moves at the same time as that of the circle; this movement is due to an actual movement of the drum, since the latter is rigidly connected with the parallel-faced glass wafer. The drum is read against the index formed by a line across the image; its graduation — in minutes, with every tenth minute numbered — is such as to enable an estimation to within a tenth of a sexagesimal minute to be made.

The sextant can be fitted with a coincidence level, visible in the field of the telescope.

This new sextant, while very compact and very robust, has been designed without losing sight of the importance of ease of adjustment and the possibility of replacing the different optical or mechanical parts.

The complete instrument weighs only 900 grammes (2 lbs.); its handy shape ensures an easy grip and perfect steadiness.

THE COOKE 45° PRISMATIC ASTROLABE

by

COOKE, TROUGHTON & SIMMS, LTD (1)

The 45° Prismatic Astrolabe was designed by Instructor-Captain T. Y. BAKER, R. N., of the Admiralty Research Laboratory. So successful is this Astrolabe that the Hydrographic Department of the British Navy has adopted it as the standard equipment for the determination of position by astronomical means. The instrument is also being used successfully for this purpose in many other countries.

General Description. — The fundamental principles of the 45° Astrolabe are shown in Fig. 1. A pentagonal, or Prandl, prism *ABCDE* is held in the position shown. The faces *AE* and *CD* are silvered, but on the former a circular area of the silvering is removed. To this face *AE* is cemented a second prism *AEF* in which the angle *AEF* is 22½°, so that the faces *FE* and *BC* are parallel. Below, and in front of, the prism block is a mercury pool.

Light from a star at 45° altitude can enter the prism block: (*a*) after reflection at the mercury pool, when it passes through the face *FE*, through the opening in the silver of the interface *AE*, and then out through the face *BC*; (*b*) through the face *AB* and then, after reflection at the face *CD* and in the silvered part of *AE*, it also emerges through the face *BC*. The first beam has undergone one reflection, the second two. As the star rises or sets, the two emergent beams move in opposite directions, one upwards, the other downwards. The measurement is made when the two emergent beams coincide exactly in direction. If the prism could be made with absolute accuracy of angles and the observation made without error, the star would, at that instant, have an altitude of 45°. In practice, however, the zenith distance is not exactly 45° but, except for errors of observation and variations of refraction, it is a constant angle for all stars observed. The method of working out the observations automatically takes account of the fact that the angle, though constant, is not exactly 45°.

The instrument has a telescope for observing purposes and it is to be noted that this telescope acts merely as a magnifier and permits the instant of "contact" to be noted with higher precision. There is no requirement of accurate alignment of the telescope axis on the line of the emergent beam as there is, for example, in observations made with a theodolite where the inclination of the optical axis of the telescope with the vertical axis of the instrument must remain constant to a fraction of a second of arc. The light grasp of the telescope is sufficient to allow observations of stars of the sixth magnitude and generally a programme will be made of selected stars of this magnitude.

Various optical accessories are added to this fundamental arrangement in order to improve the ease of making observations. Contact between two bright stars is not an

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(1) *Buckingham Works, York, England.*
15 & 17 Broadway, Westminster, London, S.W. 1.
See also *The Hydrographic Review*, Vol. IX, N° 1, May 1932, p. 218.

