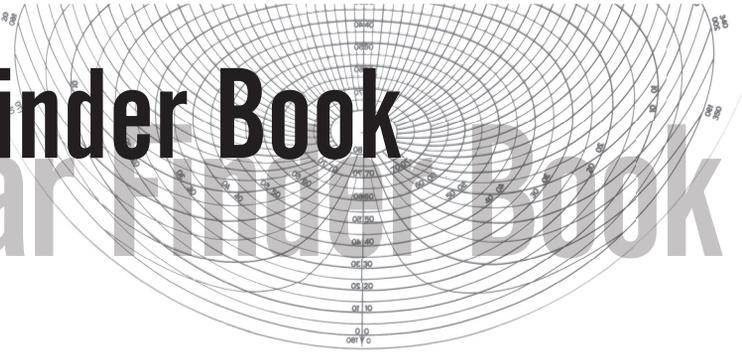


# The Star Finder Book

A Complete Guide to the Many Uses of the 2102-D Star Finder

DAVID BURCH



# The Star Finder Book

A Complete Guide to the Many Uses of the 2102-D Star Finder

Second Edition

David Burch

  
**STARPATH®**  
Seattle, Washington

*The Star Finder Book*

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## Preface

After teaching celestial navigation to over 3,000 students during the past 6 years, we have well learned the recurring questions. We especially appreciate questions and comments of former students after they navigate their first ocean crossing. Comments from new navigators are invaluable to the development of teaching methods and course materials. This booklet is one example.

Most discoveries of new navigators fall (with some shaking) into two categories: the good news and the bad news. The good news is their newly learned celestial navigation all works as it's supposed to. The sextant is not hard to use, even bouncing around in rough seas; and once the sextant sights are in hand they are confident they know where they are and how to get to where they want to go. The bad news that leads to most questions new navigators want answered before their next crossing is, skies are much more cloudy in the ocean than they thought they would be.

Under cloudy skies, the extreme value of accurate dead reckoning becomes clear very soon. But this is not the subject at hand, and improving dead reckoning procedure is easily accommodated underway without special training. The problem with cloudy skies we cover here is that of identifying unknown stars in isolated patches of clear sky. Such stars may be in view for a few minutes only, just long enough to get a sextant sight of them.

New navigators soon learn that these unknown stars may offer the only sights available for several days, and that this can occur much more often than was suspected. This is not just true in high-latitude oceans, famous for cloudy skies; it is a potential problem in all oceans including those of the Tropics. It is, therefore, a basic skill of the navigator to know how to identify stars. Fortunately, this skill is easily mastered on land, long before it might be critical to a safe, efficient ocean passage.

In the past we told students the best way to identify unknown stars is the 2102-D Star Finder, and we would spend an hour or so explaining its use. Then off they would go with this extent of preparation for the problem, whenever it should arise. We have since learned that this is not enough, and this booklet is intended to remedy this. This booklet explains the function and use of the Star Finder slowly and thoroughly, using detailed numerical examples and practical practice problems. In addition, the booklet discusses general features of star and planet choices and other practical procedures in celestial navigation.

Besides basic star identification, this booklet also elaborates on several other, more specialized, applications of the Star Finder — again, in response to questions from new navigators. These include its use in predicting heights and bearings of stars, moon, and planets for routine sights and picking optimum star-planet combinations. Navigators soon learn the value of the moon, Venus, or Jupiter for combination with star sights, since these three bodies can be seen during the brighter part of twilight when stars are faint but the horizon is still sharp.

We also demonstrate how the Star Finder can be used to answer two common questions in celestial navigation: Which days of the month offer a simultaneous sun-moon fix and what is the optimum time of day to do the sights, and how long must one wait between successive sunlines for a good running fix? These are fundamental, practical problems which are most easily solved using the Star Finder.

Another purpose of this booklet is to teach star identification to candidates for Merchant Marine licenses. Some examinations require star identification but do not require the candidate to know the details of celestial navigation by stars other than Polaris. The 2102-D Star Finder is an acceptable way to solve this part of the examination — it is also the easiest way, regardless of background in celestial navigation.

And finally, we would hope that this booklet might serve to introduce this Star Finder to interested stargazers outside the field of marine navigation. Anyone who knows (or cares to learn) how to use an Almanac can use the Star Finder to identify all stars and planets and predict their heights and bearings at any time. I suspect that if more people simply knew that the 2102-D Star Finder existed, more people would be using it, in more varied applications.

## **Preface to the 1995 printing**

This printing remains the same as the first 1984 edition, except that a few typographic errors have been fixed and the name of the booklet has changed. Within the practice of celestial navigation, the main change has been the increased use of computers. They do star ID very conveniently, but — and although the number of our students has increased to now over 13,000 and our own experience expanded some 30,000 miles — the conclusions of the early preface remain the same. The old plastic star finder will have a place onboard so long as small craft go to sea. It is the only convenient means of star ID that works when it's wet, and strangely enough, it is still more versatile than any software yet available.

## **Preface to the Second Edition**

Some things have changed, some remained the same. We have now been fortunate to have had well over 20,000 classroom students at Starpath School of Navigation and thousands more in home study courses around the world, and my own ocean experience has grown to well beyond 60,000 miles underway. And needless to say, technology has changed a lot. But the discussion of the First Edition Preface about the role of the Star Finder remains valid. The main computerized challenge to the device comes from our own StarPilot software programs for PCs and for calculators, but they too are vulnerable to the elements underway as all electronics are.

The most significant development since 1995 related to star and planet ID is the advent of several wonderful resources on the Internet. Worth special mention is the US Naval Observatory site which computes heights and bearings of all the major bodies in the sky for any date, time, and location. One can now master the Star Finder for any location on earth by simply using the data they provide to check your results. The necessary almanac data is also available online. See the Celestial Resources section of [www.starpath.com](http://www.starpath.com) for a list of links.

The bulk of this text is the same as the last edition except that we have updated some discussions and added a few star-ID illustrations, adapted from the author's book on *Emergency Navigation*. This book is also available for the first time now in an e-book format as well as in print.

If you have any questions, comments, or suggestions about this book, please do not hesitate to contact us at [helpdesk@starpath.com](mailto:helpdesk@starpath.com). We remain a full time navigation school devoted as much to the old ways of navigation as the new. We are standing by to help in any way we can.

## **Note on the 2008 printing**

The content of this printing remains the same as the previous coil-bound version. The only change is the design and binding style of the book.

