THE GEODETIC TAVISTOCK THEODOLITE.

Several information concerning the Tavistock Theodolites have been given in the following volumes of the *Hydrographic Review :* Vol. VII No. 1, May 1930, page 206 ; vol. IX, No. 1, May 1932, page 205; vol. XIV, No. 1, May 1937, page 115.

During the last few years improvements have been introduced in the apparatus and the description of the new Geodetic Tavistock Theodolite is given below from information communicated to the International Hydrographic Bureau by Messrs. Cooke, Troughton and Simms, Ltd., York (England), manufacturers of this instrument.

The principal features of the Geodetic Tavistock Theodolite are as follows :—

The mean of readings at both ends of a circle diameter is automatically indicated. One division of the horizontal circle micrometer is 0,5 seconds and of the vertical circle micrometer 1,0 second.

The circle graduations are permanently marked on well annealed optical glass and are not subject to slow changes of position as are those ruled on metal.

Both circles are observed from a position near the eye end of the telescope, whichever face is being read.

The telescope has an exceptionally large light grasp, the aperture being 2,375 in. the overall length only 8,85 in. and the magnification 20 $\times$ and 30 $\times$.

The telescope is balanced with the eye-end micrometer in position and will transit at the object end.

The first instrument of this class was made in 1931-1932 and was subsequently used on the East African Arc*. Between 1934 and 1936 several dozens of this instrument were made and a number were used on the re-triangulation of Great Britain**, whilst others were sent to Australia, Canada, China, New Zealand, Rhodesia, Russia and Sudan.

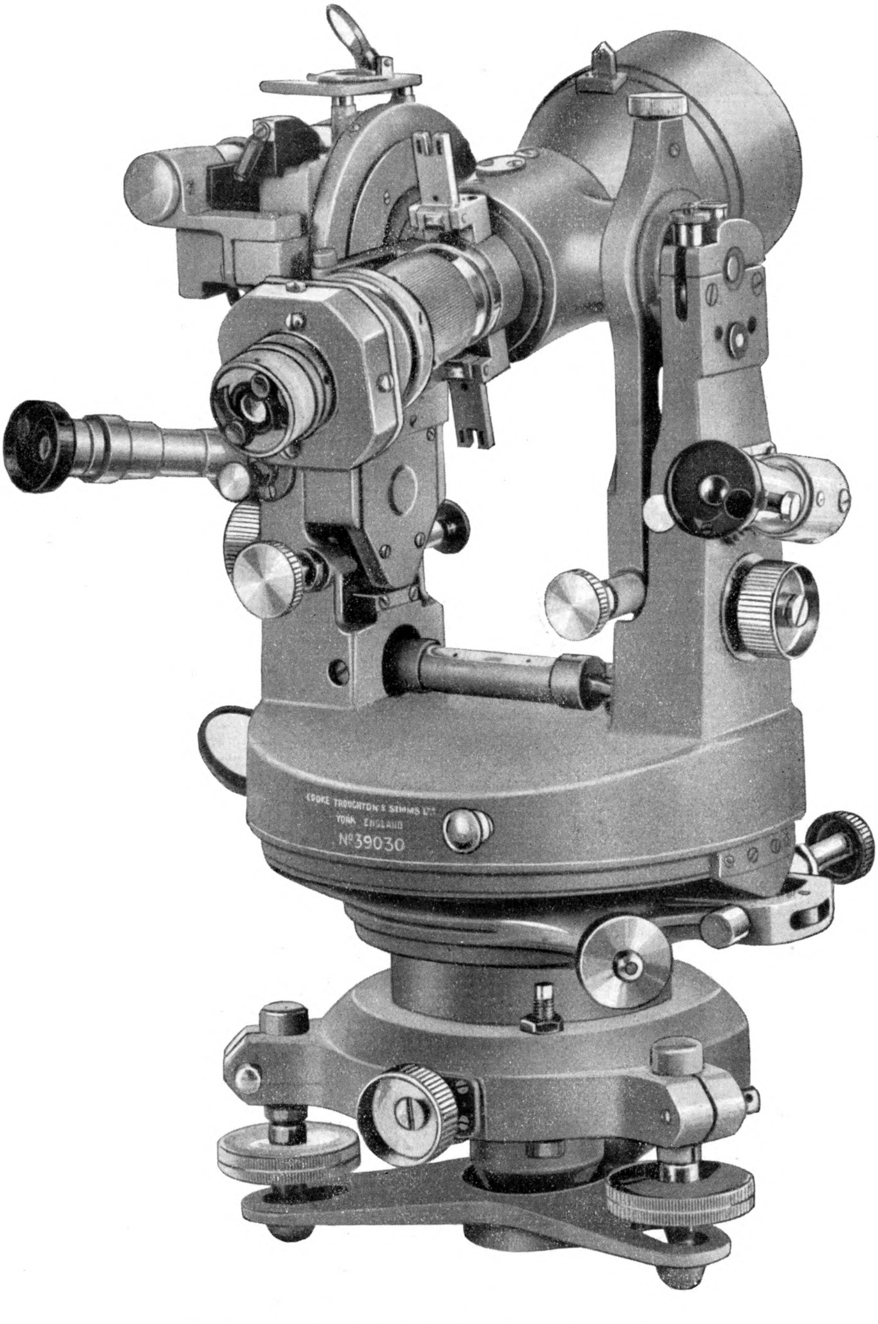
In 1937 a complete redesign was undertaken, chiefly with a view to producing an instrument of less weight and bulk ; the inspiration for which came mainly from Canada, where weight and bulk are anathema owing to transportation costs and the use which is made of air transport. The outcome is the instrument now described, the weight of which totals 42 lbs. as against 57 1/2 lbs. of the original model, whilst the bulk when stowed has been reduced from 1,27 cu. ft. to 0,87 cu. ft.

