Instruction Manual

One-Second Theodolite
With Automatic Vertical Collimation
Kern DKM 2-A

Kern & Co. Ltd.
CH-5001 Aarau, Switzerland

Mechanical, Optical
and Electronic Precision Instruments

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With Automatic Vertical Collimation
Kern DKM 2-A

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Contents

1. Description of Equipment

a) Theodolite

The DKM 2-A is a one-second theodolite of high precision suitable for

- Triangulation
- Traversing
- Deformation measurements
- Precise layout work in building construction and subsurface work
- Astronomical observations
- Optical tooling
- Photogrammetric control

Its construction features insure simple, time-saving operation and increase the reliability of measurement:

- maintenance-free vertical circle compensator replaces the collimation level,
- digitized circle reading,
- optical plummet with adjustable focus,
- two-speed azimuth and elevation tangent screws,
- cam controlled short-stroke leveling system
- coarse-fine circle orienting drive.

The theodolite is available in the following models:

- One-second theodolite DKM 2-A with upright telescope image, circle scale 360° or 400 gon
- One-second theodolite DKM 2-AC with autocollimating eyepiece with light-splitting cube, circle scale 360° or 400 gon
- Laser beam accessories to the one-second theodolite DKM 2-A

The theodolite is provided with a metal carrying case. The tool compartment in the base of the carrying case contains: 1 hexagonal, wrench with screwdriver, 1 adjusting pin, 2 Allen wrenches 0.06 in (1.5 mm)

b) Specifications

Telescope	
Magnification	32×
Objective aperture	1.8 in (45 mm)
Shortest sighting distance	4.9 ft (1.5 m)
Stadia: Multiplication constant	100
Stadia: Addition constant	0
Circles and Circle Reading	
Diameter of graduated circle:	
horizontal: numbered/unnumbered scale	75 mm/72 mm
vertical: numbered/unnumbered scale	69 mm/71 mm
Circle reading, direct	0.1 mgon/1″
Circle reading by estimation	0.05 mgon/0.2″
Magnification of reading microscope:	
horizontal circle	43×
vertical circle	48×
Compensator	
Working accuracy, better than	± 0.1 mgon/0.3″
Centering time, approximately	3 seconds
Range	± 40 mgon/2′
Compensation error, better than	5% of alidade inclination
Plate Level	
Sensitivity	22″ per 2 mm
Optical Plummet	
Focusing range	2.3 ft – ∞ (0.7 m – ∞)
Dimensions and Weights	
Height of horizontal axis	6.7 in (171 mm)
Dimensions of carrying case	11.8×6.3×8.3 in (30×16×21 cm)
Weight of instrument	13.7 lb (6.2 kg)
Weight of carrying case	5.3 lb (2.4 kg)

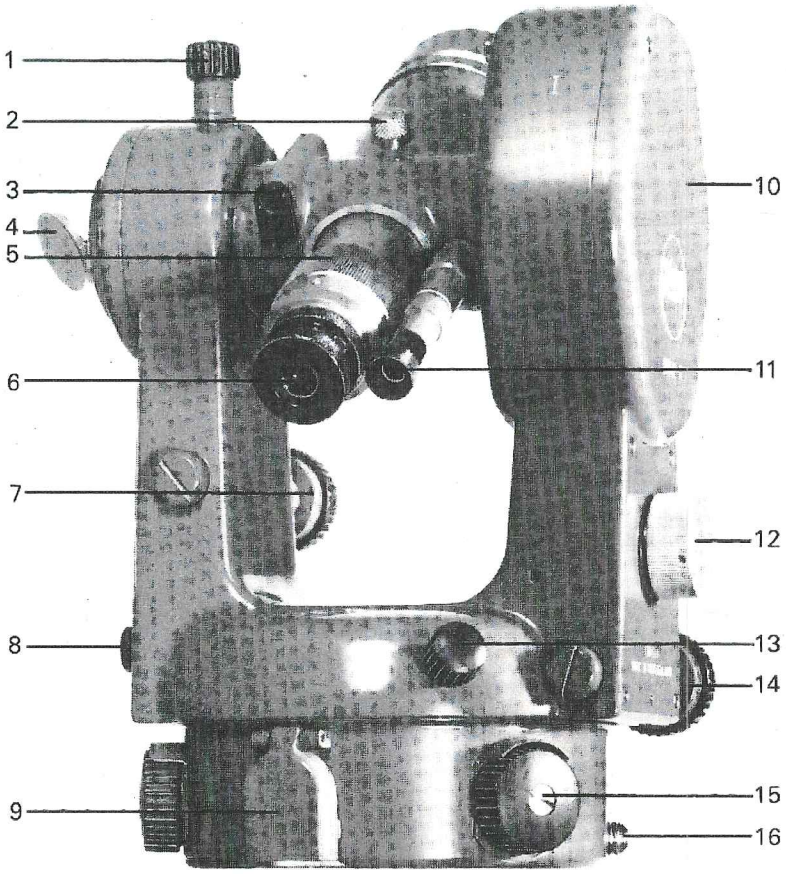

Fig. 1 Kern DKM 2-A One-second Theodolite

1 Vertical clamp
2 Mirror for reticule illumination (insert)
3 Finder collimator
4 Lighting mirror
5 Focusing ring
6 Telescope eyepiece
7 Vertical slow-motion screw
8 Optical plummet
9 Protecting cover for coarse-fine circle orienting gear
10 Index error adjustment
11 Circle reading eyepiece
12 Micrometer knob
13 Horizontal clamp
14 Horizontal slow-motion screw
15 Leveling knob
16 Terminal for electric illumination

