INSTRUMENTS

WILD GEODETIC AND TOPOGRAPHIC INSTRUMENTS
exhibited during the IVth International Hydrographic Conference, Monaco, 1937.

The instruments exhibited by the Henry WILD Surveying Instruments Supply Co, Limited, Heerbrugg, Switzerland, constitute a single well-thoughtout series. Each of them is the fruit of careful study based on an exact knowledge of the requirements of practice and on a long experience of instrument-construction. No new model has been passed for manufacture without first making absolutely certain that its design embodies the maximum of mechanical and optical excellence, thus insuring that it will be capable of achieving the utmost that can possibly be demanded of it.

The fundamental principle that all operations at the instrument should be capable of being carried out without the observer having to move from the sighting position is strictly followed, even in the smallest and simplest instruments of the WILD construction. All walking round the instrument in order to level it or to read the circles is thus avoided. Furthermore, by careful selection of the materials used in their construction, and by the adoption of compact forms capable of offering great resistance to outside influences, combined with the highest degree of workmanship and precision in manufacture, it has been found possible to construct instruments which require no field-adjustment.

The importance of luminosity in the telescopes of the WILD surveying instruments has been emphasized. High magnification is of no use if it has to be obtained at the expense of brightness of the image. It is not sufficient to be able to sight a distant object under exceptionally good conditions of lighting. It is necessary that pointings should be easily made in dull weather, and when the sighting-conditions are bad; and for this, luminosity is of first importance in the telescope, and magnification the second. All the WILD telescopes have internal focussing, which enables them to maintain a constant length, and offers the greatest possible protection against outside influences.

The plane-parallel glass plate has proved a very valuable means of increasing the accuracy of graduation-reading; it forms a component of the optical micrometer by which the circles are read. These micrometers are extraordinarily stable and resistant to outside influences. The micrometer of the Universal-Theodolite T 2 gives readings with an accuracy of the ten-thousandth part of a millimeter. It serves to read the horizontal and the vertical circle. The plane-parallel glass serves also to obtain fine readings with the precision telemeter, with the Barot micrometer, and with the precision level.

The reading of the circle with the WILD coincidence-micrometer is of very particular interest. The principle is the same in the Compass-Theodolite T O, the Universal-Theodolite T 2, and the Precision Theodolite T 3. A special prism-system brings the images of two diametrically-opposite parts of the circle simultaneously into view in the reading microscope, one immediately above the other with only a fine line separating the two. This arrangement gives at once the mean of the two diametral readings, without any calculation whatever; and the accuracy of readings is increased many times by the coincidence-micrometer.

In addition to the above important considerations, that of the weight of the instrument must not be lost sight of. It is remarkable that all the above-mentioned instrumental improvements have been combined with a very substantial reduction in weight, most of the WILD instruments weighing less than half as much as the corresponding instruments of the older types.

And finally, the use of metallic cases for surveying instruments is rapidly extending. Their very great superiority over the old wooden cases, in regard to durability, lightness, and complete water-tightness, has now been universally recognised.

In *Hydrographic Review,* Vol. IV, N° 2, November, 1927, pages 209 and 210, will be found the basic principles on which are developed the fundamental features of the reading system of the WILD theodolites.

In *Hydrographic Review,* Vol. XII, N° 1, May, 1935, are also given some additional details concerning this theodolite and on the lay-out of the Barot micrometer.

The same volume gives, page 55, a method of adaptation to the WILD theodolite of an horizontal-axis prism in order to transform it into an astrolabe.

Hereunder is an enumeration of the levels and theodolites exhibited at Monaco during the IVth International Hydrographic Conference.

THE WILD LEVEL SERIES.

— Small WILD level N° I, with or without horizontal circle.
— WILD level N° II, with or without horizontal circle.
— Large WILD precision level N° III.

In designing these levelling-instruments, the aim has been to construct a series of as few models as possible capable of covering the entire field of levelling-operations. The aim was achieved in the three above-figured instruments, each of which is capable of one of the usual degrees of precision and is suitable for a wide range of work. Careful mass-production allows of their being sold at the same price as ordinary levels, notwithstanding their great superiority.

The average error in a single line of levelling over a distance of a mile is as follows :—

Level I $\pm$ 1/4 inch.
Level II $\pm$ 1/8 inch.
Level III $\pm$ 1/80 inch.

The levels I and II are also supplied with built-in glass circle.

The tubular level mounted so as to be insensitive to temperature changes is viewed through the system of WILD coincidence-prisms which considerably increases the accuracy of the setting to the horizontal. For a quick adjustment of the orientation of the vertical axis, recourse is had to a spherical level.

The vertical axes, of hardened steel, are cylindrical in form, as this form alone has been found to give a free and very durable movement without need of occasional adjustment.

SMALL WILD LEVEL N° I, with or without horizontal circle.

For architecture, foundation work, road and railroad construction, irrigations, water works, etc.

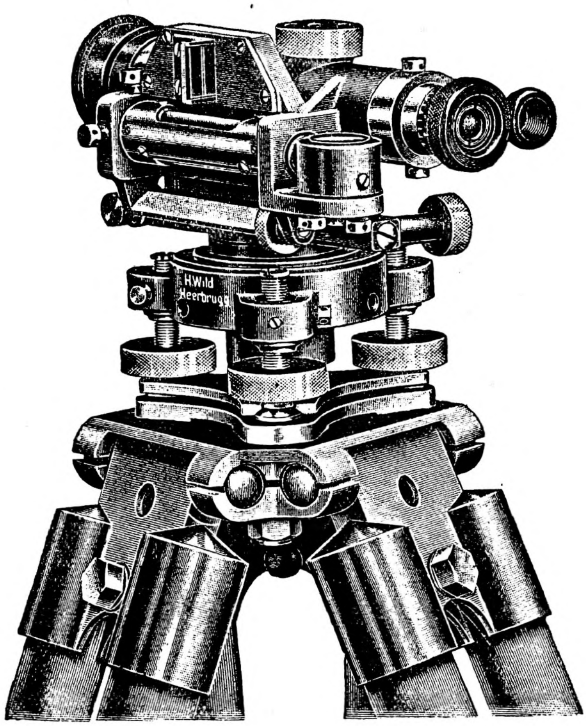


FIG. 1. *Small* WILD *level N° I,*

Attainable accuracy : ± 1/4 inch in a mile of single levelling.

Clear aperture of object-glass	1	in.
Length of telescope	6 1/4	in.
Magnification of telescope	18 ×	
Shortest focussing distance	5	feet
Longest distance for the reading of 0.4 inch.	240	yards
Longest distance for the estimation of 0.04 inch.	109	yards
Stadia-lines 1 : 100, Addition-constant	0	
Sensitivity of spherical level	8'	
Sensitivity of tubular level	40"	
Coincidence-adjustment of tubular level accurate to	1"	
Weight of instrument, approx.	3 1/4	lbs.
Weight of steel case, approx.	2 1/5	lbs.
Weight of tripod	10	lbs.

The spherical level is used for the general setting of the instrument. The tubular level is used solely for the accurate setting to the horizontal immediately before the reading of the levelling-staff. The bubble of this level is viewed through the WILD prism-system which gives two images of it to be brought into coincidence. The accuracy which this device allows is at least four times greater than that obtained by the placing of a bubble between reference marks. The level-mount and body of the telescope are formed of a single casting, so that the adjustment is invariable provided no violent jerking of the cell-mount occurs.

The resistance to motion of the 3 foot-screws can be regulated.

