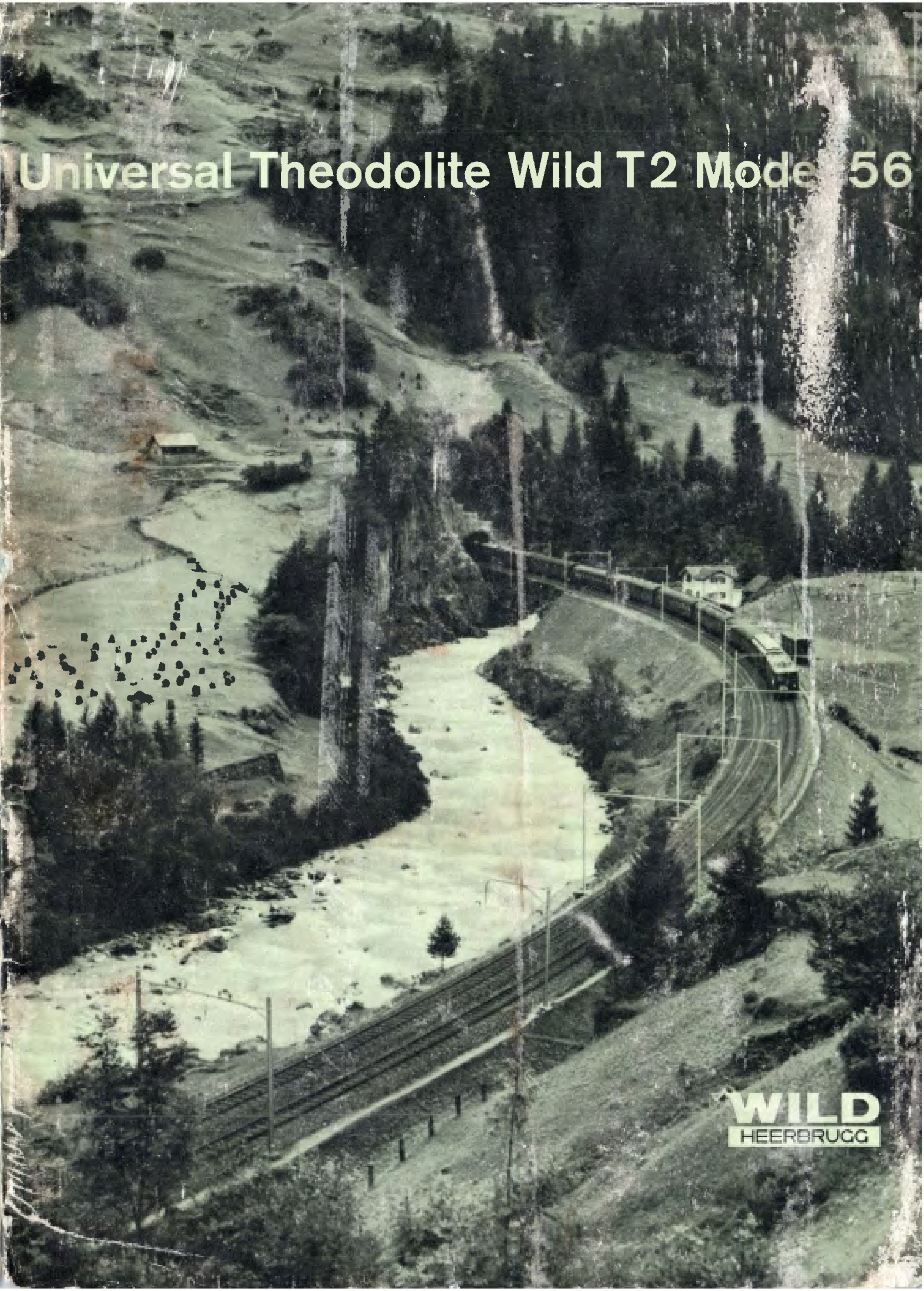
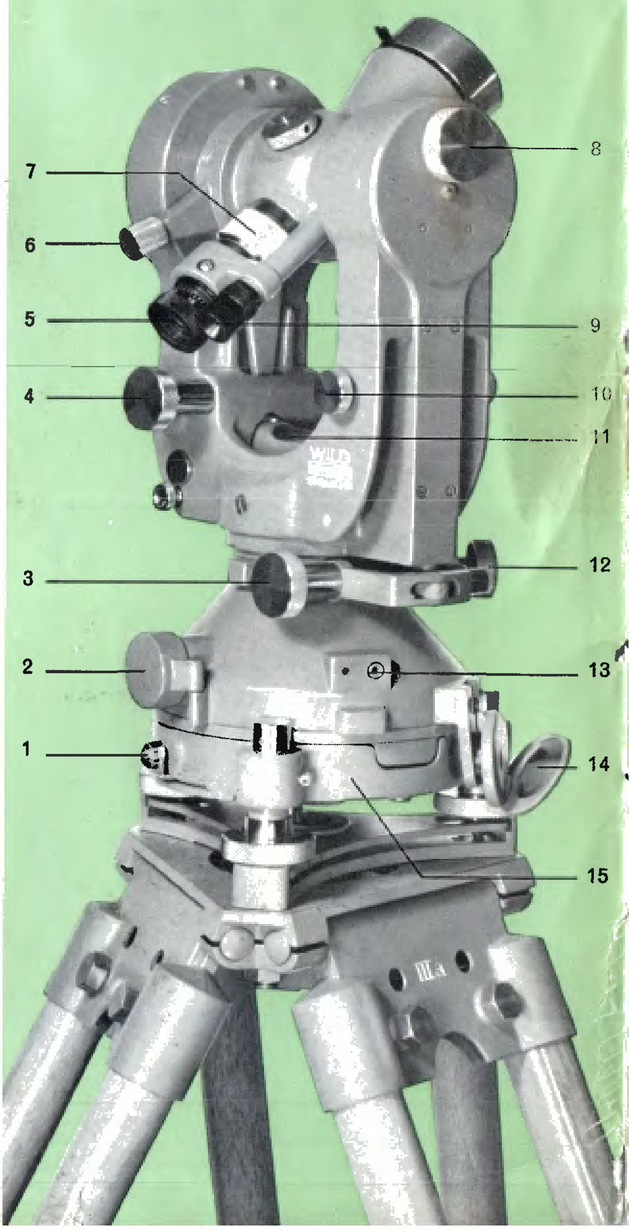
# Universal Theodolite Wild T2 Model 56



