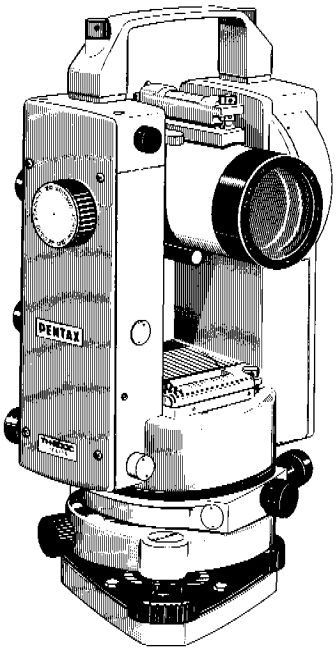
PENTAX

THEODOLITES SERIES
INSTRUCTION MANUAL

TH20D/TH20DC/TH10D/TH10DC/TH06D/TH60S/TH60E



Pentax theodolites are of the highest quality and design. We would therefore recommend that you read the instruction manual very carefully so that you will appreciate the full capabilities of your Pentax precision instrument and ensure years of trouble-free operation.

Contents

1. Notes on Care of Pentax Theodolites

To prevent accidental damage to your equipment, please adhere to the following notes which have been constructed to help you in maintaining your instrument in a precise functioning condition.

1. Unpacking

When unpacking the instrument and accessories from their container, please remember how they are positioned so that repacking may be performed correctly. The instrument should always be held with two hands after being removed from its container, and held firmly with one hand when mounting on a tripod. Refer to page 38 for the correct operation of packing the instrument.

2. Setting up

When installing or removing the instrument on or from the tripod, the instrument should be held firmly at all times. The instrument should never be left on the tripod without being fixed securely by the center screw located on the tripod. To ensure correct compatibility with the instrument, always use a Pentax tripod. Before installing the two 1.5V(UM-3) penlight batteries into their compartment, make sure that the instrument is mounted firmly on a tripod. The batteries should be inserted in the correct fashion, as described on page 19 section 5, or the lighting device will not operate.

3. Checking

Before using the instrument to take measurements, it should be examined by following the procedure outlined in section 8 of this manual. If there are any adjustments necessary, these should be carried out immediately or the equipment returned to your dealers for servicing where applicable. This procedure is always necessary regardless of the equipment age. Regular servicing of precision instruments is always advisable. Plese consult your dealers for this information.

4. Transportation

Make sure that instruments are firmly secured in position when in transit so that they cannot be damaged by movement in the trunk of a car or rear of a van. The instrument should be separated from other equipment by using materials to prevent damage from impact or shock. It is recommended that an experienced person be used to pack the instrument for long journeys. Insurance coverage should be considered when transporting precision instruments over a great distance.

5. Storage

Your Pentax instrument should be stored in a dry and dust-free room which is not subject to large variations in temperature. If the instrument is to be stored for a long period of time, the batteries in the lighting device should be removed from their compartment to prevent battery leakage and eventual damage to the instrument. Remember to remove the instrument from its container occasionally so that air may be allowed to circulate freely around the instrument thus preventing corrosion.

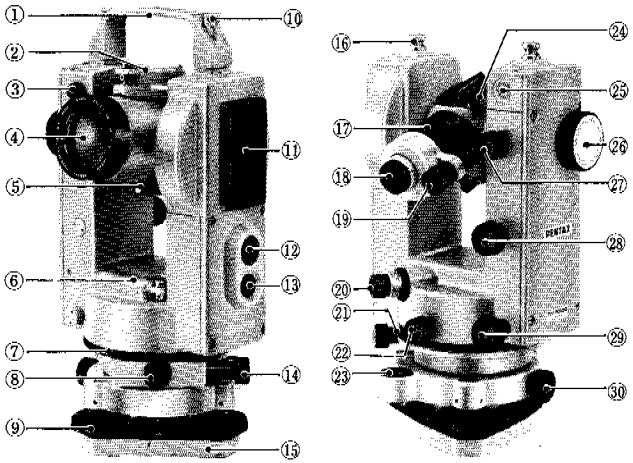
2. Specifications

	TH-20D	TH-20DC	TH-10D
Telescope			
Type	Erecting analactic optics		
Length	153 mm		
Magnification	30X		
Effective Aperture	42 mm		
Field of View	2.3 m at 100 m (23 feet at 100 feet)		
Minimum Focus	1.3 m		
Stadia Ratio	1 : 100		
Stadia Constant	0		
Resolving Power	3″		
Circles			
Diameter		Hz: 78 mm V: 78 mm	
Graduation	1° or 1G	1°	1° or 1G
Optical Micro Scale	20″ or 50cc	20″	10″ or 20cc
Optical Scale Estimation	5″ or 10cc	5″	2″ or 4cc
Sensitivity of Vials			
Telescope Vial	—	40″/2 mm	—
Plate Vial	30″/2 mm	60″/2 mm	30″/2 mm
Circular Vial		8′/2 mm	
Vertical Circle Indexing			
Type	Automatic	—	Automatic
Range	±5′	—	±5′
Optical Plummet			
Type	Erect		
Range	0.5 m to infinity		
Magnification	3X		
Field View	12 cm at 1.4 m		
Compass			
Type	Tubular		
Needle Length	50 mm		
Dimensions & Weight			
Height	305 mm	289 mm	305 mm
Width	160 mm	160 mm	163 mm
Length	153 mm		
Weight	4.0 kg	3.6 kg	4.0 kg
Case			
Height	380 mm		
Width	240 mm		
Length	210 mm		
Weight	3.5 kg		
Lighting Device	Built-in type with the 30 seconds Auto Power OFF device		
Light Source	Green LED		
Power Source	Two 1.5 V (UM-3) Penlight batteries		
EDM and Hand-grip mounting base			
Width	94 mm		
Tripod Attaching Screw			
Type	5/8″ × 11	1-3/8″ × 13	5/8″ × 11

	TH-10DC	TH-06D	TH-60S	TH-60E
Telescope				
Type	Erecting analactic optics			
Length	153 mm			
Magnification	30X			
Effective Aperture	42 mm			
Field of View	2.3 m at 100 m (23 feet at 100 feet)			
Minimum Focus	1.3 m			
Stadia Ratio	1 : 100			
Stadia Constant	0			
Resolving Power	3″			
Circles				
Diameter	Hz: 78 mm		V: 78 mm	
Graduation	1°		1° or 1G	
Optical Micro Scale	10″	6″	—	
Optical Scale	—		1′ or 0.1cc	
Estimation	2″	1″	0.1′ or 0.1cc	
Sensitivity of Vials				
Telescope Vial	—	—	—	40″/2 mm
Plate Vial	30″/2 mm	30″/2 mm	30″/2 mm	60″/2 mm
Circular Vial	8′/2 mm			
Vertical Circle Indexing				
Type	Automatic		Automatic	—
Range	±5′		±5′	—
Optical Plummet				
Type	Erect			
Range	0.5 m to infinity			
Magnification	3X			
Field View	12 cm at 1.4 m			
Compass				
Type	Tubular			—
Needle Length	50 mm			—
Dimensions & Weight				
Height	289 mm	305 mm	305 mm	289 mm
Width	163 mm	163 mm	152 mm	152 mm
Length	153 mm			
Weight	3.6 kg	4.0 kg	4.0 kg	3.6 kg
Case				
Height	380 mm			
Width	240 mm			
Length	210 mm			
Weight	3.5 kg			
Lighting Device	Built in type with the 30 seconds Auto Power OFF device			
Light Source	Green LED			
Power Source	Two 1.5 V (UM-3) Penlight batteries			
EDM and Hand-grip mounting base				
Width	94 mm			
Tripod Attaching Screw				
Type	1-3/8″ × 13		5/8″ × 11	

