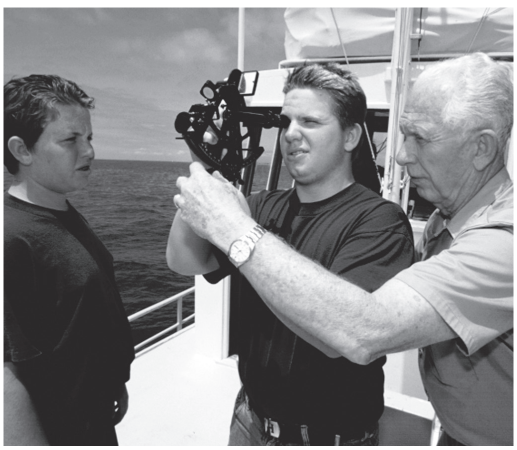
Celestial Navigation

Celestial navigation can be defined as determining a ship's position by the observation of celestial bodies (sun, moon, planets, and stars). It is a detailed subject far beyond the scope of this text, but it is hoped that the general principles will inspire Sea Scouts to learn more about the navigator's art. While less complicated in practice than it appears in theory, celestial navigation is best learned with an instructor.

The definitive reference for celestial navigation was written by Nathaniel Bowditch. His book, *The New American Practical Navigator,* first published in 1802, is still carried on board every commissioned U.S. Navy vessel. It is far too complicated for the beginner; however, a number of excellent small books are now available with the general theme of simplified celestial navigation. Those that strip away the theory and deal with practical situations are recommended.

Celestial navigation begins with the geographical position or ground point (GP) of a celestial object. The ground point is that spot on the earth where the object is directly overhead. If we can find where we are in relation to a celestial object's ground point, we can draw a line of position. When two or more lines of position intersect, we have a fix. So, if we can draw two or more lines of position related to the ground points of two or more celestial bodies, we have a fix.



To achieve this, the navigator needs some information. First, the angular height of the celestial object above the horizon must be measured. A sextant is used for this purpose. Next, the precise time of the observation must be noted. A very accurate clock, the chronometer, gives the time to the nearest half-second. Third, the navigator must know the location of the ground point of the celestial object at the time of the observation. This is looked up in the current edition of the Nautical Almanac. Finally, the navigator uses a set of sight reduction tables (where all the heavy mathematics have been done) to compute the azimuth (direction) and altitude (a function of distance) of the celestial body. Now a line of position can be drawn. Lines of position from one or two other stars give the fix at the time of the observations.

Most navigators use prepared worksheets to enter the data and compute the results. A number of factors must be considered, such as the height of the observer above the water, parallax, instrument error, etc. A good worksheet has spaces for these entries, and the navigator is not likely to forget them. Sight reduction worksheets look complicated but, with practice, are no more difficult than reconciling a checkbook. The only arithmetic involved is addition and subtraction.

