures 1 through 3 are representative of the type of drawings rendered by Garcie to illustrate the text.

Page 93 of the text: Pilotage along the Coast of Brittany: "...between the glenans (islands of) and groye (Ile de Croix) there is a shoal. The channel is divided in two parts between the shoal and groye; the third part is in the direction of glenans. To avoid the shoal keep st. nicolas island (beyond or outside?) the point pain froit (Penfret)...." and "...between glenans and the island of molinnez are two rocks. If you want to approach glenans, approach at seven fathoms and keep point pain froit (Penfret) toward the S.E. Mouton island to the promontory of penmarch is oriented NW/SE...."

Page 151 of the text: Pilotage along the Coast of Brittany:

"...If you desire to go to glenans (island of) towards the east is a beach of sand which covers point de pain froit (Penfret) you will have a ... from S, SW to W and you will have close to shore at the vas islands 15 fathoms. Maintain 10 fathoms and keep the point to the E and N.E....If you want to go beyond penmarch, go W 1/4 SW to double penmarch."

Le Grant Routtier of Pierre Garcie was the first of the important printed books of Sailing Directions for northern European waters published during the sixteenth century. An English translation by Copland, mentioned earlier, appeared in 1528 and just a few years later in 1532 the first printed Dutch Leeskart was published by Jan Severszoon Cruepel van der Shellinc.

During 1584-85 Lucas Janzoon Waghenaer publsihed his famous Spieghel der Zeevaerdt the first example of a chart atlas combined with sailing directions to be published by a cartographer. This work which was translated into English in 1588 and titled The Mariner's Mirror became very popular, so much so that it was at about this time that the word rutter gave way to the word waggoner as the term commonly used to describe a volume of sailing directions. It must be remembered, however, that it was the printed routtiers of Pierre Garcie which provided the mariner with the first really useful sailing directions of Western European waters.

Le Grand Routtier of Pierre Garcie marks a turning point in the history of the art of navigation.

Note: The page numbers in the text refer to the facsimile of Le Grant Routier *included in* Routiers of the Sea *by D. W. Waters, Published by Yale University Press, New Haven 1967. All illustrations are with the permission of Yale University Press.*

NAVIGATION NOTES

Remarks on Aspects of Polar Navigation

by Thomas D. Davies

One of the causes of misunderstanding of Peary's polar navigation stems from a basic difference between navigation at normal latitudes and navigation in the very high latitudes as one approaches the Pole. The full effect of the phenomenon known as "Convergence of the Meridians" is frequently not appreciated, particularly its effect on longitude sights.

Temperate zone navigators find longitude sights (or knowledge of longitude) essential to combine with latitude and determine a "fix" or position. Not only does this enable them to avoid hazards but it allows use of a chart of magnetic variation from which the compass course can be correctly determined from the position. Given an accuracy of the sight of about one or two minutes of arc, the position and longitude can be found with about the same accuracy. An error of 2 or 3 degrees in longitude would be thought catastrophic since it would move the position as much as 150 miles.

In the far north several different conditions obtain. At least for Peary there was no chart of variation so a "fix" would not give him compass correction data. A major departure from conditions at temperate latitudes is that an error of 2 or 3 degrees in longitude results only in a position error of 4 to 6 miles at 88°N; hardly a concern. Similarly an error in direction or compass course as much as 5 degrees, when extended 120 miles to the Pole from 88°N leads to an arrival only about 10.5 miles to the left or right of the Pole, which any explorer of that period would have considered highly acceptable.

It is clear that positional and directional errors that would be almost catastrophic in lower latitude navigation were obviously satisfactory in the polar areas. Long experience in polar regions demonstrated to most polar explorers that excessive time devoted to developing more accuracy was wasted, in a situation where *time was the essence of survival.* Review of the reports of Nansen, Cagni and Amundsen all show that they took no longitude sights on their way towards the Pole, and since there were no charts of compass variation, it follows that they were satisfied with rough directional information from LAN sights which they had to take to determine progress.

Sir Albert Markham, in commenting (unfavorably) on Peary's navigation, asserted that when trying for the Pole in 1875 he (Markham) "did not bother" to take any longitude sights, but took constant observations to correct his compass. He did not explain what these observations were. His cousin, Sir Clements Markham suggested that Peary should have taken *Amplitudes*, but these could only be taken when the sun actually went below the horizon (i.e. set) so it is still not clear what Sir Albert's method actually was in May and June at 83°N. Even when the sun did set (prior to April 10th at 83°N) the slow rate of sinking, excessive and unpredictable refraction at the horizon and the nature of the arctic ice raftering would have made such sights just as inaccurate as direction by culmination at LAN.