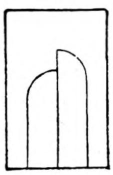
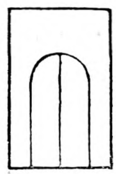
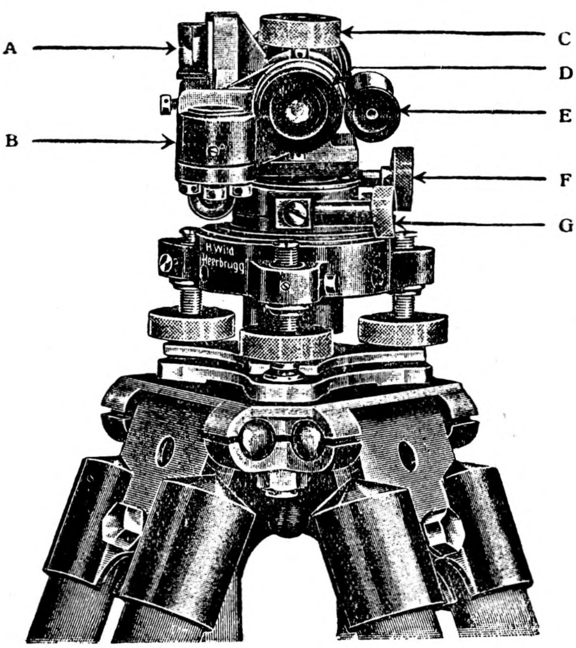


Fig. 2. *Level-bubble.*



(coïncidence)

In Level I with glass circle, the horizontal angle is read in a fixed micrometer microscope the eyepiece of which is located against that of the telescope. Circle-division 360° or 400g. Graduation-interval of scale 10'; readings can be made by estimation to 1' with certainty. The tripods IIa and IIb for the level with circle have their securing screw provided with a hook for the plumb-line.



A. *Image of bubble.*

B. *Spherical level.*

C. *Focusing head.*

D. *Eye-piece of telescope.*

E. *Eye-piece for reading circle.*

F. *Azimuth screw.*

G. *Azimuth clamp.*

Fig. 3.

Small WILD *level N° I, eyepiece side.*

WILD LEVEL N° II, with or without horizontal circle.

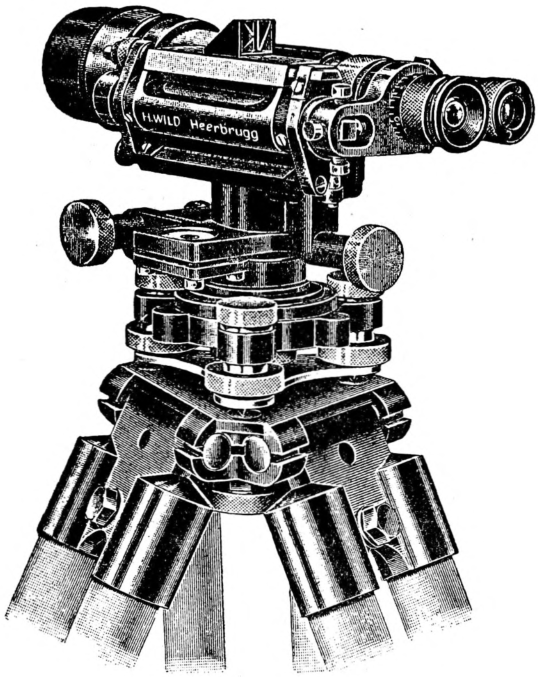


Fig. 4. WILD *Level N° II with horizontal circle* (Scale 4/11).

Suitable for levelling work, road, bridge, tunnel construction, engineering, water works, etc.

Attainable accuracy : ± 1/8 inch in a mile of single levelling.

Clear aperture of object-glass	1 9/16 in.
Length of telescope	6 7/8 in.
Magnification of telescope	24 ×
(if desired	28 ×)
Shortest focussing distance	7 feet
Longest distance for the reading of 0.4 inch.	0
Longest distance for the estimation of 0.04 inch.	327 yards
Stadia-lines 1 : 100. Addition-constant	153 yards
Sensitivity of spherical level	8'
Sensitivity of tubular level	20"
Coincidence-adjustment of tubular level accurate to	1/2"
Weight of instrument, approx.	4 2/5 lbs.
Weight of steel case, approx.	3 1/4 lbs.
Weight of tripod	10 lbs.

The very short telescope gives a particularly sharp and clear image. Focussing effected by means of a lens inside the telescope and on the position of which one acts by turning a milled ring concentric with the axis of the telescope; the telescope is completely water- and dust-tight. Azimuth orientation by means of azimuth clamp and azimuth screw. The latter is contained in a water-and dust-tight mount; its resistance can be regulated.

LARGE WILD PRECISION LEVEL N° III.

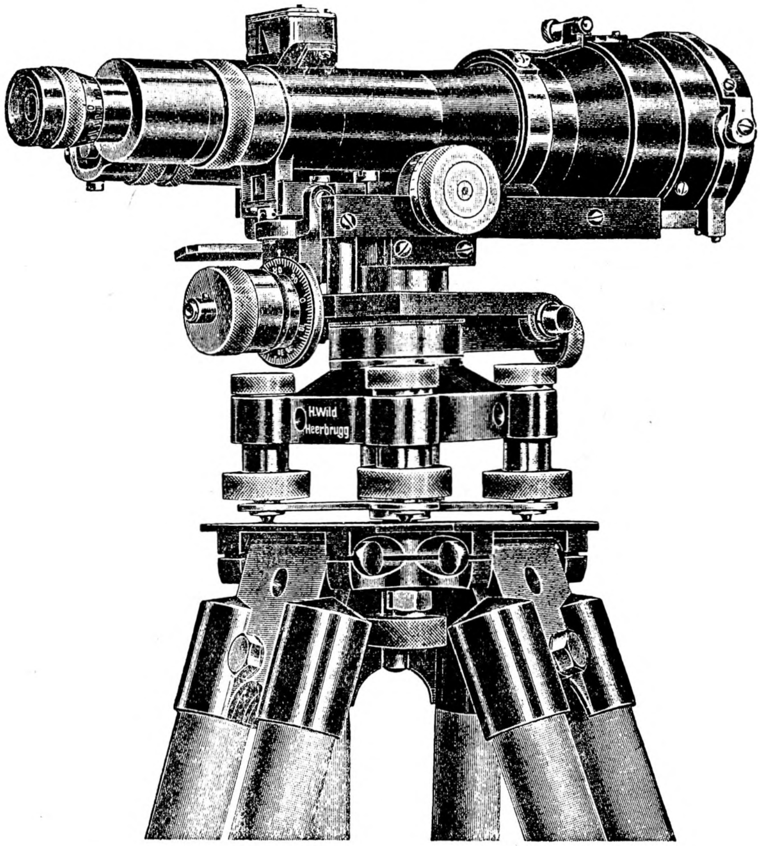


Fig. 5. *Large* WILD *precision Level N° III, with plane-parallel glass plate* (Scale 2/5).

Suitable for high-precision levelling, bridge construction, measurement of deformation, erecting of heavy machinery (turbines, dynamos, etc.), embankment subsidence measurements, etc.

Attainable accuracy, using the plane-parallel plate and the WILD invar staff : ± 1/80 inch in a mile of single levelling.

Clear aperture of object-glass	2 in.
Length of telescope without plane-parallel plate	9 1/2 in.
Length of telescope with plane-parallel plate	10 5/8 in.
Magnification of telescope	36 ×
Shortest pointing distance	14 feet
Longest pointing distance allowing the reading of 0.4 inch.	490 yards
Longest pointing distance allowing the estimation of 0.04 inch.	218 yards
Stadia-lines 1 : 500	
Sensitivity of circular level per 1/12 in. (2 mm.)	8'
Sensitivity of tubular level per 1/12 in. (2 mm.)	6"
Tubular level : Coincidence-adjustment accurate to	0,15"
Weight of instrument without plane-parallel plate	7 lbs.
Weight of instrument with plane-parallel plate	7 3/4 lbs.
Weight of steel case	4 3/5 lbs.
Weight of rigid tripod Va	10 lbs.

The lines of the diaphragm form an angle enabling accurate pointings to be effected on the levelling-staff lines. The pointing takes place by rotation of a plane-parallel plate placed in front of the object-glass effected by turning a graduated drum.