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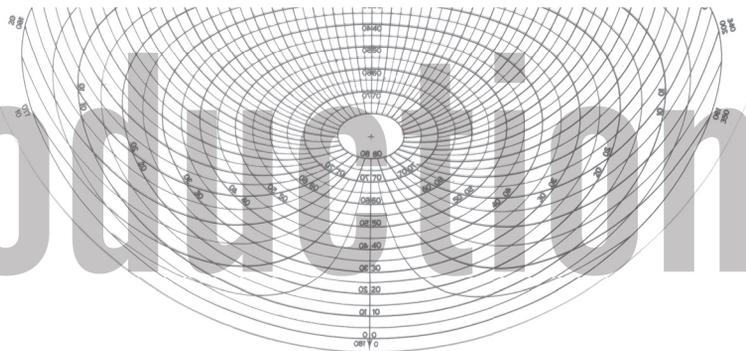
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# Chapter 1. Introduction



Various devices have been invented to help navigators identify stars and planets and solve other related problems in celestial navigation. The most popular of these was once an official government product called H.O. 2102-D. These are no longer produced by the government, but identical ones are now available from several commercial companies — trade names usually include “2102-D” to identify the product. They cost about \$35, and are well worth the investment.

The standard user’s instructions that come with these Star Finders, however, are sparse and far too terse for celestial navigation students who are new to the device. We have heard this from nearly every student who has tried to learn the use of this Star Finder on their own. This booklet is intended to correct this shortcoming and extend the discussion of this Star Finder that appears in Bowditch’s *American Practical Navigator*, Vol. I, Article 2210.

It is also in part the fault of the limited user’s instructions that this device is not any better known outside of the celestial navigator’s circle — a fairly small circle at that, and one that is growing smaller rapidly as electronic navigation aids increase in convenience and decrease in price. We hope this booklet might add new interest to this valuable tool. The Star Finder is a handy gadget. It could be especially valuable to amateur astronomers or anyone else who spends much time out of doors looking at the stars, wondering who is who, and where the planets are, and so forth.

To use the Star Finder you will also need a current edition of the *Nautical Almanac*, or its equivalent in the professional or amateur astronomer’s fields. You don’t, however, have to be an experienced navigator

to use the 2102-D Star Finder and this guide. All that is required is some familiarity with the basic terminology of celestial navigation — much of which is reviewed in this guide — and the use of your choice of Almanac. This booklet was prepared for students in the process of learning celestial navigation, but we suspect that even seasoned navigators may find the Star Finder more valuable with this expanded description of its usage.

Again, even though our emphasis throughout this guide is on navigational applications, you don’t have to go to sea to benefit from the Star Finder and this User’s Guide. But if you do plan to go to sea someday, the Star Finder is an excellent way to prepare for your celestial navigation. From your own backyard you can learn the stars you will start out with, and even look ahead to see what stars will be your guides as you approach Tahiti or The Azores some years from now.

## The Primary Navigational Applications of the Star Finder Are:

(I) To identify stars or planets after taking sextant sights of them — a circumstance that occurs on partly cloudy twilights, when only a few unknown stars are available in isolated patches of clear sky.

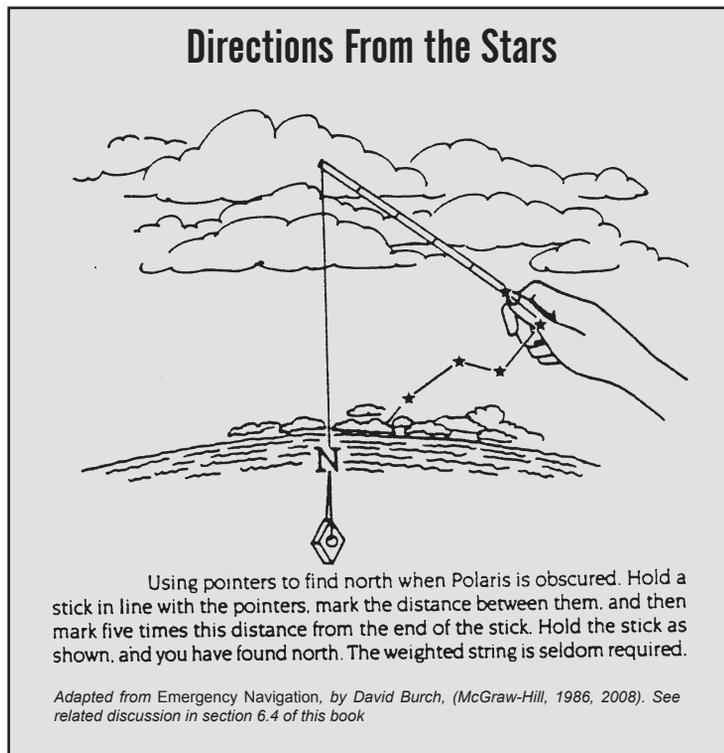
(II) To predict (precompute) the heights and bearings of stars and planets before you take sextant sights of them — a standard procedure that makes sights easier and more accurate. Precomputed sights are usually more accurate because, by knowing exactly where to look for the stars, you can take sights earlier in the evening twilight while the sea horizon is still a sharp line. It is the sharpness of the horizon that usually determines the accuracy of sextant sights.

(III) To determine the optimum time of day for simultaneous sights of sun and moon, or, more rarely, sun and Venus — a less common application, but when needed the Star Finder is a convenient way to solve the problem.

Another application is simply to use the Star Finder to help learn the stars and how they move across the sky. Or, use it to look ahead to see what stars you might use for navigation during a planned voyage in some later season. In short, to use it for whatever you

want to know about the positions and apparent motions of celestial bodies.

Once you become familiar with the use of the Star Finder, it becomes, in essence, your own pocket planetarium. You can use it to view the sky during any season, from any latitude, at any time of day or night. As you read through this guide it will be helpful to have a Star Finder at hand to identify the parts and work through the numerical examples.



# Chapter 2.

# Description of the 2102-D Star Finder



The device consists of three parts: (1) A rigid white plastic disk with stars printed on it, called the “star base” or “white disk,” (2) a set of 9 transparent templates with blue printing, which we call the “blue templates,” and (3) a special template with red printing. These parts, and a limited set of instructions, come in a round black plastic case about a foot in diameter.

The stars printed on the white disk are the 57 “navigational stars” listed on the daily pages of the *Nautical Almanac* (see appendix). One side of the white disk shows the North Pole of the sky at its center; the other side shows the South Pole. The same stars are shown on each side, but from a different perspective. The brightness of a star on the white disk is indicated by its symbol, as shown in Table 2-1

Special terms like “navigational star,” “magnitude” of a star, “declination” of a star, and a few more to be used in this section are explained later in Sec. 3.1 on terminology.

The type of star map used for the stars on the white disk is similar to the round star maps at the back of the *Nautical Almanac*, although the layout is slightly different as shown in Figs. 2-1 and 2-2. Looking at the “north side” of the white disk, stars near the rim of the disk have high southern declinations; those about halfway toward the center have declinations near 0°; and those near the center of the disk have high northern declinations.

The scale along the rim of the white disk represents different things depending on the application.

Table 2-1. Star Symbols on the White Disk

---

☉ Capella	Northern sky examples: Capella and Vega Southern sky examples: Sirius and Canopus These are “magnitude one” stars, the 20 brightest stars in all the sky. All 20 are navigational stars.
● Hamal	Northern sky examples: Dubhe and Alkaid Southern sky examples: Nunki and Hamal These are “magnitude two” stars, which are stars as bright as the Big Dipper stars. There are some 75 of these in all the sky. About 30 are navigational stars.
● Enif	Northern sky examples: Schedar and Enif Southern sky examples: Gienah and Sabik These are “magnitude three” stars, which are stars not quite as bright as Big Dipper stars, but brighter than the stars on the handle of the Little Dipper. There are some 200 magnitude three stars in all the sky. Only 7 of the brightest of these are navigational stars.

