W. J. LAFFERTY

WILD T1A

Double Centre Theodolite with Automatic Vertical Index

Instructions for Use

Attention!

Automatic Vertical Index: Unless the T1A is levelled up the image of the vertical circle will not be positioned correctly in the window of the reading microscope.

Getting Along with Instruments

A survey instrument will work efficiently only if it is carefully looked after and maintained, and if the survey methods and techniques conform to its basic properties and design. An Instruction for Use is supplied with each Wild instrument, giving explicit information regarding its care and correct use. The instruction is of no value at all if it is kept in a drawer and never studied.

Storage. If possible the instrument should be stored in a dry, dust-proof room, which does not have a big temperature range. In a humid climate it must be removed from its tightly closed container and the air allowed to circulate freely around the instrument. This is the best method for preventing mildew or fungus growth. The longer an instrument is not in use the more liable it becomes to such a growth. To counter this the instrument should be stored in an opened state (i. e. not in its container) in a heated airing cupboard, which has an electric bulb or a heating element installed, with shelves which should be either slatted or ventilated with air-holes. Care must always be taken to ensure a steady flow of air.
In extremely cold areas an instrument should not be taken into heated rooms during non-working periods but must be exposed, in a sheltered position, to the outside temperature. In this way the steaming-up of the optics and the formation of water condensation in the instrument's interior is avoided, thus allowing survey work to be restarted without additional delays.

Checking. At the start of a field season an instrument should be examined according to the Instructions for Use and, in certain cases, it will have to be adjusted. This procedure is also recommended at the end of the field season, during long intervals of non-use or after long journeys, so that the loss of valuable working time in the field, due to defective instruments, may be avoided.

Transport. For a long journey, by rail or road, the instrument should be packed in its padded transport case, which should be kept upright during the trip. When being transported by pack horse great care must be taken to ensure that it is carried upright in its container, preferably hanging down the side of the horse. When being carried over water, in small boats, it is advisable to secure the container (with the instrument inside it) firmly to the boat, as an unsecured instrument is almost certain to be lost if the boat capsizes. At all other times the best way to transport the instrument

is to carry it on one's lap (**always** in an upright position) or, at least, to wrap it up well in blankets and to stand it in such a way that it cannot suffer any hard knocks or shocks.

Unpacking. A golden rule when unpacking an instrument is to notice carefully — **and to remember** — how it is fastened in the container, so that re-packing after use may be made correctly and easily. Before lifting out the instrument the clamps must be loosened. Theodolites and Tacheometers must be gripped by the "Right" standard (i. e. the one without the vertical circle). With heavy instruments the left hand must grip beneath the tribrach in order to help support the weight. Only the T3 theodolite is taken out with a hand on each of the two standards.

Setting-Up. The instrument is then put on top of the tripod, which has already been set-up, and is clamped to it, with one hand being used to grip the instrument. The instrument must **never** be left on the tripod without being clamped to it. A level is always handled by the tribrach and pressure must **never** be exerted on its tubular level or circular bubble, which would immediately go out of adjustment.

Packing-Up. Before packing-up, all clamps and sliding bolts of the container's base-plate must be loosened, thus preparing it for receiving the instrument. The plate clamps are then loosened, the instrument gripped with one hand and the tripod holding screw loosened. The instrument is lifted from the tripod, put on to the container's base-plate and fastened to it. The instrument must **never** be left unscrewed on the tripod. After the instrument has been clamped to the base-plate all instrument clamps must be tightened, without undue force, the hood put on and the locking hooks fastened carefully.

The Instructions for Use must **always** be studied carefully and followed closely. This action, plus the use of plain, common sense, should ensure almost unlimited life from the instrument.

Contents

1. Equipment

1.1 Standard Equiment

	Stock No.	lb	kg
1 Wild T1A Double Centre Theodolite, inverted image, 360°,		11.0	5.0
in metal container	199 868	4.4	2.0
or			
1 Wild T1A Double Centre Theodolite, inverted image, 400ᵍ,		11.0	5.0
in metal container	199 869	4.4	2.0
or			
1 Wild T1AE Double Centre Theodolite, erect image, 360°,		11.0	5.0
in metal container	199 870	4.4	2.0
or			
1 Wild T1AE Double Centre Theodolite, erect image, 400ᵍ,		11.0	5.0
in metal container	199 871	4.4	2.0

Accessories in metal container:
1 screwdriver, holding two blades
and 2 adjusting pins

	Stock No.	lb	kg
1 Tripod 16a*, with rigid legs	199 876	11.9	5.4
or 16b*, with telescopic legs	199 877	12.5	5.7
or 16bL, metal, with telescopic legs	199 878	12.8	5.8

Accessories in tripod pouch:
1 plumbed with bayonet plug
1 hexagonal spanner

* after stocks are sold out, 16a and 16b tripods will be replaced by GST10 or GST20.

1.2 Optional Accessories

Miscellaneous

Leather Cap for tripod head, 16a, 16b, 16bL	113 222
Leather Cap for tripod head, with shoulder strap (for 16b and 16bL)	113 223
Centring Rod, with circular bubble,	
cm graduation	212 952
0.05 ft graduation	212 953
Telescope Level, split bubble type	199 885
Autocollimation Eyepiece GOA2, with plug-in lamp and cable (battery box if required)	175 190
Eyepiece Lamp GEB32, for using the telescope as a collimator (battery box if required)	246 279
Parallel Plate Micrometer GPM2, with counterweight, in leather case	
measuring range 10 m	199 886
0.5 in	175 156
0.02 ft	175 157
Auxiliary Lenses for short range focussing:	
lens GVO1, in case	217 898
GVO2	217 895
GVO3	217 892
GVO4	217 889
Sunshade for telescope objective	199 900
Plastic transport case (padded)	316 128
Rucksack for theodolite	166 688
Pillar Plate, with centring pin	202 489
Wild GAK1 Gyro Attachment (see brochure G1 413)	

Electric Illumination Equipment 200 823

1 Plug-in lamp with cable	199 898
1 Battery box	199 896
6 Dry cells (standard torch batteries)	166 877
or	
Electric Illumination Equipment as above but flame proof	200 824

Traversing Equipment without electric illumination 284 901

2 Targets GZM5	199 910
2 Tribrachs GDF1	199 911
1 Wood box for 2 GZM5 and 2 GDF1	199 924
2 Tripods 16b, with telescopic legs*	199 877

Electric Illumination for Traversing Equipment 284 826

2 Reflectors for GZM5 targets, each with screw-on lamp and cable	242 929
2 Battery boxes	199 896
2 Dry cells (standard torch batteries)	166 877

Traversing Equipment with Electric Illumination Equipment, comprising: 200 601

284 901 + 284 826

If required:

2 Large Target Plates GZM4, with plastic covers, for attaching to standard targets	111 212

Subtense Bar Equipment

Equipment A, with reduction tables 360°/metres	200 608
Equipment B, with reduction tables 400ᵍ/metres	200 609
Equipment C, with reduction tables 360°/feet	200 610

Equipment comprising:

1 Wild GBL 2 m Subtense Bar	196 728
1 Tribrach GDF1	199 911
1 Canvas carrying bag for GBL and GDF1	199 925
1 Battery box, with 6 dry cells, 1 connection cable and 1 handlamp	200 720
1 Tripod 16b, with telescopic legs*	199 877
1 Reduction table 360°/metres	199 917
or 400ᵍ/metres	199 919
or 360°/feet	199 918

* after stocks are sold out 16b tripods will be replaced by GST10 or GST20.

DM1 Equipment A 200 602

1	Distance Measuring Wedge DM1, with counterweight in case	199 887
2	DM1-Staves	196 737
2	Staff stands	199 912
1	Transport box for 2 staves and 2 staff stands	199 922
1	Reduction table 360°	199 916

DM1 Equipment B, for forced-centring 200 603

1	Distance Measuring Wedge DM1, with counterweight, in case	199 887
2	DM1-Staves	196 737
2	Staff carriers to fit tribrachs	199 913
2	Tribrachs GDF1	199 911
1	Wood box for 2 staff carriers and 2 tribrachs	199 921
2	Staff clamps	188 631
2	Tripods 16b, with telescopic legs*	199 877
1	Reduction table 360°	199 916
On request:		
	Reduction table 400ᵍ	243 373

Tacheometric Short-Staff, Equipment A 216 174

1	Short-Staff GVL1, 1.2 m long	196 721
1	Canvas bag for GVL1	200 453
1	Staff stand with struts	214 090
On request:		
1	Wooden box for 1 GVL1 and 1 staff stand	231 972

Tacheometric Short-Staff, Equipment B for forced-centring

2	Short-Staves GVL1, 1.2 m long	196 721
2	Canvas bags	200 453
2	Staff carriers for tribrachs	214 089
2	Tribrachs GDF1	199 911
1	Wooden box for 2 staff carriers and 2 tribrachs	200 464
2	Tripods 16b, with telescopic legs*	199 877

* after stocks are sold out 16b tripods will be replaced by GST20 or GST10.

Compasses

Circular Compass 360°, in leather case	199 882
Circular Compass 400ᵍ, in leather eaee	199 883
Tubular Compass	199 884

Plumbing Accessories

Wild ZNL Zenith and Nadir Plummet, in wood box	284 831
Wild ZBL Roof and Ground Plummet, in leather case	284 830
Objective Pentaprism, with counterweight, in leather case	199 893
Telescope Roof Plummet	199 892
Diagonal Eyepieces for telescope and reading microscope, in leather case	199 908

Accessories for Astronomical Observations

Eyepiece Prisms for telescope and reading microscope, for steep sights up to 65°	239 732
Colour Filter for telescope eyepiece prism, (black, blue and green)	199 905
Diagonal Eyepieces for telescope and reading microscope, in leather case	199 908
Eyepiece Filter for telescope eyepiece and telescope diagonal eyepiece, black	284 836
blue	284 835
green	284 834
yellow	284 833
Wild-Roelofs Solar Prism, in wooden case	199 909
Polaris Attachment, in leather case (only Northern Hemisphere)	199 888
Electric Illumination Equipment — see above	

Levelling Staves

Folding, with circular level, inverted numbering (GNL) or erect numbering (GNLE):
with cm graduation:

GNL3 3 m long	196 701
GNLE3 3 m long	196 702
GNL4 4 m long	196 703
GNLE4 4 m long	196 704

with 0.01 ft line graduation and 0.1 ft pattern:

GNL12	12 ft long	196 707
GNLE12	12 ft long	196 708

Topographic Staves

Folding, with circular level, inverted numbering (GTL) or erect numbering (GTLE), cm graduation:

GTL3	3 m long	196 711
GTLE3	3 m long	196 712
GTL4	4 m long	196 713
GTLE4	4 m long	196 714

For information on other Wild staves see brochure G1 905e

2. Technical Data

Telescope	
Magnification	28×
Clear objective aperture	1.6 in (40 mm)
Diameter of field of view at 1000 ft (m)	29 ft (m)
Shortest focussing distance T1A	5 ft (1.50 m)
T1AE	7¼ ft (2.20 m)
Multiplication constant	100
Additive constant	0
Tilting range	+90° to −65° (+100ᵍ to −72ᵍ)
Sensitivity of plate level	30″/2 mm
circular bubble	8′/2 mm
Setting accuracy of automatic vertical index	±1″
Functional range of compensator	±2′
Glass circles:	360° (400ᵍ)
Horizontal circle graduation diameter	2.9 in (73 mm)
Vertical circle graduation diameter	2.6 in (65 mm)
Graduation interval, horizontal and vertical circles	1° (1ᵍ)
Graduation interval of micrometer drum	20″ (1ᶜ)
Reading by estimation to	5″ (10ᶜᶜ)

3. Description

3.1 **The Instrument** (See fig. 1 at the end of this Instruction Manual)

3.1.1 **The Tribrach GDF1** (fig. 1)

The tribrach is the base of the instrument. It has three footscrews (3) used to set the standing axis vertical. The base plate (1) is fitted with a central thread common to all Wild tribrachs making it possible for the T1A to be set up on every Wild tripod. A spring plate (2) presses the footscrews into the base plate. The circular bubble (5) allows approximate levelling. The instrument fits into the centre of the tribrach and is held securely by the action of the swivel knob locking device (29) (arrow down = locked). By turning the swivel knob so that the arrow points upwards, the instrument can be lifted out of or placed in the tribrach. This knob is locked in position by a recessed screw in the head of the knob when the instrument leaves the factory, and the screw must be released before using the instrument for the three tripod method.

