SEXTANTS

My Modern Sextant

Notes on

HOW TO KNOW AND
HOW TO HANDLE IT

ACCURACY

HEZZANIT

RELIABILITY

SEXTANTS

My Modern Sextant

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HOW TO KNOW AND HOW TO HANDLE IT

ACCURACY

HEZZANITH
TRADE MARK

RELIABILITY

Price - 1/6

HEATH & COMPANY, NEW ELTHAM, LONDON, S.E.9

List of Illustrations.

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HOW TO KNOW AND HOW TO HANDLE "HEZZANITH" SEXTANTS.

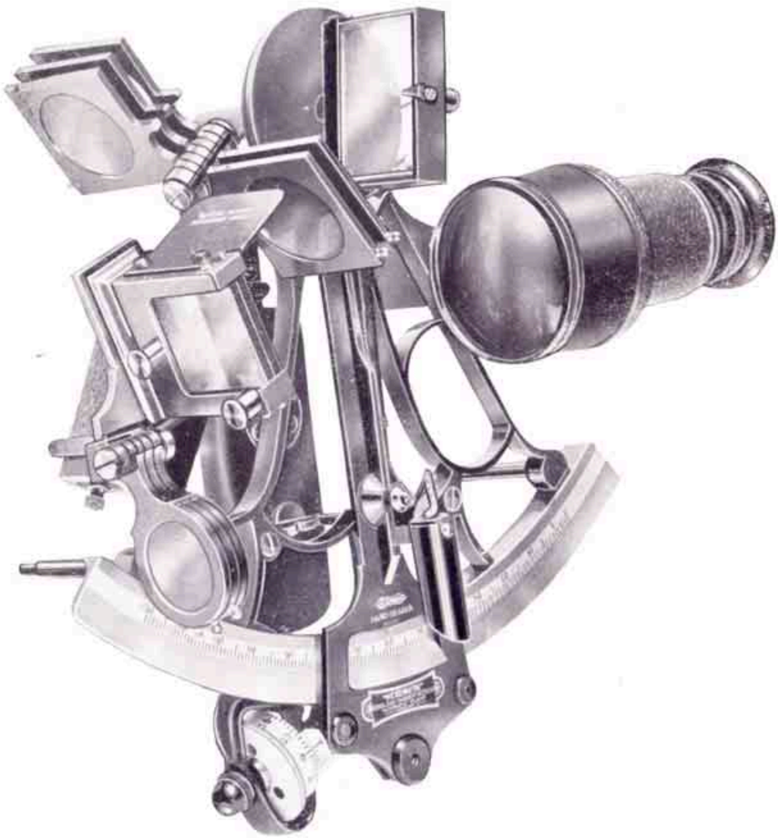


Fig. 1

THIS IS A HEATH'S MK.2 "BELL" SEXTANT.

Code Word : "SESAF."

Notice the large object glass Telescope, The absence of top-bar from the Horizon Frame, The Sea-Safe Mirrors, The Rapid-Reader Micrometer Tangent Screw, The Vernier Light, etc. It is a first class modern Sextant based on long experience in Sextant manufacture and design.

[See *also Fig.* 12].

Foreword.

In these notes on the Sextant, written in response to many requests, no attempt has been made to go into the ancient history of this beautiful instrument, nor to describe out-of-date details, nor to display abstruse technical and mathematical data. The aim has been to call attention to various important items in a modern Micrometer-Reading Sextant and to discuss interesting problems which have presented themselves during the course of manufacture or in correspondence with practical navigating officers, whose views, suggestions and criticisms on Sextant matters are always welcome. No apology therefore is due for the almost conversational style of these notes, which it is sincerely hoped will prove interesting and helpful to possessors of Sextants. Although the well-known **" Bell " Micrometer Sextant with " Sea-Safe " Mirrors** has been taken as a model, the notes apply in large measure to all " Hezzanith " Micrometer Sextants and in many instances to other types also, and particular attention is called to the **Duralumin frame Sextant** mentioned in the Supplementary Note on page 34. The Patent " Hezzanith " Rapid-Reader Micrometer Tangent-Screw referred to herein is the logical development of the Patent Endless Tangent Screw introduced many years ago by Mr. G. Wilson Heath, and which at the time was said to be the most important improvement in Sextants since Hadley's day ! Be that as it may, the Micrometer Tangent Screw has apparently come to stay and so it has been considered unnecessary to discuss the older form of vernier reading in these notes.

G.A.H.

—— 1937 ——

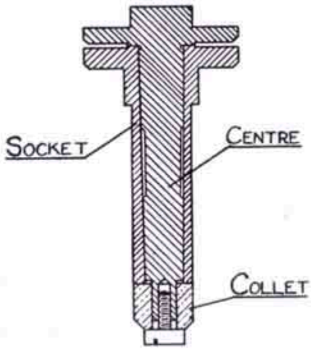


Fig. 2
The "centre" must revolve **freely** but **without shake.**

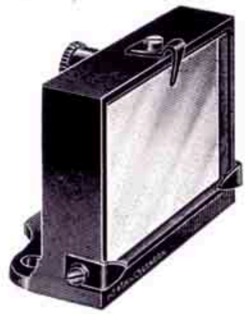


Fig. 3
The Sea-Safe Index Mirror in rectangular frame.

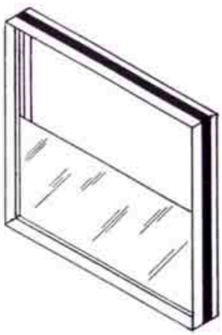


Fig. 4
The Sea-Safe Horizon Mirror.
Impermeable—Hermetically Sealed.

Fig. 5
Notice the strong rectangular frame without top-bar for the Sea-Safe Horizon Mirror.

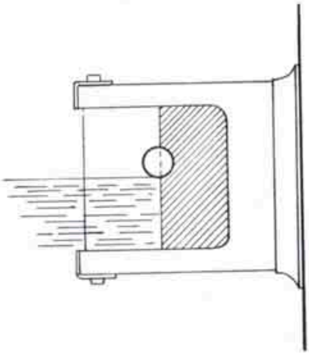


Fig. 6 (with half-silvered Mirror and no Top-Bar).

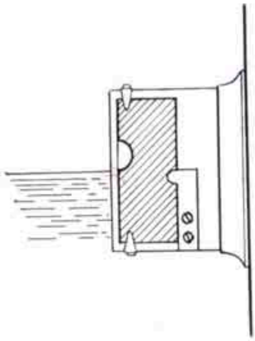


Fig. 6A (with fully silvered Mirror and Top-Bar).

This shows why the unsilvered portion of the Horizon Mirror is useful.

Also the great practical advantage of having no TOP-BAR on the Horizon Frame.

CHAPTER I.

NOTES ON VARIOUS COMPONENTS OF THE SEXTANT.

1. **The "Centre" Axis** of the Sextant must have a perfectly free movement, although of course no shake. We frequently find when examining instruments sent in for repair, that somebody has tightened up the centre screw (Fig. 2) with disastrous results. It is impossible to measure angles to an accuracy of 10″ unless the "centre" is a perfectly good fit in the socket, and also revolves perfectly freely.

To test this, remove the "Dispositive" from the Rising-piece Socket (it will probably be necessary to remove the Rising Spring piece too, by unscrewing the Rising-Piece screw until the spring piece is free, and then drawing it out of the Socket). The "Index" can now be swung away from the arc and it is possible to test if the "Centre" is perfectly free. By grasping carefully the Index Mirror Frame (do not touch the mirror) and attempting to give it an upward and downward movement, any slight shake will be revealed. It is better for the "centre" to be too loose than too tight.

Incredible as it may seem, we had a sextant to repair in which the "centre" and socket had been bent, and in order that the centre should revolve, somebody had "chipped up" with a cold chisel the top bearing surface of the socket, thus withdrawing the bent centre sufficiently from its socket to enable it to rotate somehow ! !

The victim had bought this somewhere as a second-hand sextant ! Had he applied the simple test suggested on page 17 the imposition would have been revealed.

> See that the "centre" revolves freely, and please don't tamper with it.

2. **The Mirrors** are made of accurately ground and polished glass, which is optically plane and parallel. We have had Sextants sent to us for repair, in which somebody, ignorant of the requirements, had put in mirrors made of ordinary plate glass, the result being absolutely hopeless, it being impossible either to see a defined image of the object or to get a true altitude.