---

Using earth coordinates, the rim scale represents the Local Hour Angle of Aries (Sec. 3.1); using sky coordinates, the rim scale represents Right Ascension, which is the same as  $360^\circ$  minus Sidereal Hour Angle. But don't worry for now about the technical meanings of this scale and how they are related, because once we have the Star Finder set up for a given location and date, this rim scale will simply become a 24-hour clock face, with each  $15^\circ$  corresponding to 1 hour of time as shown in Fig. 2-3.

The positions of the sun, moon, and planets are not shown on the white disk because their positions among the stars change daily. The white disk, however, can be written on with pencil (and easily erased), so we can add these positions to the disk once we look up their sky positions (declinations and Sidereal

Hour Angles) in the *Nautical Almanac*. We can also add other stars if we choose, but this is not a common practice. Most important to note is this: we can identify all stars with this device, even those that are not printed on the white disk.

To use the Star Finder we place the appropriate blue template (the choice depends on our latitude) on the pin at the center of the white disk. The blue template is then rotated to set it for the proper time, and then the heights and directions of the stars can be read directly from scales on the blue template. In rare cases, this simple operation of placing the template on the center pin of the white disk is not as trivial as it should be — especially on some new units, or newly used templates as you sail into new latitudes. On some new units the pin fit is very tight. You might end up commenting on the designer as you try to get

the thing on there. But the fit must be snug if the readings are to be accurate. If the fit happens to be tight at first, don't drill the holes bigger, they will loosen with usage.

One approach to getting a tight template onto the pin is to lay the white disk on a hard flat surface, and gently press the template over the pin, pressing on opposite sides near the pin. But don't press too hard because the pin can pop out of the white disk. If you lose the pin, you end up using a wooden match, or some such thing, in its place - which works, but is more trouble, and so forth.

The 9 blue templates are labeled according to the latitude of the observer. There is one template for every  $10^\circ$  of latitude, beginning at latitude  $5^\circ$ .

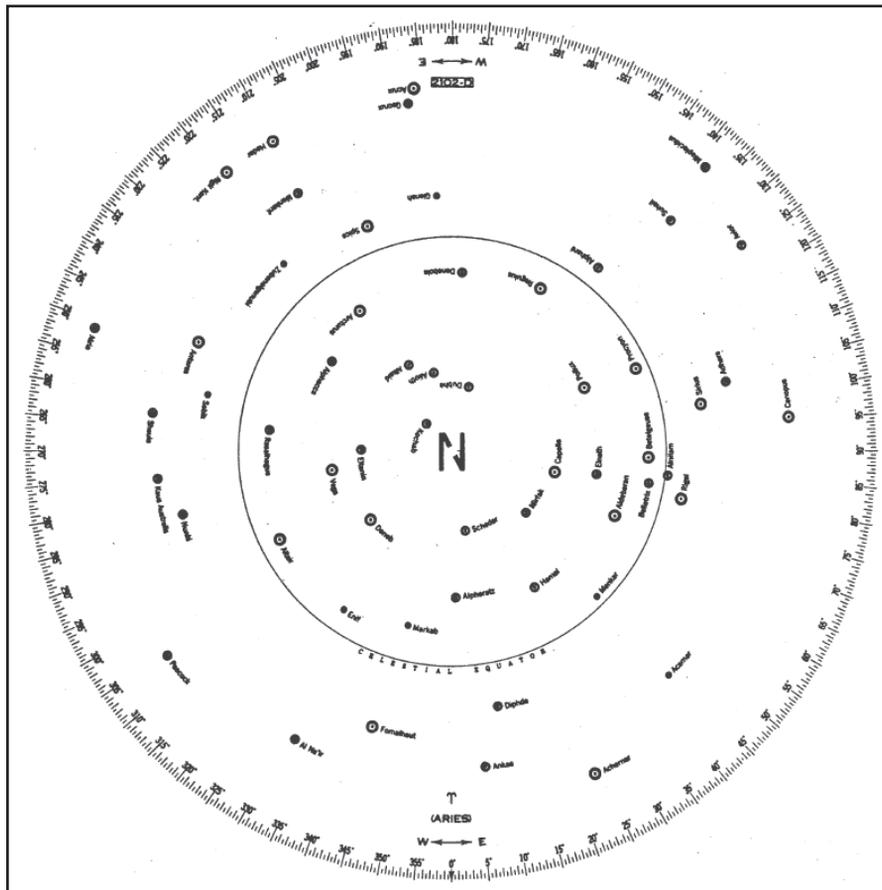


Figure 2-1 North Side of the white disk of the 2102-D Star Finder

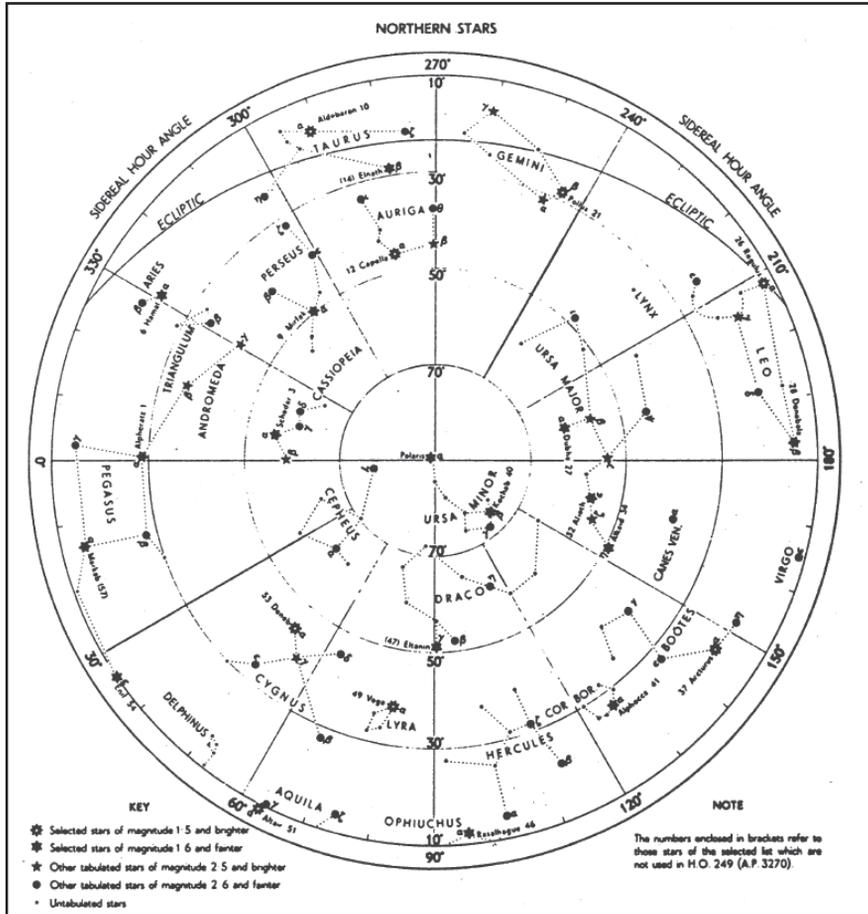


Figure 2-2 Round star map of the northern stars from the Nautical Almanac. (Larger Views in the Appendix.)