3.1.2 **The Lower Part** (fig. 1)

This comprises the centring flange, the standing axis system, the horizontal circle and their associated parts. The centring flange, which fits in the tribrach, is screwed to the axis sleeve. The axis stem turns inside the sleeve. With the lower plate clamp (26) tightened the horizontal circle carrier is locked to the axis sleeve, and with the upper, horizontal clamp (25) tightened it is locked to the alidade. The horizontal circle turns with the alidade when EITHER the lower plate clamp (26) is loosened, the horizontal clamp (25) is tightened and the alidade is turned by hand, OR when both clamps are tightened and the lower plate drive screw (27) is turned. With both clamps loosened the circle can be turned and set by using the milled setting ring (6). The lower clamp and drive are only used for setting the circle (see 4.6.1) and for the repetition method (see 4.6.4), when measuring angles they are not touched and this is why they have a distinctive shape.
The horizontal circle is made of optical glass and is divided into 1° intervals on the 360° or 1ᵍ intervals on the 400ᵍ system.

3.1.3 **The Alidade** (fig. 1)

This is the upper part of the instrument which turns around the standing

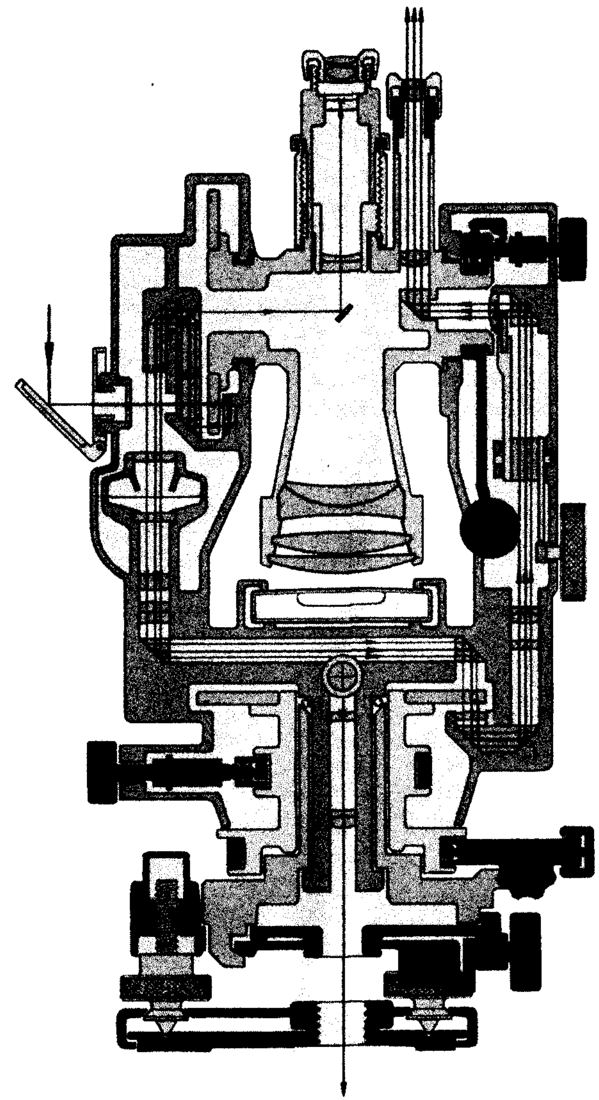


Fig. 2 Tripod pouch and accessories

axis. It carries the telescope, the vertical circle (15), the reading microscope (21), the illumination mirror (12), the optical micrometer and its setting knob (23), the plate level (9) and the optical plummet (7) utilising the hollow standing axis. The horizontal clamp and drive (25, 24), together with the vertical clamp and drive (19, 22) are used for pointing the telescope to the target. The glass vertical circle, graduated in the same way as the horizontal circle, rotates with the telescope about the tilting axis. The effect on the vertical circle reading of any residual non-verticality of the standing axis is eliminated by the automatic vertical index.

3.1.4 **The Automatic Vertical Index** (fig. 3)

On the way to the reading microscope, the image of the vertical circle passes through a transparent container filled with silicon oil, which is as clear as glass. If the standing axis of the theodolite is exactly vertical

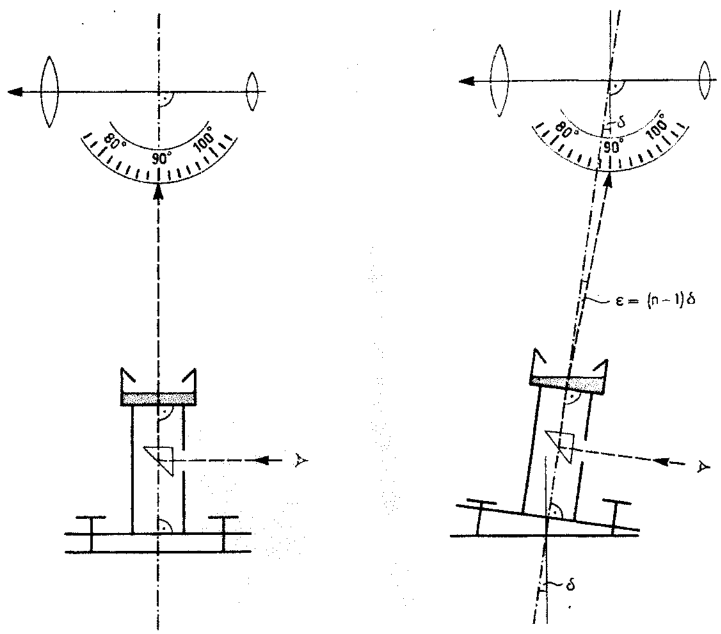


Fig. 3: Functioning of the automatic index: left – the standing axis is vertical; right – the standing axis is out of plumb by the small angle δ; both illustrations are for a horizontal sight.

(fig. 3, left), the bottom of the container and the surface of the oil are parallel and the rays will pass through without deviation. However if the standing axis is inclined to the vertical by a small angle δ (fig. 3, right), the oil forms a wedge of angle δ. If the refractive index of the oil is n, the deviation of the rays is (n - 1) δ. This deviation compensates for the influence, on the vertical circle reading, of any small residual non-verticality of the standing axis. The refractive index is influenced by temperature, however with the oil used the factor (n-1) changes by only 0.1% for a 1° change in temperature. Assuming a relatively large non-verticality of the standing axis of 60″, corresponding to a variation in the position of the plate level of 4 intervals when turning the alidade through 180°, the error introduced by a difference in temperature of 50°C from the standard temperature of + 20°C is only $0.05 \times 60'' = 3''$. As such large differences in both temperature and levelling up will hardly ever occur, any error in the automatic index will always be within the measuring accuracy of the T1A.

3.1.5 **The Telescope** (figs. 1 and 4)

In spite of the shortness of the telescope, which transits at both ends, high quality optics are obtained, by using a four lens objective system. The telescope is focussed by turning the milled sleeve (20) and the reticle is focussed by turning the telescope eyepiece (11). The vertical cross-hair of the reticle (fig. 4) is a single line above the horizontal cross-hair and a double line below it, with the lines interrupted slightly to form a fine cross at the centre. The single line may be used to split and the double line to straddle the target. The stadia have the normal 100 multiplication constant and are made short to prevent the possibility of reading the horizontal cross-hair by mistake. The telescope's additive constant is zero.

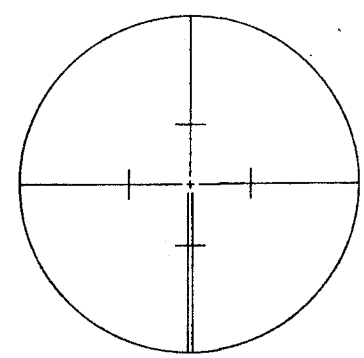


Fig. 4 The reticle

Turning the knob (16) rotates a small mirror inside the telescope, it is used for regulating the illumination of the reticle when electric lighting is used. For sighting to the zenith the standard eyepiece (11) can be removed and replaced by a diagonal eyepiece.

3.1.6 **The Container** (fig. 5)

This consists of a base plate of light metal and a steel hood. The base plate has two pairs of metal pillars, on the grooves of which rest the metal bolts (8) which extend through the base of the telescope standards. When the clamping hooks are fastened over the bolts the instrument is safely and rigidly fixed to the base plate. When packing, the red stripe on the side of the instrument should be matched with the red dot on the centring flange. See 4.8 for packing up the instrument.

3.2 **The Tripod***

The T1A is generally used with the 16b tripod, as the telescopic legs of the 16b permit easy setting up on all types of ground. A metallic tripod with telescopic legs, the 16bL, is also available.
On each tripod there is a pouch containing a plumb bob, with string and bayonet plug adapter, and a spanner. There is also a metal bracket on each tripod to hold a battery box.
The tripod head has a large central opening, within the range of which the instrument can be moved when centring over a point. Inside this opening is the large screw which secures the instrument to the tripod. The screw is hollow so that the optical plummet's line of sight can pass through it. The screw is attached to the tripod plate in such a way that it can never be lost.

* The tripods 16a and 16b will be replaced by the modern tripod GST 20 and later by the tripod GST 10. The new tripods will be available with telescopic legs only.

4. Instructions for Use

4.1 **Setting Up the Tripod**

The tripod should be set up in the best possible position to ensure easy centring and levelling-up of the instrument. The legs must be positioned so that the plumb-bob lies within an inch of the ground mark, with the fixing screw (to which the plumb-bob is attached by means of a bayonet plug adapter) in the centre of the tripod head, which must be as horizontal as possible. The legs are pushed into the ground with the observer's knee and leg along the leg of the tripod. If the tripod shoes do not penetrate to an equal depth the horizontality of the tripod head must be re-established. With a telescopic tripod this is easily done by extending or retracting one or two of the legs. With a rigid tripod the leg beneath the tilted section should be shifted radially, thus restoring horizontality without disturbing the centring too much. For the final precise centring the instrument is merely moved about on the plate, with the fixing screw loosened. The clamping screws on tripods with telescopic legs should be tested before the instrument is attached.

4.2 **Setting Up the Instrument**

Place the container on a firm surface, pull the ends of the carrying strap outwards to release the hooks and then take off the metal hood (fig.5). Pull the two side levers upwards and disengage the clamping hooks from the holding bolts (8). Lift the instrument out of the base of the container, place it on the tripod and secure it to the tripod by immediately tightening the tripod fixing screw by a moderate amount (over-tightening will put strain on the footscrews). Finally, close the container.
In hot weather, if the T1A is to be used to the limit of its precision, an umbrella should be used to protect it from the direct rays of the sun. It is advisable to rotate the alidade and the telescope several times to ensure an even distribution of oil in the bearings.

4.3 **Centring and Levelling Up**

4.3.1 **Centring with the Plumb Bob**

In calm conditions the plumb bob can be used quite safely for the final centring of the instrument to within ± 0.08 in (2 mm). The central fixing screw is loosened and the instrument moved around the tripod head until

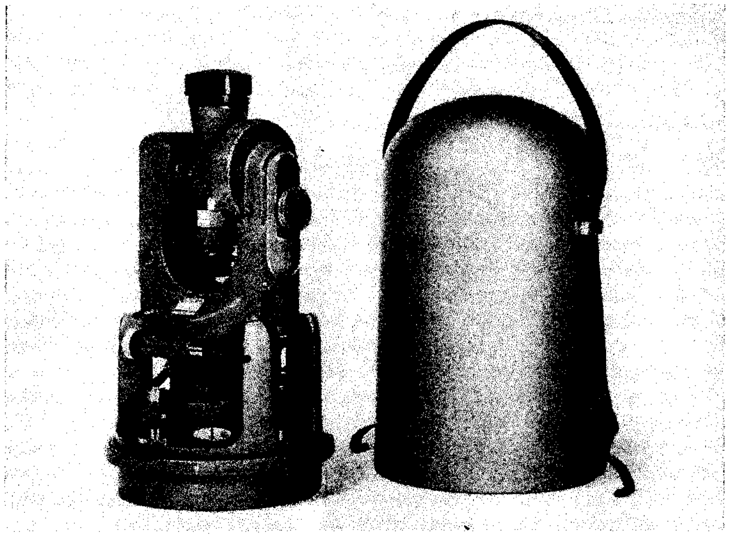


Fig. 5 Wild T1A attached to the base of the container

the plumb bob, which is attached to the fixing screw by means of a bayonet plug adapter, lies immediately above the station mark. The fixing screws is retightened and the instrument levelled up as described below in section 4.3.3.