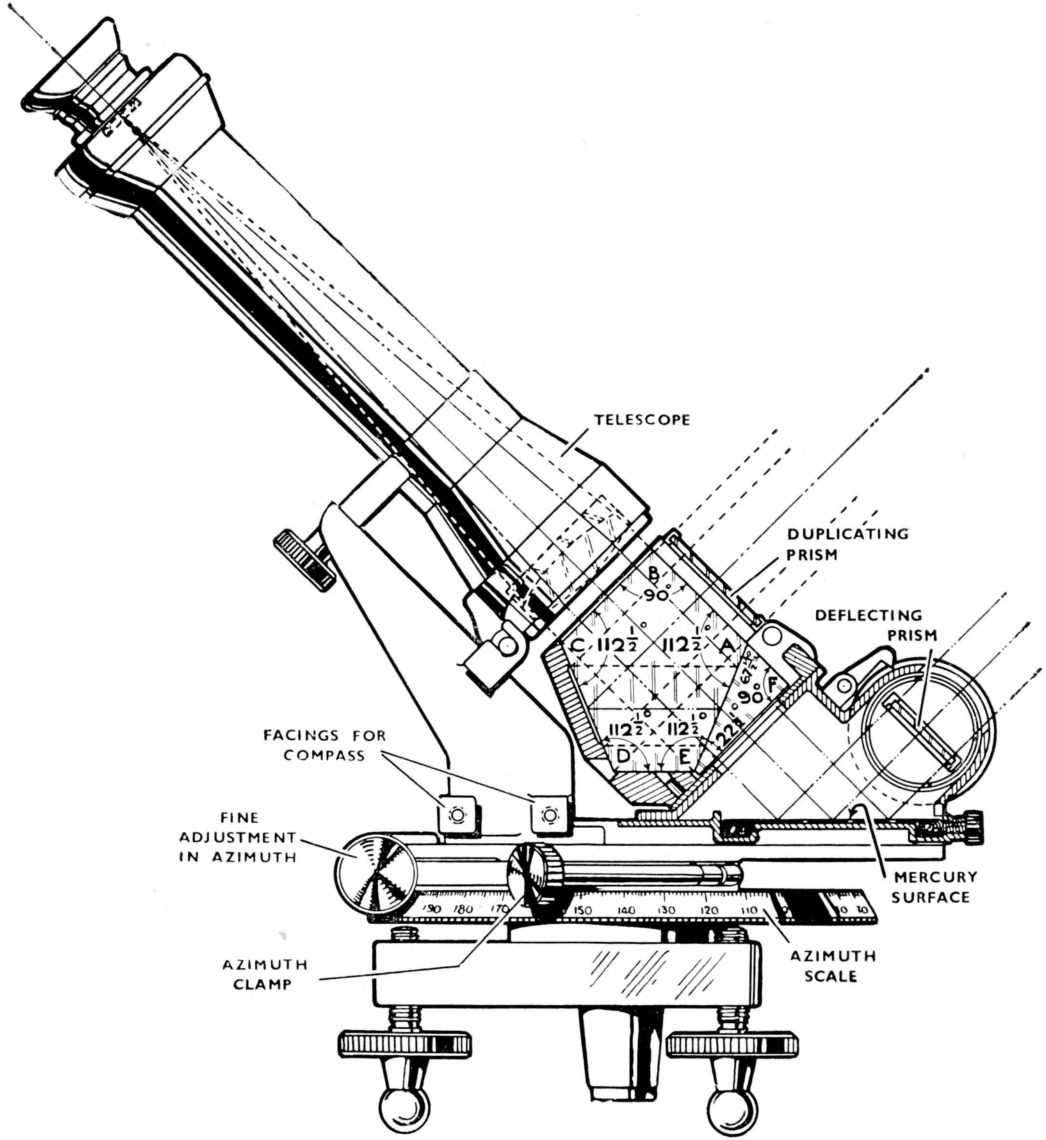


FIG. 1 *Side elevation* — *Vue latérale*

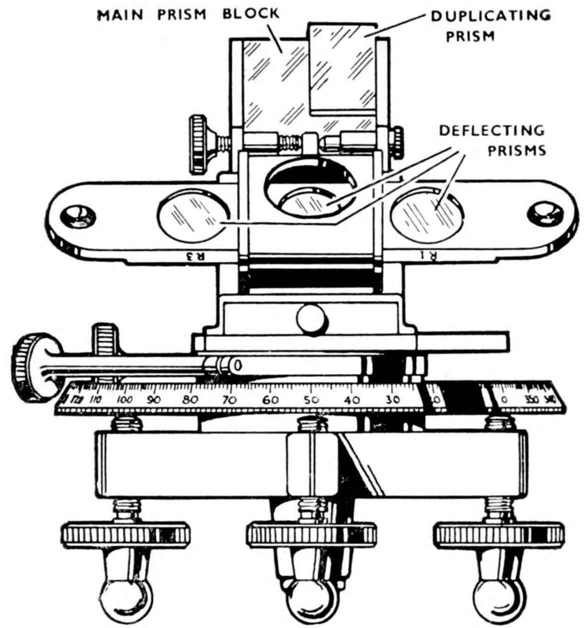


FIG. 2

Front elevation (telescope removed) — *Vue de face (lunette retirée)*

THE COOKE 45° PRISMATIC ASTROLABE — L'ASTROLABE A PRISME A 45° DE COOKE observation for which the eye has a very high degree of acuity, and in order to reduce the spread of errors of observation the following device is adopted. A weak deviating prism is fitted over half the aperture of the direct beam (i. e. the one entering the prism block through the face *AB*) and one half of this beam is thus deflected laterally by about 3 minutes of arc, causing the direct star image to be duplicated. Owing to the magnifying power of the telescope, these two star images appear to be about three quarters of a degree apart. The observation is made by allowing the mercury image (single star) to pass between the direct image (duplicated star) and noting the instant when all three images appear to be in line. Fig. 3 shows what is happening. The spread of errors when making this setting (or noting this contact) is much narrower than when observing two single stars in contact with one another.

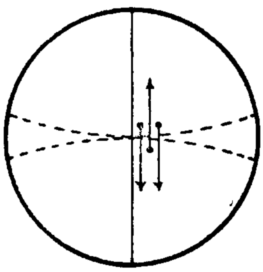


FIG. 3

A second accessory is provided for the purpose of making more than one observation on each star. If a weak prism is interposed between the mercury pool and the prism block, it can be set to deflect in the vertical plane by some small angle α, and the angle measured between the direct and reflected stars will be $90^\circ + \alpha$ or $90^\circ - \alpha$ according to which way the prism is turned round. Hence if the prism is used both ways round the zenith distances of $45^\circ + \frac{\alpha}{2}$ and $45^\circ - \frac{\alpha}{2}$ are measured. The mean is 45°. By using more than one prism (in each case both ways round) a whole series of observations can be made on each star. Different prism arrangements have been tried and the one which is found most satisfactory is a series of three prisms giving deviations of 3', 9' and 15'. The zenith distances measured are thus $1\frac{1}{2}$, $4\frac{1}{2}$ and $7\frac{1}{2}$ minutes on either side of the mean value, or six observations in steps of 3 minutes in altitude. In practice it is convenient to associate the mean of the observed with the mean of the zenith distances (45°) but, since the star does not rise uniformly, a second order correction has to be applied.