LETTER REFERENCES.

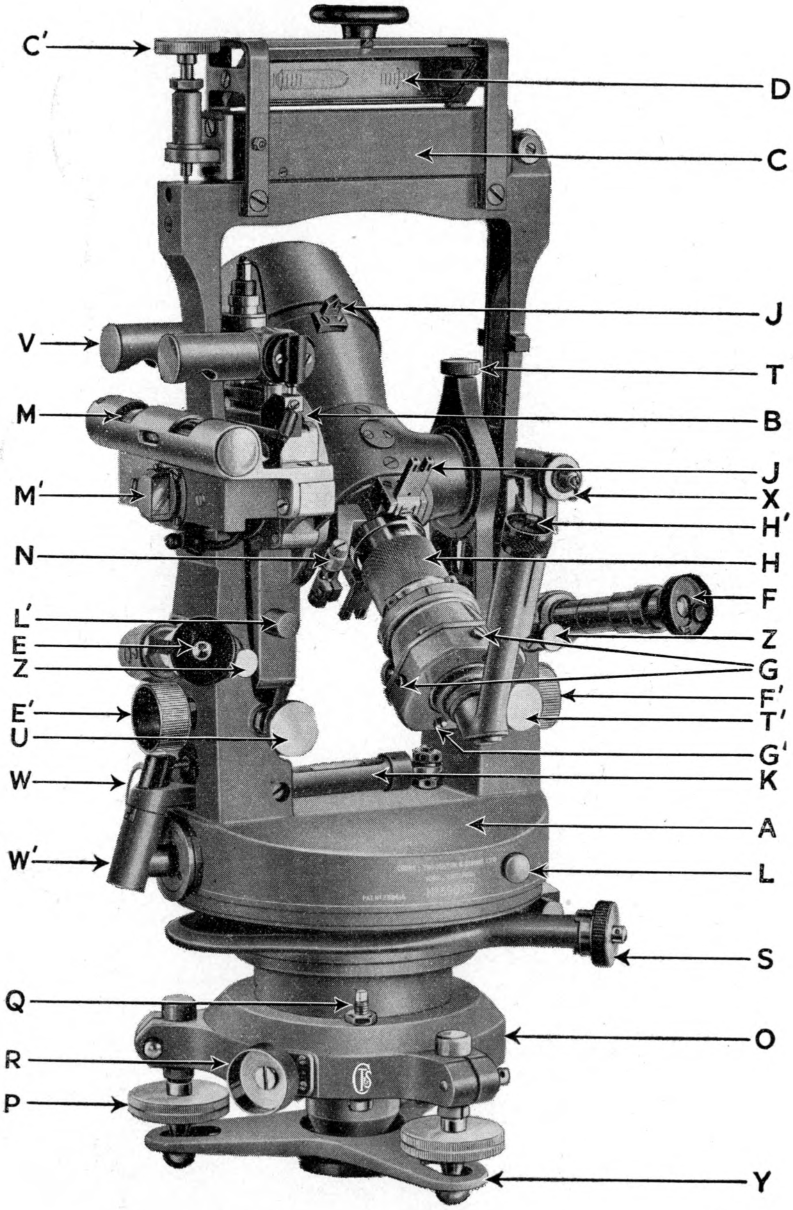
A Cover-plate containing optical system for horizontal circle.
B Box containing optical system for vertical circle.
C Striding level casing.
C' Striding level adjusting screw.
D Striding level mirror.
E Reading eyepiece for vertical circle.
E' Micrometer milled head for vertical-circle.
F Reading eyepiece for horizontal circle.
F' Micrometer milled head for horizontal circle.
G Adjusting screws of reticule.
G' Clamping screws for reticule adjustment.
H Focusing ring for telescope.
H' Diagonal eyepiece.
J Luminous sights.
K Plate spirit level.
L Screwed cap, covering opening for adjustment of reading system.
L' Screwed cap, covering opening for adjustment of reading system.
M Altitude spirit level.
M' Altitude spirit level prism-reader.
N Zero setting adjustment for vertical circle.
O Tribrach.

*See "Empire Survey Review", April, 1935. Lt.-Col. M. Hotine, R.E.

**Re-triangulation of the British Isles. "Empire Survey Review", July, 1938, Lt.-Col. M. Hotine, R.E.



THE GEODETIC TAVISTOCK THEODOLITE (half size)



THE GEODETIC TAVISTOCK THEODOLITE

P Footscrews.
Q Weight relieving adjustment screw.
R Milled head for rotating horizontal circle.
S Clamp for upper plate.
S' Slow-motion screw for upper plate (not seen).
T Clamp for telescope.
T' Slow-motion screw for telescope.
U Setting screw for altitude spirit level.
V Electric illumination for vertical circle and altitude spirit level.
W Daylight illumination reflector for horizontal circle.
W' Electric illumination for horizontal circle.
X Electric illumination to telescope reticule.
Y Plate securing theodolite to tripod head.
Z Spring plungers locking circle-reading eyepieces.

THE OPTICAL SYSTEM.

(Figures 1 and 2)

Light from the sky or an electric lamp is reflected into the instrument by the adjustable mirror A (fig. 1) and half the beam passes through each of two double-reflecting prims B into the prisms C, where it is reflected downwards by the sloping faces D through the apertures E in the prism box into the glass circle F. This illuminating beam is slightly deflected before entering the prisms C, and after reflection at the silvered surface of the glass circle receives a second reflection at D and passes on to the surfaces G and thence into the reflecting prisms H. The two beams then proceed along parallel paths into the field prisms J, where they are first directed towards each other and finally emerge united and at right angles to the plane of the diagram.