# Universal Theodolite Wild T2 Model 56 with detachable Tribrach

The Wild T2 Universal Theodolite has found a wide use all over the world owing to the ingenious simple construction of the instrument and the great care taken during all stages of manufacture to produce a precision theodolite distinguished by its outstanding resistibility.
The steadily growing sollicitations of use at extreme temperatures have led us to utilize as far as possible metals with similar thermal expansion. Thus the instrument has an excellent stability and is no more sensible to great jumps in temperature. The removable tribrach increases the accuracy of the automatic centering when working with the subtense bar and the targets.




1 Spring lever of tribrach clamp
2 Circle setting knob (under protecting cap)
3 Tangent screw for azimuth
4 Tangent screw for altitude
5 Eyepiece for telescope
6 Clamping screw for altitude
7 Ring for focussing telescope
8 Optical micrometer knob
9 Eyepiece for reading microscope
10 Inverter knob
11 Plate level
12 Clamping screw for azimuth
13 Electric light socket
14 Illuminating miror for horizontal circle
15 Tribrach

Cover-illustration:
Photo-service Swiss Federal Railways

## Contents

# Technical Data of the T2 Model 56

## Telescope

| | | |
|---|---|---|
| Magnifying power | 28 × | |
| Overall length | 148 mm | (5 3/4 in.) |
| Free lens-diameter | 40 mm | (1 5/8 in.) |
| Field at a distance of 1000 ft. | 29 ft. | |
| Reach | 10–20 km | (6–12 miles) |
| Shortest sight distance | 1,4 m | (4 1/2 ft.) |
| Largest sight distance for reading cm | 300 m | |
| Largest sight distance for estimating mm | 140 m | |
| Multiplication constant | 100 | |
| Addition constant | 0 | |

## Glass Circles

| Glass Circles | 360° | 400$^g$ |
|---|---|---|
| Horizontal circle-diameter | 90 mm | (3 1/2 in.) |
| Vertical circle-diameter | 70 mm | (2 3/4 in.) |
| Graduation of both circles | 20′ | 20$^c$ |
| Graduation of the micrometer circle | 1″ | 2$^{cc}$ |
| Accuracy of the circle readings | 0,4″ | 1$^{cc}$ |

## Levels

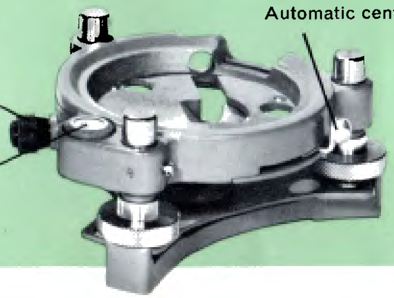
| | |
|---|---|
| Sensitivity of the plate level | 20″ for 2 mm |
| Sensitivity of the circular level | 8′ for 2 mm |
| Setting accuracy of the vertical circle level | 1″ |

## Extent of delivery

| | | |
|---|---|---|
| Theodolite 360° or 400$^g$ | 5.6 kg | (12 3/8 lbs.) |
| Container | 2.1 kg | ( 4 5/8 lbs.) |
| Tripod III a | 5.6 kg | (12 3/8 lbs.) |
| or III b | 6.4 kg | (14 1/8 lbs.) |

### The Tribrach

**The automatically controlled centering.** The theodolite is supplied with a detachable tribrach to which it is securely fastened by a special clamping device in such manner that the instrument cannot possibly fall down. By unlocking the clamp the theodolite can be removed from the tribrach and replaced by a target of the traverse equipment or invar subtense bar (automatic centering).
The targets and stadias for the automatic centering of the previous T2 model can also be used for the new model 56 on condition that the tribrach of the T2 model 56 is supplied with the suitable removable base plate.




The T16 and the corresponding targets are also suitable for use with the tribrach of the T2 model 56.
The foot screws of the tribrach are adjustable in run and enclosed dust-tight.

# Features of the T2 Model 56

**The optical plumb.** The tribrach is fitted with a built-in optical plumb, which makes centering of the instrument over the terrain point possible even under difficult conditions, such as strong wind. The image in the eyepiece is true to the original image. This is important for directly moving the tribrach on the tripod plate in the proper position without loosing time by experiments.

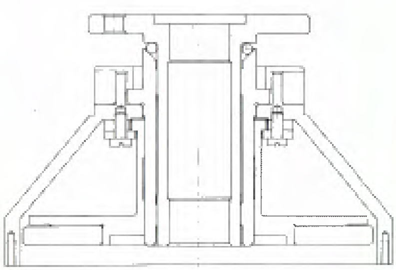
**The circular level.** The circular level mounted on the rim of the tribrach allows the quick pre-levelling of the instrument and is particularly useful for centering with the optical plumb.

### The Lower Part of the Theodolite

**The vertical axis.** The vertical axis system consists of the axle bush and the vertical axis turning therein on ball bearings, which is automatically centred by the weight of the instrument.
This arrangement has the advantage to reduce service to a minimum and to meet the heaviest duty requirements in excellent manner. It is actually the feature in high measure responsible for the dependable operation of the T2 under extreme climatic conditions.

