

CONDITIONS OF TEST FOR SEXTANTS

British Admiralty Specifications.

In the *Hydrographic Review*, Vol. VI, No 2, given in connection with and following an article on various portable instruments for measuring angles, appears certain information concerning the conditions of test for sextants imposed by the British Admiralty and on the improvements in the requirements of such tests brought into force during the last few years by the National Physical Laboratory of Teddington. (See *Hydrographic Review*, Vol. VI, No 2, page 151).

In this article reference is made to the requirements of the regulations in force up till that time; these requirements are set forth in all specifications (contracts) dealing with sextants.

The Hydrographer of the Admiralty has kindly forwarded to the International Hydrographic Bureau a copy of these specifications, the text of which is given below as a complement to the information already published on this subject in the *Hydrographic Review*, Vol. VI, No 2.

These specifications and the tests to which the instruments are submitted are severe, and it is opportune to draw attention to them as a model for the proofs to which this kind of instrument should be put.

SPECIFICATION FOR SEXTANTS.

1. Sextants are to be made in accordance with this Specification, and in matters not specifically referred to they must correspond with the accepted design, which can be inspected at the National Physical Laboratory.

2. Workmanship throughout to be of approved quality and thoroughly sound.

3. The metal portions of the instrument to be made from any metal approved by the National Physical Laboratory.

The limb is to have the front and back faces finished plane and parallel except for the circular arc on which the graduations are cut which is also to be parallel, but 0.1 inch above the front face of the limb. The thickness of the limb measured from front face to back face is to be not less than 0.4 inch, and the distance of the face of the arc not less than 0.5 inch from the back face. This thickness is not compulsory for the full breadth of all members of the limb and does not prevent the employment of "T" bars in the framework of the limb.

The pattern of the frame should conform to the accepted design. Particular attention is called to the member extending from the rising piece to the centre of the horizon glass.

4. The dividing of the arcs and verniers to be done only on approved dividing engines, and no graduation may be displaced from its true position by more than three seconds (corresponding to reading of six seconds).

5. The arc is to be divided to read to 10 minutes and is to be numbered at every 5°. The graduation of the arc must extend at least 5° below Zero and must read to at least 125° above Zero, so that in order to include the vernier the graduations must be cut from 5° to at least 142°.

6. The vernier is to be divided to read to 12 seconds and is to be numbered at every 1 minute: it should have 50 divisions corresponding to 99 divisions of the arc. The vernier must have at least 3 extra divisions at each end of its scale. There is to be no appreciable parallax between the arc and the vernier graduations, and the vernier may not be made to fit correctly by bowing.

7. The radius of the arc is to be not less than 6 1/2 inches, this is to be measured from the centre to the reading edge of the vernier.

8. The socket in which the index arm moves is to form part of the limb itself and is not to be a detachable portion that may, by slight displacement, give rise to centering error. There is, however, no objection to the socket being originally made separate and subsequently adjusted so as to make the working centre coincident with the centre of the scale provided the screws attaching the socket to the limb be soft soldered into their positions in such manner that they cannot be easily removed and in such manner that there is no risk of any displacement of the working centre through such handling as a Sextant is ordinarily liable to; and no doctoring of the centre socket to be permitted by burring or scraping the centre hole in the limb.

9. The top surface of the arc is to be plane and the axis of rotation of the index arm must be perpendicular to this plane.

10. The edge of the arc nearest to the mirror must be a section of a circular cylinder having its axis coincident with the axis of rotation of the Index arm.

11. When the telescope is fixed in position, its axis must be parallel to the surface of the limb and the mounting of the telescope must be so rigid that when reasonable pressure is applied to the end of the telescope, the axis is not deflected, so as to be inclined more than 1/2° with the face of the limb. This condition must be satisfied for all positions of the telescope's axis within 0.25 inch on either side of the position in which the line of the telescope's axis would, if produced, pass through the edge of the silvering of the horizon mirror. The adjustment for collimation is to be a permanent workshop adjustment and no means need be provided for making this adjustment subsequently. The stem of the rising piece must be of triangular section.

12. The instrument is to be provided with telescopes as follows:—

	Magnification.	External Field.	Clear Aperture.	Diam. of Emergent Pencil.		
1. Inverting	10 ± 1.	Not less than	3°.75.	Not less than 1.0 inch.	0.1 inch.	
2. Inverting	5 ± 0.5.	" " "	6°	" " "	1.0 inch.	0.2 inch.
3. Erect	2 ± 0.2.	" " "	12°	" " "	1.6 inch.	0.8 inch.

No telescope is to be more than 6 1/2 inches long and is not to project more than 3 1/2 inches outside the rising piece with the eye-piece close home.

The definition to be good over 3/4 field and free from colour.