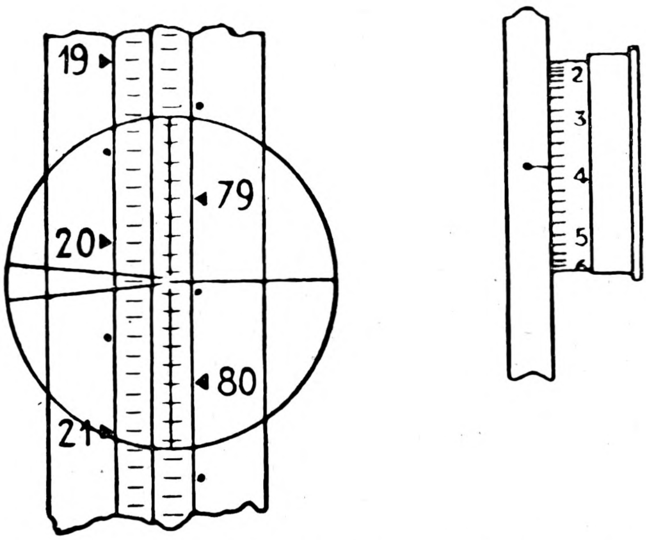


Fig. 6. *Reading on the high-precision invar levelling-staff.*

Staff ..	202
Drum ..	.38
	202.38

The maximum shifting of the sighting line is 1/4 inch. It is read off the measuring drum to within 1/40 inch.

LEVELLING STAVES.

a) *Wooden Folding Levelling Staves.*

These staves have strong adjustable hinges. They are provided with handles and their ends are protected by metal bottom shoes. The setting to the vertical is effected with reference to a removable circular level.

The graduations are simple and clear, so as to facilitate quick and sure reading from a long distance. They are furnished in lengths of 3, 4 and 5 metres. Weight 8, 10 and 12 lbs for the three respective lengths.

b) *High-precision Invar Levelling Staff.*

In levelling-operations of the highest precision, the "invar" type of levelling-staff is nowadays almost universally employed. This consists of a wooden staff, of suitable cross-section, in which is fixed a band of invar metal. The band is kept stretched by a spring and is not affected by changes of length of the wooden part of the staff. The coefficient of expansion of invar metal is practically equal to zero. The 3-metre division remains thus invariable in length whatever the temperature.

In correspondence with the application of the plano-parallel glass plate to Level III, the unit of measurement is the half-centimetre. Two mutually displaced graduations afford a check against gross error. When measuring, the staff is always set up on an iron foot-plate.

c) *Invar Subtense-Bar.*

General. — The invar subtense-bar is designed for the *indirect measurement of distances.* Whilst up to now the use of such subtense-bar required the adjunction to the theodolite of a special measuring screw, the Wild Universal Theodolite simply allows recourse to the horizontal circle of that instrument. This method was put into practice when the Wild photogrammetric outfit was invented. The results were so satisfactory that the use of the subtense-bar for the precise measurement of distances was immediately adopted. Under good conditions of observation, an experienced operator is able to measure the angle under which the subtense-bar is viewed to within 1". Thus to the use of a 2-metre subtense-bar corresponds an accuracy of 10 mm. for a distance of 64 metres. This implies of course the use of a very precise subtense-bar. If the length of the subtense-bar is determined to within 0.2 mm., the consequent systematic error is of 1 cm. in 100 metres. The length of a 2-metre subtense-bar varies by 0.5 mm. for a 20° change of temperature, which rapidly limits the conditions of employment of such instrument. Recourse had thus to be had to "invar" metal.

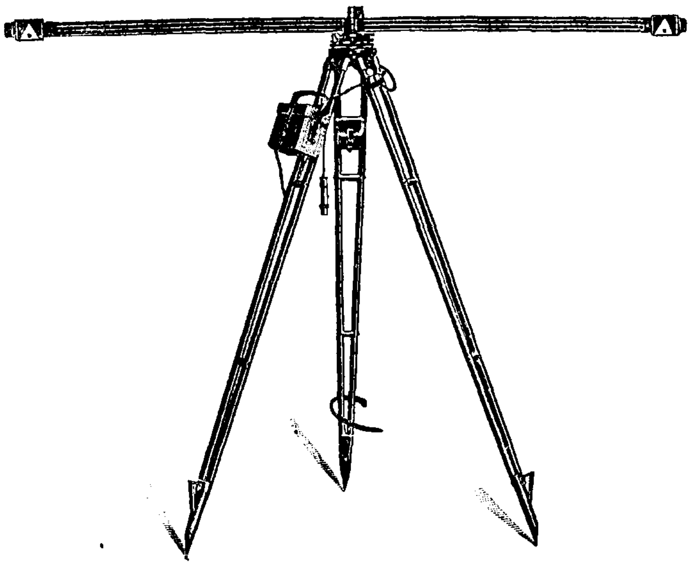


Fig. 8. *Invar subtense-bar on its tripod.*

Description of the Subtense-Bar.. — A very important new feature of this invar subtense-bar lies in the fact that it folds up, a characteristic absolutely impossible to realize with the types of invar levelling staves hitherto constructed, for instance for high-grade levelling. This outstanding advantage is particularly important for transportation.

When the subtense-bar is unfolded its two parts connected by a robust hinge are rigidly secured to one another by means of a lever fastening. Each part, formed by a tube, contains an invar wire one of the ends of which is fixed on the hinge side, the

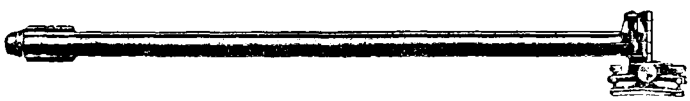
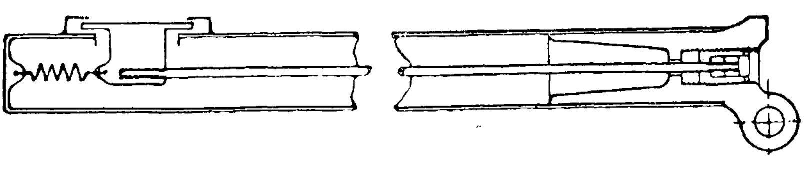


Fig. 9. *Invar subtense-bar folded up.*

other end being pulled by a spring. At the ends of the subtense-bar the wires are solid with the lining-marks; each of these lining-marks is protected by a frame in which it can move when the steel tubes expand or shrink. When the subtense-bar is folded, the openings of the frame come to rest one against the other, thus ensuring a perfect protection of the lining-marks. The wires themselves, freely suspended within the tube, cannot be deteriorated.



(internal view).

Fig. 10. *Arrangement of the invar wire inside the protection tubes.*

The sighting-marks are very carefully laid off and permit of a very accurate pointing for distances up to 700 metres. It is primarily in the case of great distances that the difference makes itself apparent as compared with the precise tacheometric device, the practical range of which is limited by the length of the divided levelling staff, this distance not exceeding as a rule 150 metres. The maximum limit of use of the subtense-bar depends solely on the precision to be obtained. Experiments carried out by Dr. ACKERL, of Vienna, (see *Zeitschrift für Instrumentenkunde*, N° 2, September, 1932) yield the following very practical formulae in which d is the distance in metres and μ the mean distance error in mm. One of the formulae is valid for distances ranging from 10 to 100 metres, the other for 100 to 350 metres and beyond; in both cases the stadia angle is supposed to be measured twice.

For d included between 10 and 100 m. we have

$$\mu \text{ (mm)} = \pm \frac{d \text{ (m)}}{4}$$

For d greater than 100 m.

$$\mu \text{ (mm)} = \pm \frac{[d \text{ (m)}]^2}{400} = \pm \left(\frac{d \text{ (m)}}{20}\right)^2$$

For measurements requiring a particularly thorough accuracy, these errors can be considerably reduced by repeating the measurement of the angle several times.

Close to the axis of the hinge is a *small telescope* the sighting axis of which is contained in a plan perpendicular to the junction line of both sighting-marks. The subtense-bar can thus be set perpendicularly to the direction of the distance to be measured.

For night work the subtense-bar can be fitted with *electric illumination*. A battery contained in a leather wallet is connected to the subtense-bar by a plug near the hinge. Two lamps illuminate each a small round window provided in each target; the centres of these windows are at exactly 2 metres from one another. As the illuminating system is identical with that of the theodolite, the same system may be used without changing the tripod when using the automatic centring device.

The *automatic centring device* is an attachment which is put into position on the tripod and centred once and for all on the station spot; it can receive theodolite or subtense-bar which are then automatically centred.