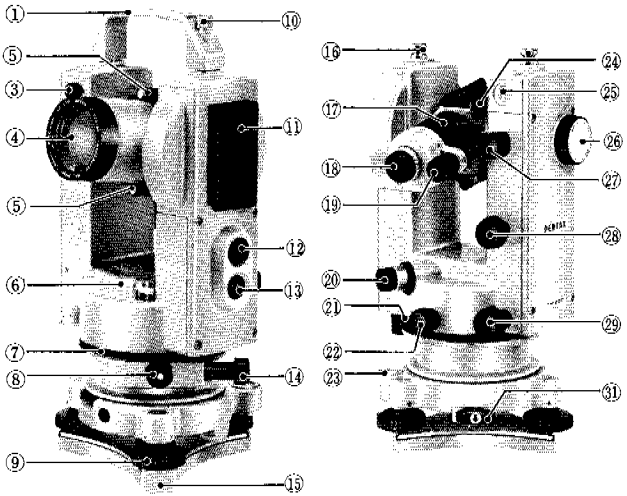
3. Description of Parts

1. TH-20DC and TH-10DC



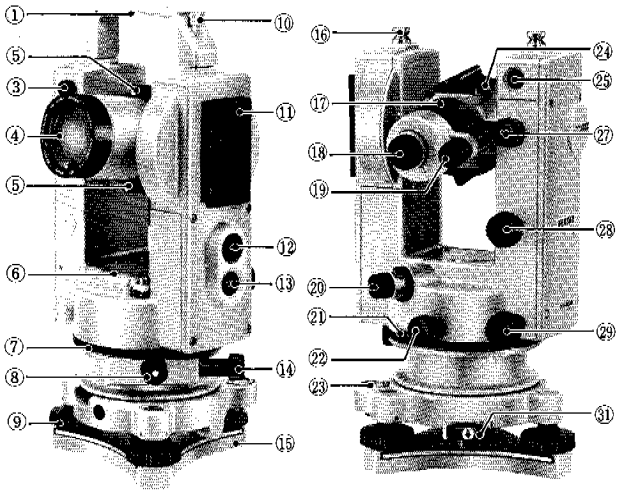
1 Hand-grip
2 Telescope vial (TH-20DC only)
3 Magnetic needle release knob
4 Objective lens
5 Collimator sight
6 Plate vial (with cover)
7 Circle rotation ring
8 Lower clamp screw
9 Leveling screw
10 Hand-grip detaching screw
11 Battery box
12 Lighting window
13 Light switch
14 Lower tangent screw
15 Bottom plate
16 E.D.M. mounting studs
17 Focusing knob
18 Telescope eyepiece
19 Circle reading eyepiece
20 Optical plummet eyepiece
21 Circle display window
22 Upper clamp screw
23 Circular vial
24 Reticle Illumination
25 Compass
26 Micro knob
27 Telescope clamp screw
28 Telescope tangent screw
29 Upper tangent screw
30 Shifting plate locking knob

2. TH-20D, TH-10D and TH-06D



1 Hand-grip
3 Magnetic needle release knob
4 Objective lens
5 Collimator sight
6 Plate vial (with cover)
7 Circle rotation ring
8 Lower clamp screw
9 Leveling screw
10 Hand-grip detaching screw
11 Battery box
12 Lighting window
13 Light switch
14 Lower tangent screw
15 Bottom plate
16 E.D.M. mounting studs
17 Focusing knob
18 Telescope eyepiece
19 Circle reading eyepiece
20 Optical plummet
21 Circle display window
22 Upper clamp screw
23 Circular vial
24 Reticle illumination knob
25 Compass
26 Micro knob
27 Telescope clamp screw
28 Telescope tangent screw
29 Upper tangent screw
31 Tribrach locking knob

3. TH-60S and TH-60E



1 Hand-grip
3 Magnetic needle release knob
4 Objective lens
5 Collimator sight
6 Plate vial (with cover)
7 Circle rotation ring
8 Lower clamp screw
9 Leveling screw
10 Hand-grip detaching screw
11 Battery box
12 Lighting window
13 Light switch
14 Lower tangent screw
15 Bottom plate
16 E.D.M. mounting studs
17 Focusing knob
18 Telescope eyepiece
19 Circle reading eyepiece
20 Optical plummet
21 Circle display window
22 Upper clamp screw
23 Circular vial
24 Reticle illumination
25 Compass (TH-60S only)
27 Telescope clamp screw
28 Telescope tangent screw
29 Upper tangent screw
31 Tribrach locking screw (TH-60S only)

4. Standard Equipment and Accessories

Pentax Theodolites are packaged complete with the standard accessories, as listed below. If any of these accessories are not included with your instrument, please inform your dealers immediately.

Carrying Case	1
Lens Cap	1
Lens Hood	1
Plumb Bob	1 set
Plumb Bob Hook (TH-20DC & TH-10DC only)	1
Screwdrivers (large & small)	1 of each
Adjusting Pin	1
Cleaning Brush	1
1.5V(UM-3) Penlight Batteries (Packs of 2)	2 sets

The following optional accessories are available for use with your theodolite.

- Tripod
- Target Sets
- Diagonal Eyepiece
- Eyepiece Filter

Please refer to section 9 for applications and specifications of these accessories. All accessories are available from stock from your dealers.

5. Operating Instructions

1. Preparation for surveying

(1) When coarse centering is performed using a plumb bob

1) Setting up the instrument and the tripod

1. Adjust the tripod legs so that a height suitable for surveying is obtained when the instrument is set on the tripod.

(For TH-20DC and TH-10DC only)

2. Set the theodolite on the tripod head. Screw the center screw into the tripod clamp screw of the theodolite, finger tight.

3. Fix the shifting device after setting it to almost the center of the shifting range.

4. Pass the plumb bob hook through the hole in the center screw, and hang it on the ring located at the center of the theodolite lower end. Adjust the length of the string so that the tip of the plumb bob is close to the station center.

5. Move the theodolite by pushing the bottom plate with the fingertips. When the tip of the plumb bob coincides with the station, tighten the center screw securely.