Sextant mirrors must be treated with great care. Any moisture that settles on them should be lightly wiped off with a chamois leather or other suitably soft material. Sea water and sea air have a deleterious effect on the silver of the mirror, so that especial care should be used to remove moisture from the the cut edge of the silver on the Horizon Mirror, which is the part most exposed to attack unfortunately, for it is the part most desirable to be kept clean, it being the centre of the field of view where the contact is made between the celestial object and the horizon, and it coincides with the optical centre of the telescope.

In most of our best sextants we remove the top-bar of the Horizon Frame and this in addition to the fact that the annoying obscuring effect of a top-bar is done away with, has the advantage of easier access to the Horizon silver edge, for the purpose of cleaning the salt moisture away. (Fig. 5).

Note well this removal of the top bar. It is one of those simple things which mean a tremendous lot and make all the difference. The practical man will appreciate it.

In our best Sextants we have adopted a " Backing-Surround " method of protection for the silver, in which the silver is removed from where the adjusting screws bear and the backing applied to the unsilvered space formed. Also, the backing is brought about 1/32" above the cut edge of the Horizon silver and well over the edges of the glass. Thus the silver is surrounded on its **edges** as well as on its surface by the backing. Excellent results have been obtained by this method.

Another method which is safest of all is employed in the " Sea-Safe " Mirrors (Figs. 4, 5). Instead of backing the silver we cement an optically worked glass to the silvered surface. The adjacent edges of the cemented glasses are chamfered and the " V " shaped grooves thus formed are filled with cement. It is obvious these " Sea-Safe " Mirrors are rendered thus quite safe and impermeable to the action of sea air and water. Such mirrors necessarily cost considerably more than the single mirrors, but the advantage gained may be considered worth the extra cost.

While on the subject of Horizon Mirrors it may be pointed out that the reason there is an unsilvered portion is to enable exact contact to be made between the two objects observed ; because the unsilvered portion **partially** reflects the reflected object. On the other hand when fully silvered Horizon Mirrors are used the reflected object is suddenly cut out of the field of view which lies outside the silvered Horizon Mirror (Fig. 6, 6A). Fully silvered Horizon Mirrors are used chiefly in Surveying Sextants reading to one minute.

Mirrors being subject to damage and distortion if carelessly handled, should be touched as little and as tenderly as possible.

3. **THE SHADES** are made of "Sextant-Neutral" glass, a glass developed by the British Scientific Instrument Research Association, for the purpose. Some so called neutral glass shows an objectionable red colour when two or more shades are superimposed. The Sextant-Neutral does not vary its tint but merely its density on super-imposition. For the very lightest shade however we usually employ a yellowish tinted glass for the purpose of removing slight glare, such for example as is sometimes encountered on the horizon (see also Polarisers, Page 27). The shades are optically worked to the same accuracy as the mirrors, otherwise they would displace the image and give a false angle-reading. In N.P.L. or "Hezzanith" certified Sextants no appreciable error can accrue from the shades which are all carefully tested before use. Formerly in some instruments the shades were made reversible so that the error could be eliminated by meaning sets of readings with the shades in both positions. Such devices are no longer required, present methods of manufacture and certification being a sufficient safeguard against shade error.

To test the shades make a contact of the sun's limbs using with the telescope (preferably the inverting) a dark eye shade for this purpose. Next remove the eye shade, or put a lighter one on the telescope according to requirements, and bring the shade to be tested into position. If the contact is still perfect the shade is accurate.

When examining shades which are found to have an error care must be used to record the correct sign. If to obtain contact the angle is **higher** than the true reading the corrective sign will be negative, —. If the angle is **lower** than the true reading the corrective sign will be positive +.

A table can be made giving the correction for every shade and combination of shades, but as stated above in N.P.L. certified Sextants, correction for shade error can be ignored.

It is worth remembering that the dark eye-shade on the Telescope cannot produce any error in the reading of the Sextant.

Sometimes one or two extra and fainter images of the Sun (ghosts) may be seen in the field of view. These are reflections between the surfaces of the shades when two or more are used together. It is always best if possible to use one shade (more than two should never be required) and to avoid the natural tendency to use too bright a Sun. Eye strain and consequent error are eliminated by a proper use of the shades.

4. **THE SEXTANT MICROMETER TANGENT SCREW** which we call the **RAPID-READER,** is essentially different from the usual vernier-reading index. In the latter the vernier reads the actual angle through which the index mirror reflects the sun or star, the altitude of which is being read ; but the Rapid-Reader measures the number of teeth and parts of a tooth which the Tangent Screw worm must pass in order to move the mirror the required angle. These teeth cut on the back of the arc of course correspond to sextant degrees, but it must be borne in mind that it is the teeth

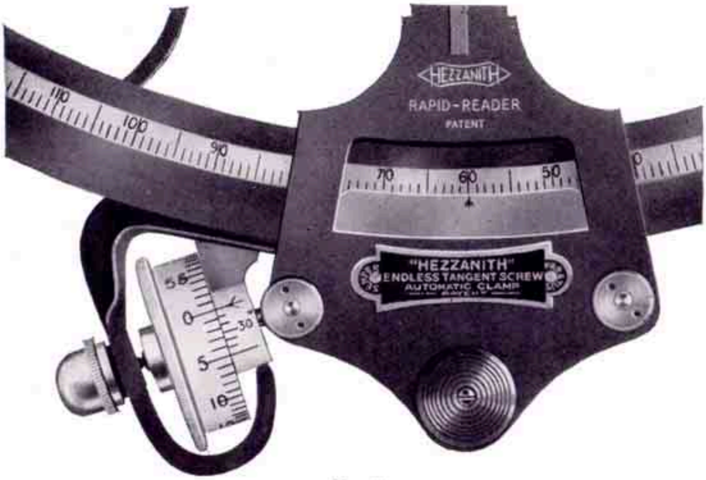


Fig. 7

This wonderful component, The "Hezzanith" Rapid-Reader Micrometer Tangent Screw is well known for its efficiency. No pull against the centre. No inaccuracy due to wear. No difficulty in reading the angle (it can be read at arm's length). In principle **sound.** In operation **simple.** In use **safe.**

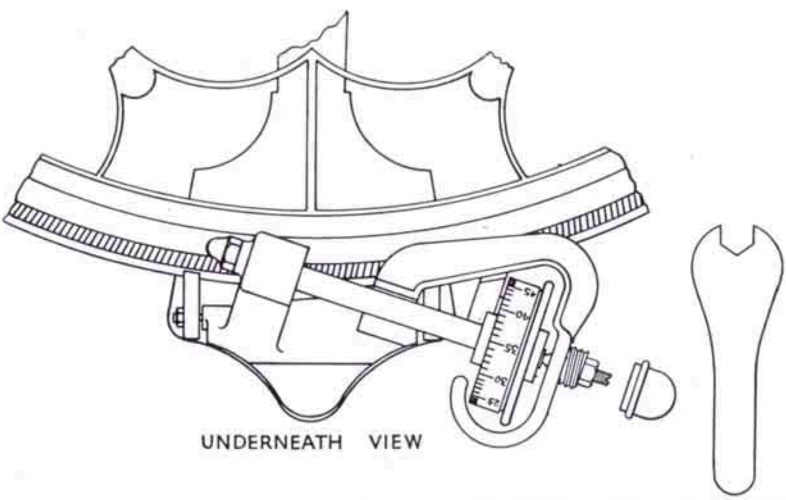


Fig. 8

Notice the RACK on the BACK OF THE ARC (not on the periphery, *ergo* no pull on centre). Also the bearing-screw, clamp nut, cap-cover and spanner for simple adjustment.

and worm that matter and not the dividing on the silver arc, which indeed **indicates** the **degrees** of angle but does not **measure** the angle.

We mention this because some have failed to realise that we have taken advantage of this fact to thicken the degree division on the silver arc, so that they cover several minutes of angle and are extremely bold and easily read and so deep that they are indelible even by rough usage. Each **actual** degree is therefore read when the **zero of the drum** coincides with the arrow of the **small** vernier, for it is the Micrometer Screw which is measuring the angle and not the divisions on the silver arc. The divisions on the drum for minutes and seconds are also extremely bold, and this combined with the fact that the movement of the drum to produce an angle of 10″ is comparatively large enables this small angle to be easily read with the unaided eye.

The details of construction of this "Rapid-Reader" are described in a pamphlet, **"The Patent 'Hezzanith' Rapid Reader Micrometer Tangent Screw"** which can be obtained on application, so there is no need to insert them here, but we would emphasise that there is no adjustment for wear necessary because the teeth are cut on the back of the arc, and the screw pressure is therefore producing no wear on the "Centre" (a fruitful source of error, see above pamphlet), and any wear on the teeth is automatically taken up.

