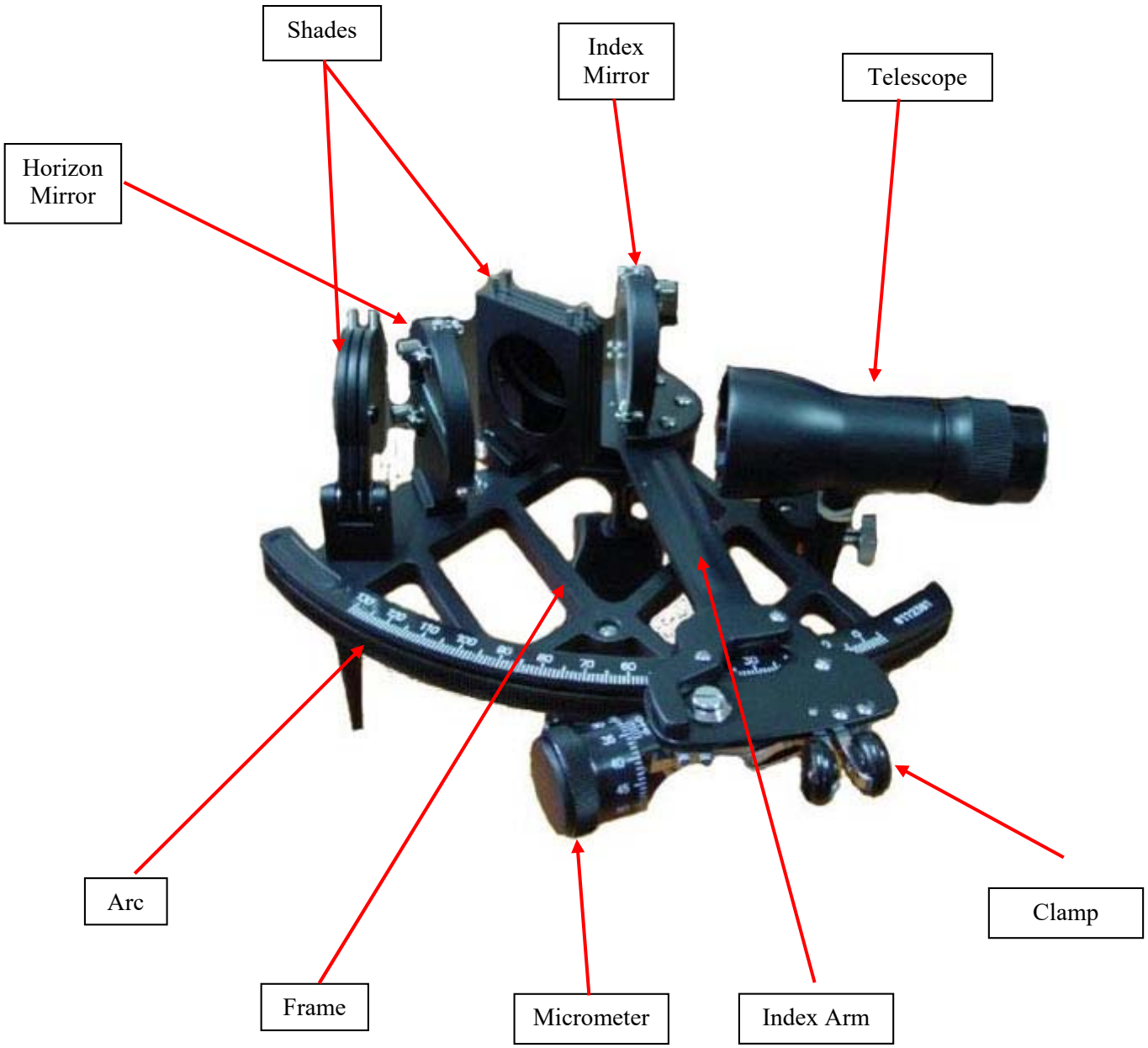
MARINE SEXTANT

INTRODUCTION

The marine sextant is used by the mariner to observe the altitude of celestial bodies as well as to measure horizontal and vertical angles of terrestrial objects. On the image of a sextant below I have highlighted the main component features:



PRINCIPLE OF USE

The principle of the sextant is based on the first law of light. That being that when a ray of light is reflected from a plane mirror the angle of incidence of the ray equals the angle of reflection. For a sextant the light is reflected twice in the same plane from the index mirror to the horizon mirror then again from the horizon mirror to the telescope.

In these circumstances the angle between the first and last direction of the ray of light is twice the angle between the index and horizon mirrors.

ERRORS

The sextant suffers from two main types of error, correctable and non-correctable. The latter as the name suggests may only be rectified by returning the device to the manufacturer for servicing.