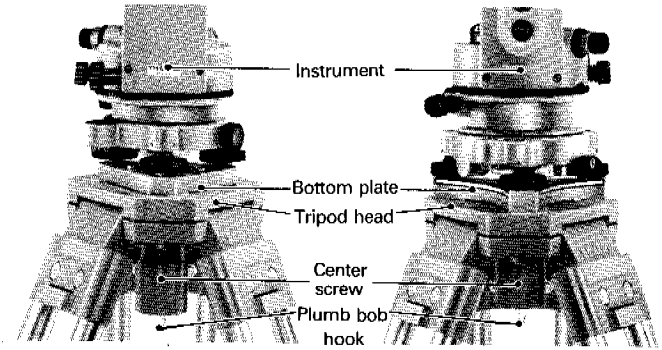


Fig. 1 Fig. 2

2. Hang the plumb bob on the hook of the tripod, and carry out coarse centering with the station on the ground. At this time, set the tripod and fix the metal shoe firmly into the ground so that the tripod head is as level as possible, the center screw is at the center of its moving range, and the plumb bob coincides the station on the ground.

3. If the tripod head is disturbed by the action of fixing the metal shoe into the ground, correct the level by extending or retracting each leg of the tripod.

2) Leveling with the circular vial

1. By adjusting two leveling screws selected at random, position the bubble in the center of the vial (see Fig. 3 (A)). (To adjust the screws at the same time, turn them in opposite directions.)

2. Adjust the remaining leveling screw, and position the bubble in the center of the circle (see Fig. 3 (B)). For the relation between the screw adjusting direction and bubble moving direction, see the arrow marks in (A) and (B) of Fig. 3.

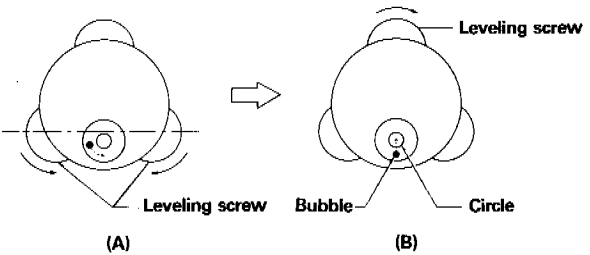


Fig. 3

3) Leveling with the plate vial

1. Place the plate vial in parallel with a line joining any two of the leveling screws. Adjust the two screws, and position the bubble in the center of the level (A of Fig. 4). (To adjust the screws at the same time, turn them in opposite directions.)

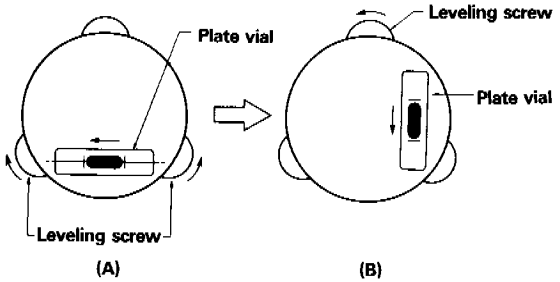


Fig. 4

2. Rotate the plate vial through 90° around the vertical axis. Adjust the remaining leveling screw so that the bubble comes to the center of the plate vial (see Fig. 4 (B)).

3. Repeat 1 and 2 by rotating the plate vial through 90° so that the bubble is positioned in the center when the plate vial is moved in any direction.

- See arrows in Fig. 4 (A) and (B) for the relation between the direction of leveling screw rotation and the bubble shifting direction.

- If the bubble is not positioned stably in the center in 3 even after repeating 1 and 2, "Adjustment of the plate vial" is necessary (see Page 40, 1 "Perpendicularity of Plate Vial to Vertical Axis")

4) Centering with the optical plummet

After 1,2 and 3 are completed, center correctly in the following manner using optical plummet.

1. First remove the plumb bob. Look through the optical plummet eyepiece, and rotate the eyepiece knob until the center mark can be seen clearly.

2. Rotate the focusing knob of the optical plummet and adjust the focus to the station on the ground.

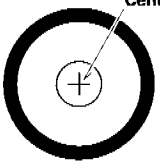


Fig. 5

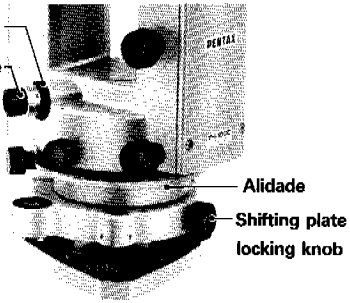


Fig. 6

(For TH-20DC and TH-10DC)

3. Loosen the shifting plate locking knob. Look through the optical plummet eyepiece, and push the alidade with the fingertips so that the reticle coincides with the station.

4. Tighten the shifting plate locking knob. Ascertain that the bubble stays positioned in the center when rotating the plate vial position in steps of 90°. If the bubble is not position in the center, adjust the leveling screw.

(For TH-20D, TH-10D, TH-06D and TH-60S)

3. Loosen the center screw of the tripod. Look through the optical plummet, and move the bottom plate on the tripod head taking care to avoid rotating the instrument until the center mark coincides with the station.

4. Tighten the center screw, and ascertain that the bubble stays positioned in the center when rotating the plate vial in steps of 90°. If the bubble is not positioned in the center of the plate vial, adjust the leveling screw.

- The focusing device permits focusing from 0.5m to ∞ with the optical plummet.

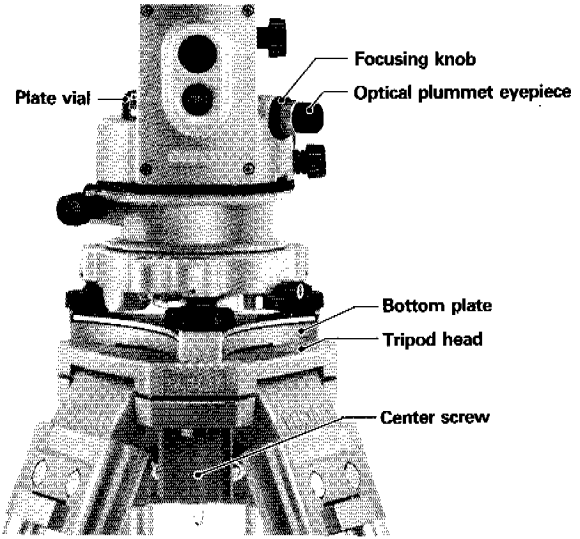


Fig. 7

(2) When coarse centering is not performed using a plumb bob

1) Setting up the instrument and tripod

1. Adjust the tripod so that a height suitable for surveying is obtained with enough extension/contraction margin left when the instrument is set on the tripod. Extend the tripod legs and fix the metal shoe firmly into the ground so that the tripod center is directly on the station observing it by eye.

2. Set the theodolite on the tripod head

2) Centering and leveling with the optical plummet

1. Look through the optical plummet eyepiece, and rotate the eyepiece until the center mark can be clearly seen.

2. Rotate the focusing knob of the optical plummet and focus on the station.

3. Look through the optical plummet, and rotate the three leveling screws to tilt the instrument so that the center mark coincides with the station.