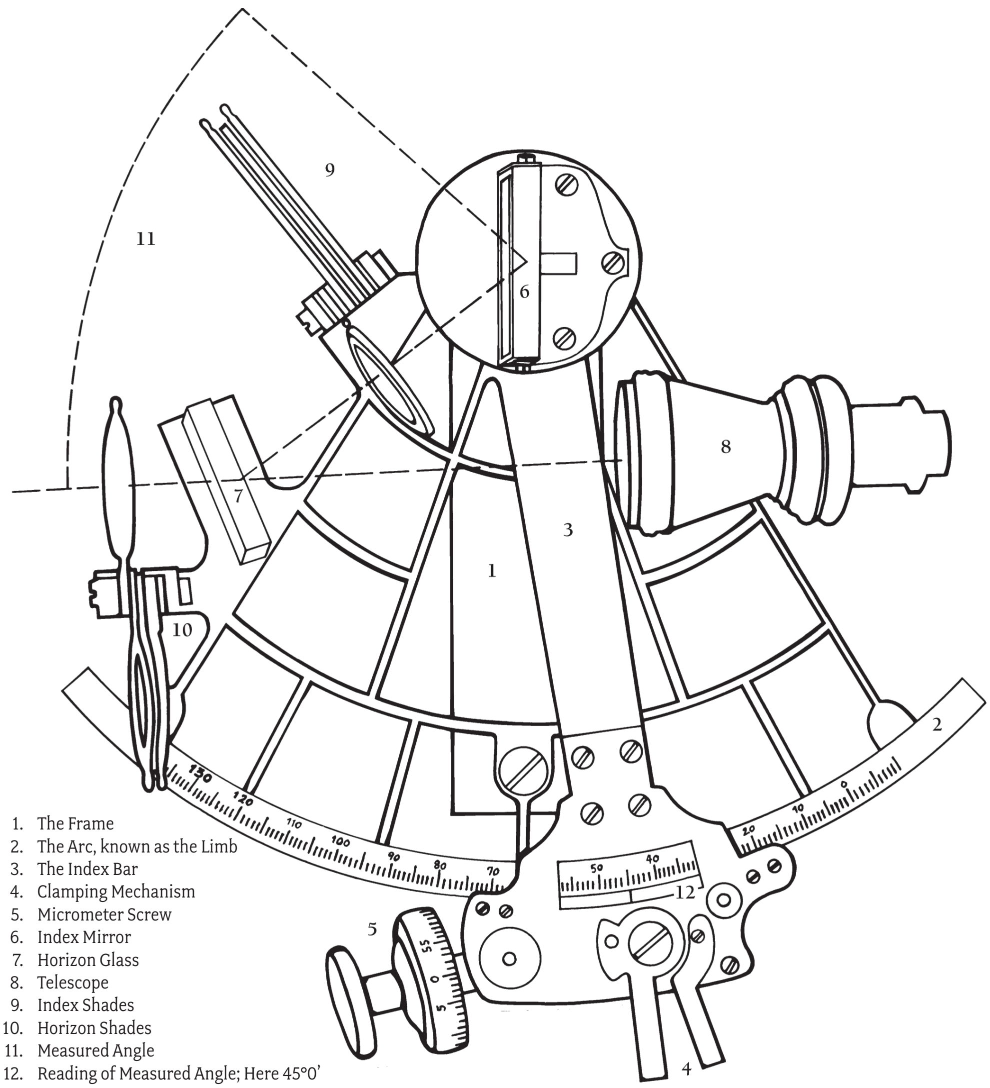
The Sextant

A sextant is the instrument chiefly used in celestial navigation. It is designed for sighting two objects at the same time (the horizon and the sun, for example) and measuring the exact angle between them. It is a precision instrument shaped like a piece of pie, and is held on edge with one hand while sight adjustments are made with the other.

Its name—sextant—comes from its lower arc, which is one-sixth (60 degrees) of a circle. The arc is divided into degrees: minutes and 10ths are read by means of a vernier (a refinement in dividing) or a micrometer drum.

The sextant takes advantage of the principle that the angle made by the last direction of a ray of light, reflected twice in the same plane, is twice the angle made by the reflecting surfaces. That sounds complicated, but it means that the 60-degree sextant arc is able to measure angles up to 120 degrees.

Using a sextant takes practice. The easiest procedure for beginners is to move the index arm to zero and point the telescope to the desired celestial object. If you are observing the sun, do not forget to move one of the sun shades into position. Now, keeping the celestial object in the right-hand, silver portion of the horizon glass, move the sextant down and swing the index arm out until the horizon appears in the left-hand side of the horizon glass. Clamp the index arm and make fine adjustments with the micrometer drum or tangent screw until the split image shows the object exactly at the horizon.



1. The Frame
2. The Arc, known as the Limb
3. The Index Bar
4. Clamping Mechanism
5. Micrometer Screw
6. Index Mirror
7. Horizon Glass
8. Telescope
9. Index Shades
10. Horizon Shades
11. Measured Angle
12. Reading of Measured Angle; Here 45°0'

For the sun or moon, the upper or lower limb (or edge) of the object should be exactly at the horizon. For a star or planet, it should be centered on the horizon line. Now rock the sextant back and forth a few times to see that the object has been measured at its lowest point. This check will assure that the sextant is perfectly vertical. When you're satisfied with the sight, note the exact time, and read the elevation from the arc and micrometer drum or vernier scale.

Since a sextant measures angles very accurately, it has uses other than in celestial navigation. It can be used to measure distances. The height of lighthouses and other visible landmarks are listed on charts. If you measure the angle between the top and bottom of a lighthouse whose height you know, knowledge of simple trigonometry and a tangent table can give you your distance from the lighthouse (the distance equals the height divided by the tangent of the angle).

The sextant used by a professional navigator is a delicate and expensive instrument. A number of plastic sextants now on the market are surprisingly accurate and modestly priced. The old-time navigator might be horrified at the notion of a plastic sextant, but they have been used successfully on a number of occasions by yachtsmen in round-the-world cruises. In fact, a perfectly adequate beginner's sextant can be purchased for less than the almanac and reduction tables needed to use it.