Principal Advantages. — Several important advantages differentiate the measurement of distances with the subtense-bar from the measurement with the steel tape or the chain :

1. The measurement is absolutely independent of the conformation of the country. The subtense-bar makes it possible to measure without difficulty over hill, valley, inaccessible places, yet again over tall vegetation fields without the accuracy being impaired. It is merely on flat land devoid of obstacles that the steel tape is capable of yielding results as good as the invar subtense-bar, and this again only in the case where the latter is used on comparatively long ranges. The possibility of being able to work in all kinds of country, and with rapidity, makes the subtense-bar the ideal instrument for quick but accurate measurements.

2. The fact of being able to adapt the accuracy of the measurement to the requirements of the work constitutes, besides, a very distinct advantage. The measurement error is in effect proportional to the square of the distance. If it is desired to carry out a very accurate measurement, it is therefore appropriate to divide up the whole of the distance to be measured into small stretches. If the accuracy plays but a secondary rôle and, on the other hand, one is anxious to carry out the work in a minimum of time, long stretches are directly measured.

The following two examples set forth the possibility of variation of the precision in the measurement. They show up to what extent the relative errors vary when the distance to be measured is divided up into more or less long stretches.

The first example refers to a distance of 500 metres. Error of one angle measurement 1". Depending on whether the total distance is measured in one single operation or by 50-metre stretches, the total error is ± 0.61 or ± 0.019 metre.

Division of total distance:				*Mean error of total distance:*		*Mean relative error:*
1	500	metre stretch		$\sqrt{1} \times 0.61$	$= \pm$ 0.61 m	1 : 800
2	250	metre stretches		$\sqrt{2} \times 0.151$	0.21	1 : 2'400
3	166.7	»	»	$\sqrt{3} \times 0.067$	0.12	1 : 4'160
4	125	»	»	$\sqrt{4} \times 0.037$	0.074	1 : 8'760
5	100	»	»	$\sqrt{5} \times 0.0242$	0.054	1 : 9'270
6	83.3	»	»	$\sqrt{6} \times 0.0169$	0.041	1 : 12'000
7	71.4	»	»	$\sqrt{7} \times 0.0123$	0.033	1 : 15'000
8	62.5	»	»	$\sqrt{8} \times 0.0095$	0.027	1 : 18'500
9	55.5	»	»	$\sqrt{9} \times 0.0075$	0.022	1 : 23'000
10	50	»	»	$\sqrt{10} \times 0.0061$	0.019	1 : 26'000
20	25	»	»	$\sqrt{20} \times 0.0016$	0.0072	1 : 70'000

The second example concerns a total distance of 2000 metres. Error of one angle measurement 1". If the whole be measured in one single operation, the error is ± 9.8 metres; if on the contrary the total 2000-metre distance be divided up into 40 50-metre stretches, the error on the length is ± 0.04 m. only. The relative accuracy is 1 : 204 in the first case; in the second case 1 : 52'000. Alone a device in the shape of the WILD invar subtense-bar permits of such perfect adaptation to the variations of the accuracy required.

Division of total distance:				*Mean error of total distance:*		*Mean relative error:*
1	2000	metre stretch		$\sqrt{1} \times$ 9.80 m	$= \pm$ 9.80 m	1 : 204
2	1000	metre stretches		$\sqrt{2} \times 2.45$	3.47	1 : 580
4	500	»	»	$\sqrt{4} \times 0.61$	1.22	1 : 1'640
5	400	»	»	$\sqrt{5} \times 0.39$	0.87	1 : 2'300
10	200	»	»	$\sqrt{10} \times 0.098$	0.31	1 : 6'500
20	100	»	»	$\sqrt{20} \times 0.0242$	0.11	1 : 18'500
40	50	»	»	$\sqrt{40} \times 0.0061$	0.04	1 : 52'000

3. The above possibilities of variation offer a third advantage. Longer sighting stretches must be chosen when it is a question of measurement with greater tolerance. In this case a smaller number of pointings is necessary than would be required with the tacheometric devices for which the maximum distance is limited by the length of the levelling staff or by the size of the image necessary for an exact reading. The invar levelling staff thus enables one to perform the measurement very quickly.

4. A further advantage of the use of the subtense-bar is derived from the fact that the horizontal is obtained straightaway, the measured angle being independent of the tilt of the telescope of the theodolite. It is thus *no longer* necessary to *resolve* the distance obtained to the horizontal.

Cursory Method of Operation. — The tripod is first centred on the station point by means of a plumb-line. The subtense-bar is unfolded after clamping the closing device at the free ends of the tubes, and the clamping lever which maintains the two units in the extension one of the other is closed.

The subtense-bar is set up on the tripod and the securing screw is tightened whilst checking the centering. The subtense-bar is set to the horizontal by means of the three levelling screws whilst observing the circular level. The locking screw of the azimuth motion is released and the subtense-bar trained perpendicularly to the direction of the theodolite by means of the small special telescope. Finally the locking screw is tightened up and announcement is made that the setting up is completed. For the folding up of the instrument first the small telescope is turned down; the subtense-bar is then removed from the tripod and *folded up when thus released from the tripod.* In case of use of the automatic centering device, the subtense-bar alone is removed, the automatic centering device remaining secured to the tripod in order to receive the theodolite thus automatically centred.

The distance in metres (for 400g or 360°) or in feet (for 360° only) is read off the table supplied with the subtense-bar. The number obtained indicates always the horizontal distance.

The *adjustment* of the subtense-bar is effected at the works. Care should be taken not to interfere with this adjustment as the latter can only be accomplished with the aid of a *comparator.* The robust construction of the subtense-bar and the protection of the invar wire render any disarrangement of the instrument impossible.

THE WILD THEODOLITE SERIES

— WILD Compass-Theodolite T 0.
— WILD Double Centre Theodolite T 1.
— WILD Universal-Theodolite T 2.
— WILD Precision Theodolite T 3, for First and Second Order Triangulation.

The precision of circle reading of these instruments is as follows :

	360°	400g
Compass-Theodolite T0	1'	1'
Double Centre Theodolite T1	6"	10"
Universal-Theodolite T2	1"	1"
Precision Theodolite T3	0.2"	0.5"

1. WILD COMPASS-THEODOLITE T 0.

The detailed description of this instrument and of the Barot micrometer which may be associated to it for the measurement of distances is given in *Hydrographic Review,* Vol. XII, N° 1, May 1935, pages 148 to 151.

In the new models of this instrument the base-plate forms at the same time the base plate of its circle. The instrument can therefore be placed and clamped on its stand still in its case. After removal of the air-tight cover, it is only necessary to bring the bubble of the circular level to centre for observations to be at once commenced.

As this small instrument will often be carried in the field attached to its stand, it can be protected against any accidental damage and from moisture and dust, by simply placing the cover over it. In case of rain occurring suddenly, the cover gives complete protection, without the theodolite having to be removed from its stand.

2. WILD DOUBLE CENTRE THEODOLITE T 1.

Diameter of horizontal circle	3 in.
Diameter of vertical circle	2 in.
Clear aperture of object-glass	1 9/16 in.
Length of telescope	5 3/4 in.
Sensitivity of circular level	8' per 1/12 in.
Sensitivity of horizontal level	30" per 1/12 in.
Sensitivity of level of vertical circle	40" per 1/12 in.

The instrument may be divided in two parts, the removable foot-piece with foot screws and the actual theodolite, in such a way as to be able to set up on the foot-piece, whilst preserving the centering, either the theodolite or a target.

Double Centre Device. — In order to secure repetition, the most simple, robust system has been selected, incapable of giving rise to fortuitous motion of the alidade when the graduated arc or conversely is manipulated. This system consists of two concentric solid cylindrical axes, the one (external) with the graduated arc, the other (internal) with the alidade, separated from one another by an axis rigidly secured to the lower plate of the theodolite. The axes of the graduated arc of the alidade, perfectly adjusted on the fixed axis which separates them, cannot thus be geared to each other.

The clamp with fine-adjustment of the graduated arc is at the lower part of the instrument, just above the levelling screws, whereas the clamp with fine-adjustment of the alidade is above the horizontal circle; these driving devices, which are moreover different by their outer shape (appreciable difference by the feel) cannot thus be confused.