4.3.2 **Centring with the Centring Rod** (optional accessory)

The centring rod consists of two telescopic sections. A circular level is attached to the lower section and the whole is suspended from a bayonet type plug which connects with the tripod fixing screw. For centring, place the pointed end of the rod on the station mark and then move the instrument over the tripod head until the bubble of the rod's circular level is centred. Now turn the rod through 180° and if the bubble is no longer in the centre of the setting ring move the instrument over the tripod head so as to take up **half** of the discrepancy. Tighten the fixing screw and level up the instrument as described in 4.3.3. With the centring rod it is possible to centre the theodolite to ± 0.04 in (± 1 mm).
The height of the theodolite's tilting axis can be read (to 0.05 ft or 1 cm) on the upper part of the rod, with the upper lip of the lower part serving

as the reading index. This height is valid with the footscrews in the centre of their run and provided that the point of the rod is engraved T1A (centring rods for other instruments will not give the correct height). For adjustment of the centring rod see 6.9.

4.3.3 **Levelling Up**

As a memory aid in levelling up, it should be noted that the **level** bubble follows the direction of the **left** thumb when turning the footscrews. The alidade level should be protected from direct sun rays as these may cause the bubble to run off, giving a false level. The instrument has to be levelled up accurately before centring with the optical plummet. An approximate levelling is made by using the footscrews to centre the circular bubble. Then proceed as follows:

1. Horizontal clamp (25) open and optical plummet (7) over a footscrew A. Footscrews B and C are turned by equal and opposite rotations until the plate level bubble (9) is centred.
2. Turn the alidade through 90° in a clockwise direction and centre the bubble with footscrew A.
3. Turn the alidade in the same direction through 90°. If the bubble is not centred then take up half the error of run using the footscrews B and C.
4. Turn the alidade again in the same direction through 90° and take up half the error of run using footscrew A.

The whole procedure is repeated until the bubble remains in the same (though not necessarily central) position through a full rotation of the alidade. The instrument is now correctly levelled up. (A bubble which remains central is more convenient, see 6.3).

4.3.4 **Centring with the Optical Plummet**

The built-in optical plummet is used for the accurate centring of the instrument over a given ground mark, within instrument heights of between 1 to 2 m (3 to 7 feet). Within this range the centring accuracy obtained is approximately ±0.01 in (±0.3 mm), with a well defined ground mark.
Set the instrument over the ground mark by eye, or preferably with the plumb bob, and centre the circular bubble. Pull out the eyepiece of the optical plummet (7) until the reticle and the image of the ground mark are sharp and parallax-free. Slacken the tripod fixing screw and move the instrument across the tripod head until centring is obtained, then tighten the screw and level up as in 4.3.3. Look through the plummet and check the centring, re-centre and re-level if necessary. Now turn the alidade through 180°, any deviation of the reticle from the ground mark is corrected by mo-

ving the instrument to take up half of this deviation. The instrument must be re-levelled if necessary.
The centring is correct when, for a full rotation of a levelled up alidade, the reticle stays on the mark or describes a small circle around it. (See adjustments 6.7).
Advice for centring: move the instrument in parallel shifts, i. e. avoid rotating the tribrach in relation to the tripod head as this disturbs the centred bubble.

4.3.5 **Centring under Roof Points**

The instrument can be centred under a plumb bob suspended from a roof or ceiling point, by lining up the tip of the plumb bob with the small pin at the centre of the telescope (fig. 1, 16). Before doing this the instrument must be levelled-up (as in 4.3.3) and the telescope set horizontal (i. e. the vertical circle set to read 90° or 100ᵍ). Another method is to use the telescope roof plummet (see 5.8).

4.4 **Focussing and Sighting**

4.4.1 **Telescope Reticle**

The telescope is aimed at the sky or towards a uniformly light background, such as a piece of white paper or a wall. The dioptric black ring on the eyepiece (11) is turned until the cross-hairs are sharp and black. To ensure that the cross-hairs are focussed correctly (thus avoiding eyestrain) the ring should again be turned anticlockwise until the image just starts to go out of focus. A small clockwise rotation will again focus the hairs so that they are sharp and black once more. This setting is constant for one observer and the dioptric scale number should be noted so that the eyepiece focussing can be set quickly and correctly at all future instrument stations.

4.4.2 **Image Focussing**

The horizontal clamp (25) and the vertical clamp (19) are loosened and the target roughly sighted along the open sights of the telescope. Both clamps are then tightened and the drive screws (24 and 22) turned to bring the target near the intersection of the cross hairs.
The focussing sleeve (20) is then turned until the object is seen in the telescope, clearly and without parallax. Arrows on the focussing sleeve indicate the correct direction for focussing to infinity (∞). The observer must move his eye slightly, sideways and up and down, to ensure that there is

absolutely no apparent movement of the image in relation to the cross-hairs. If such a movement is detected it means that parallax still exists between the reticle and the image and this must be removed by a small re-adjustment of the focussing. Focussing does not affect the sharpness of the reticle (as described in 4.4.1).

4.4.3 **Sighting**

After correct focussing has been obtained, the telescope is ready for pointing. By turning the horizontal drive screw, the single vertical cross-hair can then be made to split the target or, if the double vertical hair is to be used, the target may be straddled.
For fine pointings, to obtain vertical angles, the vertical cross-hair should first be moved a little to the left or right of the target and the horizontal cross-hair then brought on to the target by means of the vertical drive screw. The last turn of a drive screw should always be made clockwise (i. e. against its spring), in order to avoid the possibility of a "backlash" error.

4.5 **Circle Readings**

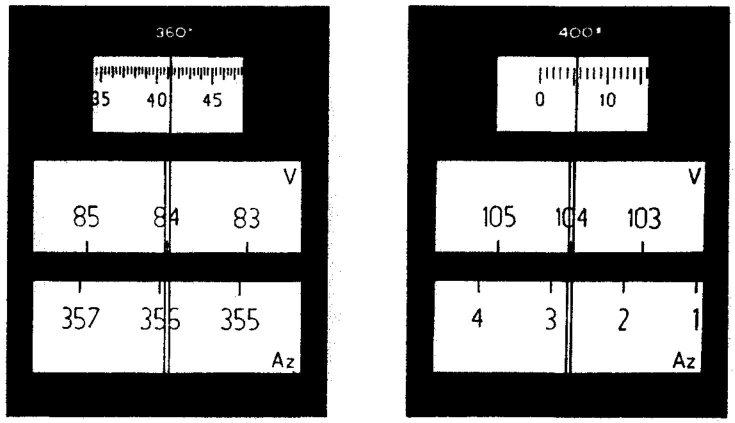
4.5.1 **Illumination**

For daylight observations the illumination mirror (12) is opened and turned towards the light source, so that the circles, viewed through the reading eyepiece (21), are illuminated evenly and distinctly.
At night the mirror is removed (merely by pulling it out of its socket on the left-hand standard) and replaced by a lamp holder, which is connected to the battery box (see 5.2).
When using electric lighting, the reticle illumination is controlled by a mirror inside the telescope. The mirror is turned by means of the small milled knob (16) on top of the telescope tube. In the centre of this knob is the small pointer used for centring under roof points (see 4.3.5) and also for a backsight.

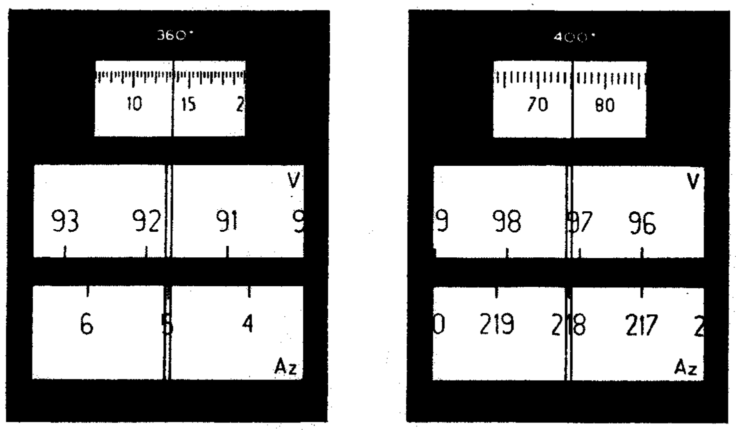
4.5.2 **Taking Readings** (fig. 6)

Obtain correct illumination (see 4.5.1), then turn the eyepiece of the reading microscope (21) until the circles and the index are in focus. In the field of view of the reading microscope (fig. 6) are seen part of the horizontal circle (Az) at the bottom, part of the vertical circle (V) immediately above, and the micrometer scale at the top.

The graduation interval for the circles is 1° (1^g). The graduation interval of the micrometer scale is 20″ (1^c) and reading by estimation can be made to 5″ (10^{cc}).



84°41′15″ 104.0549
Vertical circle



5°13′35″ 218.7529
Horizontal circle

Fig. 6 Circle readings

For horizontal circle readings turn the micrometer knob (23) until, in the window Az, one of the graduation lines of the circle is centred between the double index. Read the degrees (or grades) for this graduation line and then, using the single index line, read the minutes and seconds (or decimals of a grade) from the micrometer scale. Only one graduation line can be centred between the double index, the only exception being in the rare case when both the minutes and seconds are exactly zero (e. g. 5°0′00″ and 4°60′00″) and in this case the values are the same so there is no ambiguity.
Vertical circle readings are taken in the same way, i. e. using the window V and the micrometer. After rotating the alidade it may be necessary to wait for a second or two to allow the vertical circle to steady – this is because of the automatic vertical index. Note also that because of the automatic index the instrument must be levelled up or the image of the vertical circle will not be positioned correctly in the window V.
See fig. 6 for examples of circle reading.

4.6 Measuring Angles

4.6.1 Setting the Horizontal Circle for the Initial Bearing

When measuring angles and particularly when doing setting out work, it is usual to set the horizontal circle so that the reading to the R. O. (Reference Object) will be a predetermined value – e. g. zero or the bearing (azimuth) of the line. The procedure is as follows:

1. Loosen the horizontal clamp (25) and the lower plate clamp (26). Turn the milled ring (6) until the required degree line appears in the reading microscope. Tighten the horizontal clamp.
2. Set the micrometer scale to the required minutes and seconds by turning the micrometer knob (23).
3. Set the required degree line between the double index by turning the horizontal drive (24).
4. Turn the alidade by hand until the R. O. is roughly sighted. Tighten the lower clamp and bring the vertical cross hair onto the R. O. target by using the lower plate drive (27).
5. The lower plate clamp and drive screws must not be touched for subsequent pointings as they are only used for setting the circle (and for the repetition method, see 4.6.4).

4.6.2 Measuring a Single Horizontal Angle

The measurement of the angle between two directions is essential in traversing. If the required accuracy has not to be better than 30″ or 1^c, it may be sufficient to observe in the Face Left position only. To improve the accuracy the angle must be measured on both faces and the mean taken. The sequence for measuring a single angle on FL and FR is:

Step	Face	Target	Swing
a	Left	1 (RO)	clockwise
b	Left	2	clockwise
c	Right	2	anticlockwise
d	Right	1 (RO)	anticlockwise

In this sequence step a. would usually be carried out as described in 4.6.1 for setting the required reading to the R. O. The lower plate clamp and drive are then no longer touched and steps b, c and d require the use of only the horizontal clamp and drive.

If greater accuracy is required the measurement may be repeated, i. e. additional sets may be observed and the mean of them all taken to obtain the accepted value. If two sets are to be observed the setting for the second one should be 90° greater than for the first and, with four sets 45°, 90° and 135° should be added (i. e. for n sets the setting should be changed by 180° ÷ n). In all cases the minutes and seconds should also be altered. When the 400^g circle is being used 50^g, 100^g and 150^g, respectively, should be added to the initial settings (or 200^g ÷ n).