Telescope and collar to be fitted with interrupted threads and a mark to show position for engaging. Screw thread 18 per inch, external diameter measured on crests of threads to be between 1.200 and 1.198 inch, 6 to 8 threads to engage for not less than 3/4 of their length when telescope is in position.

13. The optical axis of the telescope objectives is to coincide with the axis of the body tubes.

14. The telescopes are to have focussing adjustments, consisting of a simple drawtube, etc.

15. The reading microscope is to consist of a simple lens, of a diameter not less than 1/2 inch and focal length 1.0 inch ± 0.1. The lens is to be mounted in such a manner that it can be placed with its axis passing through any point of the vernier edge. The mounting of the lens must allow its being brought down to 3/4 of its focal length from the arc. The method of mounting must conform generally with that employed on the accepted design and be such that light falls easily upon the arc and vernier when the Sextant is being used in the manner customary when reading the arc.

16. Only the approved forms of clamp and fine motion movements to be fitted.

17. *Sizes of Mirror* :—

Horizon Mirror—*Height between 1.593 and 1.598 inch
 Width between 1.293 and 1.298 inch
 Index Mirror — Width between 1.993 and 1.998 inch
 *Height between 1.293 and 1.298 inch
 Thickness of mirrors to be between 0.140 inch and 0.160 inch

Openings in Frame :—

Horizon Mirror Frame—*Height between 1.600 and 1.605
 Width between 1.300 and 1.305
 Index Frame — Width between 2.000 and 2.005
 *Height between 1.300 and 1.305
 *Height means vertical to plane of instrument.

When mounted, the edge of the index glass which is nearer the limb is to be 0.1 inch nearer the limb than the corresponding edge of the horizon glass. The mirrors are also to be mounted so as to give as much light as possible when large angles are observed.

18. All mirrors and shades are to have both surfaces plane polished to a high degree of accuracy. No deviation of light passing through them must exceed 5 seconds. There are to be four shades to the index glass, and two shades to the horizon glass, one of which is to be a specially light horizon shade. Two shades for the telescope of approved density are to be provided in metal caps fitted to slip on to the end of the telescope.

19. Shades to be of a satisfactory neutral tint and to have their transmission not more than twice, or less than half, that of the shade on the accepted pattern.

20. Adjusting screws to mirrors are to be of the capstan-head type, with suitable covering caps. One adjusting screw is required on the index mirror for removal of perpendicular error. Two on the horizon mirror for removal of side error and index error. The silvering where the screws bear on the mirrors to be removed to allow the screw point to bear directly on the glass.

21. The general accuracy to be such that the error in any angle from all sources is not to exceed 0'.8.

22. The handle to be of good size, but when the instrument rests on a level surface on its three legs, the handle must clear the surface by at least 1/4 inch.

23. The instrument as a whole to be uniformly finished all over of a dull light, or medium grey colour.

24. All instruments to be packed in a solid hard wood case of approved pattern and fitted with handle and lock and key. The bearers must be so arranged that they cannot press upon the index arm of the Sextant and admit of the index bar being left in any position between 0° and 90°.

25. Each instrument to be numbered and all fittings marked with this number. All instruments to be marked with a small broad arrow (↑) in positions adjacent to the numbers referred to in the present clause 25.

26. Each instrument to be sent to the National Physical Laboratory, Teddington, and to pass the tests to which it will be subjected.

 TESTS TO BE APPLIED TO ADMIRALTY SEXTANTS.

Frame.

1. The frame will be examined to see that it is stiff.
2. The surface on which the graduations are made will be examined (with a small spirit level) to see that it is plane.

Fittings to Frame.

3. The telescope rising piece will be examined to see that it is stiff.

4. The frame holding the horizon mirror will be examined to see that it is stiff and rigidly fastened to the frame.

5. The frame holding the index mirror will be examined to see that it is stiff and rigidly fastened to the index arm.

6. The fittings of the clamp and tangent screw will be examined. Appreciable backlash or loss of time, or motion of the vernier perpendicular to the tangent to the arc on changing the direction of rotation of the screw or under other circumstances, or undue stiffness or slackness in the working of the screw, will involve rejection.

7. Any bending of the index arm in the plane of the angles to be measured due to want of stiffness of the arm or to tightness of the index pivot will involve rejection. This may be tested by seeing if the values recorded by the instrument for the same angle differ by as much as 0.2' when the angle is measured with the index moving (*a*) in the direction of angle increasing, (*b*) in the direction of angle decreasing.

8. The screws and other fittings by the removal of which access is obtained to the centering adjustment, will be examined to see that they are so securely sealed that the adjustment cannot be readily tampered with.

9. The screws by which the telescope axis is adjusted to be parallel to the plane containing the angle to be measured will be examined to see that they cannot be readily altered.