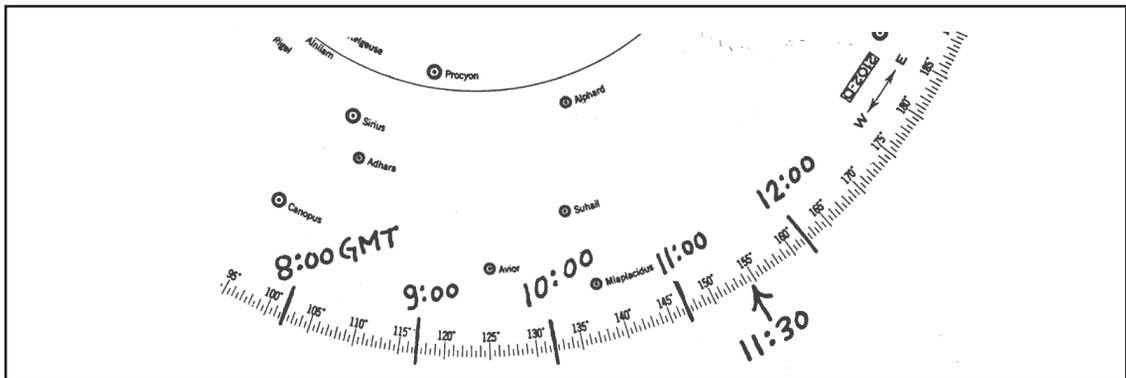


Figure 2-3 Time scale on the white disk. After one point on the rim scale is assigned a specific time, the remaining time scale follows at 15° per hour. You can use any time scale: Watch Time, Zone Time or GMT.

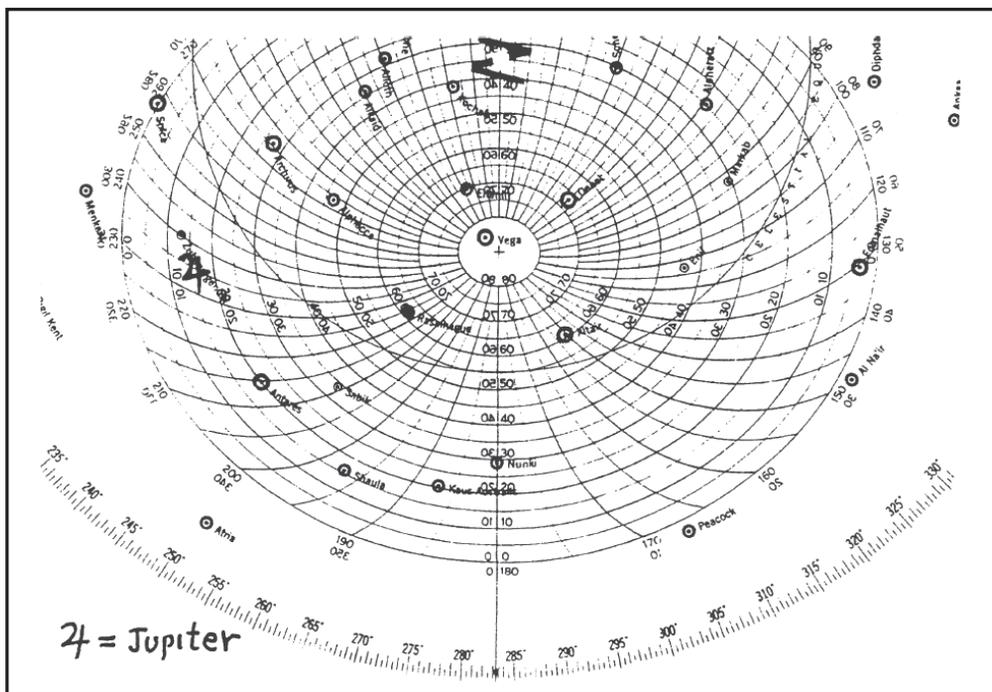
For most applications at sea we use the blue template that corresponds most closely to our dead reckoning (DR) latitude — for practice on land, use the one closest to your known latitude

There is a “north” and “south” side to each blue template. The north side of the 450 template, for example, is the side labeled “Latitude 45° N.” You can see the label for the south side through the transparent template, but it will appear backwards. For all applications in the Northern Hemisphere use the north side of the white disk with the north side of the blue template facing upward so you can read its label properly. When viewing stars from the Southern Hemisphere use the south side of the blue template on the south side of the white disk.

Each blue template contains two overlapping sets of curves. One set represents the angular heights of the stars; the other set gives the true bearings of the stars. In the terminology of celestial navigation, the

height of a star would be its calculated altitude ( $H_c$ ), and its true bearing would be its azimuth ( $Z_n$ ). The same printed scales apply to all celestial bodies: sun, moon, stars, and planets. The azimuth scale is the one that goes from 0° to 360° in 5° intervals around the diagram. The altitude scale goes from 0° (on the horizon) to 90° (overhead) in 5° intervals across the diagram. The proper numerical scales to use are the ones that can be read properly. Numerical scales for the other side of the template can be seen through it, but they appear backwards. Figure 2-4 shows a blue template in place on the white disk and lists a few heights and bearings that can be read from these scales.

The red template is a special one used to plot sun, moon, and planet positions onto the white disk. It is also used for identifying sighted stars that do not appear on the white disk. The concentric circles on the red template correspond to lines of equal declination on the white disk. Circles on the center part of