When only one set is being observed it is a good idea to change the setting of the circle at the end of the first half set. After transitting to the Face Right position the milled ring is used to change the setting by about 90° (100^g). Each half set is reduced to the R. O. separately and the results meaned afterwards.

4.6.3 Measuring Sets of Directions

It is often necessary to measure the directions to several targets from one station, this is of course common in triangulation. The measuring routine is the same as that described in 4.6.2 except that there are more targets. With the theodolite in Face Left the circle is set to the required reading, the alidade is swung clockwise and target 1 (RO) is fine pointed using the lower plate clamp and drive (see 4.6.1). The lower plate clamp and drive now remain untouched until the circle setting has to be changed again. The alidade is turned clockwise and targets 2, 3, 4...n are observed (using the horizontal clamp and drive). After the last target, n, the telescope is transitted to Face Right, then with an anticlockwise swing the targets are observed in the reverse order, i. e. n...4, 3, 2, 1 (RO).

If additional accuracy is required more sets can be taken with different circle settings as described in the last two paragraphs of 4.6.2.

4.6.4 Measuring a Single Horizontal Angle by the Repetition Method

The method is mainly used for the accurate measurement of parallactic angles i. e. for subtense bar or subtense base measurements. The procedure is as follows:

1. With the instrument in **Face Left** the circle is set to a little more than zero, target 1 is then fine pointed using the lower plate clamp and drive as described in 4.6.1. The horizontal circle reading is now taken.
2. The lower plate clamp remains tightened. The horizontal clamp is loosened and the alidade turned to sight target 2. The horizontal clamp is now tightened and target 2 is fine pointed with the horizontal drive.
3. The horizontal clamp remains tightened. The lower plate clamp is loosened and the alidade swung back to target 1. Target 1 is fine pointed by turning the lower plate drive. The circle reading on target 1 is now exactly the same as it was on target 2.
4. Repeat step 2
5. Repeat step 3
6. Repeat step 2

   etc.

The procedure can be repeated any number of times but this number must be carefully counted. The final value of the measured angle is given by:

$$\frac{\text{final reading on target 2 - initial reading on target 1}}{\text{number of repetitions}}$$

It is a good idea to take the reading to target 2 after step 2. This gives a measure for the angle and can be used as a check against miscounting. The whole procedure may be repeated on Face Right and the two results meaned.

4.6.5 Carrying Bearings

In traversing it is fairly common to carry bearings from one station to another. Consider the theodolite to be at traverse point 1 and measuring the angle between the traverse RO and traverse point 2. The observation procedure should be modified so that the last pointing is on Face Right to station 2. The FR reading to station 2 is locked on the circle by keeping the horizontal clamp tight and loosening the lower plate clamp. At station 2 a Face Left sight is made to station 1 and fine pointing is done by using the lower plate clamp and drive screw. Thus the FL reading, station 2 to station 1, will be the same as the FR reading, station 1 to station 2, i. e. the correct bearing has been set.

By this procedure the correct bearing (plus or minus a small amount which must be allowed for when taking the mean of FL and FR) can be carried through the traverse.
If it is sufficient to take measurements on Face Left only, the bearings can be carried but correct bearings will only be obtained at the odd numbered (1, 3, 5....) traverse points. At the even numbered points (2, 4, 6....) a 180° constant will be introduced.

4.6.6 Measuring Vertical Angles

With the telescope in the Face Left position bring the horizontal hair onto the target by means of the vertical drive (22). The vertical circle is then read. If the observer knows the instrument is properly adjusted for vertical collimation error and if an accuracy of 1′ or 2^c is acceptable, it will be sufficient to measure the angle in Face Left only. For an accurate measurement the telescope must be transitted and the observation repeated on Face Right. The reading A_L on Face Left is the zenith angle ζ, the reading A_R on Face Right is $(360° - \zeta°)$ or $(400^g - \zeta^g)$. The vertical angle β (elevation + or depression –) can be derived from the vertical circle readings as follows:

$$\beta_L = 90° - A_L° \text{ or } 100^g - A_L^g$$
$$\beta_R = A_R° - 270° \text{ or } A_R^g - 300^g$$
$$\beta = \tfrac{1}{2}(\beta_L + \beta_R)$$
$$\zeta = \tfrac{1}{2}(A_L - A_R) \quad \text{(360° or 400}^g\text{ has to be added to } A_L\text{)}$$

Example

360°

A_L	= 83°23′10″	β_L	= +6°36′50″
A_R	= 276°36′20″	β_R	= +6°36′20″
A_L+A_R	= 359°59′30″	β	= +6°36′35″
A_L-A_R	= 166°46′50″	ζ	= 83°23′25″

400ᵍ

A_L	= 107.864^g	β_L	= - 7.864^g
A_R	= 292.154^g	β_R	= - 7.846^g
A_L+A_R	= 400.018^g	β	= - 7.855^g
A_L-A_R	= 215.710^g	ζ	= 107.855^g

Reduction by this method is self-checking. The sum A_L+A_R should always be constant within ± 10″ or ± 0.3^c. The difference of A_L+A_R

from 360° or 400^g is twice the vertical collimation error which can be adjusted as described in 6.6.

4.6.7 Measuring Vertical Angles with the 3 Wire Method

If the vertical angle has to be measured several times in order to increase the accuracy and to expose gross reading errors, the two horizontal stadia hairs as well as the horizontal cross hair are used on both FL and FR. Let U_L (Face Left) and U_R (Face Right) be the vertical circle readings with the upper stadia hair, A_L and A_R with the centre hair as before, and L_L and L_R with the lower hair. In the example the numbers in brackets indicate the sequence of observing. The vertical angle β is calculated from:

$$\beta° = \tfrac{1}{2}(FR - FL - 180°)$$
$$\beta^g = \tfrac{1}{2}(FR - FL - 200^g)$$

Example using T1A, inverted image:

U_L	83°06′00″ (1)	A_L	83°23′10″ (2)	L_L	83°40′20″ (3)
L_R	276°19′15″ (6)	A_R	276°36′20″ (5)	U_R	276°53′40″ (4)
	193°13′15″		193°13′10″		193°13′20″

Mean	193°13′15″
–	180°00′00″
2β	= +13°13′15″
β	= + **6°36′38″**

i. e. at Face Left and at Face Right one starts to observe always with the upper hair in the field of view.

4.7 Tacheometric Observations

For tacheometric work it is usually sufficient to use the theodolite on Face Left only. The telescope has stadia lines (multiplication constant 100 ×) for measuring the distance to a vertical (or a horizontal) staff. The staff is read where it is cut by the lower stadia hair and the upper stadia hair. The difference between the staff readings is called the intercept, I, and for a horizontal sight 100 times the intercept is the horizontal distance from the centre of the instrument to the staff. If the line of sight is inclined the vertical angle (β) must be measured (reading on Face Left is usually sufficient) and the horizontal distance D is calculated from:

$$D = 100 \cdot l \cdot \cos^2 \beta \quad (\beta = \text{vertical angle})$$
$$D = 100 \cdot l \cdot \sin^2 \zeta \quad (\zeta = \text{zenith angle})$$

If the difference in height is needed also, the reading (z) where the staff is cut by the centre hair is taken. The height (i) of the theodolite's tilting axis above the ground point is also measured. The difference in height ($\triangle$H) between the ground at the instrument station and the foot of the staff is:

$$\triangle H = 100 \cdot l \cdot \sin \beta \cos \beta + (i - z)$$
$$\triangle H = 100 \cdot l \cdot \sin \zeta \cos \zeta + (i - z)$$

To simplify the calculation it is useful to sight the staff so that $z = i$. A special tacheometric slide rule or tacheometric tables (e. g. F. A. Redmond's Tacheometric Tables) will be useful for reductions.

4.8 Packing Up

The container is opened, the hood is removed, and the clamping hooks are turned outwards so that the T1A can be placed on the support pillars. The illumination mirror of the T1A is closed, the telescope is set to the zenith, the alidade is turned until the red stripe is in line with the red dot, all the instrument clamps are then tightened slightly. The tripod fixing screw is undone, the instrument is lifted off the tripod and placed in the base of the container so that the holding bolts (8) rest in the grooves of the support pillars. The hooks are placed over the bolts and are then locked by pressing the levers down. The hood of the container is replaced and fastened by means of its locking hooks. The tripod is folded up.
If the instrument is wet the hood should be removed as soon as possible to allow the T1A to dry out.

5. Optional Accessories

5.1 Miscellaneous

5.1.1 Telescope Level

The telescope level allows the theodolite to be used for spirit levelling. The sensitivity of the bubble is 60″ per 2 mm and the coincidence setting of the split bubble permits an accuracy of ± 2″. The mean square error of a difference in height is therefore about ± 1 mm in 100 m or ± 0.04 inch in 100 yds.

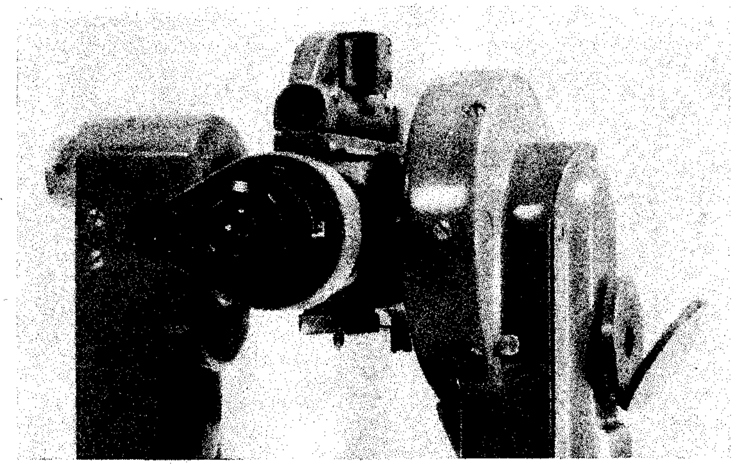


Fig. 7 Telescope Level

To mount the level: Put the telescope in the Face Right position, remove the two screws from the flat area on top of the telescope and then fix the level in position by means of these screws.
To adjust the telescope level: Set up a vertical staff about 50 m (yds) away from the theodolite, put the telescope in the Face Left position and, by means of the vertical drive (22), set the vertical circle reading to 90°00′00″ or 100.000ᵍ, then read the staff where it is cut with horizontal

cross hair. Transit the telescope to the Face Right position, set the vertical circle to 270°00'00" or 300.000⁹ and read the staff again. Now, by using the vertical drive, set the horizontal hair to the mean of the two staff readings (i. e. to the horizontal line of sight) and turn the adjusting screw of the telescope level until the two ends of the bubble are in coincidence.

5.1.2 **Autocollimation Eyepiece GOA** (fig. 8)

The normal bayonet fitting telescope eyepiece is removed and in its place the autocollimation eyepiece is inserted. The autocollimation eyepiece is connected to the battery box and the light source illuminates the reticle. By means of a beam splitter positioned between the eyepiece and the

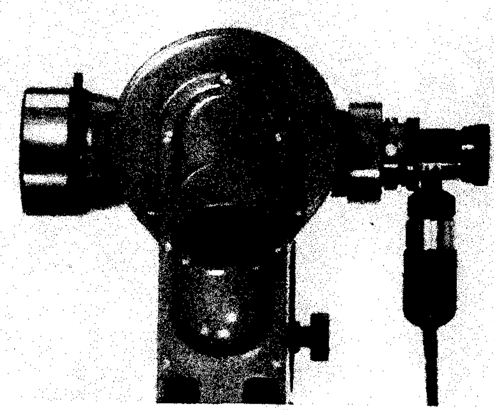


Fig. 8 Autocollimation Eyepiece GOA

reticle, it is possible to view not only the reticle cross itself, but an inverted mirror image of the cross as reflected from a plane mirror, if the telescope is focussed to infinity. If the plane mirror is at right angles to the line of sight, the real reticle and its inverted mirror image will unite symmetrically at the focal point in the plane of the reticle plate. This method of autocollimation enables the T1 to be used for many types of alignment and machine positioning tasks.