**The horizontal circle.** This glass circle is mounted on the outer side of the axle bush and is well protected by the casing surrounding the lower part. The horizontal circle is orientated as desired by drive knob.

**The illumination.** The light necessary for reading the horizontal circle is introduced into the instrument by means of an adjustable mirror fixed to the conical base. The artificial illumination required at night or in tunnels is supplied by an electric lamp replacing the mirror. The holder is connected to the socket on the cone by wires mounted inside the instrument. The holder on the alidade for mounting the mirror or the electric lamp for the illumination of the vertical circle is connected to the same socket over slidecontacts.


1


2

Explications of the above illustrations

1 Vertical axis-system

2 Horizontal circle

3 Alidade

4 Telescope of T2

## The Alidade

The alidade is the movable part of the instrument that is screwed to the flange of the vertical axis. It consists of the supports, the level, the horizontal axis, the telescope and the vertical circle, together with the circle reading-device comprising the optical micrometer and the microscope.

**The horizontal axis.** The steel axle is mounted in bearings mounted on the top of the two alidade supports. It is supplied with two concentrical ground axle rings onto which a striding level can be fitted.

**The control knobs.** All control knobs for adjusting the instrument are arranged in convenient manner on the alidade. They are dimensioned in such manner to be readily operated even under difficult observation conditions.

**The telescope.** The telescope of the T2 has an overall length of 148 mm (5¾ in.) and can be reversed both from the objective and the eyepiece end. Notwithstanding the shortness of the telescope it proved possible to practically eliminate the chromatic aberration. By a reflex-reducing coating of the lenses the brilliancy of the image has been greatly improved, which proves advantageous at weak illumination. The excellent resolving power of the telescope is particularly valuable for the observation of distant faintly visible signals and small stars.

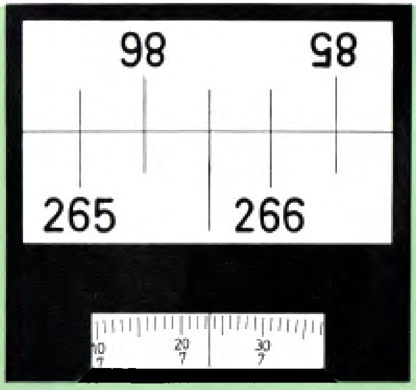
**Reading the circles.** The readings are made in the T2 with the microscope mounted adjacent to the telescope eyepiece. The coincidence adjustement of diametrical graduations is effected in fully satisfactory manner under all conditions. This is mainly due to the precise and simple construction of the optical micrometer.

3

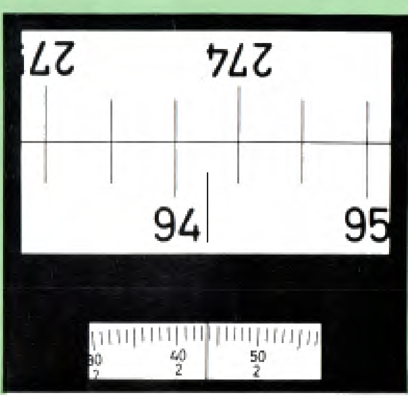
4

**The plate level.** For the exact levelling of the T2 the plate level mounted in the middle between the two supports of alidade is employed. This central arrangement allows the observation of the bubble equally well in both telescope positions and furthermore prevents the running away of the bubble on turning the alidade.

**Horizontal circle 360°**



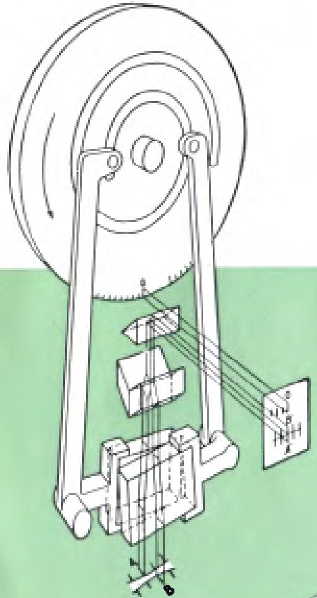

# Reading Examples

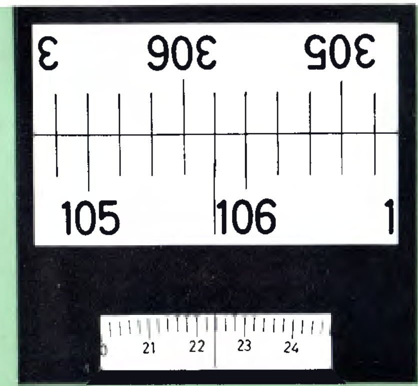


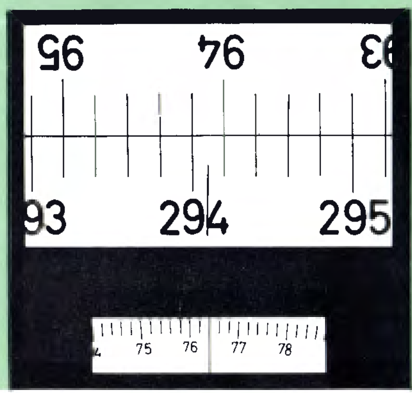

Above: circle reading 265° 47′ 23.4″

Below: circle reading 94° 12′ 43.6″

**Vertical circle 400$^g$**






Above left: Diagram of the optical micrometer

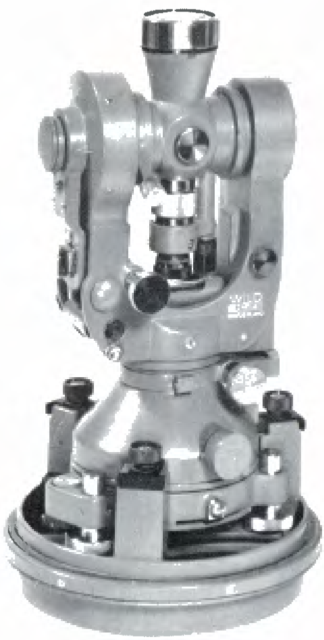
Above right: Optical micrometer of the T2