Diffraction pattern of the star image. — No star image can be perfect and it is important that the diffraction patterns should be such as to minimise any possible effect on the accuracy of measurement. The mercury image is formed by a circular pencil of light rays and has a circular diffraction pattern. The two images of the direct star are formed by semi-circular pencils and the division is made in such a way that the diffraction patterns stretch out laterally in the field of view. Thus when the three star images are in correct contact, although none of them is a point, yet their symmetry with respect to a horizontal line enables the observer to judge when they are aligned almost as well as if they were exact points.

Detailed description

Stand. — The stand is mounted on levelling screws and can be adjusted by means of a circular bubble. Nothing approaching the exactness of level of a theodolite is needed, but only such rough accuracy as will ensure that the mercury will not run seriously to one side of the copper surface on which it rests. About ten minutes of arc is ample.

Azimuth Circle. — Attached to the stand is an azimuth circle divided into degrees. The circle is friction tight and can be set so that the zero indicates true north. This setting is done by the aid of a magnetic compass fixed to the moving part of the instrument. The function of the azimuth circle is to provide a ready means of picking up the star.

Body. — The main body, holding telescope, prism block, deflecting prisms, etc., turns on a vertical axis in the stand. The motion is controlled by an azimuth clamp with a tangent screw for fine motion. This fine motion is needed during the six observations on each star in order to avoid a second order error which can be explained in the following way. Supposing there were in the sky at the instant of observation not only the particular star under observation but a series of others on either side of it, all at the same 45° zenith distance, this array of stars would appear in the field of view of the telescope stretching from side to side, not in a straight line but lying on a very shallow curve. The reflected images would lie on a similar curve, but inverted, and the two curves would have tangential contact (assuming perfection in the 45° angle of the prism) at the centre of the field. Hence any other star of the array would not be quite in contact with its opposite number, the amount of separation being proportional to the square of the distance from the centre. If an observation of a star were made off the central vertical wire, the measured zenith distance would not be quite the standard one associated with the prism, but would differ from it by this second order value. An error of 1" would be involved if the star were observed about a quarter of a degree away from the centre. The vertical thus serves as a guide to the observer and it is easy, after a little practice, to take all observations within about five minutes of arc on either side of the wire. Within this region the second order error is negligible.