2. Operation

a) Setting Up the Centering Tripod

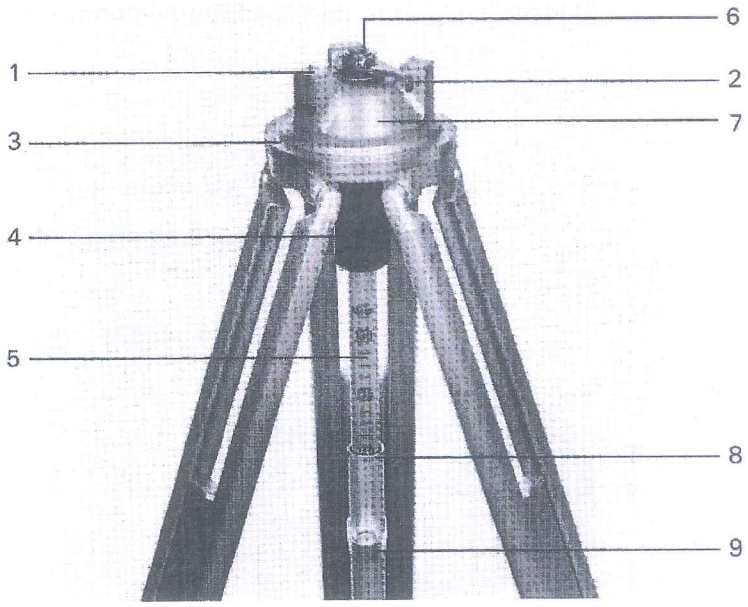

Fig. 2 Centering tripod

1 Instrument support surface
2 Locking lever
3 Tripod plate
4 Clamping grip
5 Centering rod
6 Centering socket
7 Tripod head
8 Guard ring, reading position of instrument height
9 Bull's-eye level

Normal setup

Set the tripod over the station. Grasp the carrying strap above the toggle catch and pull outward. Then remove the tripod head hood. Loosen the clamping grip (4) and extend the centering rod (5), inserting its tip into the station point. Make sure that the tripod head (7) is in its central position, i.e., concentric with the engraved circle on the tripod plate (3). Roughly plumb the centering rod using the bull's-eye level (9) by lengthening or shortening the tripod legs. Shift the tripod head on the tripod plate until the bull's-eye level is centered. Tighten the clamping grip.

To check the centering it is recommended that the centering rod be turned through 200 gon (180°). If the bubble moves off center, the tripod head should be shifted until the bubble is in its reversal position (midway between the first and second centering positions of the bubble).

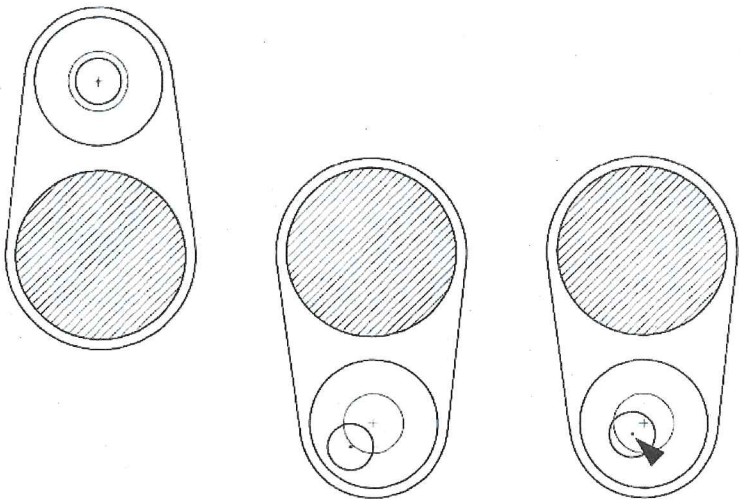

Fig. 3 Centering by Level Reversal

Setup over point above grade

For a station on a wall or boulder, the centering rod can be unscrewed from the clamping grip. The bull's-eye level housing is removed from the rod and, after unscrewing the guard ring (8, Fig. 2), screwed into the clamping grip (Fig. 4 and 5). Centering must then be done with the optical plummet or with a plumb bob.

The instrument height is measured by means of a yard stick between the ground point and the red mark on the housing of the vertical circle.

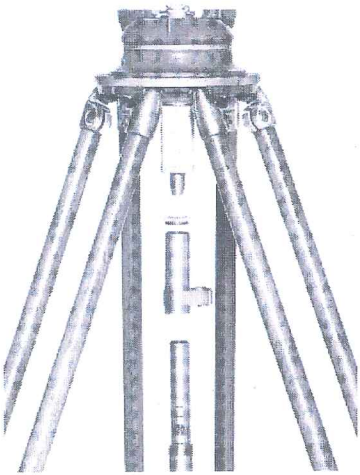

Fig. 4 Removing the Centering Rod

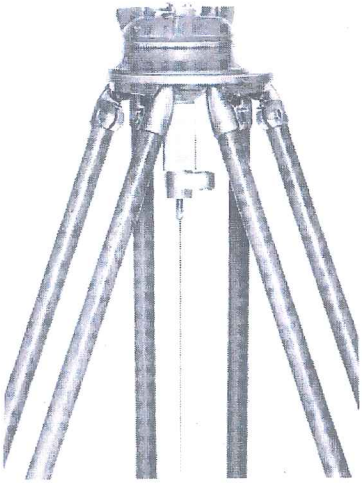

Fig. 5 Insertion of Bull's-eye Level and Plumb Bob

Setup over point below grade

The centering rod may not be long enough to reach the station point. For such a situation extension pieces 0.5 m long that can be attached to the centering rod are available as accessories.