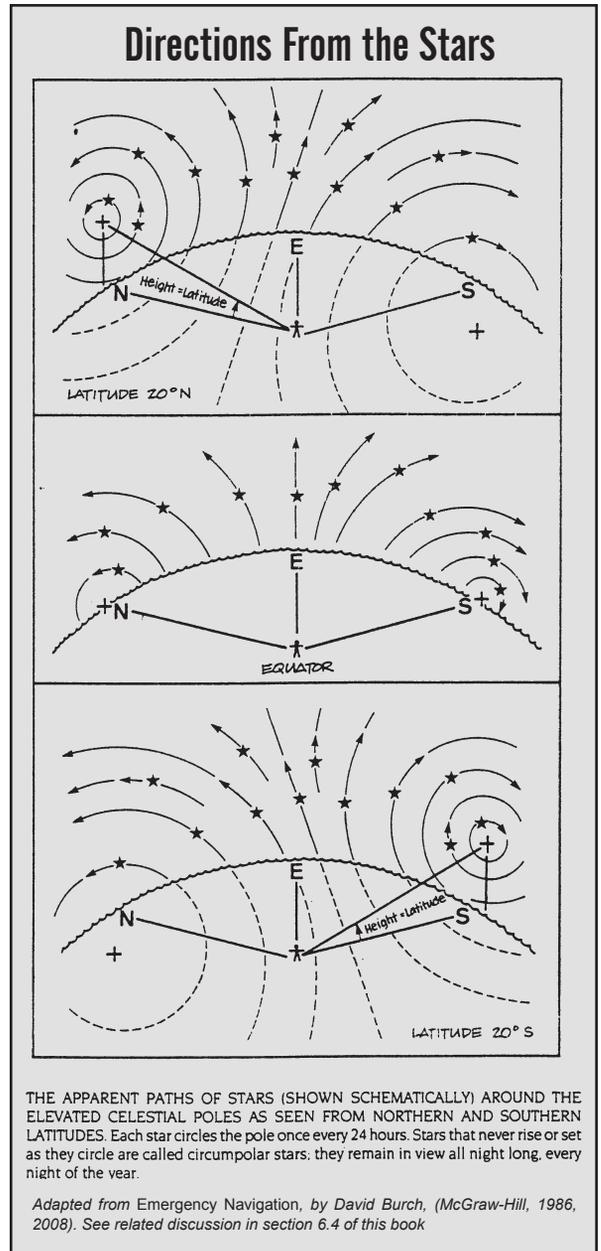
**Figure 2-4** The blue template for 35° N in place on the north side of the white disk. The blue-template arrow is set to Local Hour Angle Aries = 283.5°, which, in this example, corresponds to a GMT of about 15:30. The Star Vega is near overhead, bearing to the NW; Antares bears about 215° at a height of 20°. Arcturus bears 276° at a height of about 27°. Spica is just below the horizon to the west, and Fomalhaut is rising at about 130°. Altair is about 62° high bearing about 151°. The planet Jupiter is about 15° high, bearing 235°. All Star Finder bearings are True bearings.

the red template are solid lines; the outer ones are dashed lines. We will later use this difference to distinguish between north and south declinations when identifying an object that is not printed on the white disk. A declination scale is printed along a radial line. The slot in the red template is used for plotting sun, moon, and planet positions on the white disk.

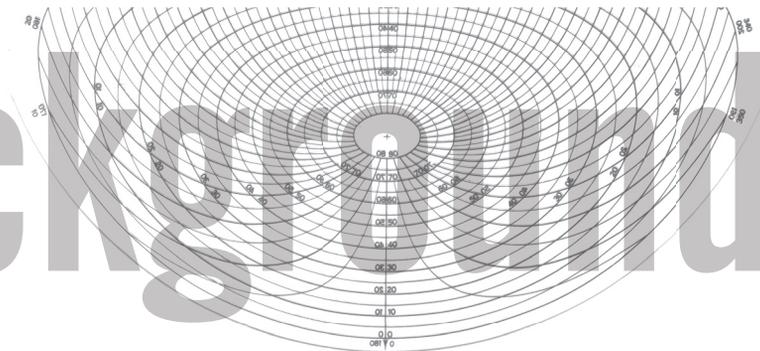
The scale along the rim of the red template can be ignored; it has no significant practical use. There are also north and south sides labeled on the red template, but since the rim scale is not needed for any practical application, we can use either side of the red template for all applications. The south side of the red template, however, will prove the more convenient for all applications because of the way the declination scale is printed.

### 2.1 British Star Finder N. P. 323

Although it looks different, the British Star Finder N. P. 323 is essentially the same as the 2102-D. Examples and instructions of this book apply to it as well. The latitude templates are orange on N. P. 323, not blue, and they are only printed on one side. Both star finders give templates for every  $10^\circ$  of latitude, but N. P. 323 starts at latitude  $0^\circ$ , not  $5^\circ$ . The white disk of 2102-D is replaced with a white paper card in N. P. 323 and there is no pin in the center, which makes its alignment and rotation slightly more difficult. The sizes of the scales are the same, so they have the same accuracy. There is no equivalent to the 2102-D's red template given with N. P. 323, but this is not actually required for either of them. In short, the two star finders are the same for all practical purposes, though the 2102-D is slightly easier to use and probably more durable than its paper counterpart.



# Chapter 3. Background



## 3.1 Terminology and Celestial Motions

**T**he 57 stars printed on the white disk are the so-called “navigational stars.” These are, by definition, the stars listed on each of the daily pages of the *Nautical Almanac* — the same 57 stars appear on each page. These include the 20 brightest stars, but the remaining 37 are not the next brightest ones. The remaining stars were chosen because of their position, as well as their brightness, to provide a uniform distribution of stars across the skies for navigational use. You could, if necessary, navigate by any one of several hundred stars visible on a clear night, but it is more convenient to use the navigational stars whenever possible. The *Nautical Almanac* lists (at the back of the book) the necessary star data for another 100 or so stars, but these are not officially called navigational stars.

A “northern star” is a star with a north declination, meaning it circles the earth above the Northern Hemisphere at a latitude equal to its declination. This is the definition of declination; it is the latitude over which the star circles. Each star circles the earth over its own unique latitude. And this latitude, its declination, remains constant, essentially forever. If your latitude equals a particular star’s declination, then that star must pass directly overhead once a day, all year long. During some seasons it passes during daylight hours so you won’t see it, and in other seasons it is visible at night but doesn’t actually go over head at night, but it goes by once a day nevertheless. A “southern star” has south declination and circles the earth over the Southern Hemisphere.

From either hemisphere, we can see both northern and southern stars. Looking low in the sky from any latitude, north or south, we see northern stars to

the north, and southern stars to the south, and both northern and southern stars when looking east or west. The stars we see overhead depend on our latitude. In northern latitudes, only northern stars pass overhead; in southern latitudes, only southern stars pass overhead. Any star that passes precisely overhead (crosses our zenith) must have a declination equal to our latitude. Now a fact that is not at all obvious: From any latitude, north or south, southern stars always rise south of due east and set south of due west. Likewise, northern stars rise north of east and set north of west. This is the reason we see both northern and southern stars when looking east or west from any latitude. Without the use of a planetarium it is somewhat difficult to picture how this comes about, but Fig. 3-1 might help clarify this. Soon we will be able to see this directly from the Star Finder. This can be a handy thing to know when it comes to star ID.

With the use of the Star Finder, every object in the sky can be precisely located once we know its declination (Dec) and sidereal hour angle (SHA). These are equivalent to a star’s latitude and longitude on a star map or star globe. When first learning celestial navigation, we might tend to think that only stars have an SHA, since we only use this SHA when navigating with stars. But every object and every vacant point in the sky has an SHA. It is equivalent to the longitude of the point in the sky, just as the declination is equivalent to the latitude of the point in the sky. Every point in the sky is uniquely specified by its SHA and Dec, just as every point on earth is uniquely specified by its latitude and longitude. We will use this concept when discussing the location of the moon and planets among the stars.