The equipment can be used in two ways. Either the line of sight is given (e. g. representing the axis of machinery) and the plane mirror has to be set perpendicular to this line of sight by turning the mirror, or the plane of the mirror is fixed and the line of sight has to be established perpendicular to this plane. In the latter case, the telescope, focussed to infinity, is pointed on to the mirror. If the circular image of the objective does not appear in the field of view, the observer moves his head behind the instrument until he sees this image in the mirror. The theodolite is now moved to a position halfway between the observer's eye and the initial instrument position. After pointing again to the mirror the reflected image of the reticle cross should appear in the field of view. Using the horizontal and vertical drive screws, the reticle cross is brought into coincidence with its reflected image. Autocollimation is independent of the shortest focussing distance of the telescope.
It is important to note that if either the mirror or the telescope turns by a small angle then the rays reflected back from the mirror show twice the deflection angle. This doubles the pointing accuracy in relation to normal methods.

5.1.3 **Eyepiece Lamp GEB32**

The eyepiece lamp illuminates the reticle from behind and converts the telescope into a collimator. First, focus the telescope to infinity (i. e. on a distant object) and then remove the standard eyepiece (11) by slightly turning the bayonet ring (14). Secondly, fit the eyepiece lamp and clamp it by turning the bayonet ring. Finally, connect the plug of the lamp to the battery box socket (5.2) or to a 4.5 V transformer.

5.1.4 **Parallel Plate Micrometer GPM2** (fig. 9)

The parallel plate micrometer, which can be fitted in front of the telescope objective, is used to measure small displacements from the telescope's line of sight by shifting the line of sight parallel to itself. It consists of a mounting with a parallel glass plate which can be tilted by turning the graduated micrometer drum. The mounting has two notches, at 90° to each other, by means of which the micrometer is positioned to measure displacements in either the horizontal or the vertical plane. In addition, the micrometer can be turned around the objective so that, if required, displacements in any other direction can be measured. The metric version has a range of 10 mm (5 mm on either side of the telescope's line of sight), direct reading is to 0.2 mm and estimation is to 0.05 mm. The non-metric versions have ranges of 0.5 inch and 0.02 ft, direct reading is to 0.01 inch and 0.001 ft and estimation is to fractions of these amounts.

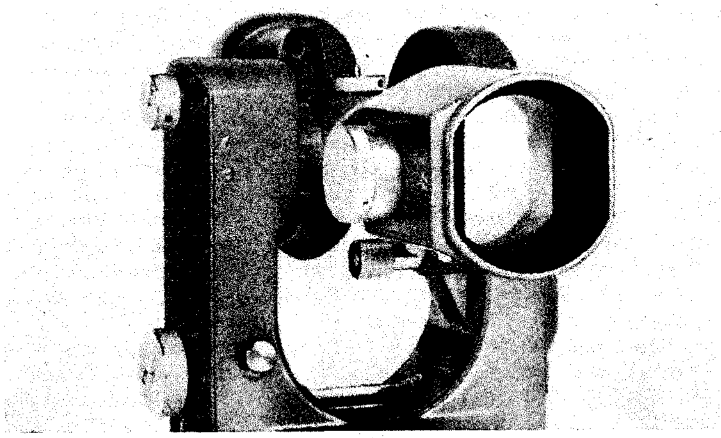


Fig. 9 Parallel Plate Micrometer GPM2 with counterweight

5.1.5 **Auxiliary Lenses**

Auxiliary lenses, which can be attached to the telescope objective, enable observations to be made at distances below the normal minimum focussing range. During the observations, which should be made on both faces, the position of an auxiliary lens must not be disturbed. In order to eliminate the possibility of errors when combining short and long range observations, it is essential that each target should be viewed immediately on both faces. The focussing range in metres (1 m = 39.37 in), for each of the four auxiliary lenses now available, is given in the following table and is dependent on whether it is used with a telescope with an erect or an inverted image:

Lens	T1A Focussing Range	T1AE Focussing Range
	(m)	(m)
GVO1	2.25–0.96	2.25–1.14
GVO2	1.15–0.70	1.15–0.79
GVO3	0.80–0.56	0.80–0.62
GVO4	0.62–0.48	0.62–0.51

5.1.6 **Pillar Plate** (fig. 10)

When observing at concrete pillars or similar points, the weight of the pillar plate and its three, pointed supporting studs ensure a stable set up. For centring the pillar plate, remove the centring pin with circular level from its housing, press the pin down, into the plate's fixing screw, and put the point of the pin on the station mark, then move the plate until the bubble is centred. As a check on the pin's circular level, turn the pin through 180° and if the bubble is displaced take up half of the displacement by moving the pillar plate slightly. Then screw the theodolite onto the plate.

5.2 **Electric Illumination** (fig. 12)

An electric lighting set, consisting of a battery box with accessories, is used for night observations and underground work. The box, which can be fitted to the tripod, holds six dry cells (standard single cell torch batteries). The inner three are connected in series with the switch and plug sockets, the outer three are kept in reserve as spares. The box contains a plug-in lamp with cable, four reserve bulbs and, if ordered, a hand lamp. The switch serves as a variable rheostat for regulating the brightness of the plug-in lamp. The two battery sockets are opposite the carrying handle and are protected by a sliding cover which is operated by a push button. The outer socket, for the cable of the plug-in lamp, is controlled by the rheostat switch and is used for the instrument illumination. The other socket is connected directly to the batteries and is used for the hand lamp (or eyepiece lamp, or autocollimation eyepiece).

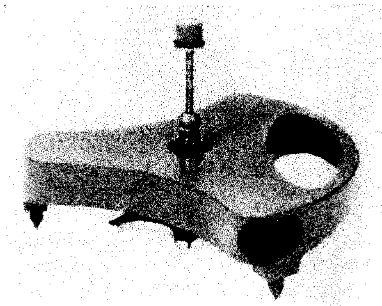


Fig. 10 Pillar Plate

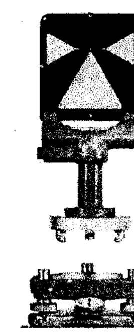


Fig. 11 Target GZM5 removed from the tribrach

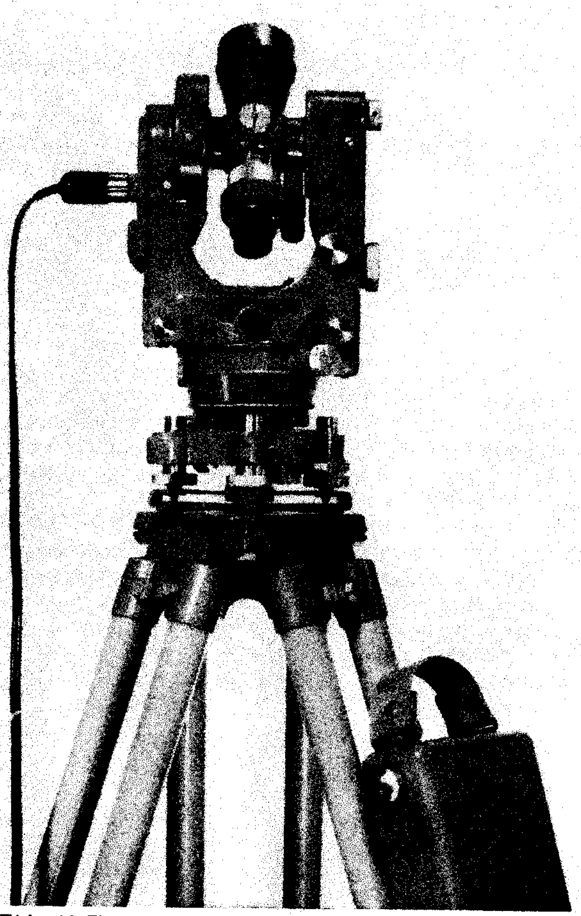


Fig. 12 Wild T1A with Electric Illumination Equipment

The illumination mirror (12) is removed and replaced by the plug-in lamp. The mirror should be kept in a safe place. The bulb (4V, 1.4 W) can be removed after unscrewing the chrome ring on the lamp. The reticle illumi-

nation can be adjusted by turning the knob (16) on top of the telescope. A special flame-proof battery box is available for use in explosive conditions (e. g. in mines) and is provided with a lock which can be opened only with a special key, which is not taken into the mine. As miners' lamps must be used for general illumination, there is no connection for a hand-lamp.

5.3 **Traverse Equipment**

The traverse equipment consists of at least two extra tripods, two extra tribrachs and two targets. The tribrach and the centring flange of a target are identical to those of the theodolite. The target can be removed from the tribrach (fig. 11) and be replaced by the theodolite without any loss in centring. The centre of the target cross is at the same height above the tribrach as the tilting axis of the theodolite. For setting up the target over a station mark, a plumb bob is provided in the tripod pouch, and an optical plummet and tubular level (sensitivity 60" per 2 mm) are built into the upper rotatable part of the target (the level is adjusted in the same way as the plate level of the theodolite – see 6.3; the adjustment for the plummet is described in 6.8). For centring the target under roof points, there is a white mark on top of the target in the extension of the standing axis. For night work or in mines, a reflector, with lamp and cable, can be attached to the rear side of the target, the cable is then plugged into a battery box on the tripod (see 5.2).
In daylight, for ranges over 1 km (5/8 mile), the Large Target Plate GZM4 can be attached to the standard target. This allows sights up to 8 km (5 miles).
With the traverse equipment, the three tripod method of traversing is used. Centring is carried out only once at each station and, as the traverse proceeds, targets and the theodolite (and even a subtense bar, a DM1 staff, a GVL1 staff, a ZBL or a ZNL plummet) are interchanged in the tribrach – i. e. forced-centring.

5.4 **2-m Subtense Bar GBL** (fig.13)

The 2 metre subtense bar is a practical device for quick and accurate distance measurement. If the theodolite is set up over point A and the subtense bar is over B, it is necessary to measure only the parallactic angle between the bar's two targets and then look up the horizontal distance AB in the distance tables supplied with the equipment. For night or underground work a battery box, with connection cable and hand-lamp, is required. The bar is wired for electric lighting and there is a plug-in lamp behind each of the two targets.

If the parallactic angle is measured four times with the T1A (the repetition method may be used) the following mean square error (m_D) for a distance (D) should be obtained.

D =	20	40	60	80 metre
m_D =	±0.2	±1	±2	±4 cm

(1 m = 3.28 ft, 1 cm = 0.033 ft)

For further information see brochure G1412e.

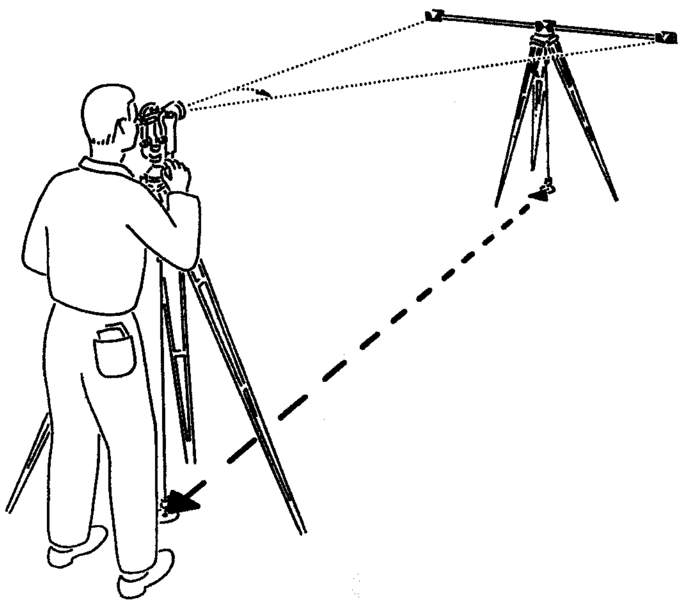


Fig. 13 Measuring distances with the Subtense Bar GBL

5.5 **Distance Measuring Wedge DM1** (figs. 14 and 15)

The DM1 provides another method of tacheometric or optical distance measurement. Unlike ordinary stadia which have an accuracy of 1/1000 its accuracy is between 1/5000 and 1/10000 of the distance measured. It is used for general traversing and property surveys, especially in con-