This theodolite may be equipped with the following accessories :

A device for electric illumination of the diaphragm, circles and micrometer; a diagonal eyepiece for observations up to the zenith, which is screwed in in place of the ordinary eyepiece; exchangeable traversing targets with assured centering and electric illumination.

The Theodolite T 1 can be used as tacheometer for distance-measurement by means of a stadia diaphragm constituted by two small horizontal lines situated at equal distance on both sides of the horizontal axial line of the diaphragm, or by a distance-wedge placed over the objective which enables a double image of an horizontal staff vernier to be obtained. By the vernier, distances up to 100 metres can be read with an accuracy of two or three centimetres. In the case of inclined sights the reading has to be multiplied by the cosine of the inclination to reduce it to the horizontal distance (*see* figure).

The distance can also be worked out by means of the Double-Image Reducing Telemeter, an accessory which is also placed on the objective and the principle of which has been described in *Hydrographic Review,* Vol. IV, N° 2, November 1927, page 212.

The Barot-WILD reducing telemeter, which is mounted on the objective of the theodolite, permits the horizontal distance to be read directly from an upright staff. The fine measurement is accomplished by means of a vernier reading directly to 5 centimetres by estimation to single centimetres. The telescope of the theodolite can be reversed either way with the telemeter in place. The counterpoise is conveniently placed outside the supports.

3. WILD UNIVERSAL THEODOLITE T 2.

The theory of this type of theodolite has been developed in *Hydrographic Review,* Vol. IV, N° 2, November 1927, pages 210 to 212. The original description of the Henry WILD Universal Theodolite and of its Tacheometric Duplicator will also be found in the pamphlet published by Engineer Jacques BAROT in the *Journal des Géomètres experts français,* February-March, 1929.

Diameter of horizontal circle	3 3/4 in.
Diameter of vertical circle	2 in.
Clear aperture of object-glass	1 9/16 in.
Length of telescope	6 7/8 in.
Sensitivity of level-bubble	20" per 1/12 in.
Sensitivity of level of vertical circle	30" per 1/12 in.
Sensitivity of Striding-level	5" per 1/12 in.
Sensitivity of Horrebow-level	5" per 1/12 in.

In the 1937 model represented in the figure, the vertical circle has been placed entirely inside the support. The track of the luminous beam has been modified and the illumination improved. The shorter telescope is reversible both ways, even after adaptation of the duplicating tacheometer on the objective, or of the diagonal eyepiece for zenithal pointings.

In the new 1937 model, besides the changes which are visible from the outside, the instrument has also undergone important modifications of the internal construction. It is known that the working of the conical vertical axis hitherto generally employed is affected by changes of temperature, becoming stiffer or easier, and that it is necessary to regulate the working by raising or lowering the axis of the alidade. In micrometer-theodolites the magnification is thereby altered and leads to very objectionable errors of reading. It has, however, been found that cylindrical axes, which owing to the high precision of workmanship work excellently at first, undergo in the course of time slight deformations which lead to a lessening in the accuracy of angular measurement.

The new axis combines the good points of both systems while avoiding their defects. The cylindrical alidade-axis is centred near its lower end by a narrow bearing in the axis-socket. Its upper end is supported and centred on balls which work in a conical enlargement of the axis-socket. The figure below will make clear the construction, which is as simple as it is reliable, and is much to be preferred to the old one.

A similar change has also been made in the bearing of the horizontal axis, so as to exclude any possibility of the axis getting out of its proper position. The fixed cylindrical axis-trunnion is ground away at the bottom for a width of a few millimetres towards either side, so that the cylindrical axis-socket which turns with change of inclination of the telescope does not bear against the bottom of the fixed trunnion, but against its flanks. The working is thus similar to that of a Y bearing.

Besides this change of form, a change has also been made in the material used for the axes, another kind of steel being now used which enables them to be hardened by chemical means instead of by chilling. The new material is consequently extremely stable against secular deformation, and seizure of the axes is impossible.

Thanks to the improved design of the axis-system and of the entire instrument, which secures an even higher degree of stability, the WILD theodolite has once more undergone a marked rise in quality.

The WILD Universal-Theodolite, adapted for all triangulations up to the third order, and even up to the second order, enables one to carry out in the best possible conditions all kinds of work and to confront the various problems which the explorer may be called to resolve during his expedition.

It comprises complementary devices of electric illumination; eyepiece-prisms for inclined sights up to 65° above the horizontal; an objective-prism, deflecting the incident light-rays through a right angle, for the measurement of vertical angles; a Double-image prism-compass; a prismatic astrolabe-attachment; a distance-wedge and a precision telemeter.

The metal case, which serves for packing the instrument, has undergone various practical improvements. The hood is secured to the base-plate by a convenient lever fastening; a rubber ring serves to effect hermetic closure.

For carrying the instrument a *rucksack* is used; for transport by rail the padded packing-case is recommended.

4. WILD PRECISION THEODOLITE T 3,
for first and second order triangulation.

Since its appearance in 1927, this type of theodolite has undergone a few improvements; it had been found that a certain small modification of the axis system would contribute to an increase of accuracy. The officers of the Geodetic Survey of Canada who used the instrument in large numbers in their triangulations took a prominent part in researches which led to this modification. The principal advantage of the new arrangement lies in the fact that any microscopically small changes in the horizontal and vertical axes will remain entirely without influence on the accuracy of measurement, because the axes are carried in bearings in such a way as to be absolutely free from strain. The instrument is now of what the English call "kinematic design". In addition, the axes are now made of a new material which is specially resistant to deformation. Stiffness of working or any seizing of the axes, is thus rendered absolutely impossible.

Besides this principal modification, a few further improvements have been introduced bearing on illumination of the vertical circle by means of a single mirror flashing back the light through a horizontal axis. The electric illumination has also been improved.

Main particulars of the instrument.

Glass circle	360°		400g
Diameter of horizontal circle		140 mm.	
Graduation-interval of horizontal circle	4'		10c
Diameter of vertical circle		95 mm.	
Graduation-interval of vertical circle	8'		20c
Graduation-interval of micrometer-drum	0.2"		1cc
Clear aperture of object-glass		60 mm.	
Length of telescope		260 mm.	
Magnifying-power of telescope	24,30 and 40 ×		
Sensitivity of alidade-level per 2 mm.	7"		
Sensitivity of collimation-level per 2 mm.	12"		
Coincidence-adjustment of collimation-level	0.2"		
Weight of instrument	10.950 kg. (24 lbs.)		
Weight of cover	3.750 kg. (7.3 lbs.)		
Weight of stand	7.500 kg. (15.5 lbs.)		
Weight of carrier	1.750 kg. (3.8 lbs.)		

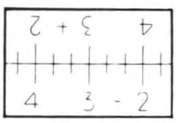
WILD T0

THÉODOLITE-BOUSSOLE

POUR LEVERS POLYGONAUX, TACHYMÉTRIE, JALONNEMENTS DÉTERMINATION DES POINTS AUXILIAIRES EN PHOTOGRAMMÉTRIE

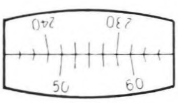
360°

cercle vertical



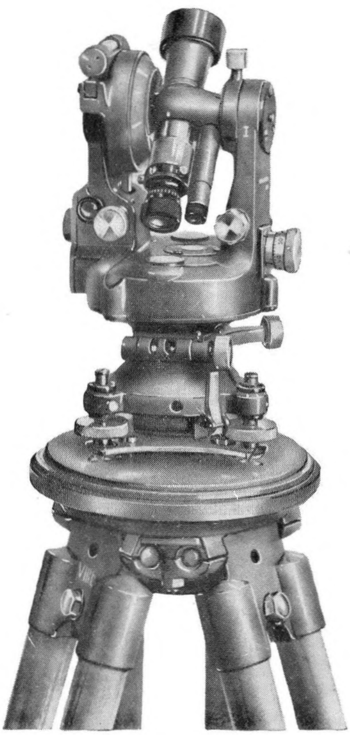
-3°0′

cercle-boussole



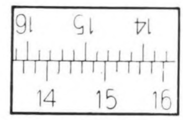
54°

(minutes au micromètre)