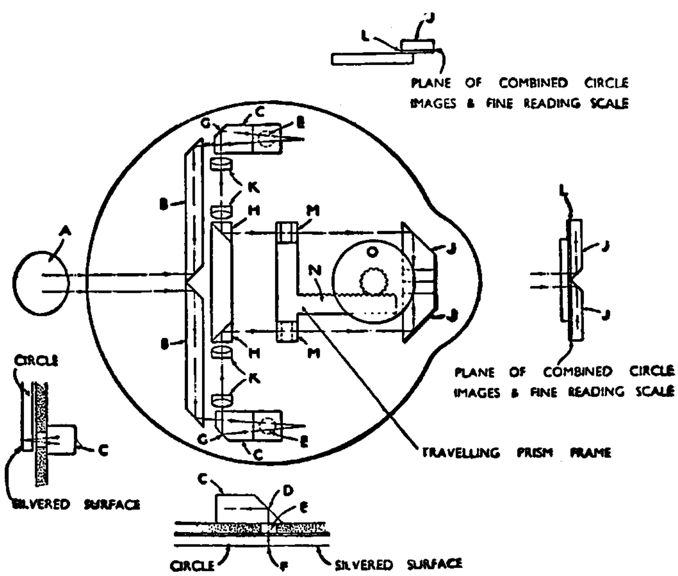


Fig. 1.—Optical system for horizontal circle.

To an eye placed to receive the emergent beam the two openings E appear to be illuminated by light reflected from the mirror A, and, as the glass circle is graduated and figured on the surface F, the lines and figures are seen as dark marks against an illuminated background.

On introducing objectives K of suitable power in the positions indicated, an image of the circle lines and figures appearing within the apertures E is thrown into the focal plane L, which coincides with the surface of the prisms J and the optical parts are so disposed that the images of the two sets of lines are brought together and appear continuous. The graduations of both scale images appear parallel to the line of junction between the prisms J, and both appear to increase numerically from left to right. In practice, only a single circle graduation of the right-hand scale image is necessary for setting purposes, and an opaque mask limits the field of view to this extent as indicated in figure 3. This diagram should be compared with the examples of figures 6 and 7, which illustrate the actual field of view of the reading microscopes. As the two apertures E are 180° apart and the surface L of the prisms J lies on the axis of the objectives K, the two graduations imaged on the line of junction between the prisms J are separated by 180° on the divided circle ; this relationship is exactly attained by suitable adjustment.

Two achromatic deflecting prisms M are mounted in a travelling frame which carries a rack N. The latter gears with a pinion attached to the glass fine-reading circle O, and the displacement of the scale images produced in the focal plane at the surface L of the prisms J by the deflecting prisms M is proportional to their distance from the focal plane L. This displacement may be readily determined by reference to suitable divisions on the edge of the fine-reading circle O.

The deviation produced by the prisms M is in a direction at right angles to the plane of the diagrams, the one deflecting the image-forming rays upwards and the other downwards. If the frame N carrying the prisms M is brought towards or away from the prisms J, the rotation of the glass circle O will indicate the magnitude of the movement and the two sets of images in the focal plane L will move as one, either to the right or the left.

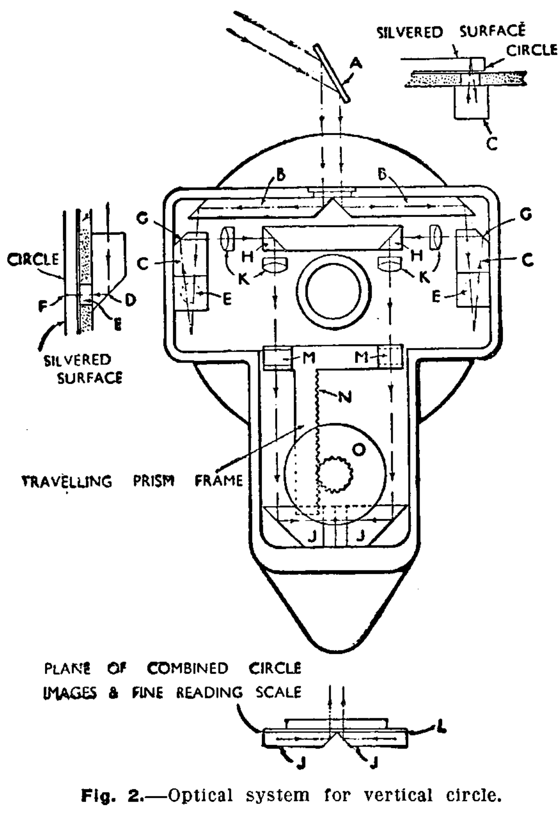


Fig. 2.—Optical system for vertical circle.