Note:
The scale on the centering rod gives the height of the horizontal axis of the instrument above the tip of the centering rod. This scale is intended for an instrument having a height of horizontal axis of 170 mm above its base. Since the height of the axis of the DKM 2-A is 171 mm, the centering rod reading must be increased by 1 mm when precise elevation measurements are being taken.

Before moving the centering tripod, make sure that the tripod head is in the center of the tripod plate and that it has snapped into this position. To fix the hood on the tripod head, hook up its cam at the plate between two of the tripod legs and lock the toggle catch.

b) Unpacking and Packing the Instrument

To open the metal carrying case pull the carrying strap above the toggle catches away from the case. Then take off the hood. Swing both

holding forks out of the way and lift the theodolite off the base of the carrying case. When packing the telescope should be vertical and clamped. Swing the holding forks into position. Set the hood on and lock.

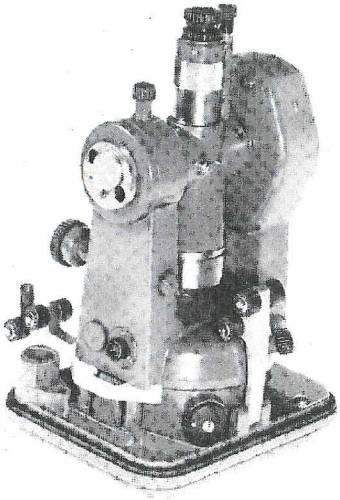

Fig. 6 Instrument in Carrying Case Base

The theodolite is well protected by the metal carrying case.

Note:
After work in rain or humid weather the instrument must be removed from the base of the carrying case and stored in a dry room (Fig. 7).

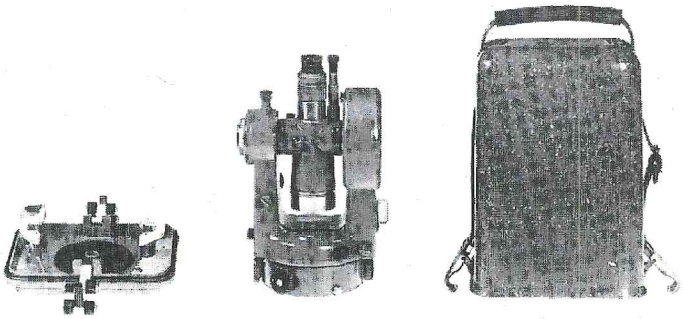

Fig. 7

c) Setting the Instrument on the Tripod

Turn the fastening lever (2, Fig. 2) of the bayonet lock on the tripod counterclockwise to the stop. Place the instrument on the tripod so that the leveling knobs are directly over the bearing surfaces of the tripod head. Fasten the instrument by turning the lever clockwise (automatical fastening with newer tripods).

Fig. 8 Setting the Instrument on the Centering Tripod

To remove the instrument from the tripod, the lever must be turned counterclockwise. The spring on the lever must be lifted over the safety lug to permit the full counterclockwise motion.

d) Centering and Leveling

Centering with the centering tripod produces an accuracy of 0.5–1 mm. For greater accuracy the optical plummet is used after the centering rod is unscrewed. The image of the ring mark of the optical plummet is sharpened by rotating the eyepiece; focusing on a station point is accomplished by pushing in or pulling out the eyepiece mounting.

Note:
Accurate centering with the optical plummet is possible only with a well-leveled instrument.

When sights are steeply inclined leveling has great influence on the precision of horizontal direction measurement. It may be that simply centering the bubble is not sufficient. Then it is necessary to find the balancing point of the level by reversal. Leveling is carried out in accordance with the following pattern:

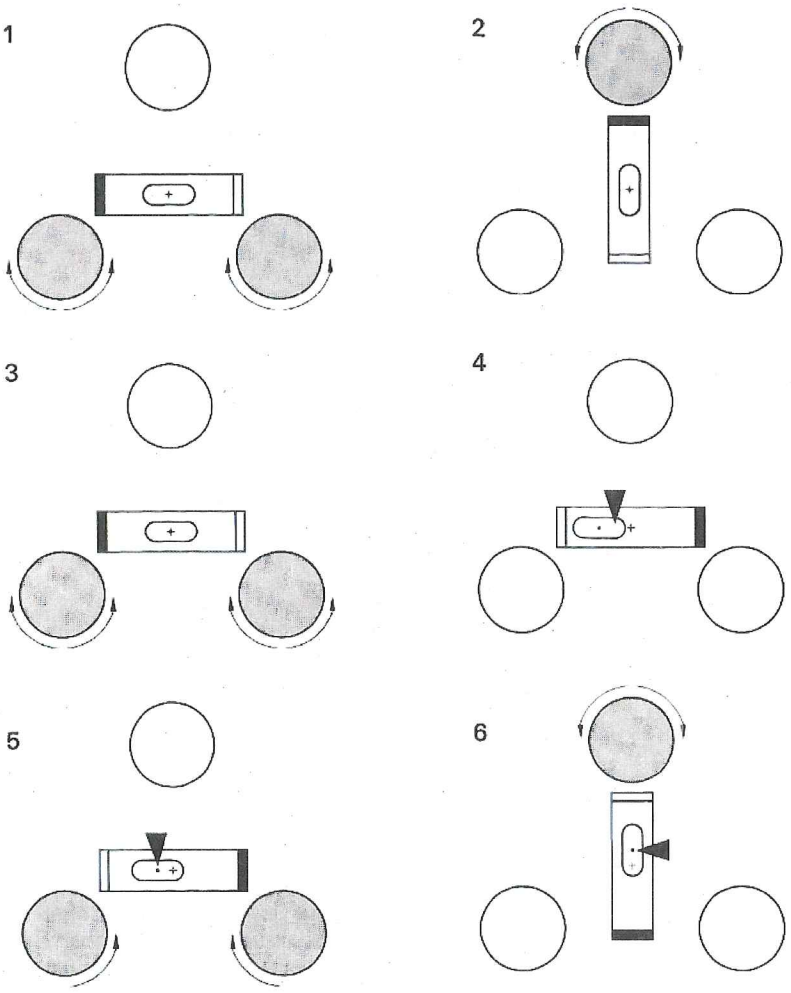

Fig. 9 Leveling the Instrument
Leveling knob to be manipulated

▼ Reversing point
+ Level vial midpoint

e) Telescope

Eliminate parallax in the usual way. Measuring precision is increased and eye strain lessened when the telescope is free of parallax.

f) Sighting

Loosen the vertical and horizontal clamps. Use the finder collimator to pick up the target in the telescope field of view. Clamp. Set the vertical hair, in the case of horizontal direction measurement, or the horizontal hair, in the case of vertical angle measurement, on the target using the horizontal or vertical coarse-fine tangent screw. Using the coarse range of the screw move the hair past the target. Reversing the rotation of the screw automatically reduces the speed: with the *same* speed of rotation of the screw, the hair moves over the target at *half* of its original speed.

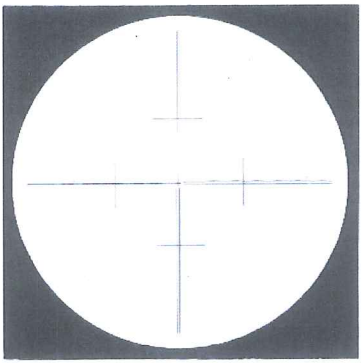

Fig. 10 Reticule Image

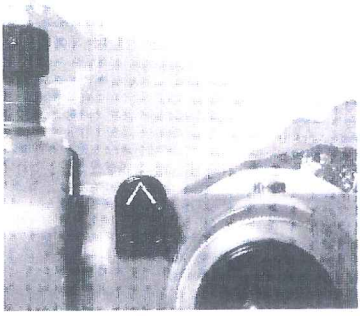

Fig. 11 Finder Collimator

g) Circle Reading

Rotate and tilt the lighting mirror until the circle images are brightly illuminated. If lighting conditions are poor, use the electric illumination. Focus the circle images sharply by turning the circle reading eyepiece.

Horizontal circle

Place the single graduation in the panel marked «H» symmetrically between the two lines of the bifilar graduation by turning the micrometer knob. Read the direction.

Vertical circle

Symmetry is established in the panel marked «V». Since the automatic compensator replaces the collimation level, the vertical angle can be read at once.

The DKM 2-A measures zenith distance (the vertical circle reads 0.0000 gon when the telescope is pointing at the zenith).

1st Telescope Position:

0 gon (0°) < positive vertical angle < 100 gon (90°)

100 gon (90°) < negative vertical angle < 200 gon (180°)

Computation of the measured vertical angle: $a = \frac{(II - 200) - I}{2}$

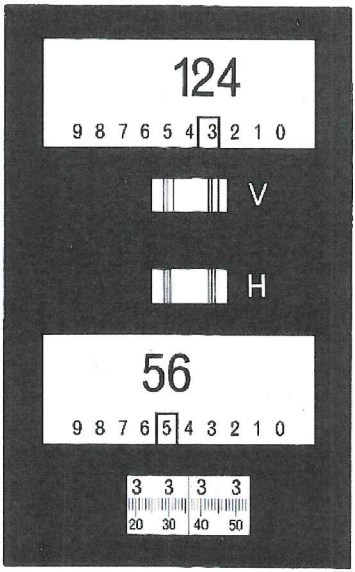

Fig. 12 Horizontal Circle
Reading 400 gon: 56.5336 gon

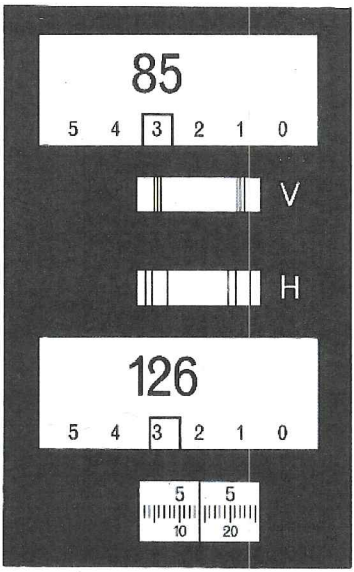

Fig. 13 Vertical Circle
Reading 360°: 85° 35' 14"

Note:

To prevent erroneous readings, the image of the vertical circle is not visible unless the instrument is leveled.

h) Measurement

Vertical angles

As the tripod movements are biggest immediately after the set up, the vertical angles should be read first and then the horizontal directions. To eliminate index error, the vertical angles should be measured in both telescope positions. For each target point the two measurements should be taken one after the other to avoid changes in the index error that would affect the measurement.