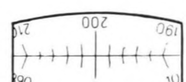
400ᵍ

cercle vertical



14ᵍ 83ᶜ

cercle-boussole



0ᵍ

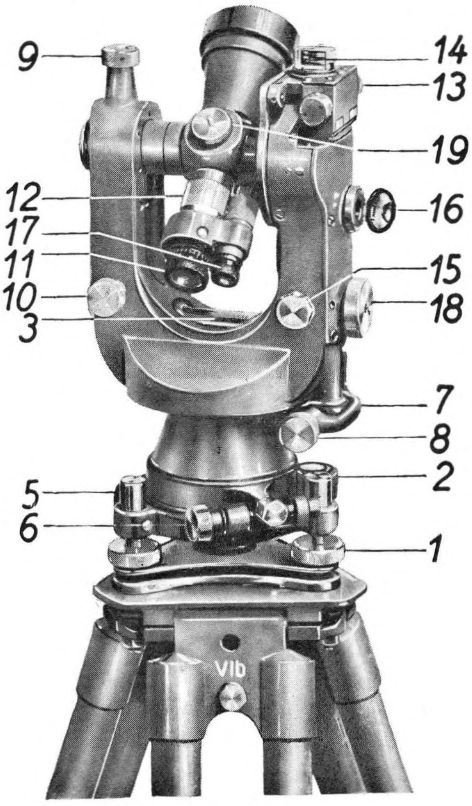
(centigrades au micromètre)

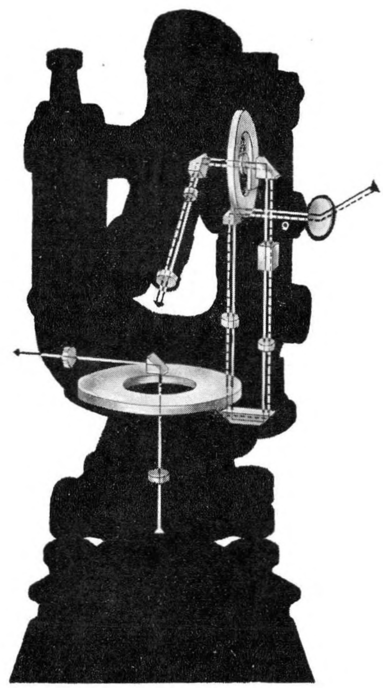
Cercles	360°	400ᵍ
Intervalle de division du cercle vertical	20′	20ᶜ
Intervalle de division du cercle horizontal	2°	2ᵍ
Intervalle de division du micromètre optique	2′	5ᶜ
Grossissement de la lunette	x10 ou x16	
Poids de l'instrument	2,2 kg.	

WILD T1

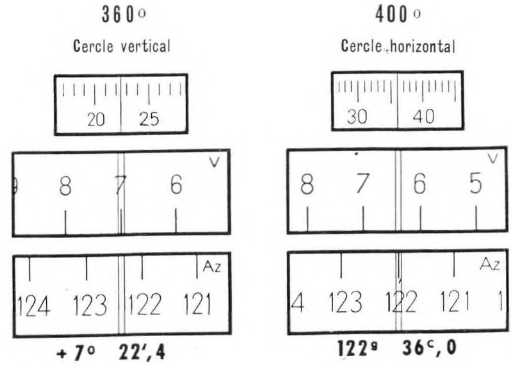
THÉODOLITE RÉPÉTITEUR

POUR LA TACHÉOMÉTRIE, LA POLYGONATION ET LA PETITE TRIANGULATION

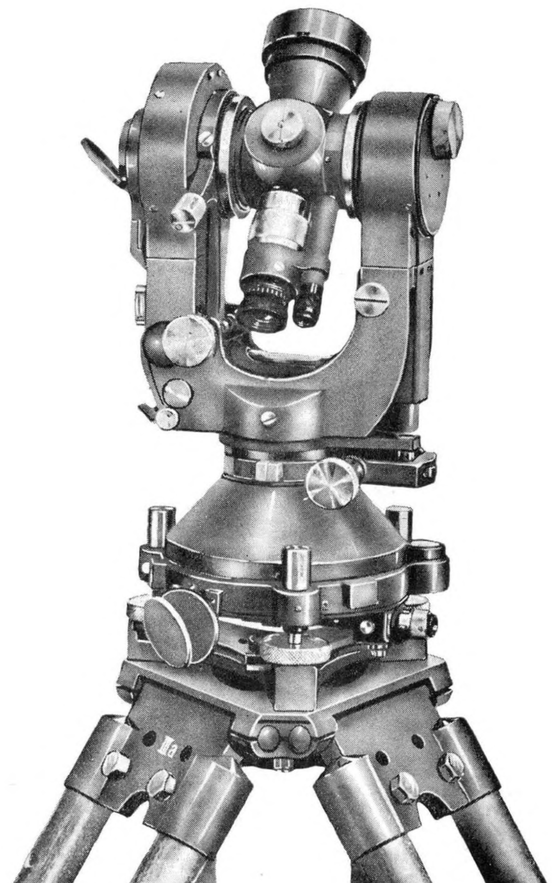


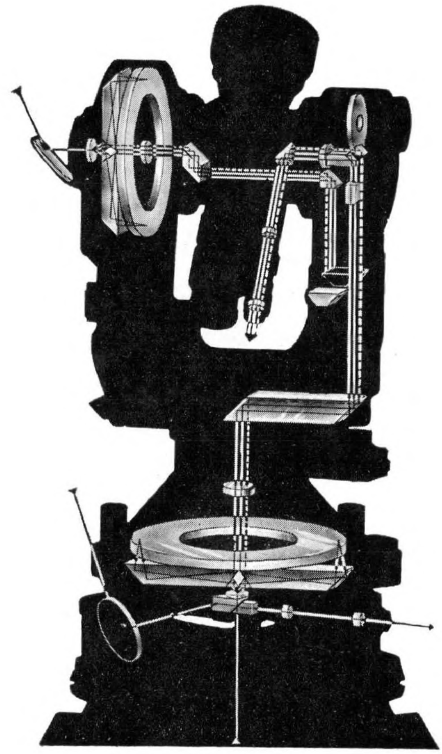


Cercles en verre	360°	400ᵍ
Intervalle de division des deux cercles	1°	1ᵍ
Intervalle de division du tambour micrométrique	1′	1ᶜ
Ouverture libre de l'objectif	40 mm	
Grossissement de la lunette	28 x	
Poids de l'instrument	3,75 kg	



WILD T2
THÉODOLITE-UNIVERSEL

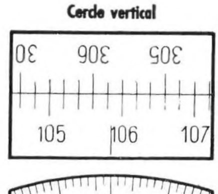




Cercles en verre	360°	400^g
Intervalle de division des deux cercles	20′	20^c
Intervalle de division du tambour micrométrique	1″	2^{cc}
Ouverture libre de l'objectif	40 mm	
Grossissement de la lunette	x 28	
Poids de l'instrument	5,5 kg	

400^g

Cercle vertical



Lecture du cercle

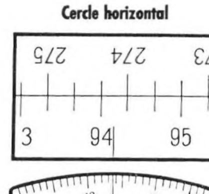
105^g 8224

Angle vertical exact

– 5^g 82^c 24^{cc}

360°

Cercle horizontal



Lecture du cercle

94° 12′ 43″,7

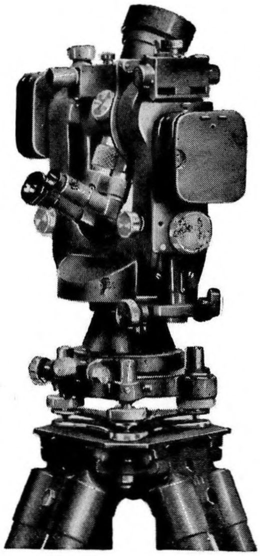


FIG. 10.

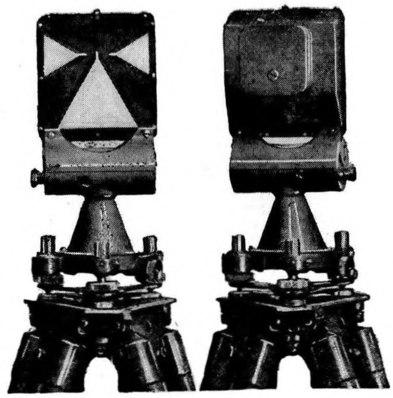


FIG. 10.