Telescopes.

10. The telescopes will be examined to see that their magnifying powers are in accordance with the specification; that they include the required field of view; that they are achromatic and give bright and clear images with good definition over at least the greater part of the field of view; that their apertures are of the specified diameter; that their object glasses have their axes coincident with the axes of their body tubes, and are mounted centrally in their cells; and that the usual wires are fitted accurately in the focus of the eye-pieces and suitably spaced.

11. The fitting of the interrupted threads will be examined to see that the threads of the telescope engage sufficiently with those of the support. The telescope after being pushed in should require to be rotated through $60^\circ \pm 10^\circ$ to come home, if the amount of rotation is appreciably more or less than this the instrument will be rejected.

Shades.

12. The shades will be examined to see that they are of suitable densities, and do not deviate the light by as much as 5".

Mirrors.

13. The mirrors will be examined to see that they give bright reflexions, and have their surfaces truly plane and parallel.

Microscope.

14. The microscope will be examined to see that it is of the required magnifying power; that it covers the required field of view; is achromatic and gives good definition over its field. The effective apertures of the lenses must not be less than those of the pattern instrument.

Graduations, Vernier, &c.

15. The vernier will be measured against the arc at intervals of not more than 15° . Wherever the vernier may be placed a space on the arc graduated as $16^\circ 30'$ must not fail to correspond with a space on the vernier graduated as $10'$ by as much as 0'.2; for instance, if when the zero of the vernier is opposite the 60° line on the arc, the 9'.8 of the vernier is opposite the $76^\circ 20'$ of the arc, or the 10'.2 of the vernier is opposite the $76^\circ 40'$ of the arc, the instrument will be rejected.

16. The instrument will be examined to see that all the divisions of the vernier and of the arc are at regular distances apart. If through any irregularity in one or both of these scales two consecutive lines of the vernier are exactly opposite two lines of the arc, showing an error of 0'.2 in the position of one line relative to the other, the instrument will be rejected.

17. The graduations will be examined to see that they are correctly numbered every 5° on the arc and every 1' on the vernier.

Assembling of Parts, &c.

18. The shades, telescopes, and other fittings will be examined to see that they are so placed that they cannot foul one another or the adjusting screws or their covers.

19. The shades will be examined to see that they are perpendicular to the path of light which goes through them to the centre of the telescope, and that they are of such a size and so placed that when in position all light reaching the telescope objective passes through them, but that they do not limit the field of view of the high power telescope nor reduce its effective aperture.

20. The mirrors will be examined to see that they are so placed with respect to one another and the collimation axis of the telescopes that light which ultimately passes along the axis of the telescope meets the mirrors at their centres.

21. The mirrors must be so placed that at large angles the amount of light received by the telescopes is not less than in the instrument of accepted design.

22. The index pivot will be tested for perpendicularity to the plane containing the graduations. When the index mirror is adjusted so that for one position the reflexion of the graduated plane surface of the arc is continuous with that part of the arc which can be seen direct at the same time, the same must be true into whatever position the index arm is rotated. Any appreciable departure will involve rejection.

23. The telescopes will be tested to see that when screwed home their axes are parallel to the plane graduated surface of the arc.

A pressure equivalent to a weight of 3 lbs. will be applied at the eye end of the telescope when focussed for distant objects. The deflection of the axis with this pressure applied is not to exceed $1/2^{\circ}$.

24. The microscope axis must be approximately normal to the plane graduated surface of the arc, and the reading edge of the vernier must come approximately across the middle of the field of view of the microscope. The microscope fitting will also be examined to see that there is ample focussing adjustment (not less than $-5D$ to $+5D$), and that in all positions the graduations are satisfactorily illuminated.

25. The fitting of the vernier to the scale will be examined to ensure that there is no parallax in reading the angle of as much as 0.2 , and that when clamped neither the vernier nor any part of it can be lifted up from the arc.

26. After the mirrors have been adjusted readings will be taken of known angles at intervals of about 15° throughout the whole length of the arc, from which the errors due to slight departures from perfect adjustment (centering, &c.) can be found. The errors due to all causes must not exceed 0.8 . The corrections found will be embodied on the certificate. If from any cause, whether determined or not, the corrections found are irregular or vary from one examination to another, the instrument will be rejected.

27. The adjustments to the mirrors will be examined to see that they are satisfactory in range, that fine movements can be made without difficulty, and that creeping does not take place after setting.

Numbering, &c.

28. The frame and all removable parts, including telescopes, microscope and shade frames, will be examined to see that they are numbered and otherwise marked according to Admiralty regulations.

Box.

29. The box will be examined to see that it is in accordance with Admiralty regulations.

Special.

30. If from any cause not specified a sextant appears to be unsatisfactory it may be rejected.