In these remarks Sir Albert was actually criticizing Peary's LAN *latitude* sights and expressed the exasperation that many have experienced when first faced with the dual sun images from the artificial horizon. However records of Marvin's sights as well as Peary's, both at the Pole and on earlier expeditions, demonstrate that with experience good accuracy can be consistently obtained in LAN sights. Sir Albert was correct in saying that determination that culmination has taken place in LAN sights can take extended periods of time, however the sun's change in direction in 30 minutes is only 7.5° and a reasonable guess as to how long previous to completion the altitude had peaked could reduce that error substantially.

The polar explorers of Peary's era were not scientists recording physical phenomena with great precision in an unexplored part of the world. They were competent leaders driving to win the Pole for fame and glory for themselves and their country. Their choice of methodology was intensely pragmatic and they used methods that would get them there and back.

New Interest in Lunar Distances

by Thomas D Davies

Recently there has been a revival of interest on the part of many of our members, in the old method for getting time from the Moon, called the *Method of Lunar Distances.* Lunar distances were actually tabulated in the *Nautical Almanac* until about 1910, since they were sometimes used to check on chronometers. I have sent a number of readers copies of the tables and instructions from the 1909 *Nautical Almanac.* In it the lunar distances to various planets or stars are tabulated daily for eight different times, together with a factor for simplifying interpolation by logarithms. However a major difficulty with the method was the extensive computation (with logarithms) necessary to correct the measured lunar distance for the parallax of the Moon (the sun also, where that was used). In addition the tables occupied substantial space in the *Almanac* and were considered so cumbersome that, with the availability of modern timekeeping methods, as well as the availability of radio time, they were discontinued. However there is an antiquarian interest and of course there could be a time when such a method would be useful in an emergency.

Member Bruce Stark of Eugene Oregon has sent me a long paper entitled *Resurecting the Lunar Distance* in which he argues for publishing a set of tables for lunar distances by the Foundation. He has studied the problem for some time and proposes a new set of tables which could be contained in a book the size of the present *Nautical Almanac.* His tables are not yet fully generated but he establishes their details, which include the use of Gaussian logarithms. The major use of tables is in determining the several corrections necessary to "clear" the lunar distance observation for use in the calculation. He uses the calculated distance between the moon and star from *Almanac* (GHA). Data for the nearest time to the assumed time is used, and the time correction calculated by simple proportion between these. He proposes to calculate this distance without modern tables (such as the *Concise Tables* in the *Almanac*). His paper is too long to publish in the *Newsletter* but he will probably respond to interest by other members, addressed to him through the Foundation.

In the next issue I will describe a somewhat different approach to lunar distances which I have been working on. It uses a unique method of establishing the moon's path and somewhat reduces the steps for both calculating the lunar distance and "clearing" it for corrections. A single hand calculator program (designed for the HP 11) accomplishes both calculations. Meanwhile we will look for interest in the subject of "lunars" on the part of members.

A Navigation Problem

by Roger H. Jones

Solution to the Problem in Issue 30.

32. Answer

At longitude 70-15.0 West the standard time difference from Greenwich is 4 hours, 41 minutes. GMT is 00-01-40, 29 September 1990. The GHA Aries at that time is 7-54.8, and the LHA Aries is 297-39.8. Using the blue template for 35 North and LHA 297.7, plot the body at a bearing of 187 and altitude of 33 degrees. Switch to the red template, North side, and align the left edge of the open slot with the penciled dot plotted on the white face plate. Read declination 22 South, and a rim scale value of about 290.3. SHA equals 360 minus 290.3, or 69.7. This equates to 69 degrees, 42 minutes of arc.

Look at the *Almanac* star listings. Thre is no star in the July to December list with a SHA of 69.7 and a declination of 22 South. However, on the page for September 28 - 30, the SHA for Saturn is 69 degrees, 42.6 minutes, and the declination at 00-00-00 on the 29th is 22-09.9 South. The body is obviously Saturn. The tip-off that it is a planet is the fact that it is a fairly bright body that is not pre-plotted as a principal navigational star, and its declination falls within the range of the open slot on the red remplate. The declinations of all navigational planets fall within the range of the open slot. If the body is fairly bright, is not a pre-plotted star, and falls within that slot, there is an excellent chance that it is a planet.