Station Instrument Height i	Target Point Target Height t	1st Observ. Position I Position II (I+II)	2nd Observ. Position I Position II (I+II)	Vert. Angle 1st Observ. 2nd Observ. Mean	Comments
3	1	99.7476		+ 0.2507	
1.618	1.667	300.2490			
		399.9966			
	4	99.8362	99.8360	+ 0.1622	
	1.635	300.1606	300.1604	+ 0.1622	
		399.9968	399.9964	+ 0.1622	
	9	99.8462	99.8460	+ 0.1522	
	1.690	300.1506	300.1502	+ 0.1521	
		399.9968	399.9962	+ 0.1522	
	2	99.9210		+ 0.0775	
	1.675	300.0760			
		399.9970			

Fig. 14 Example of Notes for Recording Vertical Angles (from Kern Field Book)

Horizontal Directions

The effect of collimation error and inclination of the horizontal axis has been eliminated by using the method of sets or direction measurements in both telescope positions.

Station	Target Point	Telescope Position I	Telescope Position II	Mean $\frac{I + II}{2}$	Mean Reduced
3	4	334.1928	134.1888	334.1908	0.0000
	5	334.1298	134.1264	334.1281	399.9373
	9	338.7468	138.7430	338.7449	4.5541
	8	343.7600	143.7566	343.7583	9.5675
	6	349.9314	149.9282	349.9298	15.7390
	1	35.7442	235.7410	35.7426	101.5518
	2	72.1638	272.1600	72.1619	137.9711
	4	390.8350	190.8318	390.8334	0.0000
	5	390.7722	190.7692	390.7707	399.9373
	9	395.3892	195.3852	395.3872	4.5538
	8	0.4030	200.4000	0.4015	9.5681
	6	6.5742	206.5710	6.5726	15.7392
	1	92.3872	292.3838	92.3855	101.5521
	2	128.8064	328.8034	128.8049	137.9715

Fig.15 Example of Notes for Recording Horizontal Directions (from Kern Field Book)

i) Layout Work

It may be done most comfortably if the initial direction corresponds to 0.0000 gon (0°00'00") at the horizontal circle.

Set the micrometer scale to read 00.0 mgon (0'00"), point to the station which defines the initial direction and set the horizontal circle approximately to zero by means of the coarse circle drive. Move the single lines in between the double lines in the panel marked «H» by means of the fine circle drive. The figure 0 of the circle numbering must stand above the 0 of the ten minutes scale.

3. Accessories

Some of the more important auxiliary equipment and attachments are listed below. (All accessories are described in Prospectus No.141.)

a) Electric Lighting

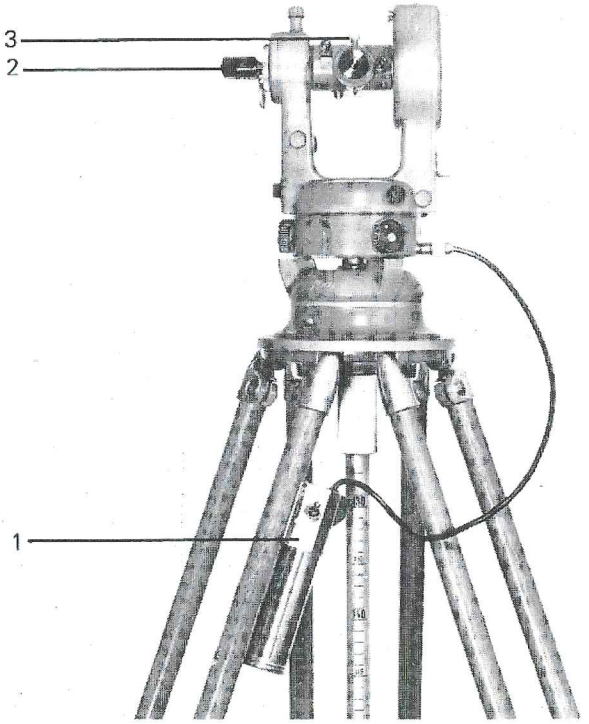

Fig.16 Electric Lighting 3V

Electric lighting 3V set for DKM 2-A, consisting of:

1 Battery case for two 1.5V batteries
2 Lighting fixture (with rheostat)
3 Mirror for illuminating the reticule

Electric lighting 3V or 6V set for DKM 2-A and DKM 2-AC, consisting of:

1 Battery case (with rheostat) for eight 1.5V batteries
2 Lighting fixture (with rheostat)
3 Mirror for illuminating the reticule
4 Lighting fixture for the plate level which can be combined with
5 Hand lamp

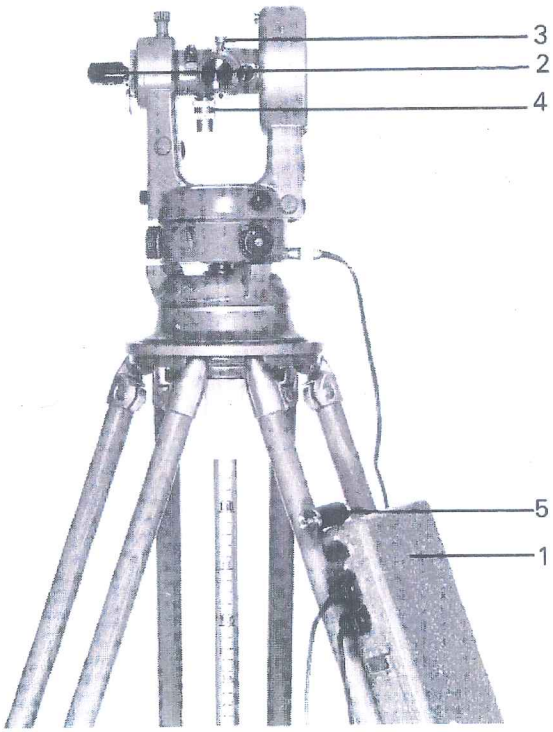

Fig. 17 Electric Lighting 3V or 6V

The use of four and of eight 1.5V batteries is shown in Fig. 18. To switch the voltage, the middle screw of the three on the rear of the case is loosened and the small metal plate in the case is shifted to the left stop (for 3V) or to the right stop (for 6V).