4. Adjust the length of each tripod leg by extending or contracting it, and position the bubble of the circular vial in the center of the circle. (When doing this, place a foot on the metal shoe of the tripod to hold it in that position.) (see Fig. 9)

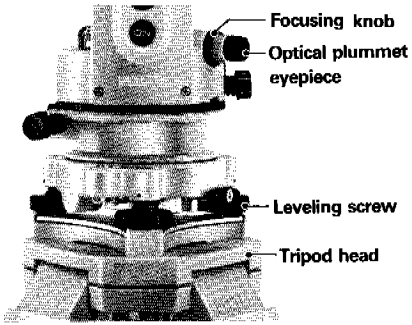


Fig. 8

Fig. 9

3) Leveling with the plate vial

1. Level the instrument as indicated in 3) "Leveling with the plate vial" on page 13.

2. After leveling the instrument , readjust the center by moving the instrument on the tripod head if necessary.

(3) Miscellaneous

1) Centering to an overhead station

The instrument can be centered to an overhead station by adjusting the center of the collimator sight to the tip of the plumb bob suspended from an overhead station on a roof or ceiling.

1. Suspend the plumb bob from the overhead station. Set the tripod so that the center of the tripod head is placed right under the station.

2. Mount the instrument with the hand-grip removed on the center of the tripod head, and level the instrument. With the TH-20DC and TH-10DC, set the shifting device to almost the center of its moving range and fix there beforehand.

3. Set the vertical circle to 90° or 270°. (270° only for TH-20DC)

(For TH-20DC and TH-10DC)

4. Loosen shifting plate locking knob and push the alidade with the fingertips so that the center mark of the collimator sight coincides with the tip of the plumb bob.

5. Tighten the shifting plate locking knob and check if the bubble of the plate vial is positioned in the center.

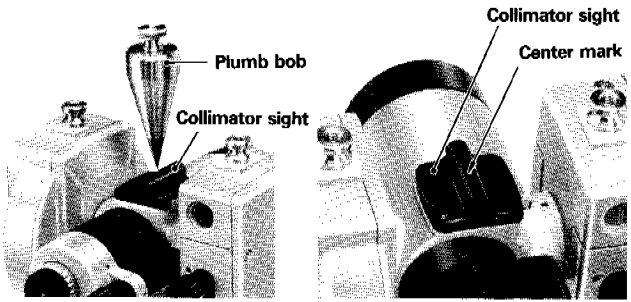


Fig. 10

(For TH-20D, TH-10D, TH-06D and TH-60S)

4. Loosen the center screw, and move the bottom plate on the tripod head taking care to avoid rotating the instrument so that the center mark of the collimator sight coincides with the tip of the plumb bob.

5. Tighten the center screw, and rotate the plate vial in steps of 90° to ascertain that the bubble stays positioned in the center. If the bubble is not in the center, adjust the leveling screw.

2) Lighting device

Press the ON button of the light switch to read the circles. The lighting will automatically turn off about 30 seconds after depression of the ON button to save battery power (Auto Power OFF Function).

1. If the circle is dark and hard to read even if the ON button is pressed, the battery is worn out and must be replaced.
   To replace the battery, remove the battery cover, and replace batteries.

2. Insert new batteries, making sure that their polarities are as shown in the box. Always replace both batteries.

3. Before going out on survey work, be sure to check that the batteries are installed.
   If no batteries are available, direct light on to the window located above the light switch (ON button) using a sheet of white paper.

4. When the instrument is not going to be used for a time, remove the batteries from the battery box.
   If the instrument is left for a long time with the batteries in it, the batteries will leak and damage the interior of the instrument.

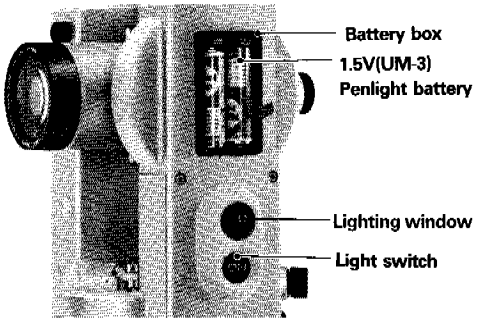


Fig. 11

3) Attachment and Detachment of Tribrach
(except for TH-20DC, TH-10DC and TH-60E)

The tribrach is detachable from the instrument if required: when replacing the instrument with a target for traversing or exchanging with an electronic distance meter for example.

A Detachment
First loosen the recessed screw with a screwdriver. Then rotate the locking knob until the arrow points upward, and lift the instrument up.

B Attachment
Mount the instrument on the tribrach with the guide marks coinciding, and rotate the locking knob until the arrow points downward.

- When the tribrach does not need to be attached or detached or it is to be transported, tighten the recessed screw with a screwdriver to fix the locking knob.

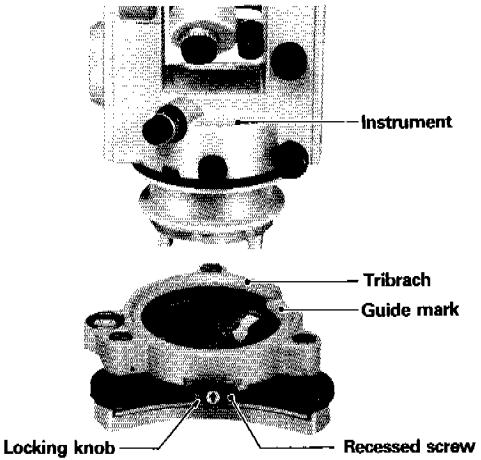


Fig. 12

(2) Surveying

1) Eyepiece adjustment

1. Remove the telescope lens cap, and attach the lens hood, if necessary.

2. Point the telescope at a bright object, and rotate the eyepiece ring fully counter-clockwise.

3. Look through the eyepiece, and rotate the eyepiece ring clockwise until the reticle appears as its maximum sharpness.

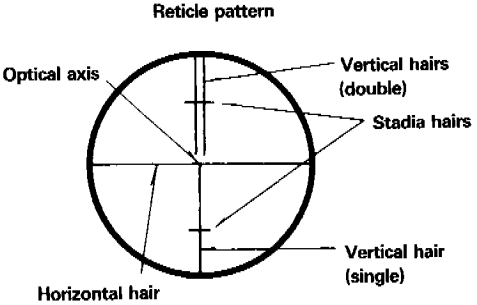


Fig. 13

2) Object sighting

1. Point the telescope at the object using the collimator sight. Tighten all clamp screws. (With the TH-20DC, use the tips of the telescope spirit level adjusting screws as a foresight and a backsight.)

2. Look through the telescope eyepiece and finely adjust the focusing knob until the object is perfectly focused. If focusing is correct, the cross hairs will not move in relationship to the object when you move your eye slightly left and right while looking through the eyepiece. This will eliminate any parallax.

3. Turn each tangent screw to correctly align the cross hairs on the object.

- Turn the focusing knob clockwise to focus on a near object. Turn the knob counterclockwise to focus on a far object.

- When aligning to an object using the tangent screw, always align by rotating the screw clockwise. If the screw is turned past the object, turn it counterclockwise to the original position and then turn the screw clockwise to align the cross hair on the object.

- Press the light switch ON button when a measurement is to be taken at night or in dark places such as tunnels.
  The reticle is illuminated by the built-in lighting device. (The brightness can be adjusted with the reticle illumination knob.)

- When no illumination is needed on the reticle, set the reticle illumination knob to mid travel.