The Micrometer Screw is mounted between centres and should revolve with an easy silky motion. It should not be stiff in its bearings, nor should it spin when released from the rack. Should any slackness develop this can be simply remedied by removing the small cap at the drum end and adjusting the centre screw which is under the cap. A small spanner is provided in the case to release and reclamp the nut fixing this screw (Fig. 8). Ordinary care is required in using this Rapid-Reader, and it is important always to bring the Tangent Screw right away from the teeth of the rack when moving the Index along the arc. This release from the "in gear" position is very simply effected by the depression of a lever by means of thumb and finger, **but to fully disengage the screw, the lever must be pressed right down to the stop**—this is self-evident, but somebody once thought that if he pushed the index along the arc the Micrometer Screw would slide over the teeth like a pawl over a ratchet-wheel ! It doesn't !— Your Micrometer Screw is—a **Micrometer Screw !**

As the **root** of the teeth of the rack is the important part, a small hard brush is provided in the Sextant Case which can be used occasionally if necessary. The rack however, is not likely to become clogged unless it is covered with a lot of sticky oil to which small bits of material will adhere. We do not advise a lot of lubrication on the rack ; just a little and **well brushed off** afterwards will keep the salt water from corroding the metal—but this will not very often be found necessary.

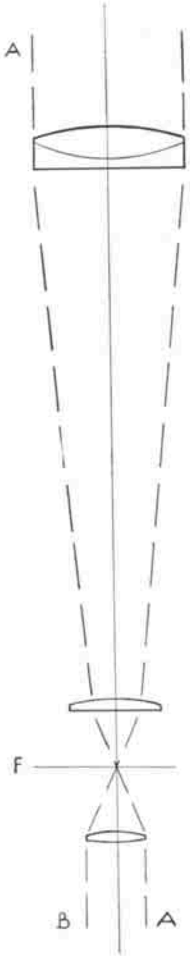


Fig. 9

THE OPTICAL SYSTEM OF THE INVERTING TELESCOPE.

Notice the Focal point "F" situated between the field lens and the eye lens. Here are placed the collimation wires and here the images of the celestial object and the Horizon are formed. Notice the lines A, B ; as they travel from the object glass to the eye they cross at "F" and this is why it is an **Inverting** Telescope.

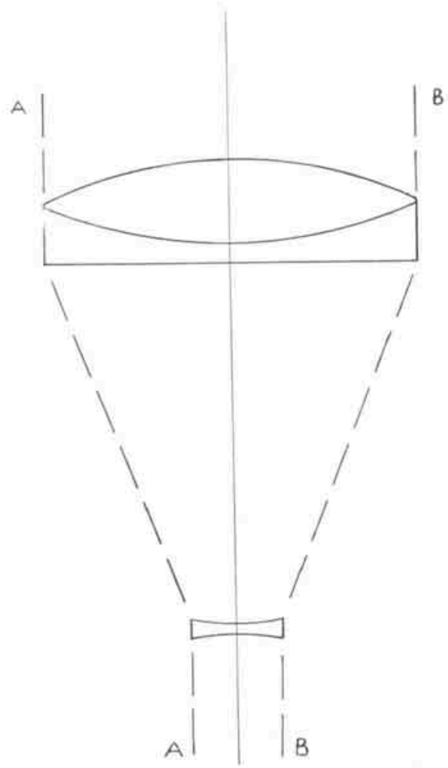


Fig. 10

THE OPTICAL SYSTEM OF THE GALILEAN ERECT TELESCOPE.

Here there is no focal point between the lenses, and the lines A, B do not cross. The image is **erect** and the illumination is good as there are only two lenses in this Galilean Telescope.

5. **THE TELESCOPES.** Some Sextants are provided with a large number of Telescopes of various magnification and types—Galilean, Inverting, Prismatic. No doubt this is very convenient, suiting as it does all conditions and individual preferences. Generally speaking however, a Sextant requires a high power telescope for adjustment purposes and for use on special occasions, as for instance when using a mercury-trough Artificial Horizon, and a low power telescope of good light transmitting quality and wide field for ordinary use and especially for star observations. These requirements are well served by using the long inverting telescope for the high power and the short conical star telescope for the lower power. **The high power telescope** is of the "inverting" or "astronomical" type because having fewer lenses than a high power "terrestrial" telescope it thus transmits more light, and the fact that it "inverts" is immaterial, since it is used for observing the Sun and Stars. Fig. 9.

As to the magnification, if the Sextant reads to 10″ or 0.2′ it really requires a telescope of not less than 9x, and the National Physical Laboratory do not issue Class "A" Certificates to sextants unless provided with telescopes of at least this magnification. Very often there is an extra eye-draw with this telescope having a magnification of 6x which is suitable for ordinary routine observations having a greater light transmission and wider field than the higher-power draw.

The low power Star Telescope, has a Galilean system of Lenses because this is the best of all telescopes for light transmission. Since the use of Stars for navigation became general, telescopes with large diameter object glasses have been introduced and now the best instruments are usually provided with telescopes with about 2″ diameter O.G.'s. Fig. 10.

As to the magnification there is a difference of opinion among users. Some prefer a very low power with a correspondingly very wide field of view (about 2x with a field of about 12°) others recommend as high a power as possible consistent with a sufficiently wide field. Our opinion is that a power of about 4x to 5x with a 2″ O.G. gives the best results. The 2x telescopes mentioned may have an emergent pencil at the eye-lens of nearly one inch, but this in our opinion is no advantage as the pupil of the eye expanded at night, is not more than 8 millimetres diameter and this regulates the amount of light that can be received by the eye. Some have thought that the higher power magnifies the image of the star ; this is not the case as the fixed stars appear as mere points of light and cannot be magnified. What happens is that Galilean Telescopes are not **perfectly** corrected to star-points and the star image owing to slight aberration appears as a tiny disc, and then seems to be magnified. If the power is such that the emergent-pencil at the eye-lens has a diameter of 10 m/m, then at night practically **all** the light gathered by the 2″ O.G. will enter the eye and both the star **and the Horizon** will appear comparatively brilliantly illuminated.

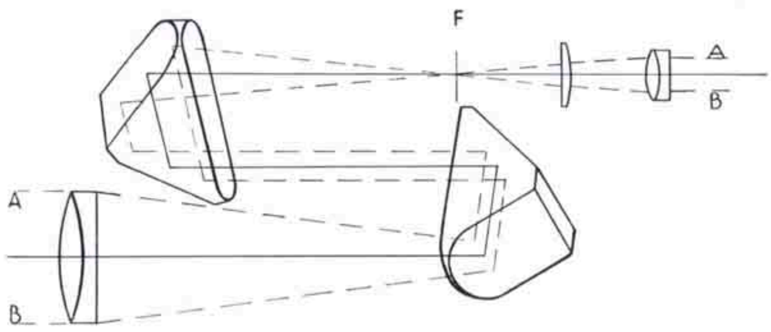


Fig. 11

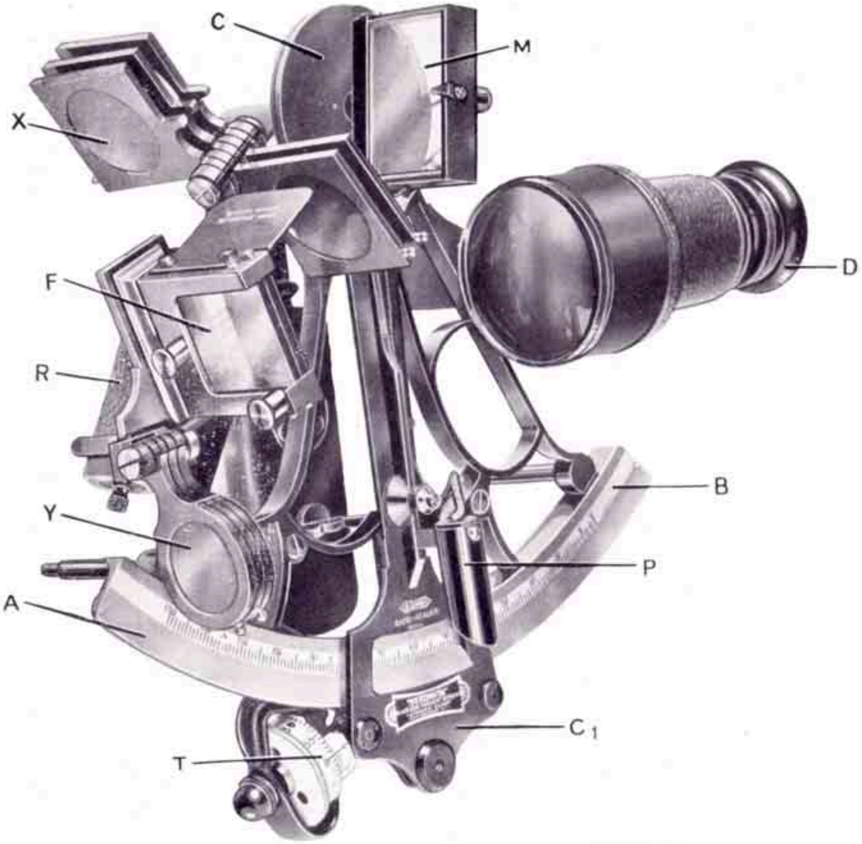
THE OPTICAL SYSTEM OF THE PRISMATIC TELESCOPE.