Correctable Errors

There are three different correctable errors which the OOW can easily rectify providing they have the knowledge to do so. These errors should be adjusted for in a particular order as follows:

First Adjustment – Error of Perpendicularity

This is caused by the index mirror not being perpendicular to the plane of the instrument. To check whether this error is present the OOW should set the index arm about half way along the arc. The sextant should be held horizontally and the OOW should look obliquely into the index mirror. The true and reflected arcs should be aligned with one another. If this is not the case then error of perpendicularity exists. This error can be resolved by adjusting the screw at the rear of the index mirror until the true and the reflected arcs are aligned.

Second Adjustment – Side Error

This occurs when the horizon mirror is not perpendicular to the plane of the instrument. There is two simple ways for the OOW to check whether this error is present. The easiest in my opinion is to observe a star. The sextant should be held vertically and the index arm set to 0°. A bright star with a low magnitude should be observed through the telescope if the true and reflected images are shown side by side then side error is present.

During daylight hours it is also possible to test for side error by setting the index arm to 0° and holding the sextant at a small angle off horizontal. You should look through the telescope and observe whether the reflected and true horizons are misaligned. In this instance it will appear that one is slightly higher or lower than the other. If this misalignment is present then once again it can be said that side error is present.

In either instance to correct for this error you should adjust the screw located on the index mirror furthest from the plane of the instrument. An easy way to remember which screw if you're unsure is side error, side screw. You should continue to make the adjustment to the screw until the image is aligned.

Third Adjustment – Index Error

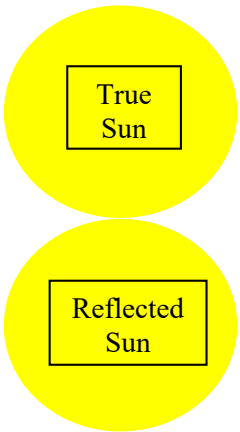
This occurs when the horizon and index mirrors are not parallel to each other when the index arm is set at 0°. There is three main methods to detect whether index error is present.

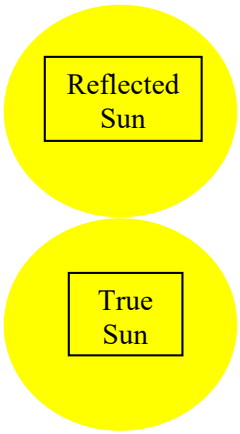
Observation of a star – Set the index arm to 0° and observe a star of a low magnitude. If the reflected star is observed higher or lower than the true star then index error must exist.

Observation of the horizon – Set the index arm to 0° and hold the sextant vertically. If the true and reflected horizons are not aligned then index error exists.

In both these methods the value of the index error can be obtained by adjusting the micrometer until the true and reflected images are aligned. The OOW can then simply observe the micrometer reading importantly noting whether the error is on or off the arc.

The final method of checking for index error is slightly more convoluted. It involves taking observations of the sun. Firstly set the index arm to approximately 32' on or off the arc and then using the micrometer raise or lower the sun so that the true and reflected images of the suns lower and upper limbs are in contact with one another, then repeated with the limbs in the opposite position, as illustrated below:





On each observation you should note the reading on the micrometer e.g. 32' on the arc and 29' off the arc. The index error is then easily calculated by subtracting the lesser observation from the greater observation and dividing the result by two. The value of on or off the arc is dictated by the greater of the two observations. The example above would be calculated as follows:

Index Error= $\frac{32'-29'}{2}$ = 1.5' on the arc.

If you are in doubt as to the accuracy of this methodology it can be verified by adding the two observations together and dividing them by 4. The result should be equal to the suns semi-diameter as tabulated in the nautical almanac for the date of the observation.

Index error can be solved using two different methods. If the error is very small for example only 1' or 2' then the mariner can simply note the value of the error and include this in their subsequent calculations. For larger errors however this error can be corrected by adjusting the screw on the horizon mirror which is closest to the plane of the instrument, making small alterations until the images are aligned.

Non Adjustable Errors:

The sextant has the potential to suffer from the following non-adjustable errors which can only be solved by returning the instrument to the manufacturer for servicing/repair.

1. **Centering Error** – Occurs when the index arm does not pivot along the exact point at the centre of the arcs curvature. This is normally caused by a worm pivot which the index arm moves on.

2. **Prismatic Error** – Caused when the faces of the two mirrors are not parallel to each other.

3. **Shade Error** – Caused by the faces of the shades not being parallel to each other. Should this error exist it is possible to use the telescope with a dark eyepiece rather than sending the whole device away for servicing.