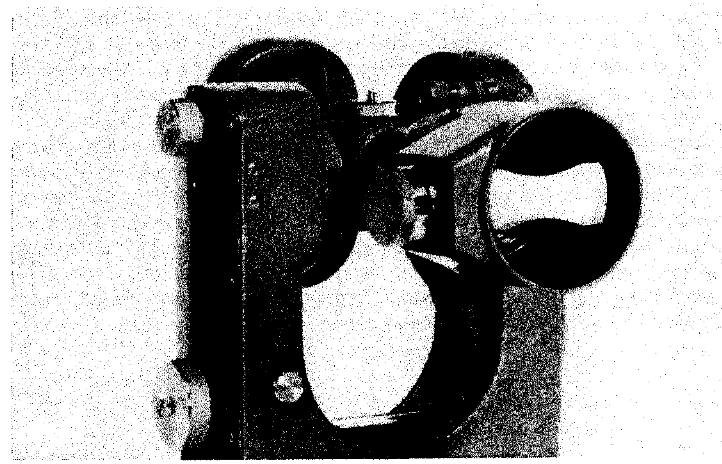


Fig. 14 Distance Measuring Wedge DM1 with counterweight

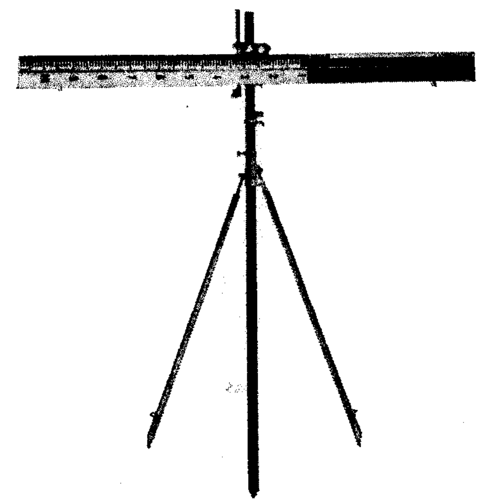


Fig. 15 DM1 Staff with staff stand (equipment A)

gested areas, where taping is often inconvenient, and it enables both the slope distance and angular measurements to be made at one set-up. The DM1 itself is a distance measuring wedge with a micrometer. It is clamped to the objective end of the telescope (fig. 14) and a counter-weight has to be attached to the eyepiece end to restore the balance. It is used in conjunction with special staves, available only with metric graduation (fig. 15). The staff is held horizontally in a carrier which is attached to a staff stand (equipment A). When traversing, the staff is held in a special tribrach carrier (equipment B) which is interchangeable as part of the normal forced-centring traverse equipment. The DM1 must be adjusted individually to the theodolite with which it is to be used.
Further details and Instructions for Use are contained in pamphlet G2305e.

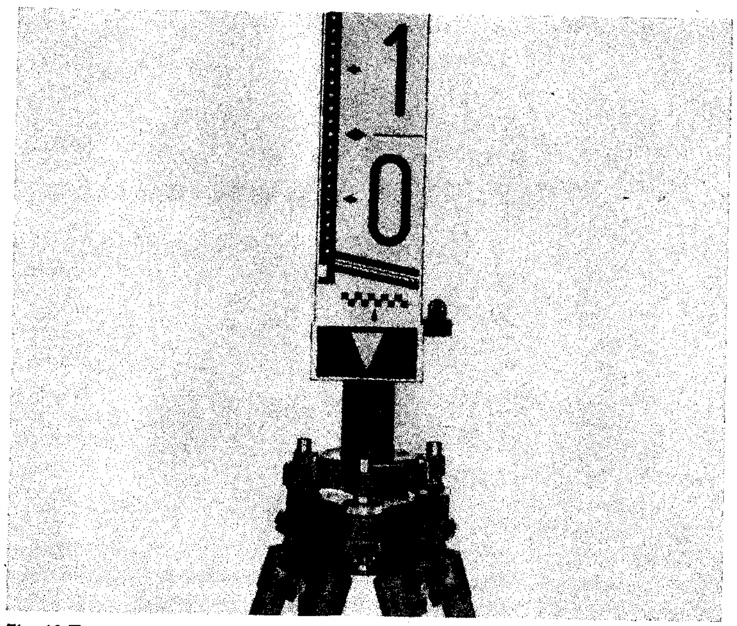


Fig. 16 Tacheometric Short-Staff GVL1, with staff carrier in tribrach (equipment B)

5.6 **Tacheometric Short-Staff GVL1** (fig. 16)

For stadia survey, instead of a normal chess-board pattern staff, the Tacheometric Short-Staff GVL1 (metric only) can be used for obtaining more precise distance measurements. The staff has erect numbers, its graduated length is 1.2 m, and it can be set up either with a staff stand (equipment A) or with a staff carrier fitting into a theodolite tribrach, i. e. forced-centring (equipment B). The GVL1 has a transverse scale with one interval corresponding to one decimetre in distance and estimation within this interval giving the centimetre. Up to 70 metres, distances measured with the GVL1 are more accurate than when observing to a normal staff. The accuracy is about 2 to 5 cm depending on the distance. For more information see the Instructions for Use G2308e.

5.7 **Compasses**

5.7.1 **Tubular Compass** (fig. 17)

The two screws are removed from the holes in the top of the right hand standard. The tubular compass is then fixed in position using special screws and the existing threaded holes. The eyepiece of the compass should be towards the observer with the telescope in the Face Left position. As long as the release button on top of the compass is pressed the

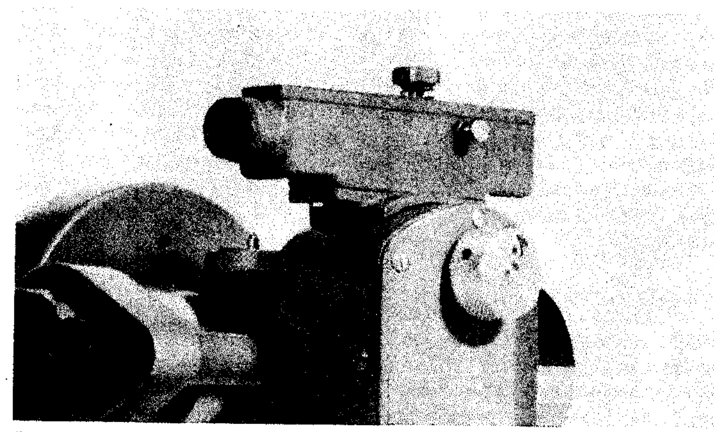


Fig. 17 Tubular Compass

needle is free to oscillate. When the two upturned ends of the needle, as observed through the adjustable eyepiece, are in coincidence, the telescope is directed to magnetic north.
Depending on the earths magnetic field, the inclination of the needle will vary. For the needle to swing correctly the local inclination must be balanced, so that the needle oscillates horizontally. To achieve this, it is equipped with adjustable weights. As the magnetic field does not vary considerably within large areas, the adjustment for inclination is made only once, and it should be made by an instrument mechanic.
If the T1A is equipped with a tubular compass the zero of its horizontal circle can be set to magnetic north and, after such a setting, magnetic bearings can be read from the horizontal circle. To set the circle see 4.6.1. After the circle is set to zero, the horizontal clamp (25) remains tightened, the lower clamp (26) remains open, the compass release button is pressed down, and the alidade is turned by hand until the ends of the needle are nearly in coincidence. The lower plate clamp is then locked and the lower plate drive (27) is turned until the two ends of the needle are in coincidence. The compass needle should always be brought into coincidence from the same direction and the last half turn of the drive screw should, therefore, always be made in a clockwise direction. By doing this, the residual friction of the compass needle always acts in the same direction. After the telescope of the T1A and its circle zero are oriented in this manner the lower plate clamp and drive remain untouched and all other pointings are made with the horizontal clamp and drive (25,24). All readings will now be related to magnetic north.
It is usual to deduce true north or grid north from the magnetic north obtained with the compass. Its deviation from true north is dependent on the magnetic declination δ and the instrument constant κ, and for deviation from grid north the meridian convergence γ must be considered. As δ varies with time, and as δ and γ vary from place to place, the sum $(\delta + \kappa)$ or $(\delta + \gamma + \kappa)$ should be determined along a line of known azimuth or grid bearing as frequently as possible, and the corrections should be applied to the observed magnetic bearings. With the capstan-headed adjusting screw of the compass, it is possible to vary the instrument constant κ within $\pm 3°$.

5.7.2 Circular Compass (fig. 18)

In contrast to the tubular compass, the circular compass is only placed on the theodolite when required. A bracket (36) is screwed to the top of the right hand standard in exactly the same way as the tubular compass (see 5.7.1). The compass is fixed to a bridge which has two folding supports. The end studs of one support fit into the bracket (36) and are locked

in position by locking sleeves (37). The other support rests on the vertical circle housing. The graduation interval of the compass circle is 1° or 1ᵍ (360° or 400ᵍ). Readings are taken through the eyepiece (40) and can be estimated to 0.1° or 0.1ᵍ. The magnet is fixed to the underside of the circle. A milled knob (38), situated under the compass, lowers the circle onto the pivot. This knob is spring-loaded so that when it is released the circle is automatically lifted off the pivot.
If the compass is not correctly balanced for the local magnetic field the circle will be inclined to the horizontal. To correct this inclination, place the compass on a levelled up theodolite, remove the three screws (42) and pull off the upper part of the housing (41). Lower the circle onto the pivot and inspect the small gap between the circle and its supporting plate. Note the position of the smallest gap and then rotate the alidade through 180°.

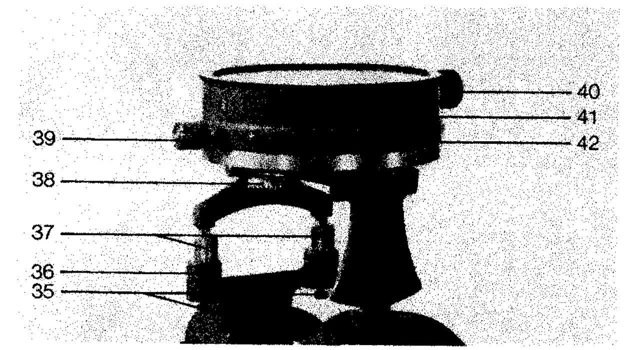


Fig. 18 Circular compass

35 Capstan headed adjusting screws
36 Mounting bracket
37 Locking sleeves
38 Milled knob for lowering the circle onto the pivot
39 Clamp
40 Eyepiece
41 Upper housing
42 Screws for 41

If the smallest gap is still at the same compass circle reading, the circle is inclined and must be adjusted. Release the milled knob in order to lift the circle off the pivot, slacken the screws of the adjusting weights and carefully slide the weights along their grooves in the appropriate directions. Continue carefully with this procedure until the gap between the lowered circle and its supporting plate is everywhere the same.

If after the 180° rotation, the smallest gap is found on the opposite side of the circle, this indicates that the bridge is inclined. In this case adjust by means of the capstan headed screws (35).
It is usual to deduce true bearings or grid bearings from magnetic bearings, the remarks in the last paragraph of 5.7.1 apply equally well to the circular compass. With the telescope aligned on a known magnetic bearing, the clamp (39) is slackened and the compass housing (41) rotated until the compass reading is correct. All subsequent readings of the compass will be magnetic bearings. Alternatively, the compass can be set to give readings related to true north, grid north, or any other reference direction including south. The compass can be read for all pointings or it can be used merely to orientate the alidade as with the tubular compass. In order that the friction of the pivot always acts in the same direction, the last half turn of the horizontal drive screw should always be clockwise.
The metal ring around the base of the compass carries a short scale. This ring can be moved independently of both the compass base and upper housing provided that the three screws underneath the compass are slackened. By turning the ring, the zero of the scale can be set to the index arrow under the eyepiece, then the screws are tightened again. By means of this scale, the compass can always be set correctly in relation to the telescope. If the declination changes, or if it is required to set the compass according to some other reference direction, the compass can be turned against this scale.