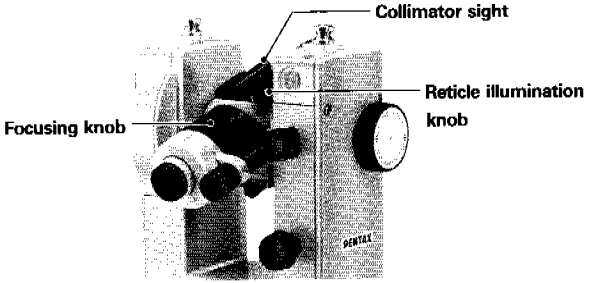


Fig. 14

3) Horizontal sighting

When performing horizontal sighting in direct leveling and in setting up horizontal surfaces, the method is different with the TH-20DC and other models. The distance from the instrument to the objects should be set as near equal as possible.

(For the TH-20DC)

Level the instrument, and then center the telescope bubble by adjusting the telescope tangent screw.

- Whenever the telescope is pointed at a new object for sighting, make sure that the bubble is in the center of the telescope. If it is not in the center, perform the sighting after correcting the bubble position by adjusting the telescope tangent screw.

(For instruments other than TH-20DC)
Level the instrument, and then look through the circle reading eyepiece and set the vertical angle (V) to 90° 0′ 0″.

- To set the vertical angle (V) to 90° 0′ 0″, first set the micro number to 00′ 00″ with the micro knob, and then operate the telescope tangent screw so that the graduation line of the circle number 90° is interposed between the index lines. (With the TH-60S, coincide the 90° graduation line with the 0′ graduation.)

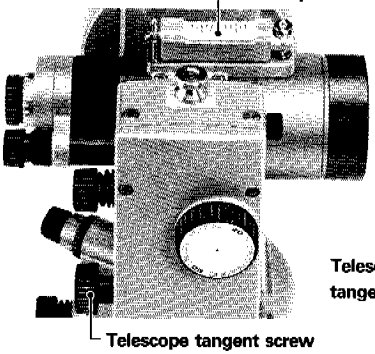


Fig. 15

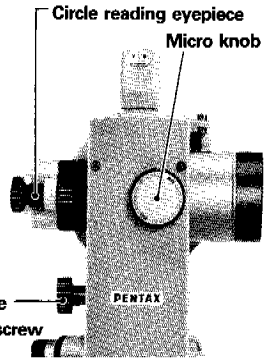


Fig. 16

- Whenever the telescope is pointed to a new object for sighting, correct the vertical angle (V) by operating the telescope tangent screw.

- For reading the circle, refer to (3) "Angle Measurement".

4) Setting up straight lines

A line joining points collimated to an object, near or distant, is a straight line. This fact is used in setting up straight lines. Setting up a point C on the straight line AB is carried out as follows.

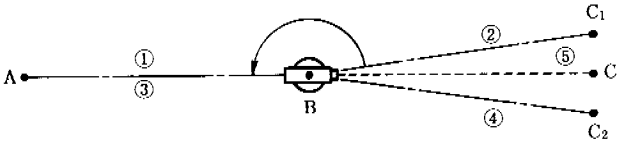


Fig. 17

1. Set up the instrument at point B on the straight line and level it. Then, sight point A.

2. Loosen the telescope clamp screw and reverse the telescope on its horizontal axis. Set a point on the line of sight and call it point C_1.

3. Loosen the upper clamp screw and rotate the instrument about its vertical axis and sight on point A again.

4. Loosen the telescope clamp screw and reverse the telescope on its horizontal axis again. Set a point on the line of sight and call it point C_2.

5. Set point C in the center of points C_1 and C_2. This point B and C is an extension of the straight line AB.

5) Setting up vertical lines

When the instrument is leveled and the telescope rotated about its horizontal axis, the line of sight generates a vertical plane, and a vertical line can thus be set up. Setting up a point B on the perpendicular at point A is carried out as follows.

1. Set the instrument on a point P at a distance equal to or longer than AB. Level the instrument and sight point A.

2. Loosen the telescope clamp screw. Point the telescope upward at the same angle as point B and set a point on the line (point B_1).

3. Move the instrument to a point which is at right angles to line AP and at the same distance as AP from point A. Level the instrument and sight point A.

4. Loosen the telescope clamp screw, and point the telescope upward at the same angle as point B and set a point on the line (point B_2).

5. Set the point B at the crossing point of the extended lines of B_1 and B_2. The line joining A and B is perpendicular.

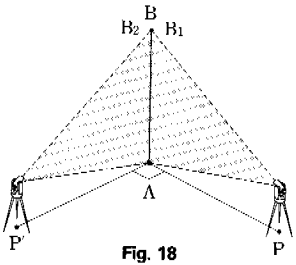


Fig. 18

- When sighting point A in procedures 1 and 3, be sure that the bubble is in the center of the plate vial.

- When more precise results are required, repeat 1, 2 and 3, 4 respectively using the telescope in the normal and reverse positions. And set B_1 and B_2 at the centers of the points obtained using the telescope in the normal and reverse positions.

- The telescope normal position means the state where the vertical circle is seen on the left of the telescope eyepiece. The reverse position is the state where the vertical circle is seen on the right of the eyepiece.

6) Stadia surveying

The stadia hairs (Fig. 13) on the reticle provide the method of measuring distance and height from the instrument center to a leveling rod.

- Calculations are easy since the stadia addition constant is 0.

When the line of sight is inclined

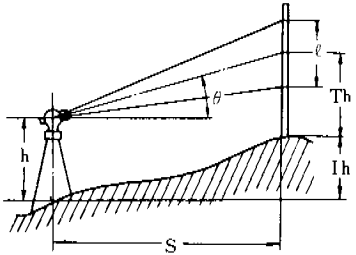


Fig. 19

$S=100\ell \cos 2\theta$
$h=50\ell \sin 2\theta$
$(Ih=Th)$

When the line of slight is horizontal

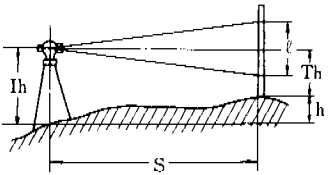


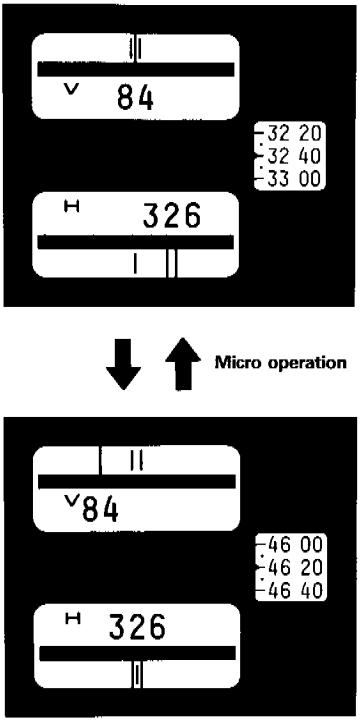
Fig. 20

$S=100\ell$
$h=Ih-Th$

S: Horizontal distance
h: Difference in elevation
θ: Vertical angle
ℓ: Difference in top and bottom stadia hair readings
Ih: Instrument height
Th: Line of sight reading