Problem No. 33

We have previously dealt with the use of the star finder in connection with night observations of a star and a planet. Many navigators, without giving deep thought to the matter, will assume that the usefulness of the 2102-D Star Finder, for all practical purposes, ends there. This is not the case. It has many uses in connection with daylight observations of celestial bodies. What bodies are available? Obviously, the sun is, and depending on the phase of the moon, it may also be available for a daylight line of position (LOP). Not so obviously, there is a third body — the planet Venus. For Venus the navigator will need a good sextant telescope and crystal clear skies, but the daylight shot of Venus is more than a mere curio. At times it can be a very real component of a two or even a three-body daylight fix. The date is December 9, 1990. What quick and practical method can be used, without calculation, to determine if the date may be optimum for a sun-moon fix? Assuming the date is within the period during the lunar cycle when a sun-moon fix may be possible, how can the star finder be used to determine the relative positions of the sun, moon and Venus, their LOP intersection angles, and the best times when optimum sights may be attempted?

NAVIGATION PERSONALITIES

Sir George Biddell Airy

by Thomas D. Davies

Any student of the history of navigation is familiar with the name of George Airy. Primarily an astronomer, his contributions to navigation were manifold. Traces of them are to found in today's navigational techniques and data.

He was born at Alnwick (England) in 1801 and was educated at Colchester grammar school and at Trinity College, Cambridge. He graduated in 1823 and became a fellow of the College in 1824 and Lucasian professor of mathematics in 1826. In 1828 he was appointed Plumian professor of astronomy and director of the new Cambridge Observatory. Regular observations were instituted in 1833 with a newly installed "mural circle." This device, going back to the observatory of the norwegian astronomer Tycho Brahe (1576), was in effect a non-telescopic meridian circle, "mural" referring to a wall on which the arc of degrees, minutes and usually seconds, was mounted.

In the same year an object-glass of 12 inch aperture was presented to the observatory by the duke of Northumberland. This objective was incorporated into a telescope of Airy's design, being completed after Airy himself had left the Cambridge observatory. In 1835 Airy was appointed Astronomer Royal, succeeding John Pond, and moved to the Royal Observatory at Greenwich. Although he had written on both astronomy and optical physics while at Cambridge it was while at this post that he did most of his important work.

The Greenwich observatory was in serious need of modernization and Airy set to work immediately. Modern equipment was installed but equally important the entire organization was placed on a scientific footing. In the course of this reorganization some 8,000 lunar observations were found and brought to light to be used by astronomers on lunar theory. These data played an important role in the improvement of the tables of the moon's motion—a vital problem in both astronomy and navigation which continued well into the next century. As noted in *Navigation Notes* in this issue, the lunar distance method was of great importance at that time, and the most cumbersome part of the method was the steps involved in "clearing" the measured lunar distance for the several corrections required. Airy was a contributor in this navigational matter, having published a method and tables in 1882.

Of interest to navigators is also the fact that Airy conducted experiments on iron ships for the purpose of determining a method of correcting the magnetic compass for the effect of the iron in the ship. His report on these was published in 1839 and was an important contribution to the solution of that nautical problem. Airy also attacked a then-current problem in physics, the determination of the mean density of the earth. He proposed to accomplish this by means of pendulum timing experiments at the top and bottom of a very deep mine shaft, thus determining the value of the earth's gravity at those two points. Using the Harton Pit shaft, a depth of 1,256 feet, he was able to calculate a mean density value of 6.566 for the earth.

In 1872 Airy embarked on a new method of treating lunar theory. It was published in 1886 after he had resigned from the post of Astronomer Royal and constituted a major contribution to that historical problem. It is noteworthy that Hansen's later *Tables of the Moon* were dedicated to Airy. He continued his writing in the field of astronomy until his death in 1892.

MARITIME INFORMATION NOTES

Provided by Ernest Brown

Special Warnings

These warnings, primarily intended to announce official government proclamations affecting shipping, are broadcast as needed. They are numbered consecutively and further promulgated in Notice to Mariners.