This is similar to the Inverting Telescope in respect of a Focal point "F" being between the object glass and the eye-piece, but the two prisms have the effect of shortening the telescope by doubling up the path of the rays and also they "invert" the lines A, B, which again being crossed at "F" emerge **"erect"** at the eye end. However there are more glass surfaces than ever in this form of telescope so the illumination is relatively inferior.

Such a Star Telescope is usually found very suitable for day or night routine observations and in practice takes the place of the 6x Inverting. It should be noted however, that the large O.G. of the Star Telescope is likely to pick up rays of sunlight, forming a glare or dazzling point of light which is inimical to good observations. This danger is guarded against in the best sextants by suitable means, e.g., the "Hezzanith" Definition Shade and the "Hezzanith" Ray-Shade which prevent the sun rays reaching the O.G. directly.

It may be well to point out that it is not possible to have collimation wires or graticules in Galilean Telescopes because there is no focal point between the object glass and the eye lens and the **image** is not formed until the rays from the object reach the retina of the eye. Reference to collimation wires and collimating is made in the section on adjustments (chapter 2).

The **Prismatic Telescope** has the same function as the Inverting but with the added advantage of compactness. It gives an **erect** image and so is convenient for horizontal terrestrial angles. Fig. 11. The fact of the image being "erect" causes the apparent movement of the observed object to be in the same direction as in the low power "Star" Telescope, and this may be considered an advantage, when both telescopes are frequently used. A word of caution may be advisable in connection with telescopes ; it should not be necessary to remove the lenses for cleaning or any other purpose and, especially in the case of a Prismatic Telescope it is best not to attempt it. If however, this is done, the greatest care must be exercised in replacing the lenses **exactly** in their original positions. We mention this because occasionally we have had telescopes sent to us for repair with the complaint that "The object is indistinct" or "the draw will not focus," and often it is entirely due to inaccurate replacing of lenses after removal.



THE "SEA-SAFE BELL" SEXTANT.

Fig. 12

A, B. Arc very boldly divided to degrees (see page 11).
C, C. Index.
F. Sea-Safe Horizon Mirror in strong frame with no top-bar (pp. 8, 34) also showing adjusting screws for Nos. 2 and 3 adjustments (pp. 19, 20), and Definition Shade (pp. 15, 34).
M. Sea-Safe Index Mirror (p. 8) showing adjusting screw for No. 1 adjustment (p. 19).
O. Large diameter Object Glass Star Telescope also called "Monocular" or "Monocle" (p. 13, Fig. 10).
P. "Hezzanith" Vernier Light (p. 33).
R. Ever-Ready Battery for Vernier Light (p. 33).
T. "Hezzanith" Patent Rapid-Reader Micrometer Tangent Screw (pp. 10, 11).
X. Square Shades (Index Shades) glazed with B.S.I.R.A. Sextant-Neutral tinted glasses (p. 9) also a cylindrical, elongating lens for Star observations (p. 33).
Y. Round Shades (Horizon Shades) B.S.I.R.A. Sextant-Neutral Tint.

CHAPTER 2.

A PRELIMINARY OR PERIODIC PERSONAL EXAMINATION OF THE SEXTANT.

A good habit to acquire is, to give one's sextant a personal examination occasionally, as follows :—

1. Ascertain that the Index moves freely on its axis, but without shake. The way to test this is explained on page 7.

2. Examine the Tangent Screw for " backlash " by measuring any angle and noting in which direction the tangent screw is being turned ; then measuring the same angle but turning the tangent screw in the reverse direction. If there is a diversity of reading " backlash " is indicated. The arrangements for adjusting the tangent screw are explained on pages 10, 11. Fig. 8.

3. Hold the instrument in such a position that by keeping the eye looking towards the lower portion of the Index Mirror a reflection of the arc will be seen in the mirror (see Fig. 13). By moving the index round the arc, this reflection can be compared with the actual arc, and if the space between the reflected and actual arc varies, the " centre " axis is not perpendicular to the plane of the instrument and probably the frame has been bent. This will cause serious errors.

4. Unless the telescope is in collimation, there are likely to be errors in the readings. By collimation is meant that the axis of the telescope must be parallel to the plane of the arc.

In modern strongly constructed instruments it is scarcely possible for the telescope to get out of collimation, and unless the rising-piece is obviously bent there is little fear of hidden error in this direction. A simple test is to screw the long " inverting " telescope in its collar and hold the instrument in such a position that inspection will clearly show whether the telescope is parallel with the plane of the arc. (See Fig. 15).

In the next section will be found further observations on the collimation of the Telescopes.

The above simple tests are sufficient to show whether the sextant is remaining in good condition and alignment.

It **has** happened that a sextant has been " borrowed " ; and it **looked** just the same afterwards—but wasn't !

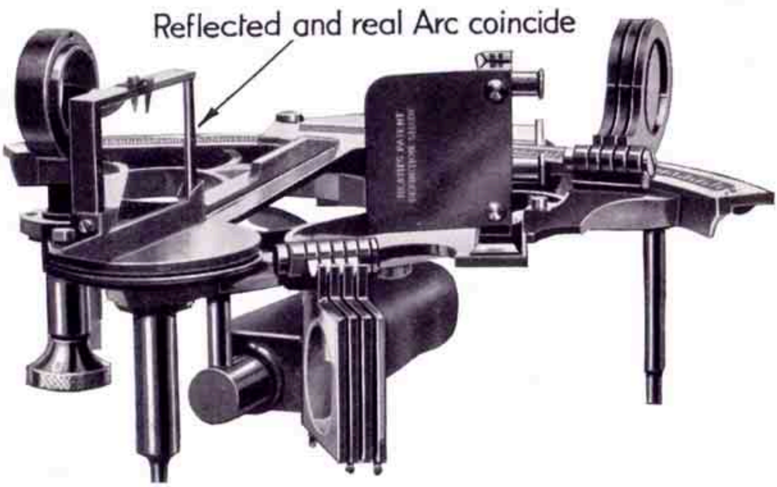


Fig. 13

This shows the Sextant held in position for testing the perpendicularity of the Index Mirror, and also that of the "centre axis." Pages 17 and 19.

THE ADJUSTMENTS OF THE SEXTANT.

The time honoured order of the four main adjustments is :—

No. 1. Set the Index Mirror perpendicular to the plane of the Sextant-limb.

No. 2. Set the Horizon Mirror perpendicular to the plane of the Sextant-limb.

No. 3. Set the Horizon Mirror parallel to the Index Mirror with the Index set at 0° on the arc (and of course 0′ on the Micrometer Vernier).

No. 4. Set the line of sight parallel to the plane of the Arc, or Collimation Adjustment.

No. 1. To **set the Index Mirror perpendicular :—**

With the Index placed about 60 degrees on the Arc, hold the instrument with the Index Mirror close to the eye as explained on p. 17, par. 3. The reflected arc seen in the mirror should appear in the same plane as the arc seen by direct vision. If not the adjusting screw at the back of the Index Mirror must be used to correct the alignment. (Fig. 13).

No. 2. To **set the Horizon Mirror perpendicular :—**

Fit one of the Telescopes in position and holding the Sextant in the horizontal position (*i.e.*, with the plane of the arc held horizontal) with the Index set at 0 degrees, observe the sea-horizon or some distant object. Both the reflected and true images should be in line ; if one is above the other the side-adjustment screw at the back of the Horizon Mirror must be used to correct alignment (the screw is sometimes at the top and sometimes at the bottom of the frame according to the type of instrument, but there is no difficulty in identifying it).

In our opinion a Sextant should not be adjusted in this horizontal position, unless it is to be used chiefly in such a position, as for example for surveying and measuring horizontal angles. It is always preferable to adjust a Sextant in the position in which it is to be used ; hence the following method for the No. 2 adjustment is, we suggest, better than that previously given.