(3) Angle Measurement

(TH-20DC and TH-20D)



(A) V = 84° 32′ 40″

(B) H = 326° 46′ 20″

Fig. 21

(TH-10DC and TH-10D)

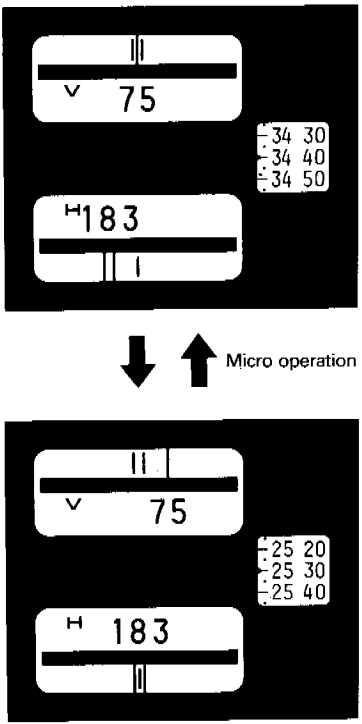
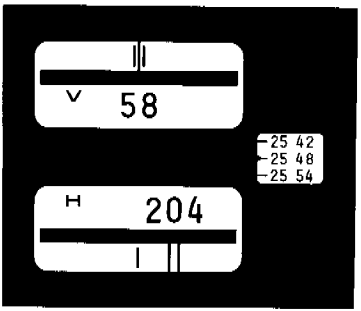


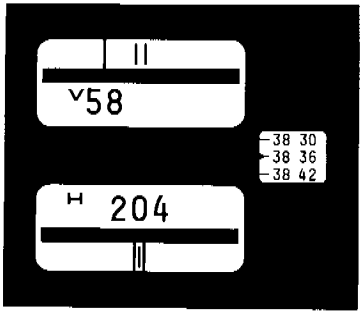
Fig. 22



(A)

V 58" 25' 48"

Micro operation



(B)

H= 204° 38' 36"

Fig. 23

1) Reading the horizontal circle (H) (excluding TH-60S and TH-60E)

1. Press the light switch ON button. Look through the circle reading eyepiece, and rotate the eyepiece ring so that the circle graduations are clearly seen.

2. Turn the optical micrometer knob until one of the index lines of the H mark seen in the lower part of the field of view comes to the center of two graduation lines (Fig. 21 to 23, B).

3. Read the circle number for the H mark and the micro number in the right side of the field of view, and take them as the measured values of the horizontal angle.
   (326° 46'20" in case of Fig. 21, B)
   (183° 25'30" in case of Fig. 22, B)
   (204° 38'36" in case of Fig. 23, B)

- Make the eyepiece adjustment described in 1 in the same way as telescope eyepiece adjustment in 2) "Observation".

- Since the optical system is designed to read two diametrically opposite sides of the circle, readings can be taken with no eccentric error.

2) Reading the vertical circle (V) (excluding TH-60S and TH-60E)

1. Press the light switch ON button. Look through the circle reading eyecpiece, and rotate the eyepiece ring so that the circle graduations are clearly seen.

2. Turn the optical micrometer knob until one graduation line comes to the center of the two index lines of the V mark seen in the upper part of the field of view. (Fig. 21 to 23, A)

3. Read the circle number for the V mark and the micro number in the right side of the field of view, and take them as the measured values of the vertical angle.
   (84° 32'40" in Fig. 21, A)
   (75° 34'40" in Fig. 22, A)
   (58° 25'48" in Fig. 23, A)

- Make the eyepiece adjustment in 1 in the same way as telescope eyepiece adjustment in 2) "Observation".

- When the telescope line of sight is horizontal, the vertical circle will show 90° or 270°. Viewed from the vertical circle, reading will increase counterclockwise (0° at the zenith).

- The instrument leveling error (within 5') will be corrected by the automatic compensator. (The automatic compensator is not provided on the TH-20DC.)

3) Reading the horizontal (H) and vertical circle (V) on the TH-60S and TH-60E

1. Press the light switch ON button. Look through the circle reading eyepiece, and rotate the eyepiece ring so that the circle graduations are clearly seen.

2. Read the scale graduations indicated by the circle number and graduation line, and take them as the measured value. In this case, read the scale graduations down to 1/10 of one graduation, that is 0.1'.

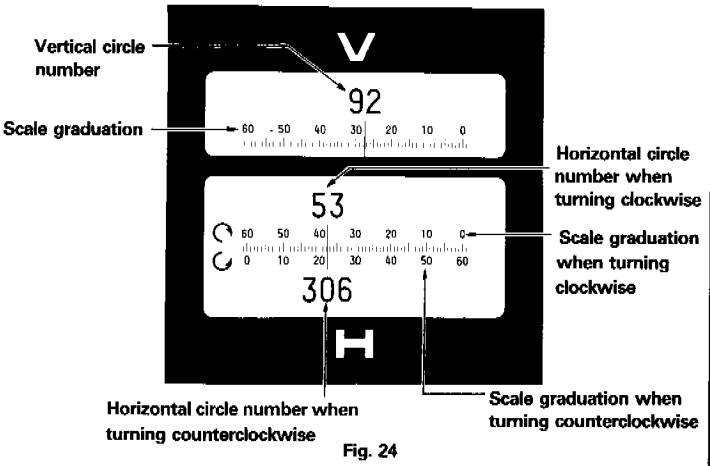


Fig. 24

A Reading the horizonal circle (H) (in Fig. 24)
Angle when turning counterclockwise: 306° 22.2′ (306° 22′ 12″)
Angle when turning clockwise: 53° 37.8′ (53° 37′ 48″)

B Reading the vertical circle (V) (in Fig. 24)
92° 27.5′ (92° 27′ 30″)

- Make the eyepiece adjustment described in 1 in the same way as telescope eyepiece adjustment in 2) "Observation".

- When the telescope line of sight is horizontal, the vertical circle will show 90° or 270°. Viewed from the vertical circle, reading will increase counterclockwise (0° at the zenith).

- The instrument leveling error (within 5′) will be corrected by the automatic compensator.

4) Setting the horizontal circle

1. Loosen each clamp screw, and turn the circle rotating ring so that the circle mark corresponding to the desired angle appears in the display window.

2. Look through the circle reading eyepiece and set the number for the desired angle (circle number) in the field of view, and tighten the upper clamp screw.

3. Turn the optical micrometer knob and set the micrometer number to the desired angle number. (This operation is not done on the TH-60S.)

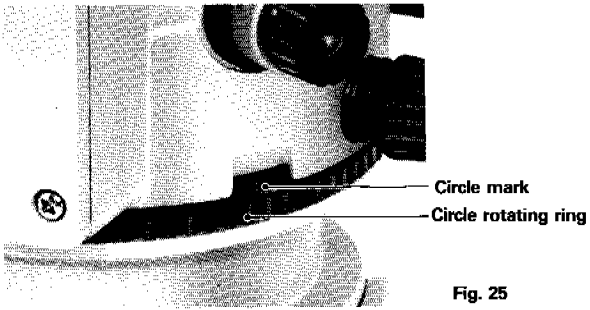


Fig. 25

4. Turn the upper tangent screw so that the index line comes to the center of the graduation lines of the circle numbers. (With the TH-60S, turn the upper tangent screw and set the scale graduation to the number of the desired angle.)