Mercury Pool. — The mercury pool is formed on the surface of an amalgamated copper plate. The pool should be about one millimetre deep. It remains on the plate by capillary action at the edge. The upper surface of the mercury is optically flat to within 8 to 10 millimetres from the edge if the pool is not too deep. The plate area is made large enough to give an ample margin for the meniscus of the mercury.

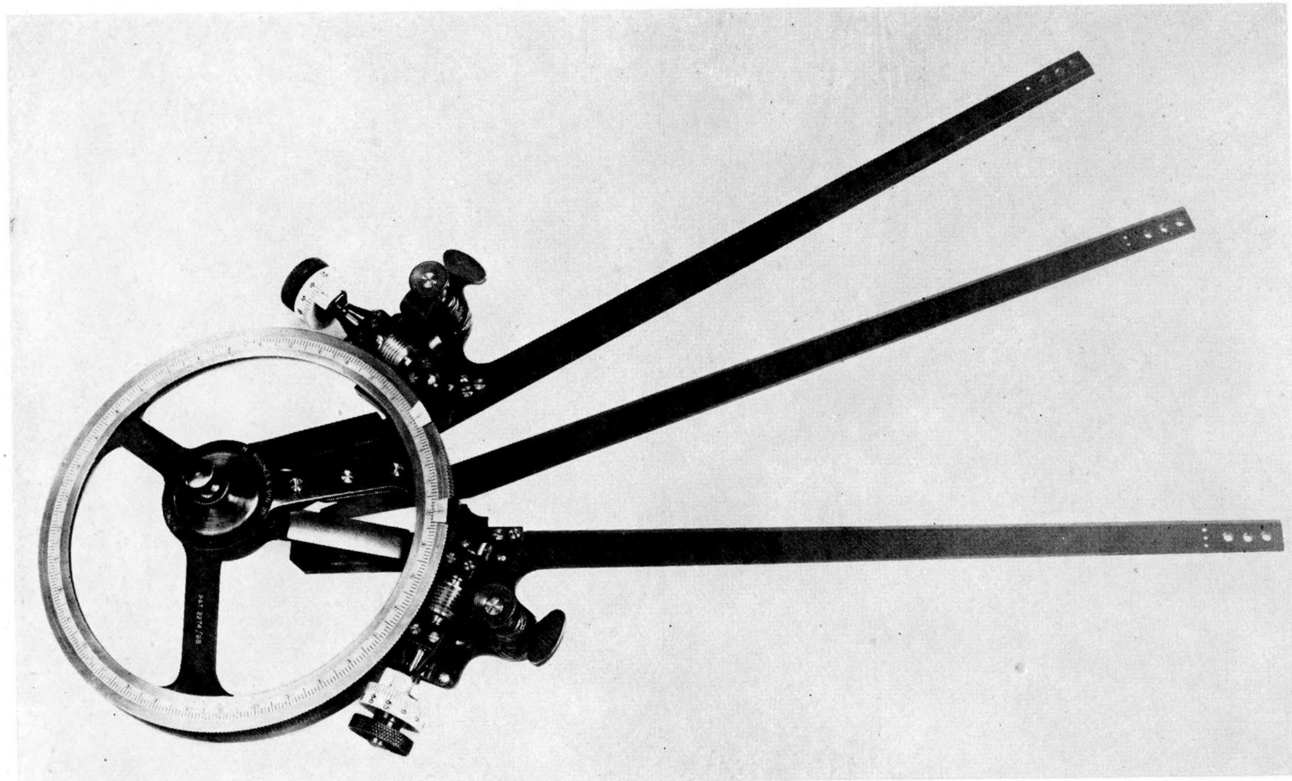
The depth of the pool can be regulated by passing a clean glass rod over the surface. The sides of the mercury trough are made one millimetre higher than the amalgamated surface and any excess of mercury can be swept off into the surrounding trough by this glass rod. The rod also serves a useful purpose in clearing any scum off the pool. If the rod is rotated in the opposite direction to that in which it is passed across the mercury the scum will be found to stick to the rod and can then be wiped off. Two or three passes of the rod across the pool are sufficient to clear the surface.