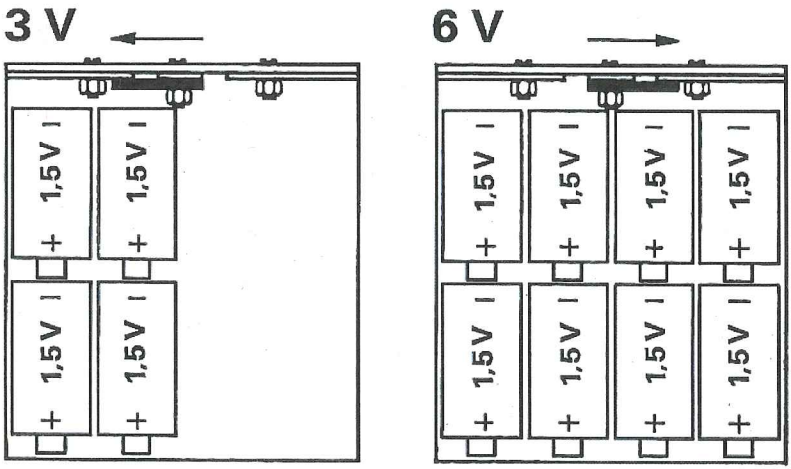

Fig. 18 Voltage Switch in Battery Case

To replace the bulb in the lighting fixture the two screws (1) are loosened and the bulb socket (2) removed. There are three spare bulbs in the large battery case. The lighting fixture is stored in the base of the instrument case.

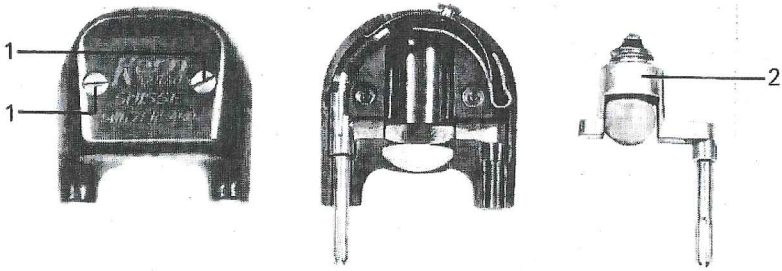

Fig. 19 Lighting Fixture

b) Electro-optical Distance Meters DM 502 and DM 503

The Kern DM 502/DM 503 electro-optical distance meters can be combined with the DKM 2-A. The distance meters can be slipped on to the telescope (in direct position) and locked. This ideal instrument combination permits simultaneous measurements of angles and distances, such as are required for cadastral surveys, traversing or precise layout work. Even with the attached DM 502/DM 503, the telescope of the theodolite, can be plunged over the eyepiece end. The power supply passes from the supply unit on the tripod to the central illumination connector on the lower part of the theodolite. Further information on the DM 502/DM 503 is contained in brochure No.145/No.127.

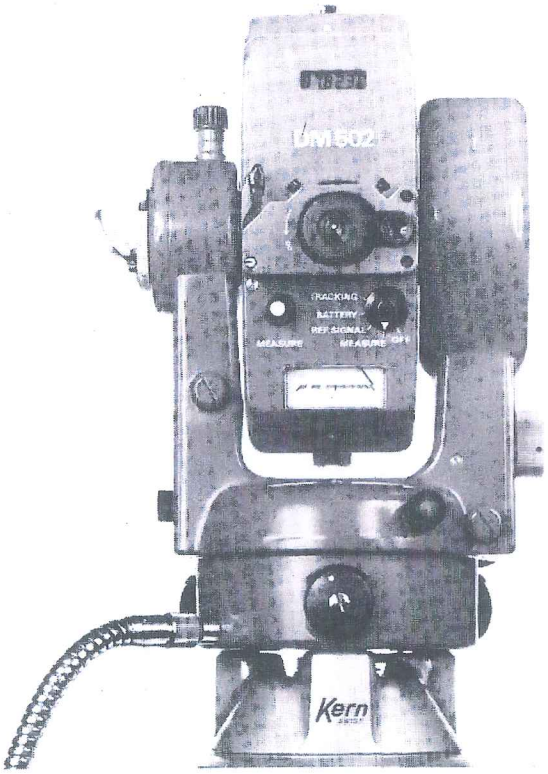

Fig. 20 DKM 2-A with attached DM 502

c) Trivets and Centering Plates

The arrangement for attaching instruments and auxiliary equipment to trivet and centering plate is the same as that of the centering tripod. While the trivet must be centered and leveled at each setup, the centering plate is permanently fastened to the pillar by three masonry bolts.

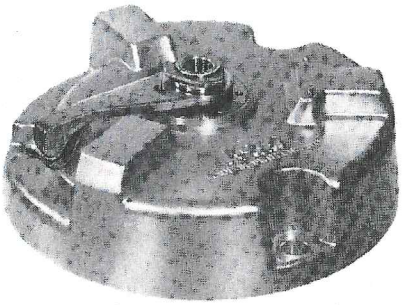

Fig. 21 Centering Plate

d) Traversing Equipment

The traversing equipment consists of:
2 Centering tripods and
2 Targets in a carrying case.
It is used for traversing when forced centering is required.

e) Invar Subtense Bar IB

The subtense bar is used to measure shorter distances with high precision.