5) Angle measurement

1. Set the instrument over the point, level it and read the horizontal circle.
2. Sight the first object accurately.
3. Point the telescope to the second object accurately.
4. Read the horizontal angle (α_1) and obtain the difference with the reading (α_0) of 3. Then, the angle (α) made by the first and second objects can be obtained.

- If the above method is repeated with the telescope in the normal and reversed positions to obtain the average of the two measurements, a more accurate result can be obtained.

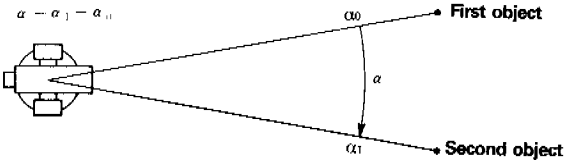


Fig. 26

6) Angle measurement by repetition

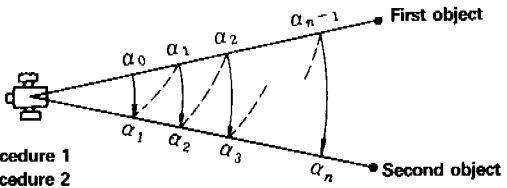
Since the vertical axis of the instrument is of the double axis independent type, a greater accuracy in angle measurement can be obtained by the repetition method. Angle measurement by the repetition method is done as follows after setting the horizontal circle.

1. Point the telescope to the first object and sight it precisely. Read the horizontal angle, and record it.

2. Sight the second object precisely. Read the horizontal angle, and record it.

3. Repeat the procedures from 1 by loosening the lower clamp screw and telescope clamp screw.

4. Count repetition of the procedures 1 and 2 as one repetition. Obtain the angle (α) made by the first and second object using the following formula:



α_0: **First reading in procedure 1**
α_n: **Last reading in procedure 2**
n: **Number of repetitions**

Fig. 27

- The number of repetitions is usually a multiple of 3.

- It is sufficient to record only the first α_0 angle and the last α_n angle readings on the horizontal circle, but recording the reading taken each time in procedure 2 makes it possible to check if an error has occurred in the intermediate operation.

- If the above repetition method is repeated with the telescope in the normal and reversed positions to find the average of the two measurements, a more accurate result can be obtained.

7) Angle measurement by the direction method

1. Set the instrument over the angle measurement base, level it and set the horizontal circle in the neighborhood of 0°.

2. Place the telescope in the direction of "1" in the normal position, and sight it precisely. Read the horizontal angle.

3. Sight 2 precisely. Read the horizontal angle.

4. In the same way, observe the directional angles 3, 4 and 5 clockwise in turn. (Fig. 28)

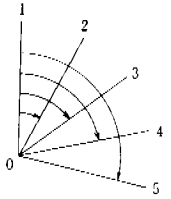


Fig. 28 Normal position

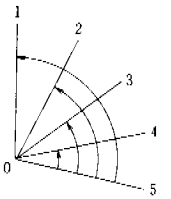


Fig. 29 Reversed position

5. Reverse the telescope, and sight "5" precisely. Read the horizontal angle.

6. In the same way, observe the directional angles 4, 3, 2 and 1 counterclockwise in turn (Fig. 29). The above is called a "one pair observation".

- Usually "two pair observations" are performed.

- For second pair observation, the circle position is rotated through 90° and observation made in the same manner as for the first pair.

- The number of observation directions is limited to six.

- The sum of seconds for observation in the same direction in the same pair ..... Double angle
  Difference in seconds for observation in the same direction in the same pair ..... Range
  Difference in double angle between first and second pairs ..... Double angle range
  Difference in ranges between first and second pairs ..... Observation range

8) Setting up horizontal angle

When setting up a fixed angle from a set point in civil engineering and other works, first set the horizontal circle at an arbitrary angle near 0°, and proceed as follows:

1. Point the telescope to the set point, and sight the set point precisely. Read the horizontal angle.

2. Determine the set angle for the horizontal circle by adding the fixed angle to the reading at the set point.

3. Loosen the upper clamp screw, and rotate the instrument around the vertical axis so that the circle mark corresponding to the set angle appears in the display window.

4. Look through the circle reading eyepiece, and set the set angle (circle number) in the field of view. Tighten the upper clamp screw.

5. Turn the optical micrometer knob and take the reading on the micrometer as the reading of the set angle.
   (This is not done on the TH-60S and TH-60E)

6. Turn the upper tangent screw so that the index line comes to the center between two graduation lines of the circle number.
   (With the TH-60S, turn the upper tangent screw and take the reading of the scale graduation as the reading of the set angle.)

7. Adjust the vertical direction of the telescope by turning the telescope clamp screw and telescope tangent screw. Mark the point focused and sight through the telescope, and take it as a set point.

9) Measuring compass angles

When the compass needle is set between the two lines in the compass indicator, the telescope always sights the magnetic north in the normal position . Thus, measurement or setting up of compass angles can be performed. Compass angles are measured as follows:

1. Set the horizontal circle at an arbitrary position near 0°.

2. Rotate the magnetic needle clamp knob to free the needle.

3. Loosen the lower clamp screw, and rotate the instrument around its vertical axis. Find the position where the needle comes to the compass indicator lines.

4. Tighten the lower clamp screw. Turn the lower tangent screw so as to position the needle in the center of the two compass indicator lines (Fig. 30).

5. Read the horizontal angle, and take it as the reading of magnetic north.

6. Sight the object station precisely.

7. Read the horizontal angle. Calculate the difference between it and the reading of the magnetic north obtained in 5, and take the result as the compass angle of the object.

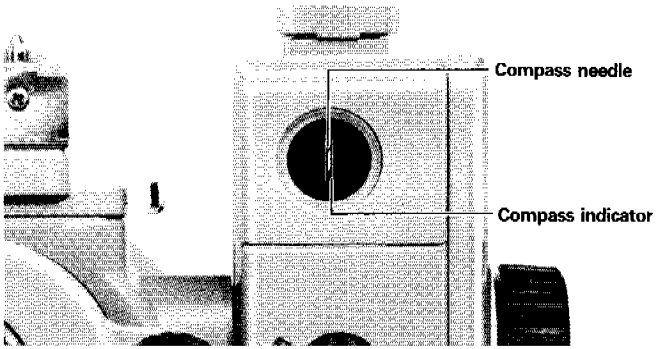


Fig. 30

- The magnetic needle clamp knob may be turned either to the left or right. The needle is locked and freed alternately at each click stop.

- Be sure to make the north as 0° to find an angle, and obtain angles clockwise.

- When finding the true north angles, local magnetic deviation must be corrected.

- After using the compass, always turn the needle clamp knob to lock the needle.

6. Maintenance and Packing

1) Maintenance

1. After using the instrument, wipe off dust and moisture and store it in its case.

2. When cleaning the exposed parts, first remove dust with the cleaning brush, then gently wipe with a soft cloth.

3. To clean the lens surfaces, first remove dust with the cleaning brush, then gently wipe with a clean cotton cloth to which a small amount of alcohol has been applied. Be sure the cloth used is clean.