The total range of movement of the prisms M of the horizontal circle is 1,25 inch and the glass circle F is divided into intervals to 10 minutes. The power of the deflecting prisms M and the magnification of the images of the circle graduations are so adjusted that a movement of the former through 1,25 inch will cause a displacement of the latter through one interval, representing exactly 10 minutes at the centre of the circle. The fine-reading circle is so divided that it records a movement of 10 minutes subdivided into minutes, seconds and half-seconds (figures 6 and 7). The exact displacement of the scale images in the focal plane may be determined by reference to the scale on the fine-reading circle O.

The reading arrangement of the vertical circle (fig. 2) differs, in that the range of movement of the deflecting prisms is 1,0 inch and the vertical circle is divided into 20-minute spaces. The fine-reading circle records a movement of 20 minutes subdivided into minutes and seconds (figures 4 and 5).

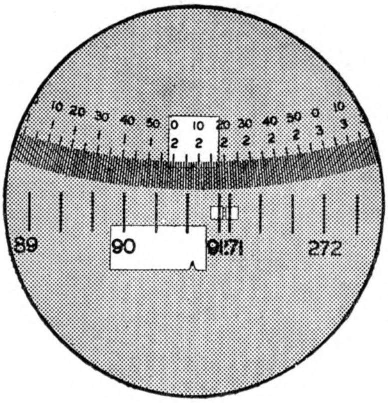


Fig. 3 shows the relative positions of the windows and of the graduations underneath them. The graduations actually shown in this diagram relate to the small Tavistock Theodolite, where the divisions on the horizontal circle are at 20 minutes instead of 10 minutes intervals, but apart from this the arrangement of the relative positions of windows and circle and micrometer divisions in the geodetic model is the same as in the smaller instrument.

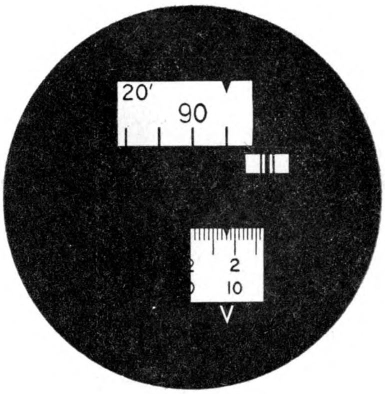


Fig. 4.—Vertical circle.

90°	20'	00"
	2'	08"
90°	22'	08"

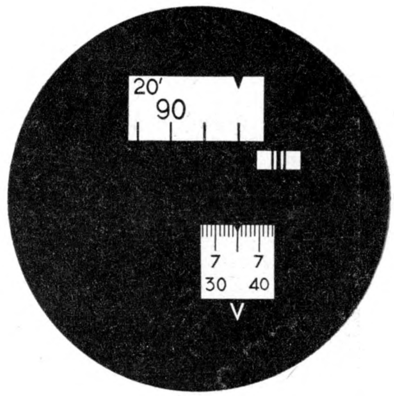


Fig. 5.—Vertical circle.

90°	40'	00"
	7'	35"
90°	47'	35"

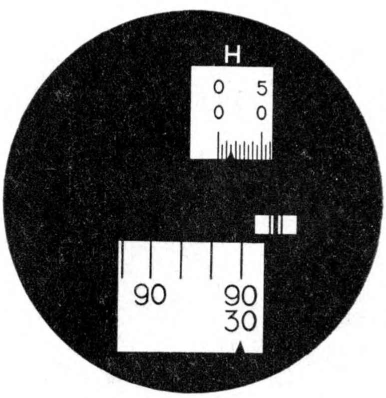


Fig. 6.—Horizontal circle.