Device for electric illumination. Exchangeable traversing targets.

Dispositif d'éclairage électrique et de lunette coudé Wild avec signaux de visée.

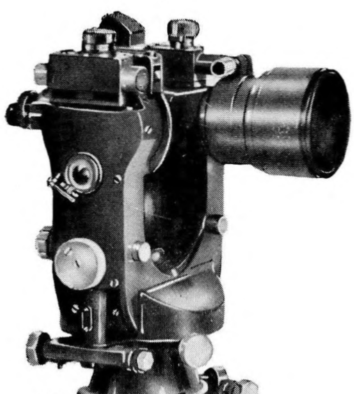


FIG. 11.

Stadiametric prism.

Prisme stadimétrique.

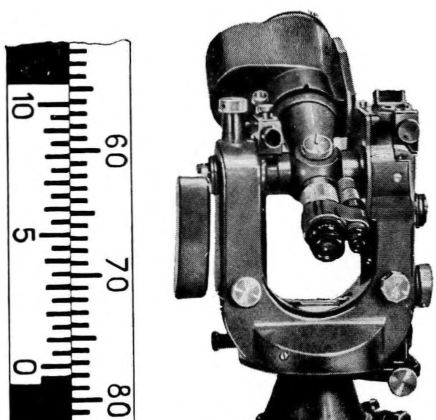


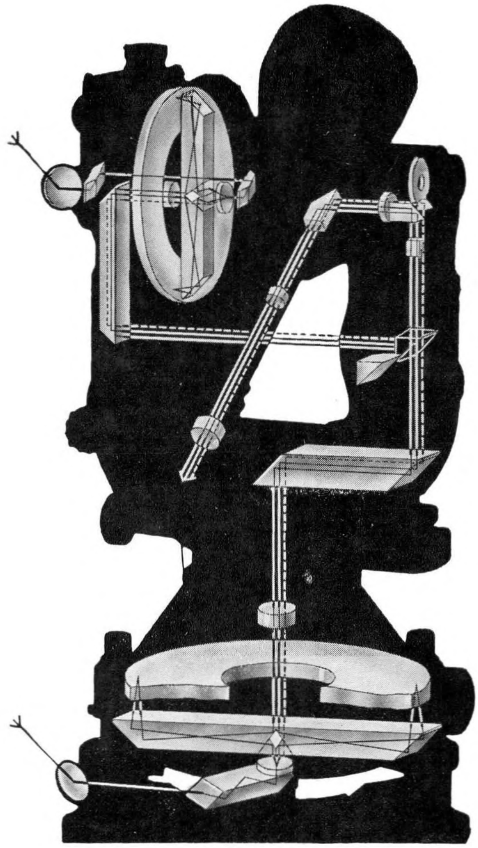
FIG. 12.

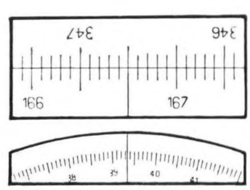
Barot-Wild reducing Telemeter.

Autoréducteur Barot-Wild.

WILD T3

THÉODOLITE DE GRANDE PRÉCISION





Cercle horizontal 360°

Lecture du cercle	166° 40	
1° Lecture du tambour		39,"4
2° Lecture du tambour		39,"3
		166° 41' 18,"7

Lecture avec micromètre optique à coïncidence

Intervalle de division du tambour du micromètre 0,"2

Grossissement de la lunette 24, 30 et 40 x

Ouverture libre de l'objectif 60 mm. Poids 11 kg.

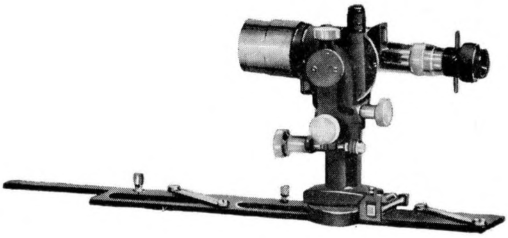


Fig. 13.
The Wild Plane Table Outfit.
Alidade avec Planchette Wild.

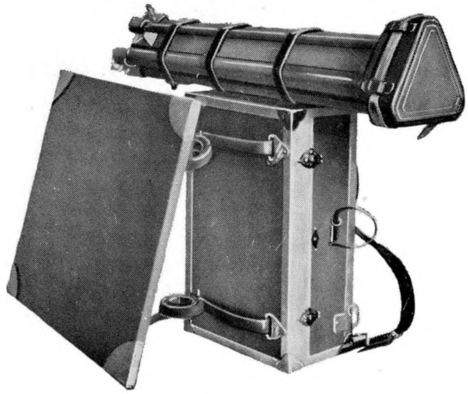


Fig. 14.
Complete Equipment.
Equipement complet.

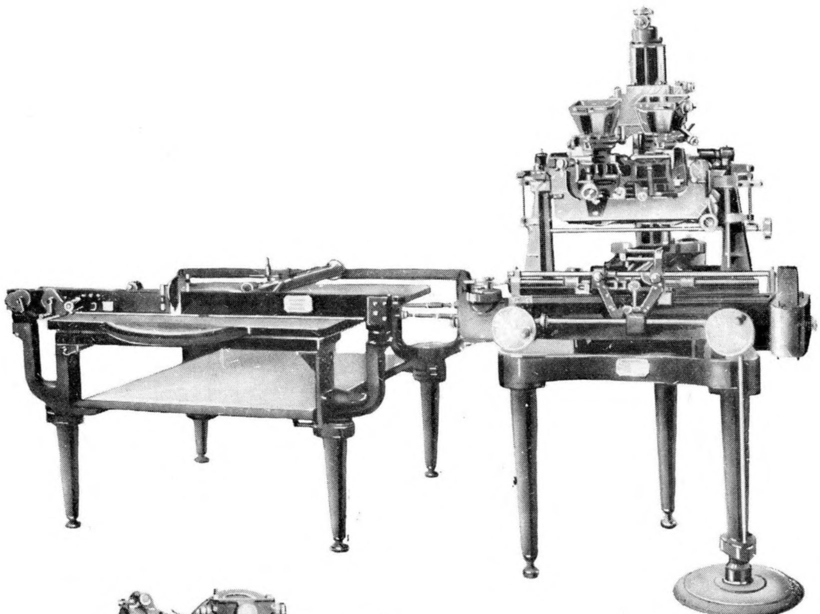


Fig. 15.
The Wild Autograph.
Autographe Wild.

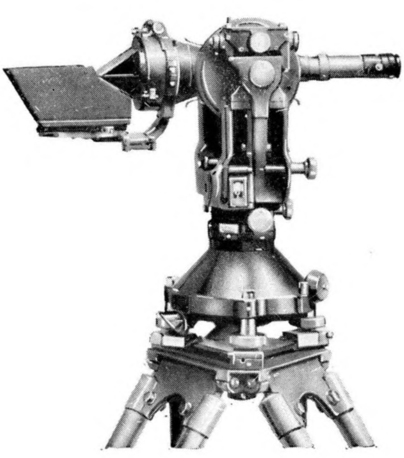


Fig. 16.
Astrolabe Attachment.
Pièce additionnelle à astrolabe.