Left: Path of the light rays through the optical system of the T2

| | | |
|---|---|---|
| Above: telescope pos. I | | 105,8224$^g$ |
| Below: telescope pos. II | | 294,1764$^g$ |
| | I = | –5,8224$^g$ |
| | II = | –5,8236$^g$ |
| | medium = | –5,8230$^g$ |

## The Packing of the Theodolite

The T2 is packed water- and dust-tight in a metal case consisting of a base plate and a hood. This packing affords the best possible protection of an instrument already highly resistant to knocks and shocks by virtue of its robust construction. The theodolite T2 is therefore not affected by difficult transport conditions, great heat or cold.



For use at extreme temperatures the instrument is lubricated with special oil and grease.

The qualities characterizing the universality of the T2 are made apparent in the following description of the manifold applications in astronomy, geodetic surveying and industry.

## Determination of Time and Latitude

**The measurement of zenith distances.** All usual methods for the determination of time and latitude based on the measurement of zenith distances can be employed. The T2 is particularly suitable for measuring circum-meridian zenith distances. If desired, the telescope can be supplied with a special built-in reticle having several ruled horizontal lines.

**The corresponding zenith distances.** For carrying out the methods of corresponding zenith distances with one east and one west star for the determination of time and one north and one south star for the determination of latitude, a Horrebow level can be screwed on the vertical clamp. Thereby small differences in the tilt of the telescope can be measured or corrected.
However, the true Horrebow-Talcott method cannot be used for the reason that it requires an eyepiece micrometer.

**The astrolabe.** For determination of time and latitude the astrolabe can be fitted to the objective of the telescope. This instrument has the advantage to make the observation simple, on the other hand it has the drawback to necessitate a considerable amount of office work tor the planning of the star programme and the calculation of the final data.

# Use of the T2 Model 56 in Astronomy

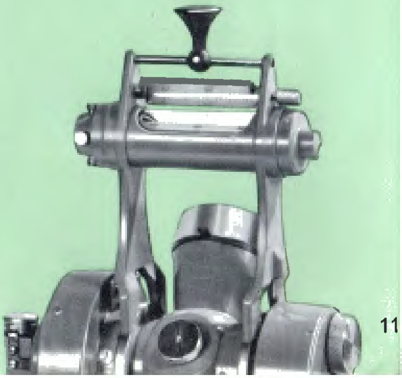
**Accuracy of measurements.** With the T2 the accuracy achieved in a few observation hours with the methods mentioned above is as follows:

The figures designate mean (square) errors. The probable error is 2/3 of the mean error.

| | |
|---|---|
| Latitude | ± 1″ resp. ± $3^{cc}$ |
| Sidereal Time | ± 0.1 seconds of time |

## Azimuth Determination

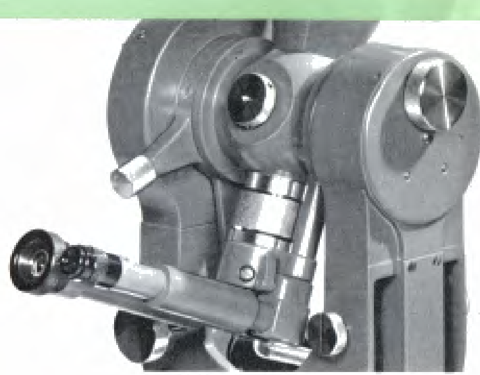
It is advantageous to employ the striding level for the accurate adjustment of the vertical axis and the measurement of the inclination of the horizontal axis. Before use of the strid-



ing level the two support rings on the horizontal axis must be deprived of the lacquer coating. We recommend customers to order the striding level together with the theodolite, or to send the instrument for adjustment to our works. In most cases the horizontal angle between the polar star and the object to be determined is measured. This method is however not applicable for low latitudes. In such case stars in the East and West near the 1st

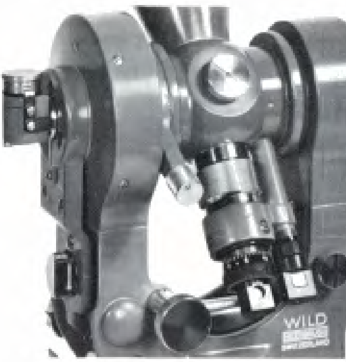
## Accessories for Astronomical Observations

**The electric illumination.** For successful astronomical observations a fully satisfactory electric illumination is very important. For



night illumination a plug socket is mounted on the conical base of the theodolite for connecting the battery case fastened to the tripod. The two mirrors are replaced by the two lamps, connected by cables inside the instrument to the plug socket. By means of the knob, which turns a small mirror inside the telescope tube, the light projected to the reticle can be adjusted.

vertical are observed. For large zenith distances the stars move only showly in the azimuth direction. The T2 allows the determination of the azimuth with an accuracy of $\pm$ 1″ to 2″ resp. $\pm$ $3^{cc}$ to $6^{cc}$, according to the latitude.