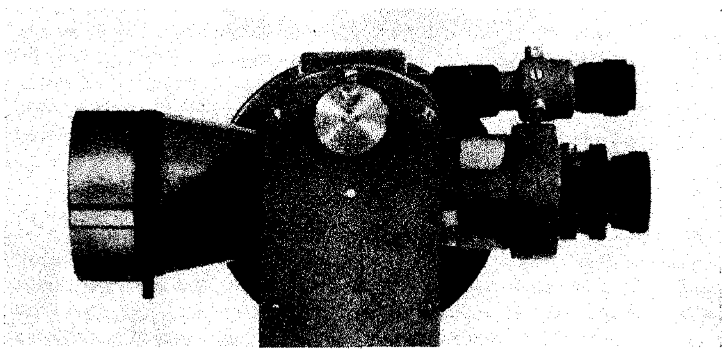


Fig. 19 Telescope Roof Plummet

5.8 Plumbing Equipment

For optical plumbing the following can be used with the T1A:
Zenith and Nadir Plummet ZNL
Roof and Ground Plummet ZBL
Telescope Roof plummet (fig. 19)
Objective Pentaprism (fig. 20)
Diagonal Eyepieces (5.9.3 and fig. 22)

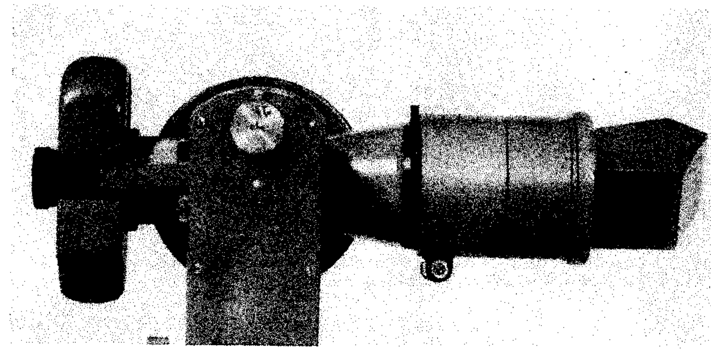


Fig. 20 Objective Pentaprism with counterweight

The **ZNL and ZBL** are independent instruments having the same centring flange as the theodolite and can therefore be interchanged with the theodolite in the tribrach, i. e. forced-centring. They are used for upward and downward plumbing. The ZNL has a plumbing accuracy of 1:30000, the ZBL 1:5000.

The **Telescope Roof Plummet** is attached to the telescope in the Face Right position in the same way as the telescope level. It is used for centring below roof points, centring accuracy is 1:5000 (see fig. 19).

The **Objective Pentaprism** is used for upward and downward plumbing (1:70000), transferring bearings to different levels, and for setting out when right-angled deflections are needed (see fig. 20).

Diagonal Eyepieces (see 5.9.3) can be used for upward plumbing (accuracy 1:70000).

For full details on plumbing equipment see brochure G1 417e.

5.9 Accessories for Astronomical Observations

5.9.1 Eyepiece Prisms for Sighting up to 25° from the Zenith (fig. 21)

The telescope eyepiece prism and the reading eyepiece prism are screwed directly into the respective eyepieces. On changing face these prisms can be rotated without affecting the eyepiece settings.

Fig. 21 From left to right: – eyepiece filter, reading eyepiece prism, telescope eyepiece prism, filter for the telescope eyepiece prism

5.9.2 Filter for Telescope Eyepiece Prism (fig. 21)

For inclined sights to the sun or bright objects, this filter can be fitted over the eyepiece prism. It can be positioned in either of three ways to give a black or blue or green filter.

5.9.3 Diagonal Eyepieces for Sighting to the Zenith (fig. 22)

The telescope eyepiece (11) is removed after a slight turn of the bayonet ring (14), and is replaced by the diagonal eyepiece. The reading eyepiece is unscrewed and the other diagonal eyepiece is slipped onto the tube and clamped by means of a small lever. After transitting via the objective end, the diagonal eyepieces can be rotated through 180°. When not in use they are kept in a leather case.

5.9.4 Eyepiece Filters (fig. 21)

These filters slip over the normal telescope eyepiece or the diagonal eyepiece. They are used for observing to the sun or other bright objects. Black, blue, green and yellow filters are available.

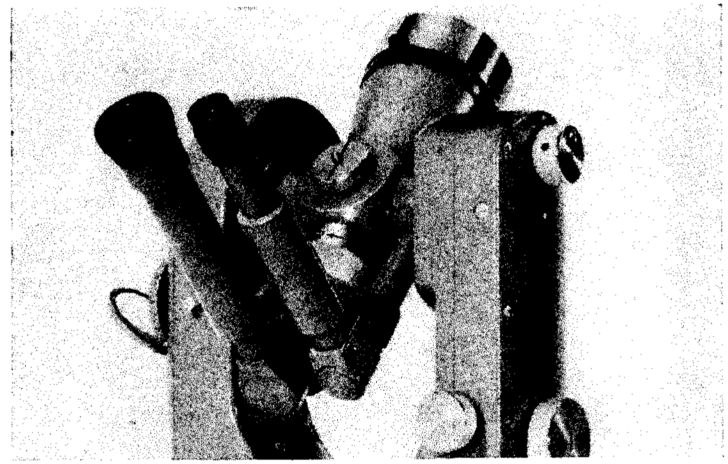


Fig. 22 Diagonal Eyepieces

5. 9. 5 Wild-Roelofs Solar Prism (fig. 23)

This fits over the objective and enables a sun azimuth to be determined rapidly by direct sighting to the sun's centre. Four overlapping images of the sun are produced, leaving in the middle a small diamond-shaped gap, which is intersected by the telescope's cross-hairs. In hazy conditions the images of the sun are slightly blurred, however this does not affect the sighting accuracy. Further details are given in pamphlet G1 403e.

5. 9. 6 Polaris Attachment (fig. 24)

Clamped to the objective end of the T1A telescope, the Polaris Attachment will enable the observer to find true north to within ±30 secs., latitude to within ±30 secs., and local sidereal time within 1 minute of time. Usable only in the Northern Hemisphere, it has the advantage that no star almanac, no sidereal time, nor any geographical data at the set up point are required and there is no need to await the elongation of the Pole Star before observing. This can be done, in fact, at any time during the night and, under good observing conditions, even in the early morning or late evening.
Further details of the Polaris Attachment are given in the Wild booklet MS 132e.

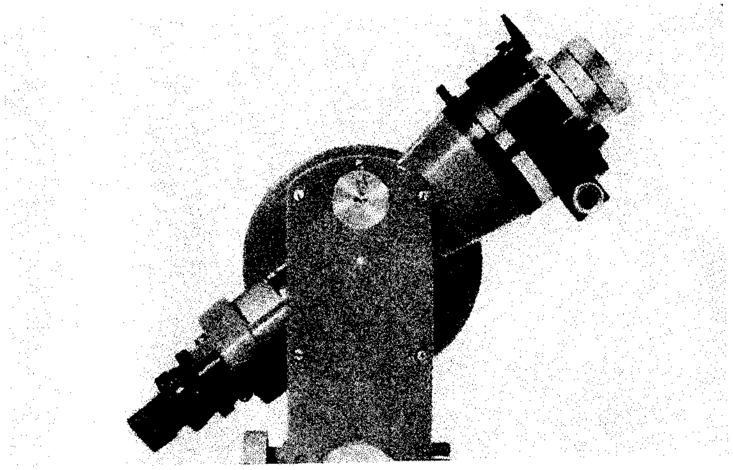


Fig. 23 Wild-Roelofs Solar Prism

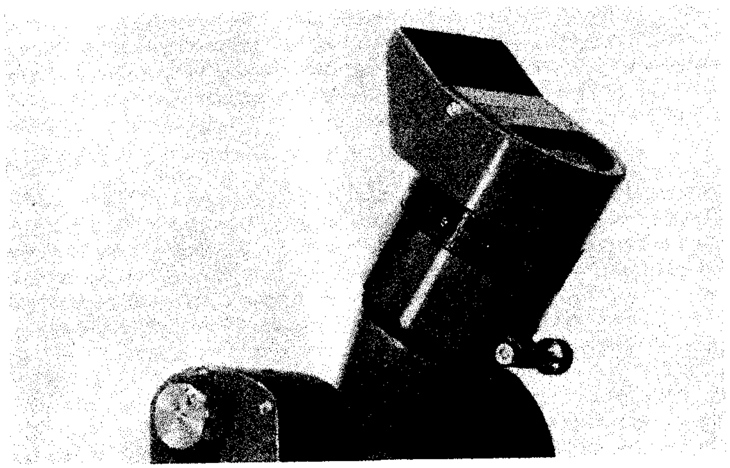


Fig. 24 Polaris Attachment

5.10 **Wild GAK1 Gyro Attachment** (fig. 25)

The GAK1, which fits into a bridge specially and permanently mounted to the standards of the T1A, provides an orientation to True North with an accuracy of ±30 seconds of arc in about 20 minutes of working time. With virtually no calculations, no waiting for sun or stars to become visible and with work possible at any time of the day or night, irrespective of visibility conditions, the GAK1 is simple to use and is of great value whenever there is a need to establish or to control the azimuth. It is of particular use to surveyors and to military users. Leaflet G1 413e gives further details about the GAK1 Gyro Attachment.

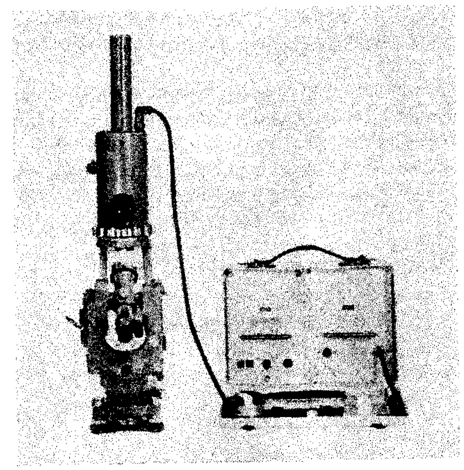


Fig. 25 T1A with the Gyro Attachment GAK1 and the Converter GKK1

6. Adjustments

6.1 **The Tripod**

The metal hinges at the top of the tripod legs and the joints between the wooden and metal parts should always be tight. A special key is supplied with each tripod and is kept in the small pouch, which is fastened to the inside of one of the legs. This key is used to loosen or tighten the tripod screws, all of which are hexagonal. The screws should be neither too tight nor too loose, the test being that, when lifting the tripod slowly by its head, the legs, spread out in their normal working position, should be just sufficiently tight to resist sinking to the ground under their own weight.

It sometimes happens, particularly in very dry climates, that the range of the screws is insufficient or that the clamps of telescopic tripods do not grip properly. If this is the case, a thin wedge can be used as a temporary remedy, but a better solution is to soak the tripod in water overnight or to wrap it in wet rags, thus allowing the wood to swell.

6.2 **Footscrews**

The footscrews must be checked with the instrument not screwed onto the tripod. Each screw should run smoothly, but not loosely. Adjustment is made by turning the footscrew slowly with one hand and, with the other, turning the capstan screw (using the adjusting pin) until the correct movement is obtained.

6.3 **Plate Level**

If, when levelling up (see 4.3.3), the plate level bubble does not take up a central position it can be adjusted as follows:

Centre the circular bubble and turn the alidade so that the optical plummet (7) is over footscrew A. Turn footscrews B and C, through equal and opposite rotations, until the plate level bubble is centred. Turn the alidade clockwise through 90° and centre the bubble using footscrew A. Now rotate the alidade through 180° and note the position of the bubble. If the bubble has run off by more than one division, take up half of the run-off by turning footscrew A and remove the other half by means of the capstan-headed screw (10). Repeat until the bubble is central for all positions of the alidade.

6.4 **Circular Bubble**

Once the plate level bubble has been "centred" (as described in 6.3) the circular bubble of the tribrach should be checked. If it is no longer centred, the displacement should be corrected by means of the three adjustment screw, which are situated underneath the bubble holder. As an adjustment screw is loosened the bubble runs towards it and, as it is tightened, the bubble runs away from it. The first adjustment screw to be turned, therefore, is the one that is the nearest to being in line with the middle of the bubble and the centre of the black setting circle. It is turned only until the bubble reaches the centre of the circle or until it can be set in the centre by means of one of the other two screws. The screws must not be turned more than is necessary to complete the adjustment.

6.5 **Horizontal Collimation Error** (fig. 26)

The horizontal collimation (line of sight perpendicular to the tilting axis) is adjusted in the factory as closely as possible. Its residual error is so small as not to affect normal work with a T1A and, if observations are taken on both faces even this small error is cancelled out in the meaned reading. Therefore to try to adjust a horizontal collimation error to zero is not recommended for two reasons. First, it is neither possible nor necessary. Second, and most important, if the adjustment screws are not set correctly (i.e. if they are too tight or too loose) the theodolite will never keep the adjustment.