90°	30'	00"
	00'	01",5
90°	30'	01",5

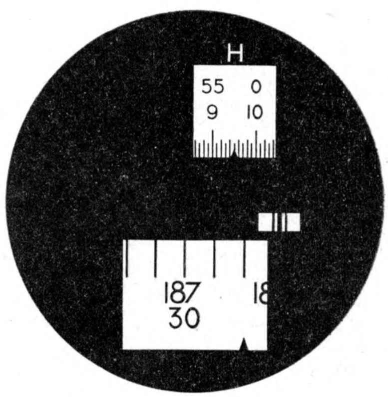
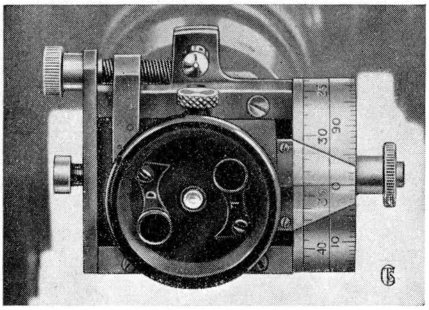
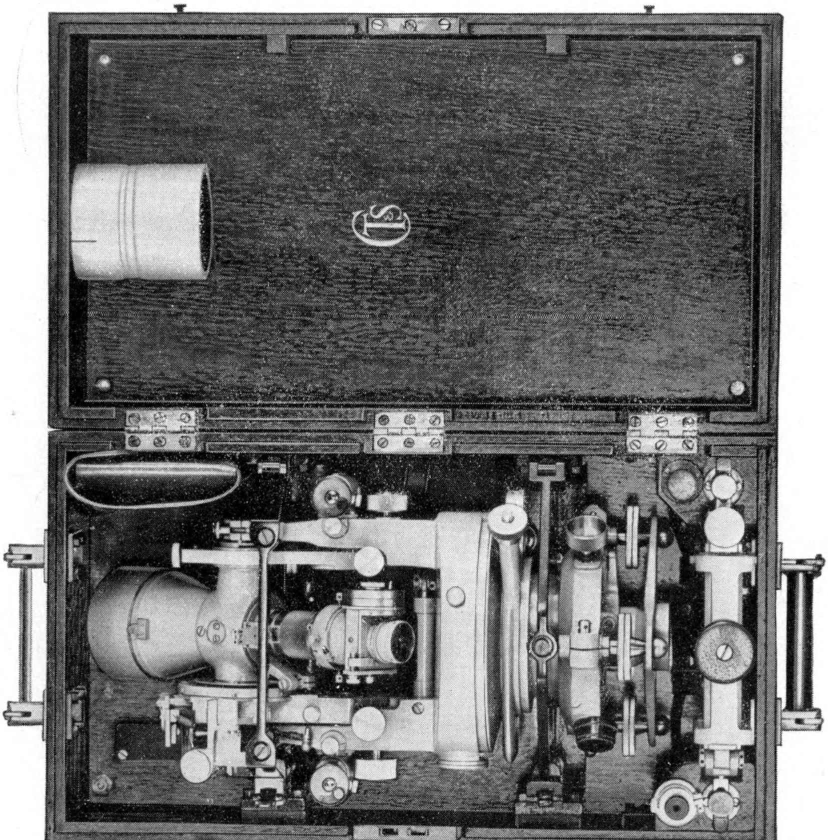


Fig. 7.—Horizontal circle.

187°	50'	00"
	09'	57",5
187°	59"	57",5



Eye-end Micrometer



GEODETIC TAVISTOCK THEODOLITE IN CASE.