Hold the Sextant with its plane vertical and with the Index set at about 0 degrees, observe the reflected and direct image of a star of low altitude. Move the Index so that the reflected star passes over the other. If it does not pass **exactly** over, the side-adjustment screw behind the Horizon Mirror must be used to correct the adjustment.

If the Sun is used instead of a star, the dark head should be used on the telescope (see p. 9) and **not** the Index or Horizon shades, unless it is ascertained that the latter produce no displacement of the image (see p. 9).

No. 3. To **set the Horizon Mirror parallel to the Index Mirror**:—

Carefully set the Index at 0 degrees (and be especially careful to set the Micrometer Head to 0 minutes, see p. 11) and with the high-power Inverting Telescope in position observe a star of low altitude. If the reflected image is above or below the other, make contact by turning the micrometer head and the reading will be the error either "on" or "off" the arc. If the error is small it is preferable not to attempt to correct it by the adjusting screw provided, but to record it, "off" the arc positive +, and "on" the arc negative —, and to apply this constant **correction** to the readings (N.B. "off" the arc means readings below 0 degrees and "on" means readings above 0 degrees).

The sea-horizon can also be used for this adjustment.

Our remarks about holding the sextant with the plane **vertical** and the line of sight as nearly horizontal as possible for the No. 2 adjustment apply equally when using a star for the No. 3 adjustment. It is always advisable to adjust an instrument in the position in which it is to be used.

To find the Index Error. The procedure is similar to No. 3 adjustment. It can be found by observation of a star of low altitude, the sea horizon or the Sun, and we are strongly of opinion that we have put these three objects in the correct order of precedence.

A star requires no shades and no calculations for semi-diameter and reads the actual datum, 0 degrees—it is likely to give the most reliable results.

Bring the direct and reflected image of the star into exact coincidence, read the Index error on the Micrometer Head. The Index correction for all angles will be positive + if the reading is **"off" the arc,** and negative — if the reading is **"on."**

The sea Horizon obviously can be used only when it is very clearly defined.

To use the Sun it is necessary of course to find the centre of the solar disc. Bring the limbs of the direct and reflected Suns into exact contact and read the angle. Then bring the reflected Sun across the direct until the opposite limbs are in contact and read the angle. The sum of the readings divided by 4 give the Sun's **semi-diameter** which being known forms a check on the accuracy of the readings ; and **half the difference** of the readings gives the Index error.

Example. Index error by the Sun. Date 11th Dec., 1936.

Reading "off" the arc 32′.8
,, "on" ,, ,, 32′.4 } add = 65′.2 ÷ 4 = 16′.3 Sun's semi-diameter.

0′.4 ÷ 2 = 0′.2 **Index Error** (correction positive + for all Readings).

If the **greater** of the two angles is " off " the arc the **Index correction** will be positive + for all readings. If the greater of the two angles is " on " the arc the **correction** will be negative — for all readings. At low altitudes the lower limb of the Sun is affected by refraction and thus there is a likelihood of error. In this case the Sextant **must** be held horizontally and the **horizontal** diameter of the Sun measured ;—but in our opinion the use of **a star** for Index correction eliminates doubtful elements and is best.

Here it may be advisable to repeat, that if the Index error is small, instead of attempting to correct it, it is preferable to record it and simply apply the correction to all readings. We emphasise this because sometimes we receive sextants for repair in which the adjusting screws have been so tampered with that they have become quite loose and this means inconsistent and inaccurate readings. If the adjusting screws can be easily moved by the fingers, beware ! They should be replaced by tighter fitting ones. (Perhaps this needs some modification, because there **are** men with a vice-like finger grip !). A very practical seaman once told us that he made a practice after adjusting his Sextant, of sousing the adjustments with sea-water and thus **setting** them by corrosion ! Whether this is a good practice may be open to question, but he had a true appreciation of the importance of having good adjusting screws **and not tampering with them when once set.**

No. 4. To **set the line of sight parallel to the plane of the arc.** [The collimation adjustment].

We do not now provide an adjustment on the Rising-pieces of our Sextants for setting the Telescope sight-line parallel to the plane of the arc. The telescopes are strongly mounted and in correct alignment when supplied and if they get out of true adjustment it suggests that the Sextant frame has been bent and possibly the Rising-piece as well. Adjusting a loose Rising-piece collar would not correct the error introduced by a bent frame, so in our opinion it is unnecessary and even dangerous to provide an adjustment, which while apparently correcting one error might still leave another large error uncorrected and perhaps unsuspected.

Our advice is, if the instrument has received so bad a blow that the telescope is obviously out of parallel with the arc, it should be overhauled by the instrument maker.

N.B.—The **" Periodic Examination " by the owner mentioned on page 17 will be useful under such circumstances.**

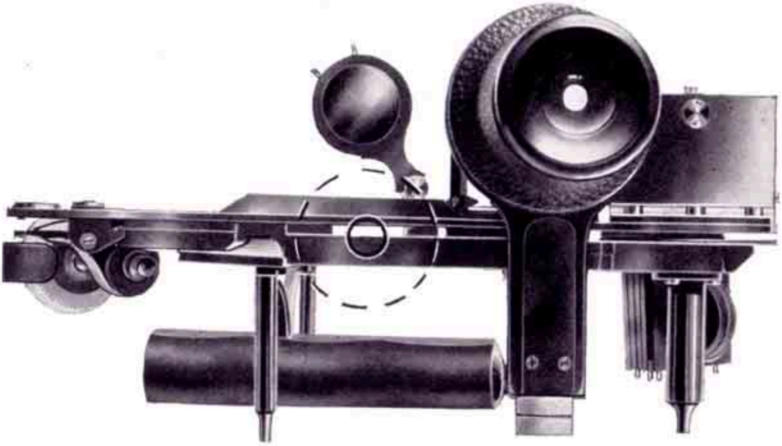


Fig. 14

This is a method of testing telescopes for collimation. Fig. 14 shows the method of sighting across the surface of the frame at a distant object, say the roof edge of a building. [N.B.—Take care that the eye is in line with the surface, neither above nor below]. Then looking through the telescope this roof edge should cut the centre of the field of view.

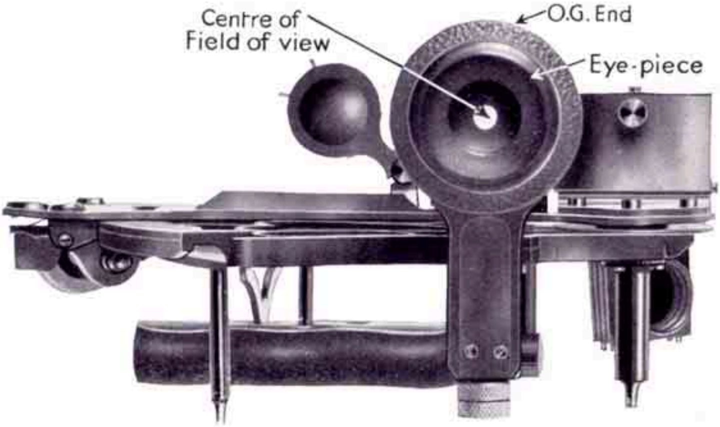


Fig. 14A

If the field of view of a large O.G. Telescope is too large to estimate the centre, an alternative is to position the eye at some distance from the eye piece **but keeping the eye piece concentric with the O.G. end as in illustration** Fig. 14A. It is then easy to estimate whether the roof edge is cutting the centre of the eye lens.

Now as to tests for collimation, a simple and satisfactory check as far as the Inverting Telescope is concerned has already been described on page 17, and perhaps reference should be made to the more elaborate test by the use of the collimation lines in the Inverting telescopes. The method is to set the lines parallel to the plane of the Sextant and at the inside line (that closest to the Sextant) to make contact with two objects (e.g. stars) about 90°—120° apart. Then move the Sextant so that the two objects are brought to the outside collimation line and if there is collimation error in the Sextant the two objects will **not** now be in contact.