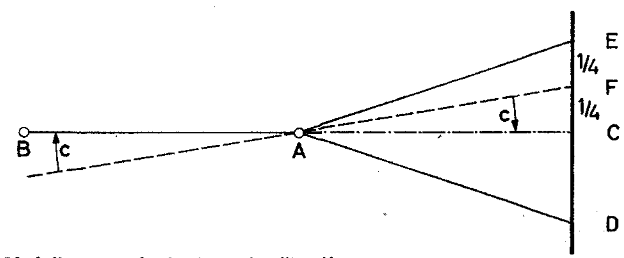


Fig. 26 Adjustment for horizontal collimation error

To determine the horizontal collimation error c:

On a flat stretch of ground set up the theodolite at A. Set a target at B so that AB is about 60 m (200 ft) and so that the target is at about the same height as the theodolite. Mark a point C so that BAC is a straight line and AC is approximately equal to AB. Set a levelling staff or scale at C so that the staff is horizontal, at about the same height as the theodolite and perpendicular to the line CAB. With the theodolite in the Face Left position, sight B with the vertical hair and then (keeping the horizontal and lower plate clamps locked) transit the telescope and read the staff where it is cut by the vertical hair e. g. at D. Turn the theodolite through 180°, sight B again (the theodolite is now in Face Right), transit and read the staff e. g. at E. The angle DAE is four times the collimation error c. If, for example, DE is 3.6 cm (0.12 ft) and AC is 60 m (200 ft) the collimation error is about 30″ or 1^{c} and for angle measurements this is quite acceptable.

To adjust:
There are four screws by the eyepiece, the adjustment is carried out by means of the two horizontal capstan-headed adjusting screws. The vertical hair is still on point E; by turning the capstan-headed adjusting screws with an adjusting pin the vertical hair must be brought to point F on the staff. F is known because EF = ¼ED. If the vertical hair is to the left of point F unscrew the adjustment screw on the left side by a small amount and immediately screw in the right one by the same amount (if the hair is to the right of F the reverse will apply). Turn the screws in this way, by equal amounts, until the vertical hair is on point F. Excessive tightening of the screws must be avoided. Finally repeat the test to see if the collimation error is now within acceptable limits, if not repeat the adjustment.

Note:
This adjustment is delicate and should only be carried out when it is absolutely necessary.

6.6 Vertical Collimation Error (Vertical Index Error)

The vertical circle should read 90°00′00″ or 100.000^{g} when the line of sight is horizontal. If it does not, the deviation is known as the vertical collimation error or the vertical index error. By measuring vertical angles on both faces and taking the mean the effect of this error is eliminated.

To determine the vertical collimation error:
Level up the theodolite. With the theodolite in Face Left bring the horizontal hair onto a well defined target, which should be at least 100 m (yds) away, and take the FL reading. Repeat in Face Right and take the FR reading. The difference of FL + FR from 360° or 400^{g} is twice the collimation error (i).

Example:

360°

			Correction	Correct value
	FL	86°14′30″	+ 1′10″	86°15′40″
	FR	273°43′10″	+ 1′10″	273°44′20″
	FL + FR	359°57′40″	+ 2′20″	360°00′00″
	2 i	–2′20″		

400^{g}

	FL	$105,822^{g}$	– 0.016^{g}	105.806^{g}
	FR	294.210^{g}	– 0.016^{g}	294.194^{g}
	FL + FR	400.032^{g}	– 0.032^{g}	400.000^{g}
	2 i	$+0.032^{g}$		

If FL + FR differs by more than 30″ or 1^{c} from 360° or 400^{g} it is advisable to adjust as follows:
Calculate the correct values as shown in the example. With the theodolite still in Face Right and with the horizontal hair still on the target, turn the micrometer knob and set the correct reading on the micrometer scale (44′20″ or $.194^{g}$). There are two capstan headed adjustment screws (13) on each side of the standard and close to the bottom of the circle. Slacken one screw by about a 30° turn, tighten the other by the same amount, and observe how the circle graduation line (273° or 294^{g}) moves in relation to the double index. Having found which way to turn the screws, slacken one by a small amount, tighten the other by the same amount, and proceed in this way (i. e. in small stages) until the graduation line (273° or 294^{g}) is centred between the double index. It is important to avoid excessive tightening of the screws. Finally, repeat the observations and, if necessary, the adjustment.

6.7 Optical Plummet

The T1 A is placed on the tripod over a ground mark, which is defined sharply by a cross or an equally distinctive mark, and carefully levelled-up. The cross-hairs of the optical plummet are set precisely on the mark in the normal way (4.3.4) and the alidade then turned through 180°. If the cross hairs are no longer on the mark, it means that the optical plummet is not in adjustment. Half of the discrepancy is corrected by shifting the theodolite over the tripod head and the other half by carrying out the following adjustment procedure: About 1½ inches to the left and right, respectively, of the optical plummet's eyepiece are two screws (see arrows in fig. 27). With these protective screws removed it is possible to reach the adjusting screws, with the aid of a screwdriver having a shaft one inch

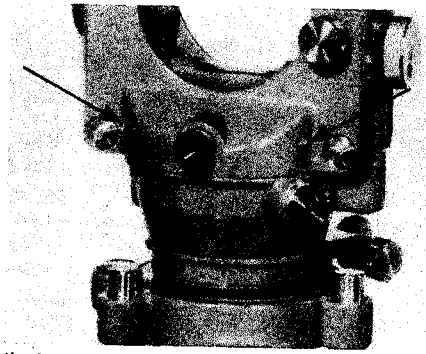


Fig. 27 Remove the two protective screws (arrows) before adjusting the optical plummet

long. These two screws and a counterspring, situated immediately opposite the eyepiece, control the position of the plummet. By slight turns of the screws the reticle of the optical plummet can be centred on the mark. The final turns should be made clockwise in order to compress the counterspring. Once the adjustment has been completed and checked the protective screws are replaced.

6.8 Targets

The adjustment of the target plate level is similar to that described in 6.3 (plate level of the instrument). The adjusting screws are found immediately above the eyepiece of the target's optical plummet.
The adjustment of a target plummet is the same as that described in 6.7, with the only difference that the two screws, of 5 mm diameter, left and right of the plummet's eyepiece are already the adjustment screws and not protective screws. The adjustment should be made step by step in small amounts and the last turn of the screws should always be clockwise.

6.9 Centring Rod

If the bubble of the centring rod is out of adjustment centring errors can easily reach an appreciable amount. The bubble must be checked from time to time. Set the T1A over a suitable mark, such as a pipe of very small diameter. Attach the centring rod to the T1A and place the point of the rod in the pipe. Move the instrument over the tripod head until the bubble of the circular level on the centring rod is centred. Now tighten the cen-

tral fixing screw. The lower part of the centring rod is now rotated through 180°. If the bubble is no longer central, the T1A must be moved over the tripod head in order to take up half the discrepancy. The other half is removed by turning the adjustment screws under the circular bubble of the rod (the screws should be turned as described in 6.4). The circular bubble of the centring rod is in correct adjustment when the bubble remains central throughout a 360° rotation of the lower part of the rod.

6.10 Staff's circular level

Any deviation of the staff from the vertical causes incorrect staff readings for the height and also for the distance. To check the circular bubble the upper end of the staff is fastened to the branch of a tree or overhang of a building so that its lower end can be moved freely. Using a plumb-bob the staff is placed accurately in the vertical. If the bubble is not now lying in the middle of its setting circle, the deviation must be corrected as in 6.4. According to the bubble fitting, this is done either with an adjusting pin or screwdriver.
The newer Wild staves have a maintenance-free circular level, which only has to be adjusted once at the factory when the staff is assembled. The level is screwed firmly to the staff and, for protection, is fitted in a groove which is exactly parallel to the axis of the staff.

7. Care and Maintenance

The Wild T1A is a precision instrument of high measuring accuracy. It must be handled carefully and kept clean. Dirt and dust should be removed only with a clean soft cloth or with a soft brush. The lenses should be treated with particular care. It is permissible to breathe on the lenses before wiping them, but liquids such as oil, benzine and water etc. should never be used for cleaning purposes. Lenses should never be rubbed with a finger.

A wet instrument should be dried when possible before being packed away in its container. It must be removed at the base as soon as possible and allowed to dry out completely.

Each instrument is provided with a small bag of silica gel when leaving the factory. These highly absorbent grains of amorphous crystals are blue when dry and pink when saturated. If they do become pink, care must be taken to ensure that the instrument is not stored in the container, which, by this time, is far too damp. The crystals themselves can be restored by pouring them from the bag into a pan and heating them just above the boiling point of water (this can be tested by drops of water). If they are overheated the crystals may burst. Once the grains have turned blue again they are allowed to cool and put back into the bag.

Each instrument is coated with a substance designed to inhibit the development of fungus growth, but, under very moist climatic conditions, the instrument should be removed from its container and stored on a well ventilated shelf, in a constant air draught and preferably with some form of heating (such as an electric bulb). Ideally, for such climatic conditions, a slatted shelf in an airing cupboard should be used.

WILD
HEERBRUGG

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Telex: 77191

1 Base plate
2 Spring plate
3 Footscrew
4 Adjusting screw for 3
5 Circular level
6 Milled ring for circle setting
7 Optical plummet
8 Holding bolts
9 Plate level
10 Adjusting screw for 9
11 Telescope eyepiece
12 Illumination mirror
13 Adjusting screw for vertical index
14 Bayonet ring
15 Vertical circle housing
16 Knob for reticle illumination, with pin for rear sight and roof centring
17 Foresight
18 Objective
19 Vertical clamp
20 Focussing sleeve
21 Reading eyepiece
22 Vertical drive
23 Micrometer knob
24 Horizontal drive, upper plate
25 Horizontal clamp, upper plate
26 Lower plate clamp
27 Lower plate drive
28 Centring flange
29 Swivel knob locking device (with safety screw)
30 Tripod

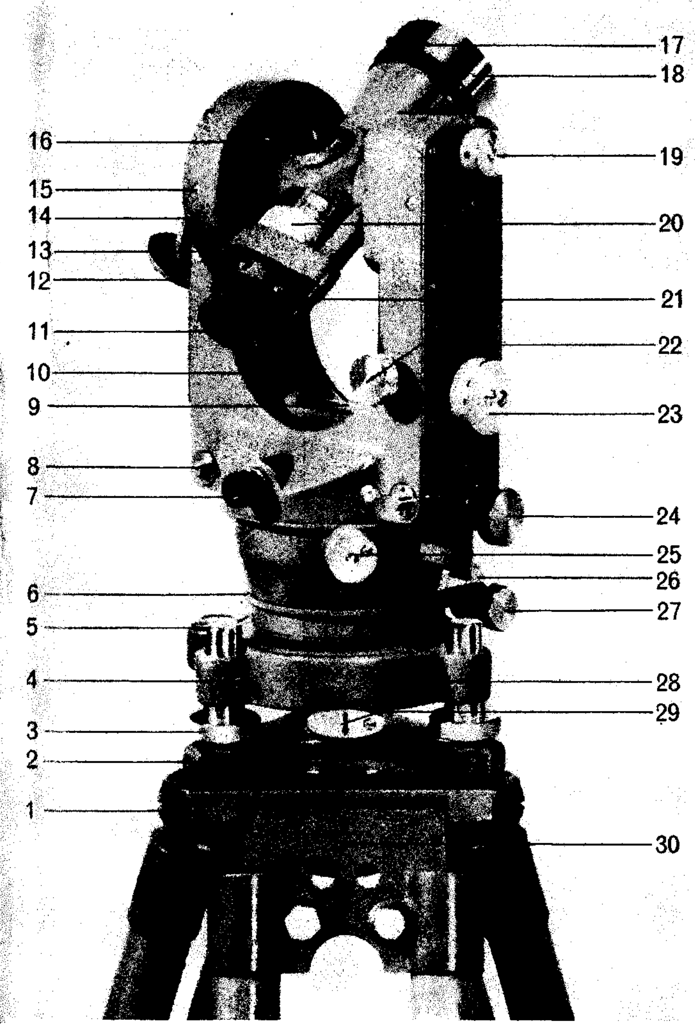

Fig. 1 Wild T1A Double Centre Theodolite