An opaque screen (see figures 3 to 7) with three clear openings is placed in the focal plane of the objectives K, this coinciding with the plane L of the prisms J. The square opening carries a pointer against which the scale on the fine-reading circle is read. The left-hand scale image of the graduations and figures of the circle F is brought into focus in the coarse-reading aperture (the largest of the three), where another pointer is provided. The third and smallest aperture is divided into two parts by a narrow opaque band, or reference mark, which covers the junction between the prisms J. The image of a circle graduation seen in the left half of the opening is from one end of a diameter of the circle F, and that seen in the right half is from the other end of the same diameter ; by suitable adjustment under the control of the observer these two images are slightly displaced, so that they are separated by an interval that allows a narrow light gap to appear on each side of the reference mark.

On turning the micrometer milled head, which also actuates the fine reading circle (seen in the square aperture), the two images in the smallest aperture appear to move in the same direction. The setting is obtained when the light spaces between the graduations and the reference mark are equal. When a setting has been made the appropriate circle division will come to rest opposite the pointer in the large aperture. The final reading is obtained by adding to the coarse-reading thus indicated the residuals given by the fine-reading circle (square aperture). It will be appreciated that the fine-reading is always additive and never more than the interval between the coarse graduations.

It will be clear from the preceding description that the two optical systems whereby the circles are read are quite independent. Access to the prism boxes is easily gained.

SPECIFICATION.

CIRCLES.—*Horizontal :* divided on glass and figured 0° to 360° clockwise at 30 minutes intervals, diameter 5 in.

Vertical : divided on glass and figured 0° to 180°, 0° to 180°. With circle right the angle from the zenith and with circle left the supplement of the zenith angle is indicated. The diameter of the circle is 2,75 in.

Both circles are read by optical micrometers, the horizontal direct to 0,5 second and the vertical to 1,0 second. Both ends of a circle diameter are involved in the setting and the result is free from error due to eccentricity of the circle.

VERTICAL AXES.—These are of conical form and of the separated and independent type, that is to say the alidade has its bearings within the sleeve attached to the tribrach and the circle its bearings on the outside of this sleeve.

TRANSIT AXIS.—The axis rotates in round bearings hinged to permit the use of a striding level. The transit axis is not balanced about the vertical axis and in consequence the circle end is low. To compensate for this the pivot at the circle end is made 0,0003 inch larger so that the striding level will reverse, notwithstanding that the transit axis is not strictly level.

The line of sight will not for this reason trace out a vertical great circle but one making an angle of 6 seconds with the meridian. The effect is, of course, reversed on changing face and complete cancellation results. Therefore the horizontal circle should always be read on both faces as is indeed customary.

An adjustable weight-relieving gear is fitted to the vertical axis, a screw passing through the tribrach and acting through a lever mechanism applies the " lift " to the axis.

SLOW MOTIONS.—Rotation of the horizontal circle is by rach and pinion operated by a knurled head. One rotation of the head corresponds to 30°. Accidental movement is prevented by a spring which must be depressed before the gears can engage. The slow motion in azimuth is by a fine thread acting through a combined lever, and one turn corresponds to 1,75 minutes. The clamp is designed so that any deformation brought about in the act of clamping cannot be communicated to the bearings beyond a negligible amount. To safeguard the instrument from rough handling the clamping action is made impersonal in the sense that the pressure applied on slackening the screw is independent of the touch of the operator. In practice, the clamp comes into operation of the release of a spring.

TELESCOPE : of the internal focusing no-constant type having an aperture of 2,375 inches and focal length of 7,3 inches, which, together with the focusing lens has an equivalent focal length of 10,1 inches. The overall length of the telescope is 8,85 inches and alternative eyepieces yielding magnifications of 20 × and 30 × are provided.

The focusing is by a knurled sleeve surrounding the telescope and the shortest distance that can be focused is 15 feet.

Luminous open sights are fitted above and below the telescope.