The whole of the mercury trough can be pulled out from the astrolabe body like a drawer. This is done when filling the pool and cleaning the surface. The drawer is then pushed back into position for observation. In the "in" position the mercury is protected from wind and preserves a good reflecting surface. Any small jar, such as the change from one deflecting prism to the next, will set up ripples and spoil the definition of the reflected image but the shallowness of the pool ensures that these ripples damp out in a second or two. It is quite noticeable through the telescope and as long as the reflected (single) image appears sharp the mercury surface must be a horizontal optical plane. In using the astrolabe the susceptibility of the mercury to disturbance must be remembered and the various adjustments (prism change, azimuth or adjustment of the main prism block) accomplished two or three seconds before contact occurs.

Main Prism Block. — This is held in a metal casing so arranged as to give easy access to certain faces for cleaning in case a deposit of moisture takes place during observations. As the whole instrument has not to be accurately levelled, it is necessary to adjust the prism block so as to make its plane of principal deflection perpendicular to the mercury pool. Unless this is done the single image will not pass between the duplicate images. The prism casing is pivotted on an axis near the lowest point and can be slightly rocked round this axis (which is parallel to the telescope axis) by a fine motion screw. Adjustment of this screw will not disturb the reflected (single) star but will make the duplicate star travel across the field. The adjustment will be necessary before the first observation on each star but should not be further required for any of the remaining five observations.

Duplicating Prism. — The weak three minute prism over one half of the entrant face *AB* is mounted in a frame which drops into a socket on the side of the main prism casing. It can be removed for cleaning or when it is required to wipe the entrant face of the main prism.

Deflecting Prisms. — The three deflecting prisms of 3, 9 and 15 minutes deviation are mounted in a slide placed in front of the reflected beam before it has reached the mercury pool. This slide can be pushed in horizontally into any one of three positions and engages with a spring detent when the prism is correctly placed in the path of the beam. In addition, the whole slide can be turned over through 180° in order to reverse the prisms. The series of six observations are thus A,B,C, (reverse) C,B,A. The angular position of the slide has to be correctly set before starting observations on any star. The edges of the slide are marked R1, R2, R3 and S1, S2, S3 respectively, R1



Micrometer Station Pointer — Stigmographe a Micromètre and S1 referring to the 15' prism, R2 and S2 to the 9' prism and R3 and S3 to the 3' prism.

For a rising star the correct sequence is
R1, R2, R3, (reverse) S3, S2, S1.

For a setting star the order is
S1, S2, S3, (reverse) R3, R2, R1.

Telescope. — This is a standard telescope of 13 mm. aperture and × 25 magnification. It is easily detachable for cleaning and stowing.

The present price of this instrument, one of which is on view in the International Hydrographic Bureau, is £102.10.0.

MICROMETER STATION POINTER.

The following is a description of the Micrometer Station Pointer manufactured by H. HUGHES & SON, Ltd., London.

In using an accurate station pointer of the older types in which the angle settings had to be made by verniers, working was slow and could not usually be carried on for very long owing to eyestrain. The vernier setting was also distinctly slow.

In the present instrument the verniers have been abolished and the angles can be set more rapidly and with much greater ease by means of the micrometers provided in place of the verniers. The micrometers read to single minutes and are easily read by the unaided eye.

The micrometers are thrown into or out of gear by thumb and finger pieces, the thumb and finger pieces serving also to move the arms round in setting the angles without lifting the instrument from the chart table.

The instruments are supplied with open centres or if preferred with raised centre and interchangeable pricker and pencil.

The usual extension arms are supplied and the attachment of these arms has been improved in detail.

When in use, the act of grasping the thumb and fingerpiece releases the clamp, the arm is moved round to the approximate angle without any alteration of the grip, the act of releasing the grip clamps the arm and a quick touch on the micrometer head finishes the exact setting of the angle. This arrangement gives the greatest possible accuracy, speed and ease of operation.

One of these instruments is on view at the International Hydrographic Bureau.

THE PRATT PROTRACTOR AND PLOTTING SCALE.

From an article in the *United States Naval Institute Proceedings,* Washington, December, 1934, p. 1740.

Mr. Herbert PRATT, a student at the University of Southern California, has invented an instrument which will enable the navigator not only to project the line of position but also to plot the line of position in his work-book or on any blank sheet of paper for any latitude from the equator to 60° north or south. The accuracy attainable with this instrument is the same as that obtained on Hydrographic Office plotting sheets 3000. Both the scales of the Pratt plotting scale and of the Hydrographic Office 3000 charts are the same, i. e. 4 inches to 1° of longitude. As the illustration depicts, it is similar