The line in the sky with Dec = 0° is called the celestial equator; it circles the earth directly above the earth's equator. The celestial meridian with SHA = 0° is called "Aries," or, sometimes, the "First Point of Aries." It is equivalent to the Greenwich meridian on earth. As the earth rotates daily beneath the stars, the Aries meridian, running from the north pole of the sky to the south pole of the sky, slides westward around the earth. It lies directly above the Greenwich

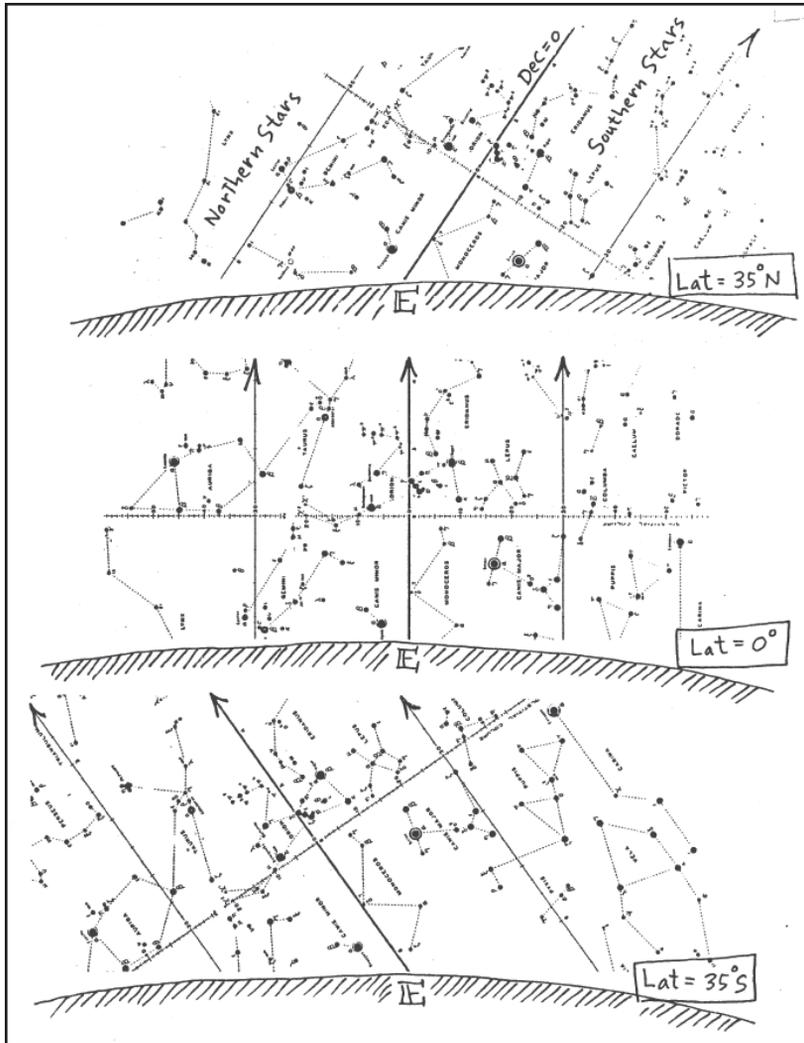
meridian once every 24 hours. Earth and sky coordinates are illustrated in Fig. 3-2.

Unfortunately, there is a slight difference in the terminology used by astronomers and navigators. Both use Dec in the same way to specify the latitude of a star, but astronomers do not use SHA for longitude. They specify celestial longitude by "right ascension." SHA is measured in degrees west of Aries, whereas right ascension is measured in time units (1 hour for each 15°) east from Aries. We will stick with the navigator's usage of SHA, but astronomers should have no difficulty in adjusting for this distinction throughout this Guide. To convert from right ascension to SHA:

SHA = 15° x (24 hr. — right ascension).

Astronomers should find the Star Finder easy to use, since the rim scale on the white disk is simply right ascension expressed in degrees.

Positions on the white disk can be pictured in terms of the (invisible) Dec-SHA grid. The star Deneb, for example, with Dec = N 45° and SHA = 50° appears on the "north side" of white disk about one inch from the center, along the radial line from the center to the 310° position on rim scale (360 - SHA). On the "south side" this star appears at the same location on the rim, but with the south pole at the center, it appears about one inch from the rim. To help understand the layout of this star map, compare the Deneb position on the white disk (Fig. 2-1) to its position on



**Figure 3-1** Rising and setting stars. Viewed from any latitude, north or south, southern stars (or any object in the sky with a south declination) always rise south of due east and set south of due west. Likewise northern stars rise north of east and set north of west. Celestial paths across the sky are always symmetric about the meridian. If a star, or the sun, rises 15° north of east, it will set 15° north of west.

Table 3-1. Brightness Versus Magnitude for Stars and Planets

Magnitude Difference	Brightness Difference	Magnitude Difference	Brightness Difference
0.0	1.0	2.6	11
0.2	1.2	2.8	13
0.4	1.4	3.0	16
0.6	1.7	3.2	19
0.8	2.1	3.4	23
1.0	2.5	3.6	28
1.2	3.0	3.8	33
1.4	3.6	4.0	40
1.6	4.4	4.5	63
1.8	5.2	5.0	100
2.0	6.3	5.5	158
2.2	7.6	6.0	251
2.4	9.1	6.5	398

the round star map from the back of the *Nautical Almanac* (Fig. 2-2).

The sun and stars are essentially fixed in space. But since the earth circles the sun, the stars behind the sun, as viewed from the earth, change continuously throughout the year. The positions of the moon and planets among the stars also change from day to day because of their orbital motions. As a result of these complicated motions, the sun, moon, and planets all appear from earth to move through the stars from day to day. This means their positions on the white disk change daily. To use the Star Finder for these bodies we must first mark their positions on the white disk and then occasionally replot them to keep their positions accurate.