These methods however, are of little use for Star telescopes and Prismatic telescopes in which no collimating lines are provided, and in which the outside shape does not indicate the line of collimation, and it does not follow that these will be "in collimation" because the Inverting telescope is (for instance the star or prismatic, etc., may have been added after the original purchase). We therefore suggest another simple method based upon the old-fashioned collimating sights. These were two small sights in shape like small right angle pieces or a mechanic's block-square (Fig. 15). Sometimes they were pierced with holes for sighting, sometimes the top edge was used. These "sights" stood at each end of the arc of the Sextant which was placed upon a steady surface. The top edges of these sights were exactly the same height from the bases and were high enough to be about in the same plane as the line of sight of the telescope. Thus a sight could be taken of the same distant object by the telescope and across these collimating sights. If the object viewed by the sights appeared in the centre of the field of view of the telescope the line through the optical centre of the telescope was parallel to the plane of the arc. We suggest a similar method, but instead of the "sights" it is quite possible to look across the top surface of the frame of the Sextant, or even the underneath surface and sight a **very distant** object. This should also appear in the centre of the field of the telescope, if the latter is truly collimated. The difference in height between the surface of the instrument and the line of collimation is negligible if a very distant object is used. If the field of view of the Star telescope is very large making it difficult to determine the centre, a simple method is to position the eye at some distance away from the telescope, so that the eye-piece is concentric with the larger object glass end of the telescope, and the object will be seen through the eye-lens, the determination of the centre by inspection presenting no difficulty. (Figs. 14, 14A).

It is obvious that the method might be elaborated by having two white rings on the two legs of the sextant close to the undersurface of the limb, and equidistant from it ; these being used as permanent sighting marks (see Fig. 14) in a similar way to the "collimating squares." The point however is not sufficiently important to justify much refinement of detail.

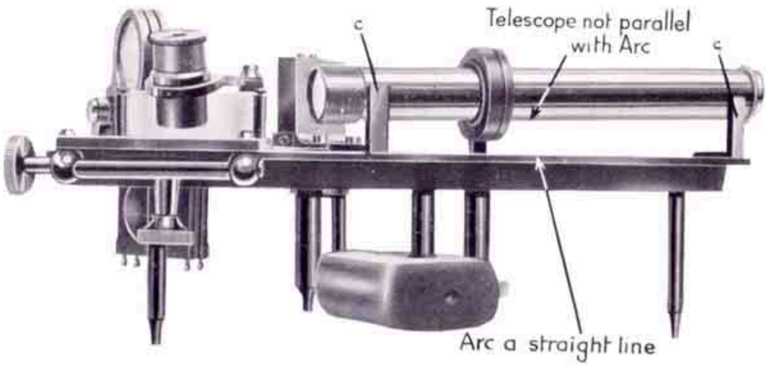


Fig. 15

This shows how to hold the Sextant to examine whether the telescope is parallel to the arc [N.B. the arc appears to the eye as a straight line]. It is about 1° in error in the illustration and this error is easily seen. Notice also the collimating sights "C.C." placed on the arc and also showing the collimation error. The top edges of these sights are used for sighting a distant object.

To give some idea of the angular error produced by telescopes being "out of collimation," we have made some tests which show the following results.

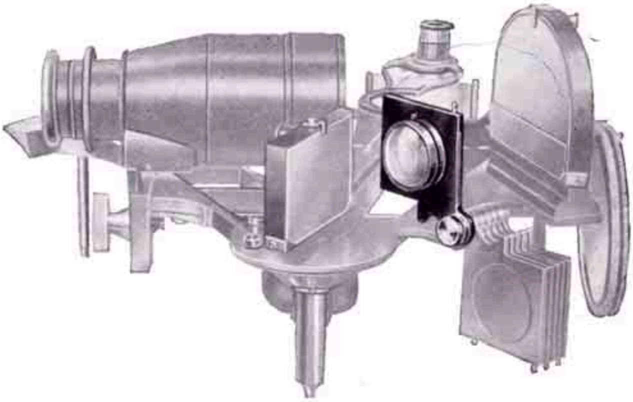
We depressed a telescope 1 degree, an amount which is easily seen by careful inspection (by method described on page 17 and see Fig. 15) to be out of parallel with the plane of the arc ; the errors in the angular reading were :—

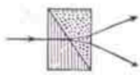
At	30	degrees	...	error	10″
,,	60	,,	...	,,	20″
,,	105	,,	...	,,	40″
,,	120	,,	...	,,	50″

These are not very large errors, but the 1 degree angle of tilt of the telescope being so apparent, it is hardly likely that a Sextant could be in such a condition **unless it has been bent by an accident in which case errors would not necessarily be corrected by collimating the telescope only.**

With a telescope depressed at an angle of a half-degree the angular error is inappreciable, but the half-degree of tilt can be readily seen by using the method of test suggested on page 17.

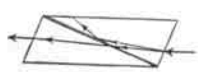
To sum up, telescopes being strongly mounted on the Sextants in true alignment by the makers, there is no need to provide loose collars and error-producing adjustments, the simple methods suggested herein of testing the collimation being at all times a useful check on the condition of the instrument.





The Wollaston Prism Illustrating Path of Ray.

Fig. 16 The Wollaston Prism on Sextant.



SECTION OF NICOL'S PRISM

Fig. 17 The Nicol's Prism.

Fig. 18 "Hezzanith" Polariser.

CHAPTER 3.

VARIOUS ACCESSORIES.

THE WOLLASTON PRISM. Fig. 16.

The Wollaston Prism is very highly approved for star observations. Certain crystals such as quartz, have the property of splitting a beam of light passing through them in a certain relation to their optical axes, into two beams. Advantage is taken of this in the Wollaston Prism, which is so constructed that the two beams emerge equidistant from the projection of the original beam.

A star image therefore becomes two stars separated usually by a distance of 16′, and in observations the horizon is brought midway between these two stars. Even when the horizon beneath the star is not well defined, accurate altitudes are obtained.

Owing to the comparatively high price of these prisms, attempts have been made to obtain a similar result by the well known device of a lens split across its optical axis and displaced the required amount.

In our opinion this is a very defective substitute, for one half of the lens produces the one image of the star, and the other half produces the other, and thus there is not a double image seen **all over** the field of view, but only in a narrow central strip. This can be dangerous, for if one star image **only** is seen and used it will produce serious error. The Wollaston Prism on the other hand shows the double star image at all portions of the field.

THE "HEZZANITH" NICOL'S PRISM. Fig. 17.

The "Hezzanith" Nicol's Prism is a crystal of Iceland Spar which has the property of polarising light passing through it. This in effect means that the glare from the horizon can be cut out by the polariser, and a clear defined horizon seen. We fit the prism in a cell which is attached to the telescope like an eye-shade.

THE "HEZZANITH" POLARISER. Fig. 18.

For the same purpose as the Nicol Prism we also use a polarising substance which is produced in thin film form, and this enables a larger field of view to be polarised, and as fitted in its cell is much more compact.

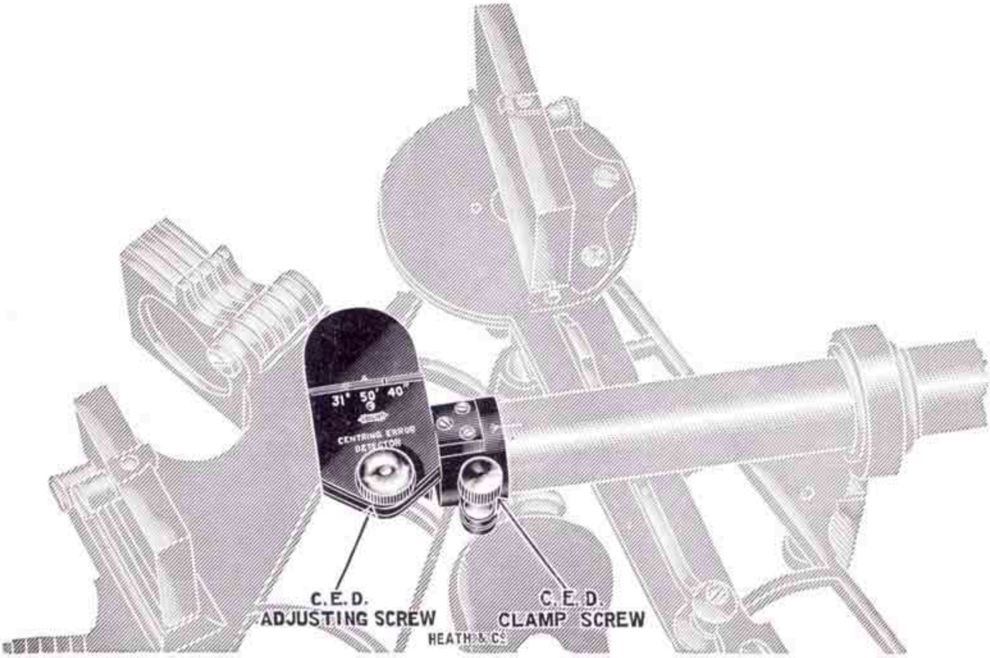


Fig. 19. C.E.D. 30° Prism in position on Sextant.

