The Mariner's Astrolabe

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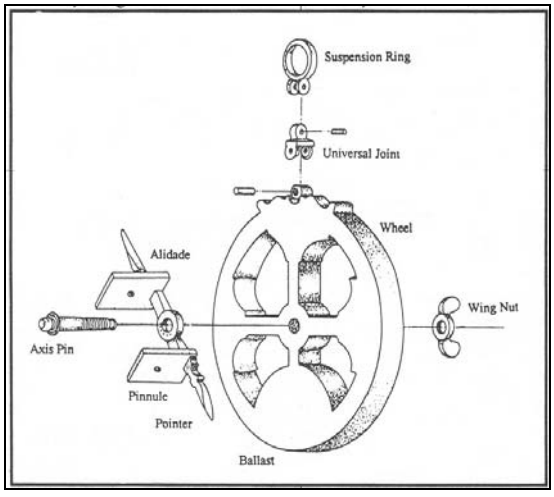
Since the inception of the MFMHS, the mariner's astrolabe has served as its logo. This is an apt symbol for an organization specializing in the study of colonial maritime culture, especially when the 1622 wreck of *Nuestra Señora de Atocha* has yielded five astrolabes, and the *Santa Margarita* one, constituting the largest single collection from a specific period. Such a large group, from only two ships, makes it clear that there was a strong reliance on astrolabes by ships of the early 17th century, but how many people really know anything about them? What exactly did they do? How were they used? The answer is really quite simple; with these beautifully crafted instruments, pilots measured the angle of the sun from either the zenith or the horizon; a measurement that could then be used to determine the ship's latitude, and its position in the vast expanse of the sea.

The mariner's astrolabe was derived from the more complex planispheric astrolabe, which was used by early astronomers to calculate the movements of the heavens. The Portuguese school of navigation, founded in the 15th century to find an eastern route to the Orient, worked to develop simpler instruments, which could be used easily by relatively uneducated seamen. At first, the angle of the northern, Pole star was measured to determine latitude, but in 1471 the equator was reached, where this star could no longer be seen. New methods needed to be developed to successfully negotiate the southern seas.



An Exploded View of a Mariner's Astrolabe. Drawing Cheryl M. Clark/MFMHS.

An Astrolabe Recovered from *Nuestra Señora de Atocha*, 1622.

It was found that the altitude of the sun was also an accurate variable for calculating latitude, and, initially, quadrants were used measure this, but these proved difficult to read accurately on rolling ships. Some time around 1480, the mariner's astrolabe was developed, and put into use. The earliest versions were large diameter discs of wood and bronze, but, by the turn of the century, solid bronze or brass construction became the standard. As their use spread, it was learned that by opening the body of the disc, and decreasing the diameter, windage was reduced, and stability increased. By broadening the lower spoke, usually with a triangular or semi-circular form, additional stability was gained by making the astrolabe bottom-heavy. Though the scales had to be reduced, and accuracy was lost with the smaller diameter, readings could be taken more easily in high wind or rough seas. By the second quarter of the 16th century, the basic form was developed - a heavy bronze wheel, somewhere around seven inches in diameter and weighing 8 to 12 pounds. This general design would remain popular for the next 150 years.

Though some minor stylistic variations can be found, the function of the mariner's astrolabe never

changed. It was always utilized to record the altitude of the sun. This was done by suspending the wheel by the ring and turning the alidade until the rays of the sun shone through both of the small holes that pierced the sighting vanes. This would provide a reading of the angle of the sun's height. Some astrolabes were engraved to measure the angle from the zenith, some from the horizon, some from both. Spanish astrolabes measured from the horizon. After 1550, Portuguese astrolabes generally measured from the zenith.

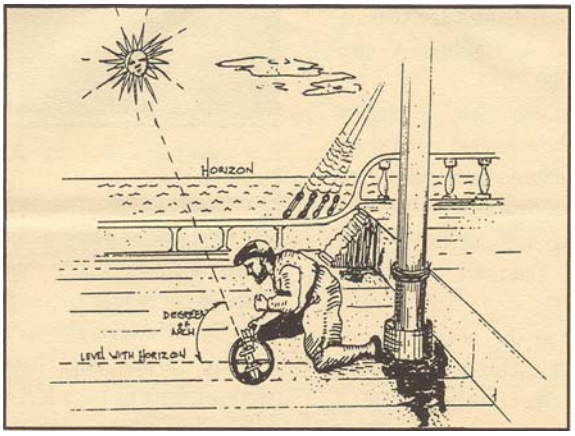
In his mariner's treatise of 1587, *Instrucción Náutica*, Dr. Diego Garcia de Palacio provides a detailed description for the proper use of the astrolabe. According to his instruction, observations of the sun had to be made precisely at noon while standing near the mainmast of the ship, where there was the least amount of pitch and roll. Suspending the astrolabe by the second finger of the right hand, the observer determined the direction of the sun by noting the angle of the shadows, and then faced it directly. The astrolabe was held side-on to the sun and the alidade rotated until the light rays passed through both pinnules. The number on the scale at which the pointer of the alidade sat would be the angle of the sun's altitude.

One other figure was needed to properly establish the ship's latitude – the angle of the declination of the sun. Declination is the angle between the sun's rays and the earth's equatorial plane, and ranges between 23.5º at the summer solstice, and –23.5º at the winter solstice. In the 16th century, tables were calculated for the declination of the sun to the north or south of the equator for a given date, and for whether it was a leap year or the first, second, or third after it.

To determine the correct latitude at which the measurement was taken, the difference between the astrolabe reading and 90º was calculated. This was then added to the declination figure from the tables. This formula is more simply expressed as:

(Zenith – Altitude) + Declination = Latitude

Theoretically, this is a simple process and calculation. From this author's experience though, taking readings on land with both an authentic *Atocha* astrolabe and a replica, it is not quite so easy in practice. The precision with which the astrolabe was crafted is the primary determining factor for accuracy. The alidade must fit snugly against the wheel, the pinnules have to be drilled in perfect



Using the Mariner's Astrolabe.
Drawing, Robert Cummings/MFMHS.

alignment, the pointers must be straight, and the scale must be cut precisely, to yield accurate and consistent readings. With a worn and slightly corroded specimen, as well as an imprecisely cast one, this was difficult. Even with a new, well-manufactured astrolabe, if one were to factor in the movement of a rolling ship, along with windy conditions, garnering a good reading must have required quite an experienced hand.

It should be noted too, that one other, key observation was made during this hands-on experiment; it is much easier to obtain readings by holding the astrolabe low, and observing the point of light that passes through the pinnules as it strikes the ground (or deck). Suspending it above one's head is not a steady position, and trying to align the alidade to sight the sun with the eye can be blinding, and does not produce consistent readings.

With accuracy being so dependent upon the construction and condition of a particular astrolabe, it is perhaps clearer why the *Nuestra Señora de Atocha's* pilot, Martin Ximénez, felt the need to carry at least five of them. Each may have had specific characteristics for varying sea, weather, or astronomic conditions, but it seems more likely that it was for sheer redundancy. Slight wear, or other mechanical damage, could render an astrolabe inaccurate, but not overtly so. By recording the sun's altitude with more than one instrument, he could have more confidence in the final measure, and, from this, the course on which the ship was sailing.

Bibliography:

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