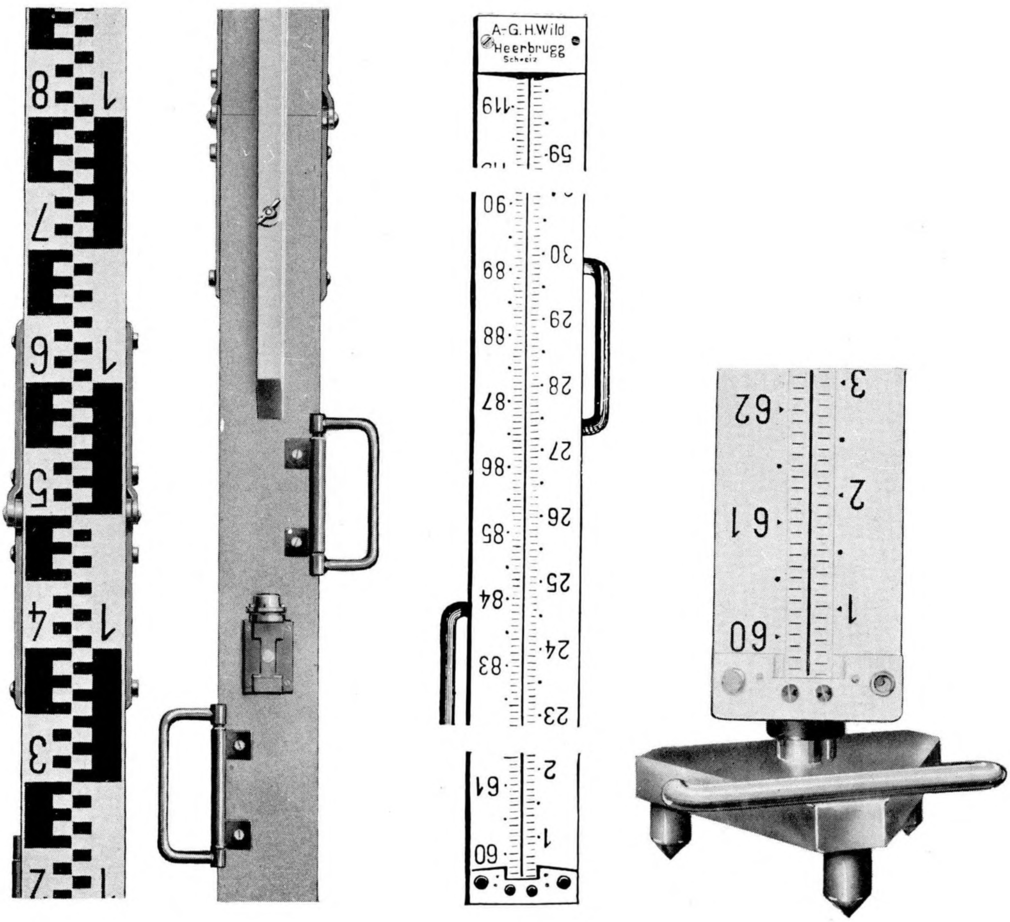


FIG 7. High-Precision Levelling Staves.

FIG. 7. *Mires invar de nivellement de haute précision.*

The collimation-error of the telescope can be corrected by moving the diaphragm by means of three screws.

For special purposes there are the following supplementary attachments :

For steeply inclined sights (the telescope allows of these up to 65° above the horizon) an eyepiece-prism can be attached, together with a dark glass for sun-observations.

If the theodolite is to be set up on a pillar, it is fastened to a heavy base-plate, which can be accurately centred by means of a centering-pin and circular level.

An astrolabe-equipment consisting of equilateral prism and mercury horizon with wind protection. The exact adjustment of the prism in relation to the optic axis of the telescope is effected by auto-collimation. A very simple adjustment for the simultaneous determination of latitude and of time by observation of a constant zenith distance of 30°.

THE WILD PLANE-TABLE OUTFIT.

Fig. 13. *Alidade* (1/5 nat. size).

Alidade-telescope :

Clear aperture of object-glass	1 9/16 in.	
Length of telescope (constant)	6 7/8 in.	
(with sun-shade	7 2/3 in.)	
Stadia-lines	1 : 100	
Addition-constant	0	
Telescope reversible either way.		
Parallel ruler with removable lengthening-piece	17 in.	
(1 inch = 25 mm, 1 lb. = 0.450 kg)		
Height from underside of ruler to rotation-axis of telescope	4 3/4 in.	
Reading microscope in vertical position, highest point above surface of table	6 1/2 in.	
Vertical circle, enclosed, watertight	360°	400g
Diameter	2 in.	
Reading direct to	10'	10'
Estimation to	1'	1'
Two adjustable levels, which can be observed simultaneously.		

Tribrach: 3 protected foot-screws adjustable for wear, strong clamp and slow-motion by endless screw, 3 screws for attachment of board.

Tripod: light, firm, with adjustable legs.

Packing : 1 sail-cloth covered wooden case, with carrying-straps for transporting the alidade and tribrach. The box also contains 1 compass, 1 level, 1 slide rule, 1 offset-scale, 1 table of tangents, 1 lens, 1 pencil-file, 1 pair of dividers, 1 plumb-bob and line, 2 adjusting-pins, and a small oil-bottle. As the result of long experience, the arrangement is very complete, yet everything is easily accessible.

Other items of outfit : 1 Teak plane-table board of the usual size, 1 folding staff.

Apart from the instruments listed above, the firm of Wild manufactures the following photogrammetric instruments :

WILD INSTRUMENTS FOR PHOTOGRAMMETRY.

Terrestrial Photogrammetry :

Photo-Theodolite with the new special Wild objective, with tilting camera and Wild theodolite.

Photogrammetry from the Air :

Precision cameras for plates and films. *Series-camera* with automatic regulation of overlap. Range of overlap from 0 to 80 per cent.

Mapping from Photographs :

The WILD *Autograph*, an apparatus of precision for the automatic plotting of maps from stereoscopic pairs of photographs taken on the ground or from the air. Bridging of tracts without fixed points by the plumb-point method. The WILD *Rectifier*, for the projectional rectification of air-photographs, with simultaneous enlargement up to 4 times or reduction down to one-third size.

Viewing-stereoscope.

H. B.

THE HUSUN FILAMENT CARD DEAD-BEAT COMPASS WITH NON-RESONANT SUSPENSION (*)

This new type of compass manufactured by Messrs Henry HUGHES & SON, Ltd, London, constitutes a great advance on the ordinary liquid compasses. The internal diameter of the current "Fleet" type compass bowl is 10 ins., that of the Card, 6 1/2 ins. The space thus provided between bowl and Card screens the latter against the entrainment influences of the liquid. Adequate expansion chambers are arranged which counteract the effect of temperature change on the liquid, thus avoiding any difficulty with bubbles.

The magnet system is constituted by short cobalt steel needles of high magnetic moment. This arrangement makes the compass highly sensitive. The qualificative "Dead-Beat" which the makers associate with this compass means that its oscillations are completely damped out. This damping out is obtained by means of fine radial filaments suspended on the underside of the Card; the friction of these filaments in the liquid warrants a perfect damping out under all conditions and precludes any oscillations arising under fortuitous causes.

The compass Card itself is manufactured by a patent photographic process which entirely eliminates any question of Card discolouration due to chemical action or discolouration of the liquid. The attached figure shows the general arrangement of the Card.

An idea of the damping out attained will be gained by indicating that the Card when deflected 45° returns to zero in 11 seconds, swings 5° beyond and returns to rest in 35 seconds.

Owing to the reduced dimensions of the needles which constitute the magnet system, any changes in the quadrantal deviation due to the length of magnets come very little into account, while a higher directive force of the system is attained.

The filaments which realize the damping out, due to the resistance of the liquid, are very light and produce only a small increase of inertia of the Card. The result thereof is that the Card thus damped does not, so to say, attain a complete period of oscillation.

Although the unique design of the "Dead-Beat" filament Card compass in itself is, in most cases, sufficient to absorb external disturbances before reaching the sensitive element, a special suspension has been provided the bowl to damp out all kinds of vibrations. Such vibrations are always produced in motor ships and the bridges are peculiarly sensitive to vibrations of certain definite frequencies.

The Husun non-resonant suspension consists of an outer band resting on four thick shock absorbing pads of a specially prepared sorbo substance (Dunlopillo); these in turn are fitted to a base flange mounted on the inside of the binnacle cylinder. To maintain a fore and aft direction for the lubber line two vertical pillars also reinforced with rubber tubes project from the base flange and pass through holes in the suspension ring. It will be noticed that, at this stage, there is a complete absence of metal-to-metal contact between the binnacle and the suspension ring. To eliminate entirely any possibility of disturbance from vibrations passing this point the compass in its gimbal is mounted in roller bearings slung from the outer ring by means of four spring-controlled plungers. The vibrationary

(*) *From pamphlets circulated by the firm* Henry Hughes & Son, *during the IVth International Hydrographic Conference, Monaco.*