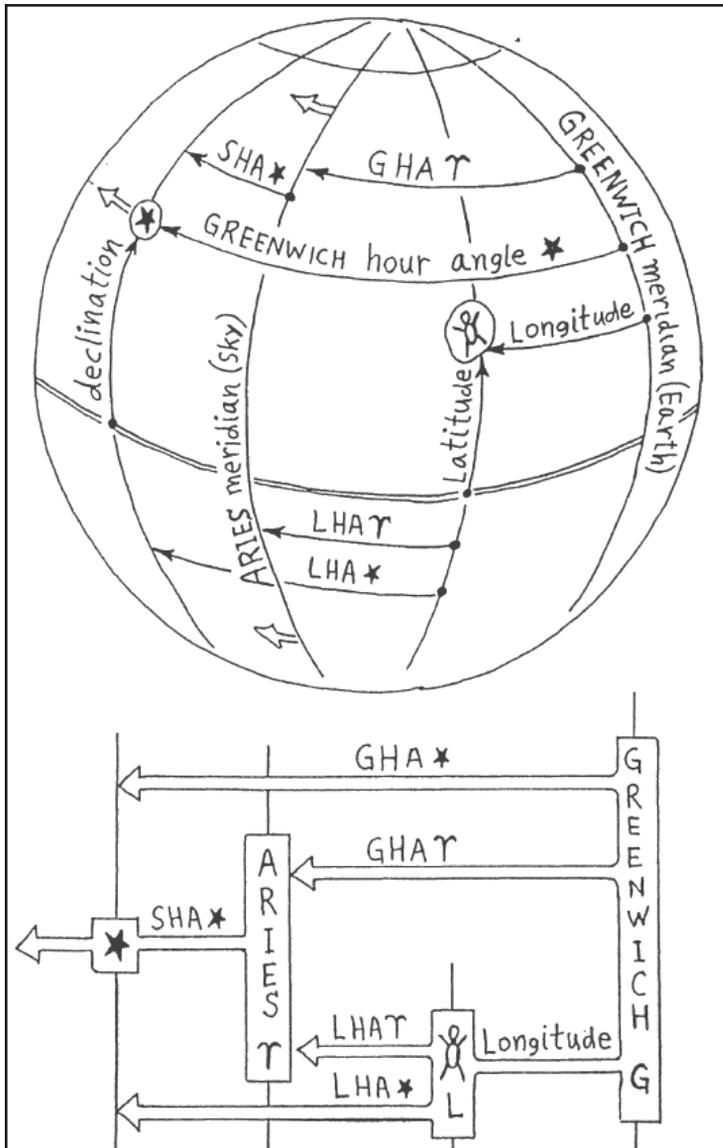
Of the five planets visible to the naked eye (Mercury, Venus, Mars, Jupiter, and Saturn), Venus and Jupiter are the two we care about the most for navigation — as discussed later in this chapter. The daily motions of these two, however, are quite different.

Jupiter moves much slower than Venus. It takes Jupiter about a year to move the length of one constellation. Its general direction is eastward through the stars, but its path across the white disk is not a simple straight line. To know precisely where it is you must check its position once a week or so. The season

and times we see Jupiter depend on the season of its neighboring stars.

The rate that Venus moves through the stars varies throughout the year. It can move as fast as one constellation per month, so it must be checked every few days or so. Venus also moves basically eastward through the stars, but its apparent motion relative to the sun — which is more important because this determines when we see it — is more complex. Venus moves back and forth, from one side of the sun to the other, about twice a year. When Venus is east of the sun (behind it), it follows the sun over the western horizon, and we see it in the evening just after sunset. When west of the sun, Venus rises before the sun and we see it as a morning “star.” In this case it sets before the sun so we can’t see it in the evening. The Planet Notes at the front of the *Nautical Almanac* give a brief description of the location and visibility of the planets for the year of issue.

The sun moves through the stars at the rate of 1° per day. It follows — year after year — a path called the “ecliptic,” which is drawn on the star charts at the back of the *Nautical Almanac*. The moon and planets also follow very nearly along this path. The band of stars along the ecliptic make up the 12 zodiac constellations, consequently the sun, moon, and planets are always found within some zodiac constellation.



**Figure 3-2** Earth and sky co-ordinate systems. The sky co-ordinates are shown projected down onto the earth. Greenwich Hour Angles are measured relative to the Greenwich meridian (G); Local Hour Angles are relative to the observer's meridian (L). Our longitude is how far we are west of the earth's reference meridian (Greenwich); Sidereal Hour Angle is how far the star is west of the sky's reference meridian (Aries).

The moon is the most evasive of all celestial bodies. It moves eastward through the stars at a rate of about  $12^\circ$  per day, or  $30'$  per hour. In other words, if the moon is directly above the star Aldebaran on one

night at, say, 10 p.m., the next night at 10 p.m. it will appear, with a slightly altered phase, about a hand width to the east of Aldebaran; the next night two hand widths to the east, and so on, as shown in Fig. 3-3. For accurate moon prediction with the Star Finder, this means you must plot it for very nearly the right time you plan to look for it. An alternative is to plot its position for every 12th hour or so, and connect the dots. You can then estimate its position from the time of day relative to the times at the dot positions.

One way to get a quick perspective on where each of these bodies is relative to the stars, or relative to the sun, is to plot the sun, moon, and planets on the rectangular star maps at the back of the *Nautical Almanac*. These rectangular maps of the ecliptic region of the sky are Mercator projections that provide a realistic view of the relative star positions. The sun, moon, and planets can always be located on these maps as shown in Fig. 3-4.

These maps will not give heights and bearings, as the Star Finder does, but nevertheless they are convenient for locating the planets relative to the stars, and the moon relative to the sun. Remember that these maps "slide across the sky" at a rate of  $15^\circ$  of SHA each hour. The maps are labeled directly with Dec and SHA, which simplifies the plotting.

### 3.2 Brightness and Color of Stars and Planets

The brightness of a star is often a valuable aid to its identification. The brightness of a star or planet is determined by its "magnitude." Star magnitudes are given in the extra star list at the back of the Almanac.

They are not listed on the daily pages, but the card insert to the Almanac has a convenient list. This card is reproduced on a page at the back of the Almanac, shown here in Fig. 3-5. Planet magnitudes are listed at the heads of the planet columns on each

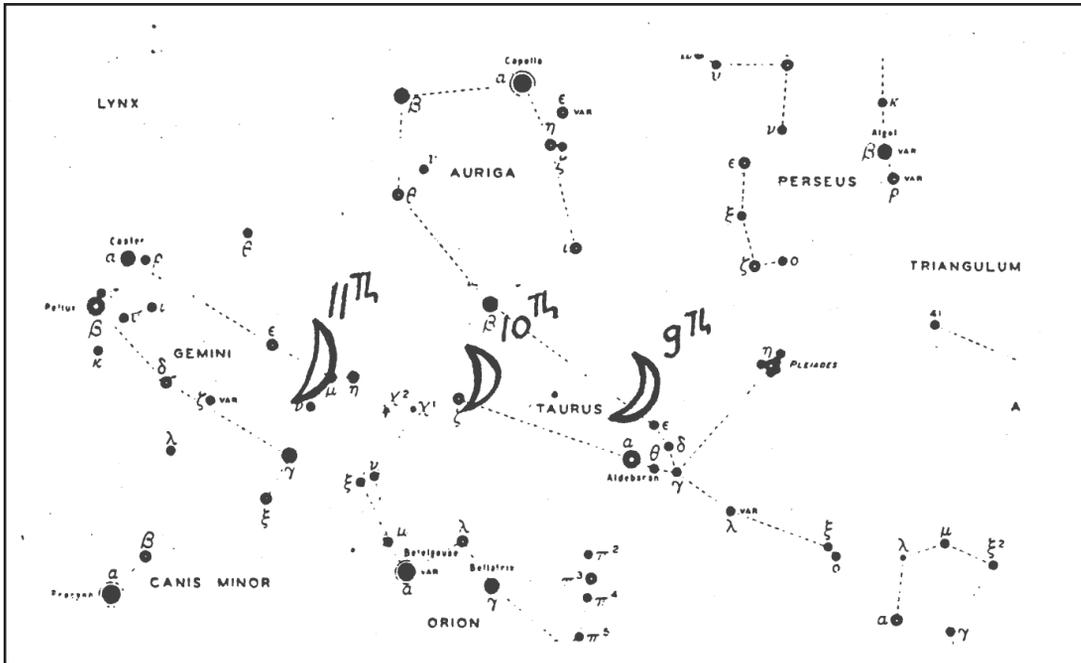


Figure 3-3 Nightly motion of the moon relative to the stars.