SPECIAL WARNING No. 80
1. IN RESPONSE TO REQUESTS FROM THE LEGITIMATE GOVERNMENT OF KUWAIT AND IN EXERCISING THE INHERENT RIGHT OF COLLECTIVE SELF-DEFENSE RECOGNIZED UNDER ART. 51 OF THE UN CHARTER, UNITED STATES FORCES WILL IN COOPERATION WITH REGIONAL AND ALLIED FORCES CONDUCT A MARITIME OPERATION TO INTERCEPT THE IMPORT AND EXPORT OF COMMODITIES AND PRODUCTS TO AND FROM IRAQ AND KUWAIT THAT ARE PROHIBITED BY UN SECURITY COUNCIL REESOLUTION 661.
2. AFFECTED AREAS INCLUDE THE STRAIGHT OF HORMUZ, STRAIT OF TIRAN, AND OTHER CHOKE POINTS, KEY PORTS, AND OIL PIPELINE TERMINALS, SPECIFICALLY, PERSIAN GULF INTERCEPTION EFFORTS WILL BE CONCENTRATED IN INTERNATIONAL WATERS SOUTH OF 27 DEGREES NORTH LATITUDE: RED SEA INTERCEPTION EFFORTS WILL BE CONDUCED IN INTERNATIONAL WATERS NORTH OF 22 DEGREES NORTH LATITUDE.
3. ALL MERCHANT SHIPS PERCEIVED TO BE PROCEEDING TO OR FROM IRAQI OR KUWAITI PORTS, OR TRANSSHIPMENT POINTS, AND CARRYING EMBARGOED MATERIAL TO OR FROM IRAQ OR KUWAIT, WILL BE INTERCEPTED AND MAY BE SEARCHED.
4. SHIPS WHICH, AFTER BEING INTERCEPTED, ARE DETERMINED TO BE PROCEEDING TO OR FROM IRAQ OR KUWAIT PORTS, OR TRANSSHIPMENT POINTS, AND CARRYING EMBARGOED MATERIAL TO OR FROM IRAQ OR KUWAIT, WILL NOT BE ALLOWED TO PROCEED WITH THEIR PLANNED TRANSIT. 5. THE INTERCEPTING SHIP MAY USE ALL AVAILABLE COMMUNICATIONS, PRIMARILY VHF CHANNEL 16, BUT INCLUDING INTERNATIONAL CODE SIGNALS, FLAG HOISTS, OTHER RADIO EQUIPMENT, SIGNAL LAMPS, LOUDSPEAKERS, AND OTHER APPROPRIATE MEANS TO COMMUNICATE HIS DIRECTIONS TO A SHIP. (SAFE NAVIGATION MAY REQUIRE VESSELS TO BE DIVERTED TO A PORT OF ANCHORAGE PRIOR TO CONDUCTING A SEARCH.)
6. FAILURE OF A SHIP TO PROCEED AS DIRECTED WILL RESULT IN THE USE OF THE MINIMUM LEVEL OF FORCE NECESSARY TO ENSURE COMPLIANCE.
7. ANY SHIPS, INCLUDING WATERBORNE CRAFT AND ARMED MERCHANT SHIPS OR AIRCRAFT, WHICH THREATEN OR INTERFERE WITH U.S. FORCES ENGAGED IN ENFORCING THIS MARITIME INTERCEPTION WILL BE CONSIDERED HOSTILE.

Omega Station Liberia has gone off-air due to the military and political difficulties in that country. When commercial power was cut at the end of June, the station continued operating using its emergency generator until its fuel supply was almost depleted. The station went off-air indefinitely on July 9, with a small amount of fuel left to maintain minimum power requirements for timing equipment, tower lights, and VLF communications. It is unknown at this time when the station will be able to refuel and come back on air. All normal lines of communication have been broken within the country and with the outside, which makes it difficult to ascertain the current situation.

Meanwhile, Omega Station North Dakota was scheduled to have its normal annual off-air for maintenance in July. This has been postponed indefinitely to avoid having more than one station off-air at the same time. The Omega system was designed to allow the periodic off-air of one station for maintenance. However, if more than one station is off, holes begin to show in the coverage. If necessary, other upcoming scheduled maintenance off-airs such as Norway in August and La Reunion in September will also be postponed.
Provided by Robert Hoyler and LTJG L.A. Archbold, USCG of the Omega Navigation System Center.

Rules of the Road.

The new edition of the Coast Guard publication Navigation Rules International-Inland (COMDTINST M16672.2B) is available for issue. COMDTINST

M16672.2A is cancelled.

The Navigation Rules contains the International Regulations for the Prevention of Collisions at Sea, 1972 (72 COLREGS) and the Inland Navigation Rules. Also included are the nine amendments to the 72 COLREGS that became effective on November 19, 1989. The Navigation Rules may be purchased from the Superintendent of Documents, US Government Printing Office (GPO), Washington, DC 20402; from GPO Bookstores located in many cities; or from GPO Sales Agents located in principle ports; stock number 050-012-00287-8; price $8.00. Telephone orders may be placed by calling GPO at (202) 783-3238.

WANTED

Lloyd M. Smith of Sarasota, FL wants to locate a copy of MARINER'S CELESTIAL NAVIGATION by William P. Crawford, published by W. W. Norton & Company.

Answers to some of the "Wanted" items from previous issues will be found in the Readers Forum.

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