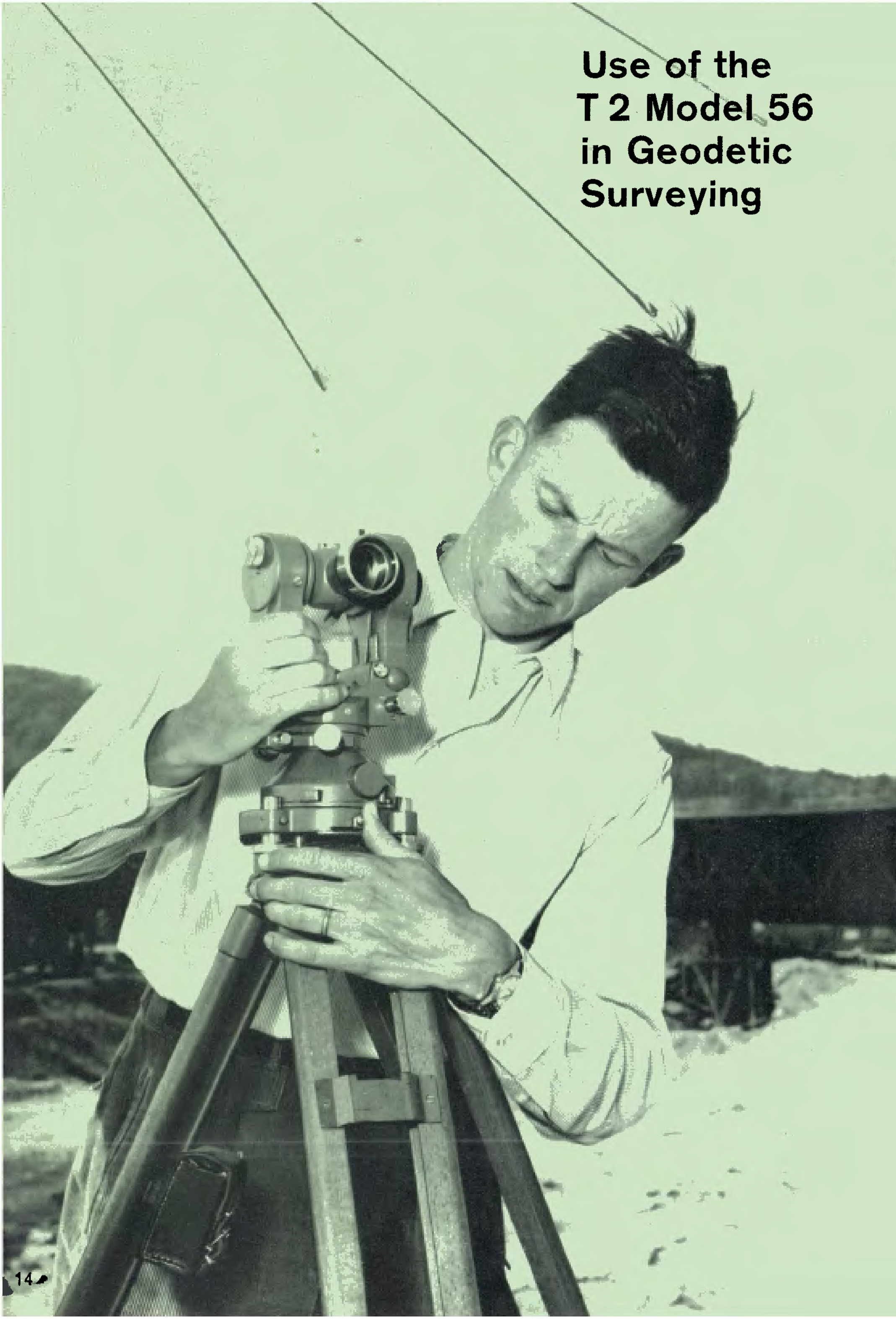

**The eyepiece prisms.** In most cases astronomical observations need steep lines of sight. For sights up to 60° above the horizon eyepiece prisms can be screwed to the telescope and the reading microscope.

◄ **The diagonal eyepieces.** For sights up to the zenith diagonal eyepieces can be attached to the telescope and reading microscope instead of the standard eyepieces.

**The sun glasses.** For observations of the sun the eyepiece of the telescope must be supplied with a dark glasse. For time and latitude determinations with the sun only measurements of the zenith distance are practicable and this near the $1^{st}$ vertical for the time and close to the meridian for the latitude. Azimuth determinations are usually made in the morning and evening.

**The polar attachment.** For rapid orientation with an accuracy of minutes on the northern hemisphere the polar attachment can be slipped over the telescope objective. It determines the North direction and the latitude with an accuracy of one minute of arc and the local sidereal time with an accuracy of one minute of time.

# Use of the T 2 Model 56 in Geodetic Surveying



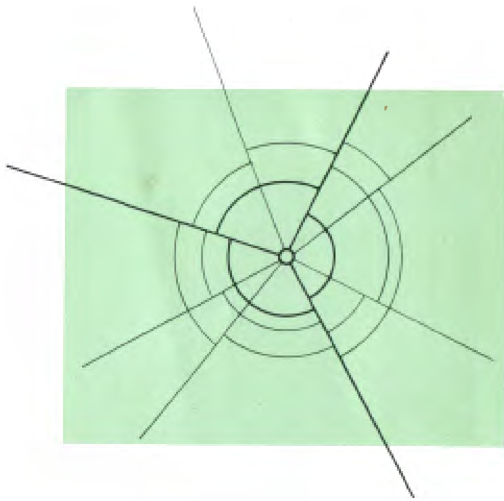
## Triangulation

The Wild T2 Universal Theodolite has an accuracy of single seconds and is suitable for triangulations with side-lenghts up to 15 km (9 miles). The telescope with a clear objective aperture of 40 mm ($1^5/_8$ in.) and a magnifying power of 28 permits the dependable observation of trigonometric points with suitable targets up to a distance of 20 km (12 miles), and much further against signal lights at night. The electric illumination of the instrument facilitates exact circle readings. Usually the theodolite is mounted on

the tripod IIIa (fitted with rigid legs). For observations from pillars a cast iron base plate with centering pin can be supplied.