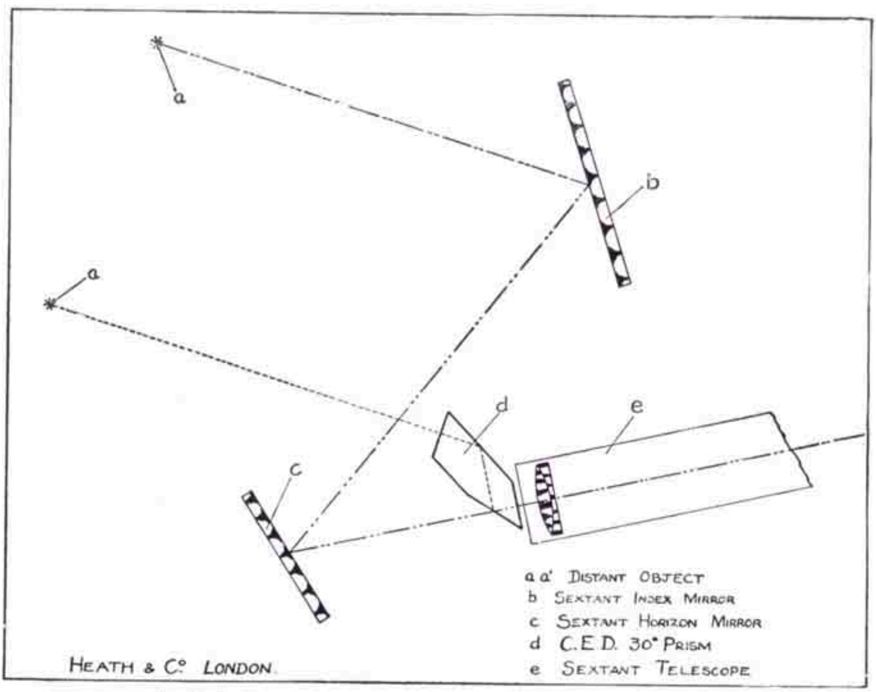


Fig. 19A. Diagrammatic View of C.E.D. 30° Prism in use.

Fig. 19, 19A. The Centring Error Detector.

CENTRING ERROR DETECTOR. Fig. 19. 19A.

The "Hezzanith" Centring Error Detector is a device to check the "centring" or ascertain the "centring error" of a sextant, and it can be used anywhere on land or sea and at any time when one distant sharply defined object can be seen. It consists of a prism which deflects the ray from the object through a known and fixed angle. The prism is clamped to the long inverting telescope (see Fig. 19) and it is possible to bring the image of the distant object (say a star), reflected from the Index mirror, to coincide with the image of the object reflected through the CED prism. If there is no centring error the angle read on the arc will be the same as the known angle of the prism, and any variation from it will be the centring error at that part of the arc. Prisms are supplied to test the arc at 30°, 60°, 90°, and 120°. Further information is supplied in a pamphlet "The 'Hezzanith' Centring Error Detector," Heath & Co.

NORMAL ANGLE BAR. Fig. 20.

The "Hezzanith" Normal Angle Bar was designed some years ago when we were investigating the side-error which was introduced into certain sextants **when held out of the normal position** for taking altitudes.

For example it was found in one instance that when the sextant in question was elevated at an angle of 45 degrees a side error of the order of 4′ was introduced. The question was twofold—(*a*) How much **angular** error was introduced by this amount of side error? (*b*) How could this side error be eliminated? With regard to (*a*) we discovered mathematically, that to cause an angular error of 30″ when measuring an angle of 45 degrees there would have to be introduced a side error of 58′ 30″, and to cause a similar angular error of 30″ when measuring an angle of 5 degrees there would have to be introduced a side-error of 16′; angles of course of impossible magnitude. In other words a side-error corresponding to 4′ when measuring an angle of 45 degrees is absolutely negligible. In practice, as the angle is taken with the line of sight horizontal (*i.e.* in the position in which the sextant is adjusted) this negligible error **does not even exist!**

With regard to (*b*) we found that it was possible to eliminate the possibility of temporary side-error in the sextant in question by mounting on it the "Normal Angle Bar" (see Fig. 20). This is a suitably shaped bar which is attached to the two side plates which hold the Telescope and the Horizon Mirror. The bar also forms a bridge to which one end of the Sextant handle is mounted. It is usually constructed of sea-resisting aluminium alloy for lightness and it gives the required result. As shown above however, this particular "side error" can be ignored; yet we have considered it advisable to discuss the function of the Normal Angle Bar not only as a matter of interest but because there may be special cases in which its use would be welcome and fully justified.

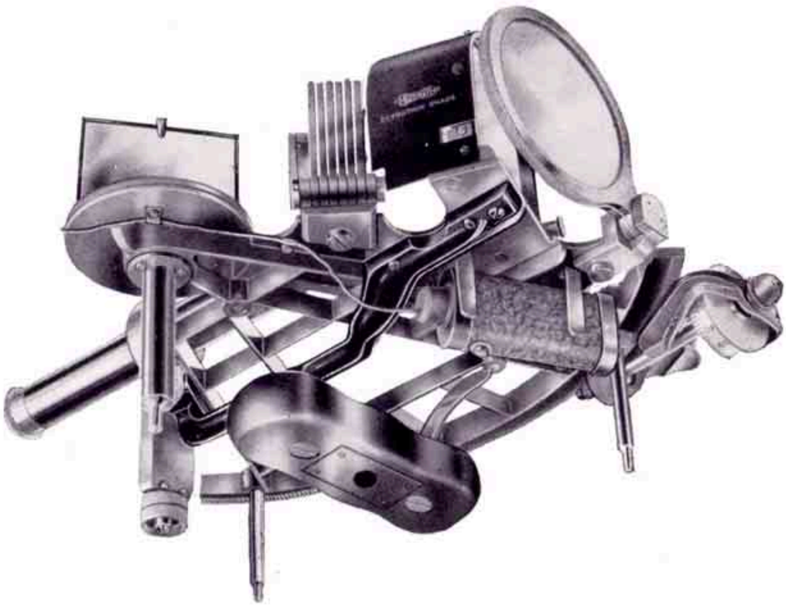


Fig. 20. The "Hezzanith" Normal Angle Bar.

THE " HEZZANITH " BUBBLE TELESCOPE ATTACHMENT. Fig. 21.

There is an insistent demand for a " bubble " artificial Horizon and **within the limits imposed by the use of a " bubble "** the " Hezzanith " Bubble Artificial Horizon gives satisfactory results. It is a simple instrument without complications and is attached to the sextant just like an ordinary telescope. In use the bubble has to be brought to the centre of the field of view where it makes contact with the image of the observed object.

As to accuracy this depends largely as in all bubble sextants on the steadiness with which the bubble can be maintained in the field of the telescope, but we have had a report from a user who states that he can be perfectly confident of results within 4′ with the " Hezzanith " attachment. His words are " 2 to 4 minutes depending on the roughness of the sea." [Continued foot of page 32

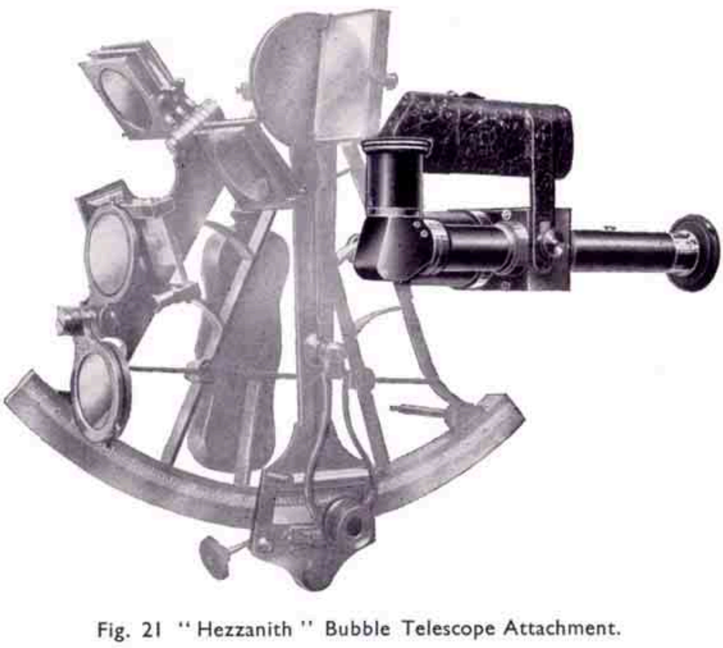
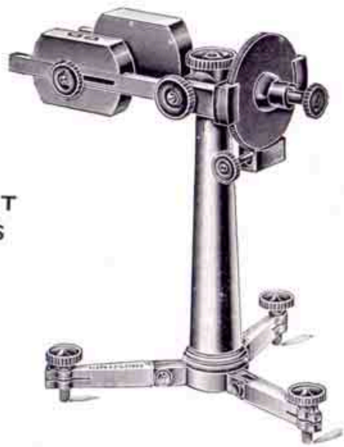


Fig. 21 " Hezzanith " Bubble Telescope Attachment.