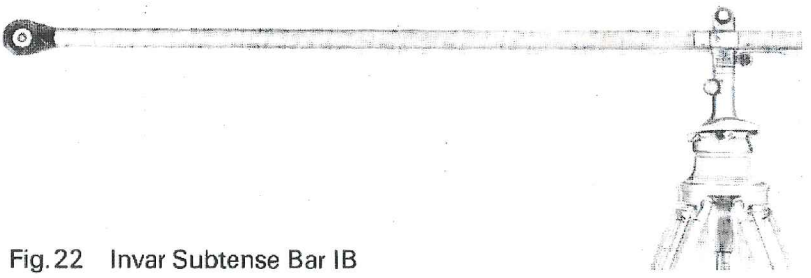

Fig. 22 Invar Subtense Bar IB

f) Autocollimation

A Gaussian autocollimating eyepiece is available as an accessory for the DKM 2-A. It is screwed in place of the regular eyepiece. Connection to the terminal on the telescope housing is made with a cable. At distances over 33 ft (10 m) or under poor lighting conditions a DKM 2-AC should be used for autocollimation.

g) Elbow Eyepieces

The elbow eyepieces allow observations to be made up to the zenith. The regular eyepieces of the circle reading microscope (1) and the telescope (2) are removed, the bent pieces (3 and 4) inserted, and the regular eyepieces screwed into the ends of the bent pieces.

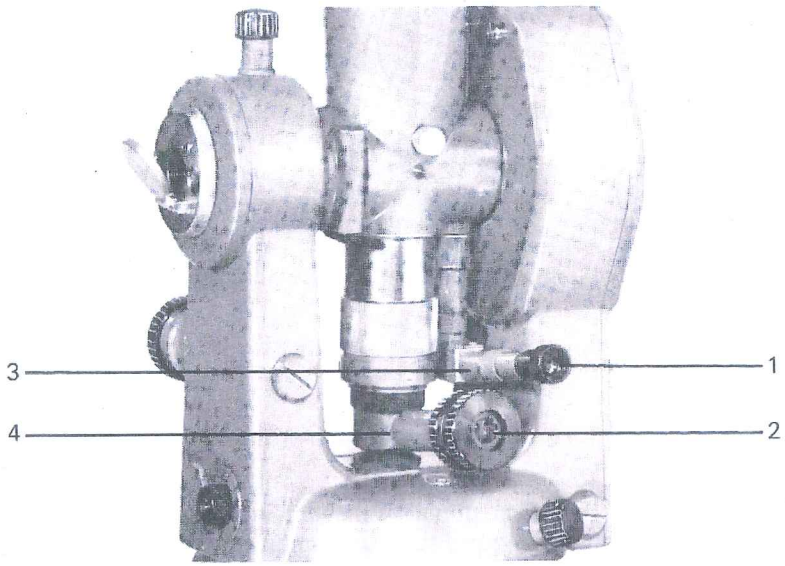

Fig. 23 Elbow Eyepieces

h) Alternate Eyepiece

Telescope magnification can be reduced to 20× by replacing the regular eyepiece by an alternate eyepiece.

4. Testing, Adjusting and Maintenance

The instrument user should not make any adjustments other than those listed below. Furthermore, it is recommended that only large errors be corrected since all instrumental errors can be eliminated by appropriate observing procedures. Index and collimation errors < 2 mgon/6" should not be corrected.

a) Plate Level

Unscrew the protective cover (1) near the optical plummet. Following the method of Fig. 9 (1, 4, 5) bring the level to the reversing point. Using the two capstan screws (2) tilt the level vial until the bubble is centered. To raise the end of the level vial, first loosen the upper capstan screw with the adjusting pin from the tool compartment and then tighten the lower screw. To lower, the lower screw should be loosened first and then the upper screw tightened. Now test the level: the reversing point must lie in the midpoint of the scale. Lastly, screw on the protective cover.

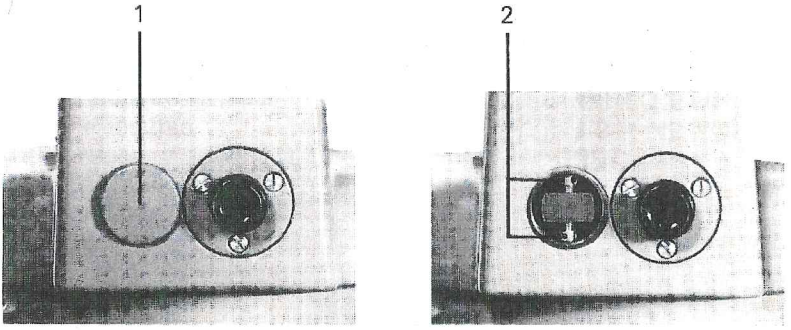

Fig. 24 Adjustment of Plate Level

b) Index Error

For a well-defined target the sum of the readings of the vertical circle in first and second telescope positions should be 400 gon (360°). Any difference is *twice* the index error i.

Reading in first position: 14.1859 gon
Reading in second position: 385.8325 gon 400.0184 gon
0.0184 gon ≙ 2 · i

To adjust, the readings are corrected by the half difference, taking into account the proper sign (–9.2 mgon). For the second telescope position set the micrometer to the correct value (23.3 mgon). Remove cover screw (1) and turn the screw (2) until symmetry is reestablished in the «V» panel. To check, take measurements on another point.