**Measuring sets of angles.** This method is frequently used in triangulation work, particularly when the number of directions to be measured is not too large, the visibility on all sides satisfactory, and the firm setting of the tripod possible. Although observation pillars provide a particularly firm base, the tripod IIIa is fully satisfactory on solid ground.

**Measuring single angles.** The measurement of single angles is preferable when the observation conditions are variable. It is often advantageous to employ the sector method in which some 3 to 4 favorably located sectors are measured first and subsequently the angles within these sectors.



The T2 has exceedingly small errors in the circle graduation and the accuracy can be further increased by repetition. For repeated angle determinations the horizontal circle should be displaced each time by the value of the previous measurement.

**Measuring vertical angles.** The vertical circle is oriented in the instrument in such manner that the zenith distance can be read directly by sighting the target in the telescope position I (vertical circle on the left). By using a coincidence level for the vertical circle it can be adjusted rapidly with high accuracy. For accurate measurements each angle is determined in both positions of the telescope and the measurements I and II must follow each other immediately for obtaining an accuracy of 1 to 2″.

## Traversing

The high precision and the light weight of the T2 model 56 makes the instrument eminently suitable for the measurement of traverses and this particularly with the automatic centering control by means of 3 tripods and 2 targets, each mounted in a tribrach of T2.

For carrying out series of traverse measurements each of the three tripods is set on a traverse point and a tribrach mounted on each tripod and centered over the point. The two outer tripods have targets mounted in their tribrach supports, the theodolite being fixed to the middle tribrach. After having measured the angle, the two targets and the theodolite are removed from their tribrach, carried forwards to the next traverse point and set again in the free tribrach. The front target can only be mounted and centered over the next station point, after the last tripod with its tribrach has been brought forward.

Target of invar subtense bar

Target of traverse equipment
with tribrach of T2

Target of traverse equipment on tripod III a with electric illumination

The side-lenghts can be measured with the subtense bar mounted in a tribrach.

The complete traversing equipment comprises:

1 T2 model 56 with tribrach, tripod and container

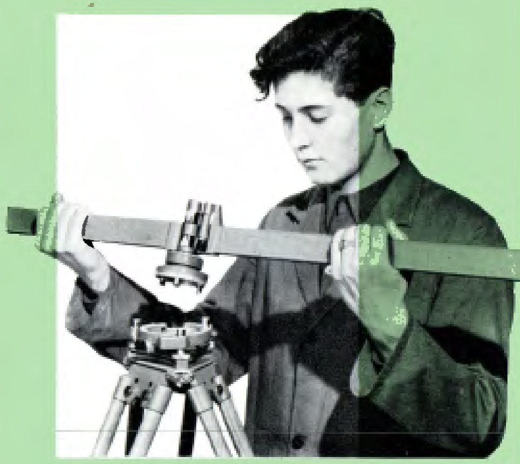
2 Targets, each with tribrach and electric illumination, in wooden case

2 theodolite tripods (additional) and if required

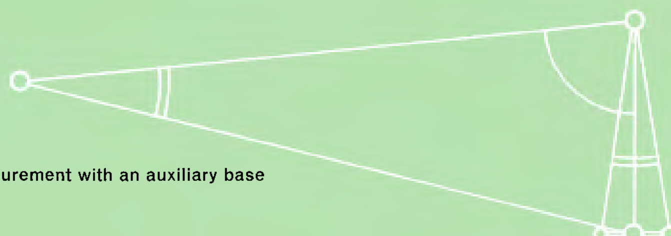
3 battery cases

◄ **Distance measurement with the invar subtense bar.** The T2 in combination with the invar subtense bar is eminently suitable for distance measurements of various types. The subtense bar is a collapsible tube to be mounted horizontally on the tripod of the theodolite and provided with two measuring marks maintained at a distance of exactly 2 m from each other by means of an invar wire freely suspended inside the tube and stretched by two springs. The measuring marks can be illuminated from the back and the necessary cables are mounted inside the tube, which is supported in the middle by a demountable tribrach exactly conforming to the theodolite tribrach. By the aid of a small sighting telescope the invar subtense bar is adjusted to a position at right angles to the line of sight. The horizontal angle formed between the two measuring marks is determined with the T2 and the horizontal distance from the instrument to the subtense bar can be read from the supplied table.
The accuracy of the measurements made with the subtense bar is reduced in a ratio square to the distance measured. For short distances the measurements are highly accurate. Assuming an angle measuring error of 1″ (= $3^{cc}$), the error in distance would be, for 50 ft.: 0.02 inch, for 100 ft.: 0.09 inch, for 200 ft.: 0.36 inch, for 500 ft.: 2.22 inch, for 1000 ft.: 8.88 inch.

However, by measuring a distance of 1000 ft. in 10 parts of 100 ft., the total error would be reduced to only ± 0.28 inch apart from small centering inaccuracies. For large distances highly accurate measurements can be achieved thereby that an auxiliary transverse base is determined with the subtense bar and the angle between the ends of the auxiliary base measured at the other end.