The telescope is in balance with the eye-end micrometer in position and transits at the object end.

RETICULE.—Glass or web reticules may be used.

SPIRIT LEVELS.—Plate: 20 seconds per 2 mm. run.
Alidade: 10 — 2 mm. —

The alidade level is not adjustable relatively to the vertical prism box, instead the vertical circle may be rotated in relation to the transit axis by means of a slow motion screw carried by a bracket attached to the telescope.

The alidade level is read from either face by a prismatic reader and is set by means of a fine pitch screw either before or after pointing the telescope.

ILLUMINATION.—The circles are arranged for illumination either by day-light or by 4 volts lamps.

Electric illumination is also provided for the alidade level and for the telescope reticule. A battery and rheostat are attached to the tribrach and an independent dimming device is fitted to control the intensity of the axis illumination.

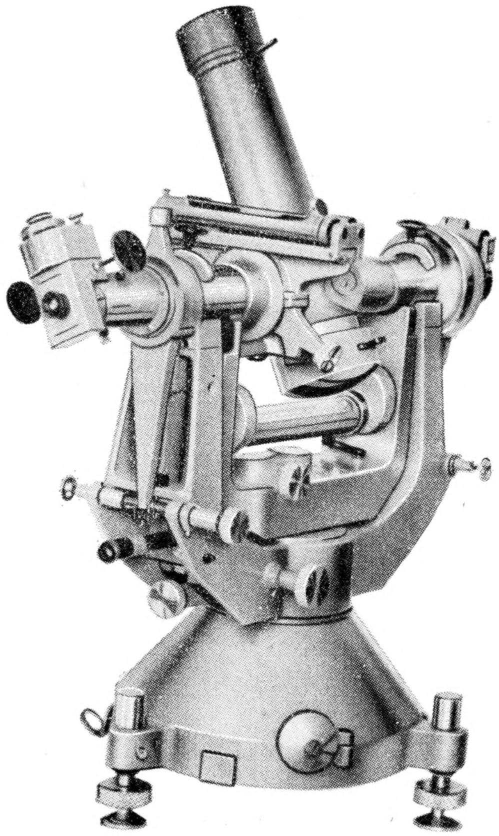
LEVELLING BASE.—The 3-screw system is employed and means of taking up wear is provided. The spherical ends of the footscrew are held to the trivet stage by a spring plate.

STOWAGE BOX.—The instrument is contained in a strong metal cradle which is securely attached to the base of the mahogany box. An outer canvas case can be supplied.

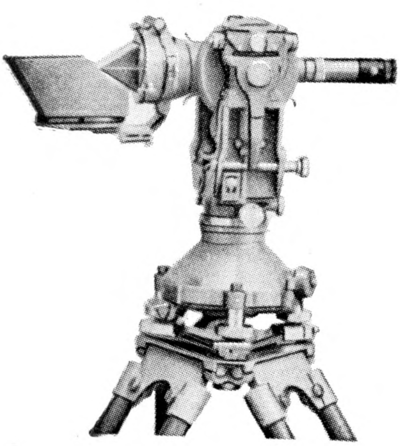
TRIPOD.—Open framed beech legs of round section with centring movement of 1 inch.

EYE-END MICROMETER.—The instrument can be supplied with an eye-end micrometer arranged for rotation through 90° so that it may be used either for zenith distances or right ascension. An inner drum records the number of complete revolutions made by the micrometer thread while the outer drum indicates fractions of a revolution. The complete eye-end with micrometer can be interchanged with the standard eye-end without disturbing the balance of the telescope.

STRIDING LEVEL.—The striding level is chambered and has a sensitivity of 2 to 3 seconds per mm. run. It is read by a mirror from the observing position and is adjusted by a fine pitch levelling screw. A Talcott level can be fitted to the instrument when required. The level is mounted in a similar manner to that of the striding level.



Wild Astronomical Theodolite (T-4 Model).



Wild Prismatic Astrolabe Theodolite.