SEXTANT STANDS



Model No. 1
Fig. 22

Hezzanith Model Mk. 2.
Fig. 23

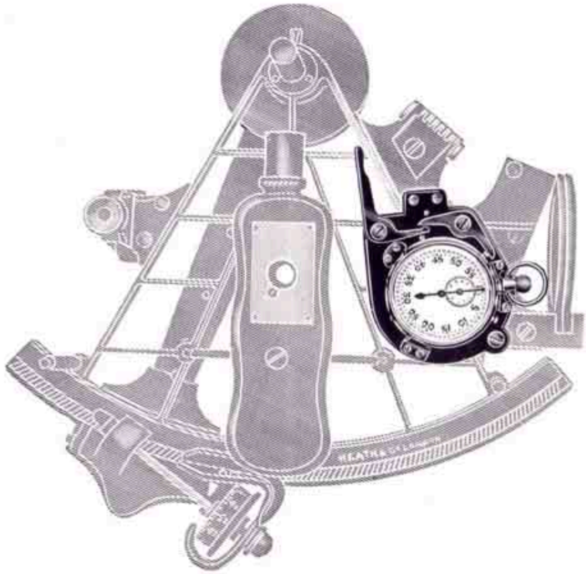


Fig. 24 The Hezzanith Dotting Watch.

From page 31]

This does not agree with a report of tests of bubble sextants which has come to our notice, in which it is stated that "for a moderate sea" no greater accuracy than fifteen minutes can be expected with a bubble.* Obviously the conditions under which these instruments are used profoundly affect the accuracy of the results.

We make an Artificial Horizon Sextant on a similar principle to the "Hezzanith" attachment, but a description of this is outside the scope of these notes.

* *"Use of Bubble Sextant at Sea" by E. O. HULBERT (1933).*

SEXTANT STANDS. Figs. 22, 23.

The handles of most of our better class sextants are fitted with a standard-size socket which fits the "Hezzanith" Sextant Stands. The latter are made in two qualities :—the simple form being the well-known stand as shown in Fig. 22. The "Hezzanith" Mk. II. Sextant Stand (Fig. 23) is much more elaborate and convenient, its chief advantage perhaps being its adjustments. The sextant is depressed to the desired angle by means of an endless tangent screw with rapid release and automatic clamp. The counter weights are adjustable and contain a level for maintaining the plane of the sextant in the correct vertical position for measuring an altitude.

Index Level.—For those who use the Trough Artificial Horizon either with or without the Sextant Stand, a very useful accessory is a small spirit level suitably mounted on the index bar of the sextant. Whatever the angle of depression of the sextant telescope, the index is moved over the arc until the bubble is in the centre of its run ; the image of the observed star reflected from the index mirror, will then be found in the field of view and exact contact can be effected.

"HEZZANITH" VERNIER LIGHT.

See Fig. 12., Ref. P., page 16.

The "Hezzanith" Vernier Light is designed so that it can illuminate the micrometer drum and vernier and also the zero mark and reading of the arc.

If necessary it can be swung well away from the readings of the instrument. The electric battery is fitted conveniently on the instrument ; but **not** inside the handle as in our opinion such a position usually limits the size of the battery too much.

The Ever-Ready batteries provided for on the "Hezzanith" Vernier Light are everywhere obtainable and very easily renewed.

THE "HEZZANITH" DOTTING WATCH. Fig. 24.

The "Hezzanith" Dotting Watch is so fitted on the Sextant that by the depression of a lever at the exact moment of contact a dot is recorded on the face of the watch, which thus registers the exact second the observation was taken. The "dots" are easily cleaned from the face of the watch after observations.

ELONGATING LENS FOR STAR OBSERVATIONS.

This lens mounted like one of the Index Shades (see Fig. 12) is a cylindrical lens of 1·25 Diopters which has the property of elongating a star-image into a streak.

The fixed stars appearing to us as points of light, there is no way of magnifying a star-image ; but it can be elongated by this method.

The elongation being horizontal is also a means of ascertaining that the portion of the horizon used is vertically below the observed star.

CORRECTION LENSES.

We are sometimes asked to insert in a Sextant telescope a lens made to the prescription for correction of astigmatism in the eye of the user.

Special arrangements must be made for this according to the telescope used and it can be made removable as an ordinary telescope eye-shade, or fitted permanently.

SUPPLEMENTARY NOTE ON SEXTANT FRAMES.

We illustrate (Fig. 25) our Duralumin Frame Sextant. The natural corollary of the introduction of the Micrometer Tangent Screw is that the Sextants should be made as small as possible—for legibility is no longer improved with length of radius. In this Duralumin Sextant the radius is made as short as possible consistent with the optical lay-out. In the latter the size of the O.G. governs dimensions to a great extent and we have had before us in the whole design the important feature which has been called " Ease of Use." This really covers a multitude of details two of which, **as examples,** are the removal of the top-bar from the large Horizon Frame and the provision of Ray-shades for day use. The top bar of a Horizon Mirror, sometimes containing an adjusting screw, is annoying to the observer as it comes across the Horizon. In many of our Horizon Mirrors, both the single type and the "Sea-Safe" we do away with this top-bar entirely and a clear unobstructed horizon is seen in the field of view. (See Fig. 6).

The other point mentioned, namely, the Ray Shades is important because the large O.G. Telescope is now used for sun observations as well as for stars. At certain altitudes a beam of sun strikes the O.G. and becomes a bright dazzling point in the field of view, very baffling to the observer, unless provision is made to prevent it. The "Hezzanith" Ray-Shade and Definition Shade have been designed for this purpose. Very many other features are taken into consideration all combining to produce the result—**" Ease of Use."**

The frame being made of Duralumin is **extraordinarily rigid** and, in accord with modern ideas it is in a solid rounded style—a complete departure from the Edge Bar and Plate patterns so long in use. Its rigidity is such that it is practically impossible to bend it by even considerably rough usage.

The Makers claim that Duralumin possesses the strength and hardness of mild steel, and it offers a remarkable resistance to sea-water.

The following figures give an idea of the astonishing rigidity of this metal as compared with Gun Metal of which Sextant Frames are usually made :—

Maximum Stress of Gun Metal	...	14-16 tons per sq. inch.
" " Duralumin	...	25-35 " "

GEO. A. HEATH, A.M.I.Mech.E., F.Inst.P.
HEATH & CO., New Eltham, S.E.9.

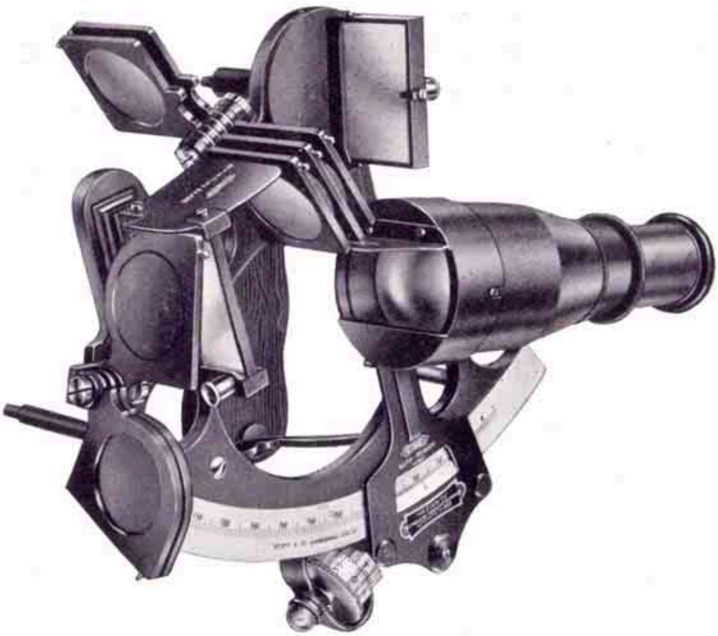


Fig. 25 The Mark VI M. Duralumin Frame "Hezzanith" Sextant.

[Radius to outside of arc $6\frac{1}{2}''$].

The "**Ease-of-Use**" Sextant.

Lightness—Legibility—Rigidity.

INDEX.

J & S., Leeds