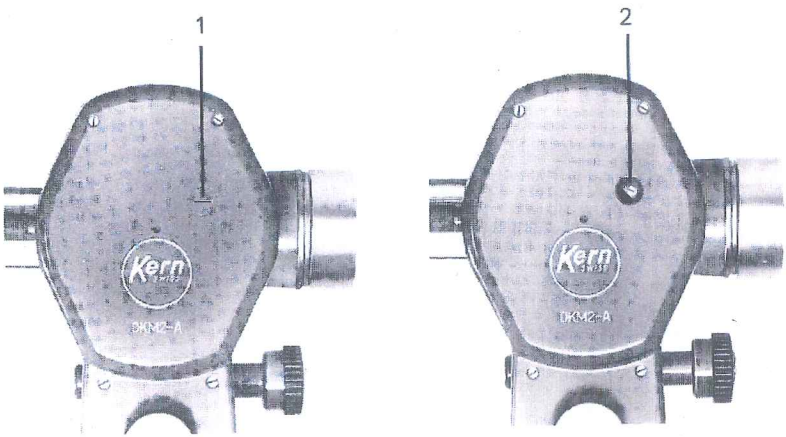

Fig. 25 Adjustment of Index Error

c) Collimation Error

For a well-defined target (close to the horizon) the readings of the horizontal circle in first and second telescope positions should differ by 200 gon (180°). Any discrepancy in the difference is *twice* the collimation error c.

Reading in first position: 98.7345 gon
Reading in second position: 298.7459 gon 0.0114 gon = 2 · c

In the second telescope position set the micrometer to 40.2 mgon and reestablish symmetry in the «H» panel using the horizontal slow-motion screw. The reticule is then shifted until the vertical hair splits the target. This is done by alternately loosening and tightening screws 1 and 2 with the two Allen wrenches. For a check, repeat the measurement on another target.

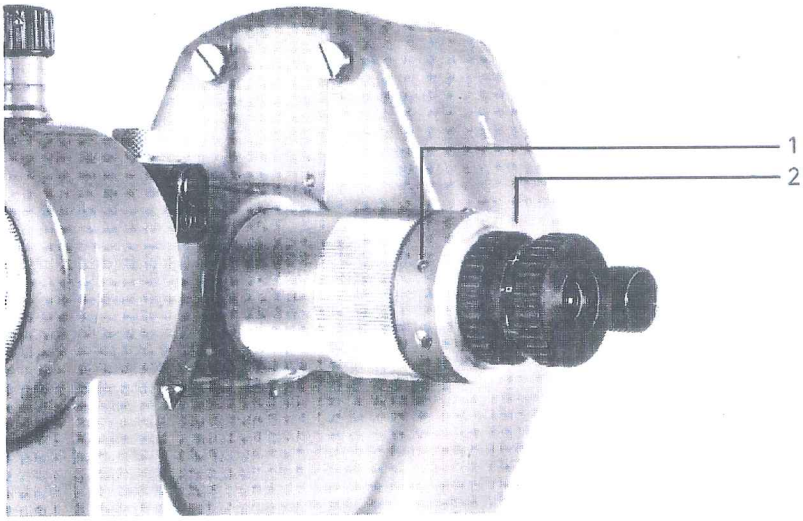

Fig. 26 Adjustment of Collimation Error

d) Optical Plummet

The axis of the optical plummet must coincide with the vertical axis of the instrument. To test, observe the plummet point while the alidade is turned through a complete revolution. If the plummet does not remain on the original point, the correct location of the plummet is at the center of the circle it generated when the alidade was turned. The adjustment must be made in an authorized Kern service facility.

e) Bull's-eye Level

The bull's-eye level of the centering rod is checked by reversal (Fig. 3). If necessary, the reversing point is moved to the middle of the circular mark with the three capstan screws (2, Fig. 27).

f) Tripod Leg Joint

The tripod leg joint should have a snug motion. The motion is regulated by rotating the turnbuckle (1, Fig. 28) with the shank of the hexagonal wrench.

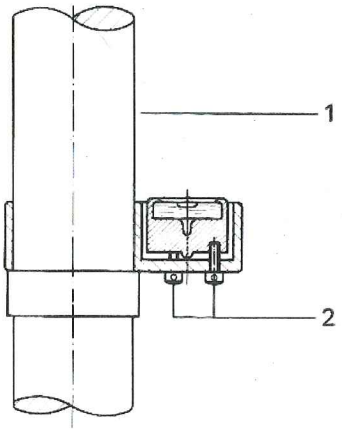

Fig. 27 Adjustment of Bull's-eye Level at Centering Rod (1)

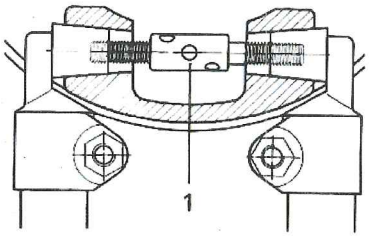

Fig. 28 Regulating the Tripod Leg Joint

g) Maintenance

Maintenance consists of keeping the instrument clean and protecting it from water. Do not use oil, grease or kerosene for cleaning. When dirty or wet, the instrument should be rubbed down with a dry cloth. Special care should be taken in cleaning the optical parts. Carelessness can result in scratch damage. The optical parts should be polished with a clean tricot cloth completely free of oil. Grease spots and fingerprints should be removed with a clean cloth moistened in ether. After work in rain or humid weather the instrument should be stored in a dry place and removed from the base of the carrying case to insure complete drying (see Fig. 7).