4. **Graduation Error** – This error is caused by imperfections on the arc or the scales of the micrometer/vernier.

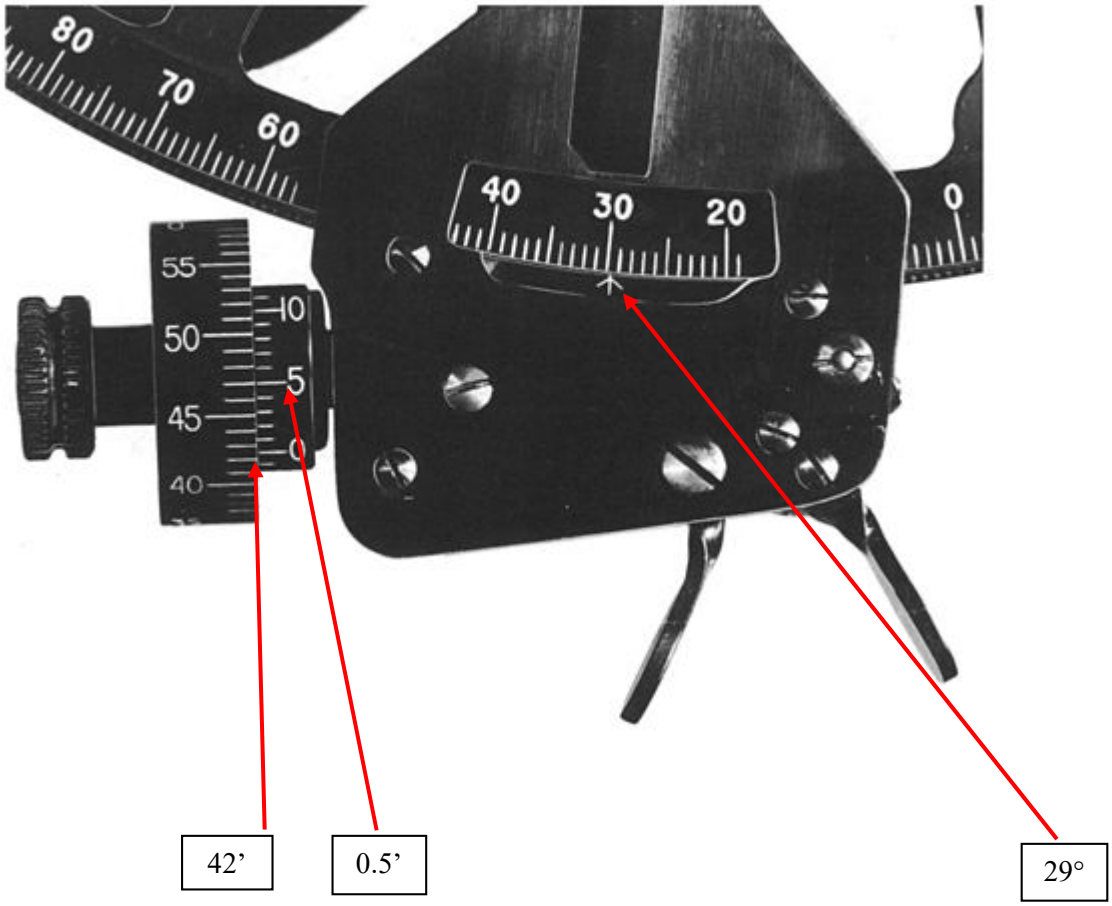
5. **Worm and Rack Error** – Occurs by failures in the worm and rack gearing of the micrometer and main arc.

6. **Collimation Error** – Occurs when the telescope is not parallel to the plane of the instrument.

Instrument Error

The sextants manufacturer calculates all of the nonadjustable errors at the time of production or servicing and issues each sextant with a certificate in its case. These errors are combined into a single 'instrument error' which is given as on or off the arc.

HOW TO READ A SEXTANT



As well as being able to correct the instrument the OOW must understand how to read it. There is three steps in this process.

Firstly you must note the number of full degrees indicated in the arrow on the index arm pointing to a corresponding value on the sextant arc in this example 29°.

Secondly you should note the number of full minutes which can be obtained by reading the nearest value on the micrometer drum which is beside the 0 graduation on the Vernier scale. Here is reads 42’.

Finally the fraction of a minute is obtained by examining the Vernier scale. The mark which most matches a mark on the micrometer drum indicates the value. In this instance 0.5’.

By observing the image above you can state that the reading for this sextant is 29°42.5’ on the arc.

CONCLUSION

Despite the advancements of modern technology the sextant remain an essential tool for obtaining celestial observations. It remains important that every deck officer is aware of how to use, correct and read a sextant.