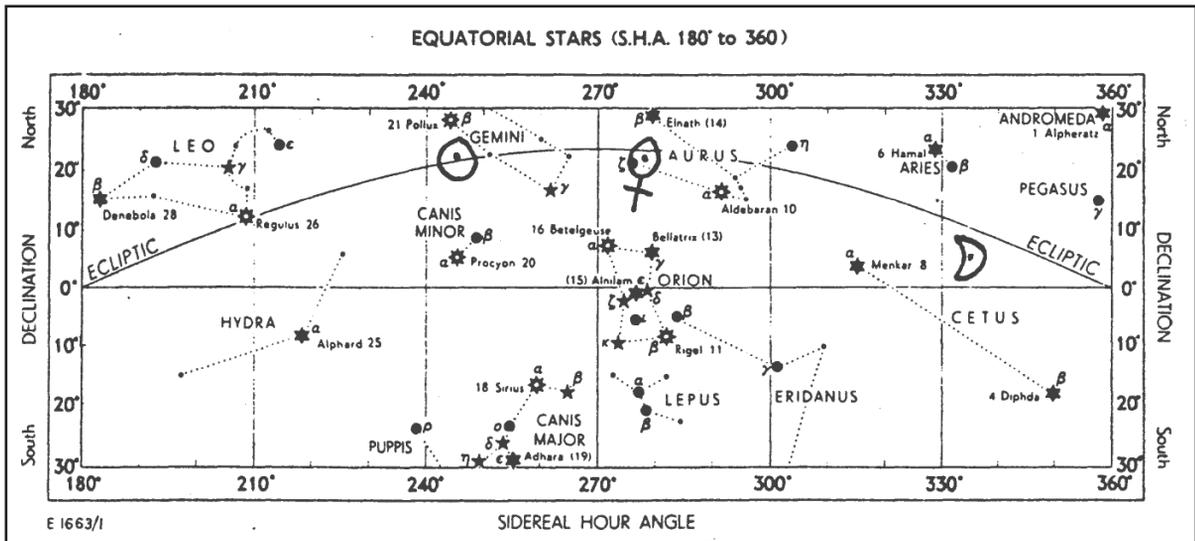


Figure 3-4 Rectangular star maps from the Nautical Almanac. These provide a quick means of locating the relative positions of sun, moon, and planets. The plotted positions are for July 14th, 1982. (Larger Views in the Appendix.)

1982 DECEMBER 21, 22, 23 (TUES., WED., THURS.)																		
G.M.T.	ARIES			VENUS <b>-3.4</b>			MARS +1.3			JUPITER -1.3			SATURN +0.9			STARS		
	G.H.A.	G.H.A.	Dec.	G.H.A.	Dec.	G.H.A.	Dec.	G.H.A.	Dec.	G.H.A.	Dec.	G.H.A.	Dec.	Name	S.H.A.	Dec.		
21 00	89 14.2	168 01.1	523 59.0	138 05.7	519 21.8	212 18.4	519 07.6	238 31.9	5 9 58.4	Acamar	315 35.7	S40 22.6						
01	104 16.7	183 00.1	58.9	153 06.1	21.3	227 20.3	07.8	253 34.2	58.5	Achernar	335 43.7	S57 19.8						
02	119 19.1	197 59.2	58.7	168 06.6	20.7	242 22.2	07.9	268 36.4	58.6	Acruz	173 35.6	S62 59.9						
03	134 21.6	212 58.2	58.5	183 07.1	20.2	257 24.2	08.0	283 38.7	58.6	Adhara	255 30.5	S28 56.8						
04	149 24.1	227 57.2	58.4	198 07.5	19.7	272 26.1	08.1	298 40.9	58.7	Aldebaran	291 15.8	N16 28.5						
05	164 26.5	242 56.3	58.2	213 08.0	19.2	287 28.0	08.2	313 43.2	58.8									

INDEX TO SELECTED STARS, 1982				
Name	No.	Mag.	S.H.A.	Dec.
Acamar	7	3.1	316	S. 40
Achernar	5	0.6	336	S. 57
Acruz	30	1.1	174	S. 63
Adhara	19	1.6	256	S. 29
Aldebaran	10	1.1	291	N. 16
Alioth	32	1.7	167	N. 56
Alkaid	34	1.9	153	N. 49
Al Na'ir	55	2.2	28	S. 47
Alnilam	15	1.8	276	S. 1
Alphard	25	2.2	218	S. 9

No.	Name	Mag.	S.H.A.	Dec.
1	Alpheratz	2.2	358	N. 29
2	Ankaa	2.4	354	S. 42
3	Schedar	2.5	350	N. 56
4	Diphda	2.2	349	S. 18
5	Achernar	0.6	336	S. 57
6	Hamal	2.2	328	N. 23
7	Acamar	3.1	316	S. 40
8	Menkar	2.8	315	N. 4
9	Mirfak	1.9	309	N. 50
10	Aldebaran	1.1	291	N. 16

Figure 3-5 Star and planet magnitudes listed in the Nautical Almanac.

daily page because their brightness changes slowly throughout the year. The same magnitude scale applies to stars and planets.

Unfortunately, there is not a simple correspondence between the numerical magnitude of a star and the visual brightness that we perceive. Each magnitude difference of 1.0 implies a brightness difference of 2.5. The magnitude scale is logarithmic, which means we need special tables, such as Table 3-1, to

figure the actual brightness difference between two stars, or between a star and planet. And to complicate things even further, the scale is inverted; the lower the magnitude number, the brighter the star.

The faintest stars we might navigate by would have a magnitude of about 3.0 although it would be rare to use such a faint star. A typical bright star has magnitude 1.0, which we could say is 2.0 "magnitudes" brighter than the faint magnitude 3 star. But the ac-

Table 3-2. Navigational Stars that are Distinctly Reddish <sup>a</sup>

"Mag. One" <sup>b</sup>		"Mag. Two"		"Mag. Three"	
Betelgeuse	1.87 <sup>c</sup>	Suhail	1.65	Enif	1.55
Antares	1.84	Gacrux	1.55	Schedar	1.18
Aldebaran	1.52	Eltanin	1.52	Markab	1.02
Arcturus	1.23	Kochab	1.47		
Pollux	1.02	Alphard	1.44		
		Atria	1.43		
		Hamal	1.15		
		Ankaa	1.08		
		Dubhe	1.06		

(a) Including yellowish and orangish. Listed in descending order of "redness."

(b) Grouped according to the approximate magnitude scale discussed in the text.

(c) These numbers are an indirect measure of their "redness" — the bigger the number the redder the star, but the differences are slight. Two stars with the same number, however, should appear about the same color.



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