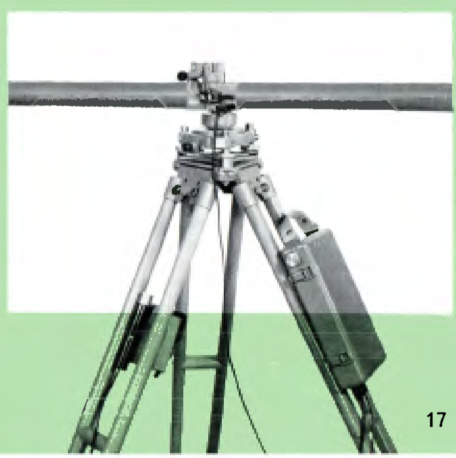


Mounting the invar subtense bar on the tribrach



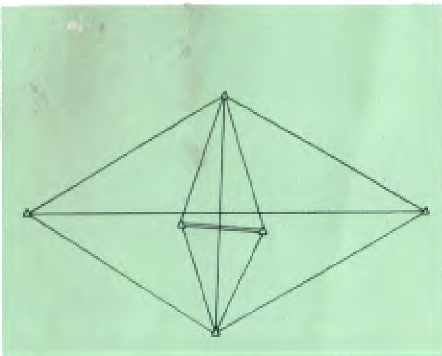
Distance measurement with an auxiliary base

Invar subtense bar with electric illumination



In such manner even the base line for a small independent triangulation can be determined. It is apparent that the combination of theodolite and subtense bar is eminently useful for solving numereous survey problems.

**Distance measurement with the reticle stadia lines.** The reticle of the telescope is supplied, in addition to the cross hairs, with two short horizontal lines above and below the horizontal middle line and two equally

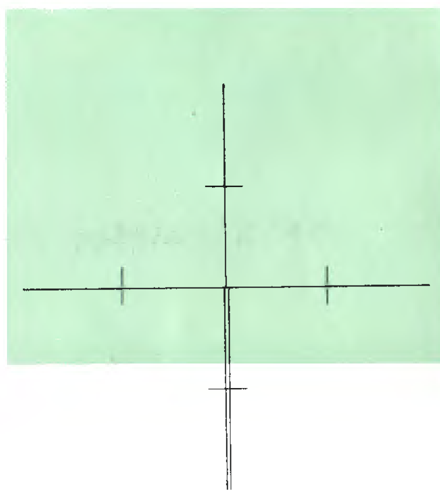


short vertical lines on the left and the right of the vertical middle line.
These lines allow distance measurements with a vertical or a horizontal graduated staff. They define on the scale of the staff an intercept of a length corresponding to the hundreth part of the distance from the theodolite to the staff, on condition that the telescope is in the horizontal position. By reading centimetres on the staff the distance is obtained in metres. However, this demands the vertical staff to be truly perpendicular and the horizontal staff to be truly level and at right angles to the direction from the instrument to the middle between the two sighted staff graduations.
Should the telescope be tilted the read intercept is too large and requires reduction. If the zenith distance of the vertical circle is z, the intercept measured with the vertical staff must be multiplied with the factor $\sin^2 z$ and the intercept measured with the horizontal staff with the factor $\sin z$. Such distance measurements with the T2 have an accuracy of $\pm$ 10 cm for a distance of 100 metres.

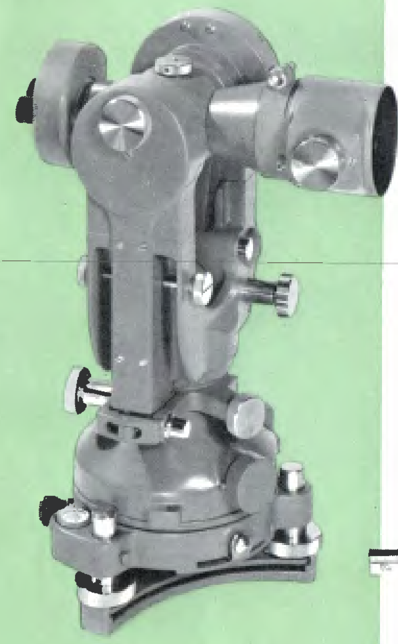
Should the distance measurement be part of a topographic survey, the direction to the staff is read to an accuracy of 1 minute on the horizontal circle without using the optical micrometer.

Left: Base line with annexed triangulation

Below: Reticle plate of the T2 telescope

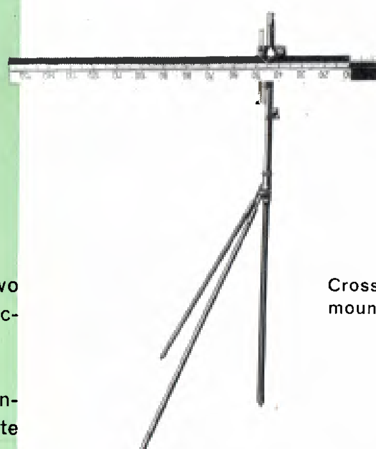


**The precision telemeter DM1.** This device is slipped over the telescope objective and a counterpoise fastened to the other end of the telescope. The normal equipment comprises 2 cross-rods and 2 staffstands, so that during measurements on the one cross-rod the other can be mounted on the next point.



The telemeter supplies in the telescope two overlapping images that are laterally displaced to each other.

The image displacement amounts to the hundreth part of the distance from the theodolite to the rod. By means of the vernier and the optical micrometer the distance can be read in metres with an accuracy of single centimetres. For obtaining the horizontal distance, the scale value must be multiplied with sine of the zenith distance read on the vertical circle. For a distance of 100 m the accuracy is 1 to 2 cm, on condition that the air is calm. The measuring range of the telemeter is about 100 m, and under favorable conditions as much as 150 m.

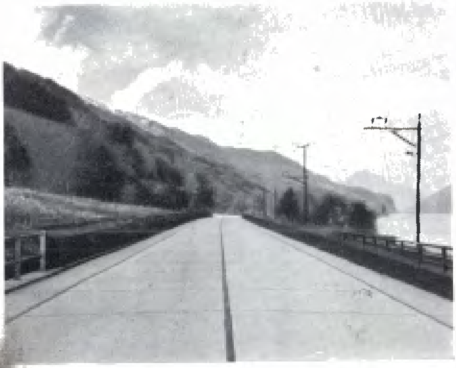


Cross-rod for DM 1
mounted on staff-stand

**[illegible] out straights.** For such work the [illegible] circle is seldom employed. It is [illegible] to repeat directions from back- [illegible] forwards by turning the telescope [illegible] horizontal axis. This transitting [illegible] be carried out in both telescope positions [illegible] small collimation errors can be [illegible] avoided. By beginning the back sight one [illegible] in telescope position I (vertical circle [illegible] left) and another time in telescope position II (vertical circle on the right) the fore sights supply two different points and the middle between these points is on the straight to be determined.

**Staking out curves.** The high accuracy of angle measurements made with the T2 allows the use of all usual methods based on the measurement or the staking out of angles. The most advantageous are those in which a larger number of directions are to be determined from a single station. Insofar as the distance measurements need not to be of high accuracy they can be measured on a vertical staff by means of the stadia lines of the telescope. If the sighting direction is inclined to the horizontal by the angle $\beta$, the read scale intercept must be reduced by multiplication with the factor $\cos^2\beta$, for which purpose a topographical slide rule can be employed.

For more exact distance measurements up to 50 m the steel tape is used. Large distances are measured optically with the precision telemeter DM 1 and a cross-rod, whereby an accuracy of 1 to 2 cm per 100 metres can be achieved under good observation conditions. For inclined sighting the values obtained must again be reduced by multiplication with the factor $\cos\beta$, for which a slide rule or a trigonometric table can be used.



**Staking out tunnels.** The direction of the tunnel must be determined with great care at both ends. For short tunnels it mostly suffices to establish a connection to an accurately measured outside traverse of the terrain, but larger projects demand a dependable triangulation. Such requirements can nearly in all cases be met with the T2. However, long tunnels under mountains make an elaborate triangulation survey often necessary for which a high precision theodolite is indispensable for observation at distances of 20

and more kilometres (12 and more miles). Such work must be done under control of an experienced geodetical surveyor.
As soon as the construction period amounts to several months or even years, the necessity arises to carefully secure the main direction points in front of the tunnel portals in such manner that alterations in their position can be readily ascertained at any time.
The staking out of a tunnel is effected in two stages, the preliminary survey and the check survey. The alignement of the tunnel axis is secured as early as practicable in the first stage by marks in the form of bolts fixed to the roof of the tunnel. The setting of these ridgebolts is adjusted by direction reporting with the theodolite in both positions.
The check survey must be repeated periodically and consists of traverse measurements over large distances. For reducing errors as far as possible it is advantageous to employ the traversing equipment with automatic centering control comprising the theodolite, 3 tripods, 2 targets and the electrical illumination outfit. For the check survey a detailed observation program must be prepared for avoiding as far as possible interruptions of the construction work.
Distance measurements in the tunnel are usually made with steel tapes. For check measurements in the built out tunnel the invar subtense bar is, however, eminently suitable.

**Staking out mines.** For such purpose a special electric illumination is available that is flame-proof (fire damp) with the use of the standard battery case supplied with a lock. This precaution prevents the unauthorized opening of the battery case in the mine.
For mine surveys the traversing equipment with automatic centering control is particularly useful. The check points are marked by bolts cemented into the roof of the galleries, which are mostly supplied with hooks for the plummet. For centering below the ridgebolts the T2 telescope is provided with a pointer indicating the centre of the instrument at the horizontal position of the telescope. The targets are also supplied with pointers.

Battery case with lock for flame-proof illumination of the T2 in mines

For reporting directions through shafts of a depth up to about 50 m, the rotatable pentagon prism is placed on the T2 objective. This replaces the theodolite with eccentric telescope formerly used for such purpose.

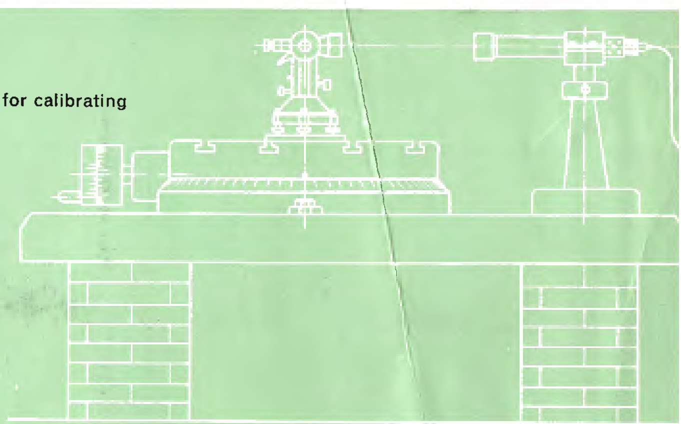
For the accurate testing of the perpendicularity an optical plummet is available, which can be placed in the tribrach of the theodolite without disturbing the centering.

# Use of the T2 Model 56 in Industry

The T2 is particularly suitable for measuring the angular displacement of small and large rotary tables with high accuracy, as its light weight permits the use of the instrument practically everywhere. The T2 is placed centric on the rotary table, and independent of the table a collimator at the height of the telescope of the theodolite.

The collimator consists of a telescope without eyepiece, focussed to infinity, with illuminated reticule, and with the objective directed towards the theodolite. By setting the theodolite telescope, also focussed to infinity, to the objective of the cross mark is made visible and can the same as a point at an infinite d. The telescope of the theodolite is po. the collimator and the horizontal circle The the rotary table together with theod. is turned in a measure read on the ro table, the theodolite again pointed at the c limator and the horizontal circle read. The difference of the two circle values is the exact angle of displacement for comparison to the measure read on the rotary table and for its correction.

Arrangement of T2 and collimator for calibrating the graduation of a round table



**This is an example of the various uses for the T2 for exact industrial measurements. The experts of Wild Heerbrugg are always ready to advice to clients for the satisfactory solution of such problems.**

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Optical Precision Instrument Makers
Phone (071) 7 24 33
Cables: Wico Heerbrugg