2) Packing

Pack the instrument in the plastic case as follows.

1. Set the telescope almost horizontal, and tighten the upper clamp screw and telescope clamp screw, lightly.

2. Align the yellow dots, and tighten lower clamp screw, lightly.

3. Insert the instrument correctly into the case with the yellow dots towards you. (Fig. 31)

4. Close the case lid and lock the clamp. (Fig. 32)

- Insert the accessories as shown in Fig. 31.

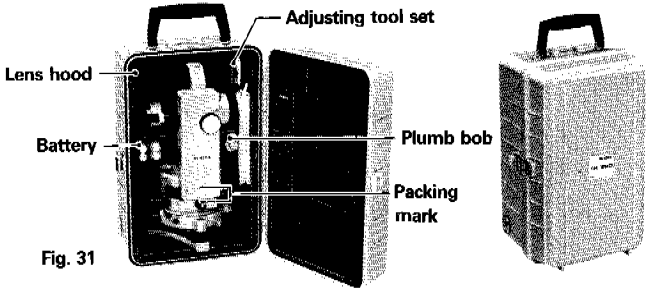


Fig. 31

7. Precautions

- For highly accurate surveying, shade the instrument and tripod from direct sunlight.
- Handle the instrument carefully while taking measurements. Always avoid using excessive force.
- Except when illuminating the cross hairs, always set the reticle illumination lever to the mid point.
- Take care to avoid turning the tribrach locking knob accidentally or forgetting to fasten it.
- Keep in a dry place.
- Take care to avoid subjecting the instrument to shocks or vibration during transportation.
- Should dirt, etc., appear inside the lens, never attempt to disassemble the instrument yourself. Consult a specialist.
- Should faults arise as a result of dropping the instrument or other accidents, never force the parts or disassemble the instrument yourself. Have it repaired by a specialist.
- Always make sure that the tripod is not defective.

8. Inspection and Adjustment

1. Perpendicularity of Plate Vial to Vertical Axis

1) Inspection

1. Align the plate vial in parallel with a line joining any two of the leveling screws. Then, adjust the two screws to center the bubble in the vial.

2. Rotate the plate vial through 90° around the vertical axis. Adjust the remaining one leveling screw to bring the bubble to the center.

3. Rotate the plate vial through 180° around the vertical axis.

4. No adjustment is necessary if the bubble of the plate vial is in the center.

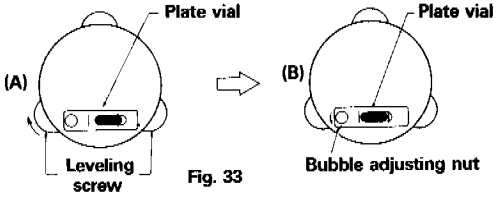


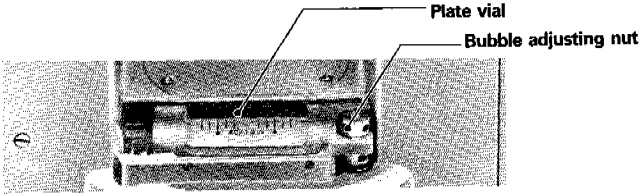
Fig. 33

2) Adjustment

1. If the bubble of the plate vial moves from the center, bring it half way back to the center by adjusting the leveling screw which is parallel to the plate vial. (Fig. 33, A)

2. Correct the remaining half by adjusting the bubble adjusting nuts with the adjusting pin.
(Fig. 33, B and Fig. 34)

3. Repeat- 1) 1, 1) 2, 1) 3, 1) 4.



2. Perpendicularity of Circular Vial to Vertical Axis

1) Inspection

No adjustment is necessary if the bubble of the circular vial is in the center after inspection and adjustment of "Perpendicularity of the Plate Vial to the Vertical Axis".

2) Adjustment

If the bubble of the circular vial is not in the center, bring the bubble to the center by turning the bubble adjusting screw with the adjusting pin.

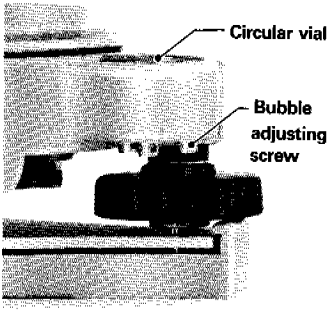


Fig. 35

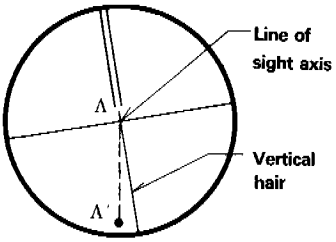


Fig. 36

3. Inclination of Reticle Pattern Cross Hairs

1) Inspection

1. Set an object point A on the line of sight through the telescope.
2. Move point A to the edge of the field of view by adjusting the telescope tangent screw (point A').
3. No adjustment is necessary if point A moves along the vertical line of the reticle.

2) Adjustment

1. If the point A does not move along the vertical line, first remove the eyepiece cover with a screwdriver.

2. Loosen the four cross hair adjusting screws uniformly with the adjusting pin. Rotate the cross hair around the lens of sight axis, and align the vertical line of the cross hairs with point A'. (Fig. 36 and Fig. 38)

3. Tighten the cross hairs adjusting screws uniformly.
   Repeat the inspection and check that the adjustment is correct.

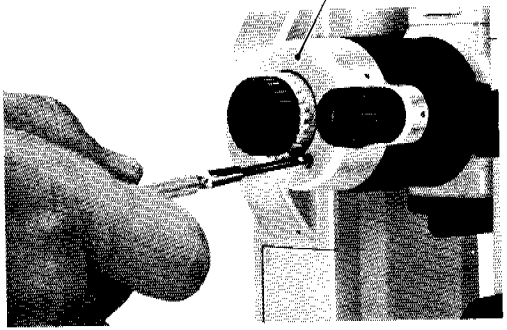


Fig. 37

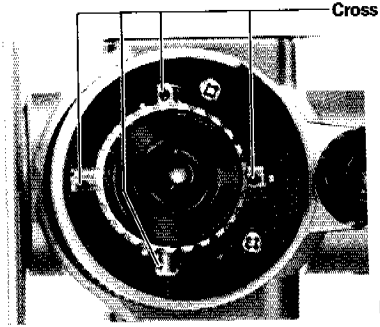


Fig. 38

4. Perpendicularity of Line of Sight to Horizontal Axis

1) Inspection

1. Set an object point A at a distance of 30 to 50m away from the instrument, and sight it through the telescope.

2. Loosen the telescope clamp screw and reverse the telescope around the horizontal axis. Mark a point set on the line of sight at about the same distance to the object point A, and call it point B.

3. Loosen the upper clamp screw, and rotate the instrument around the vertical axis. Sight point A again.

4. Loosen the telescope clamp screw, and reverse the telescope around the horizontal axis. Mark a point on the line of sight at about the same distance as point B, and call it mark C. (The telescope has now returned to its normal position.)

5. No adjustment is necessary if points B and C coincide.

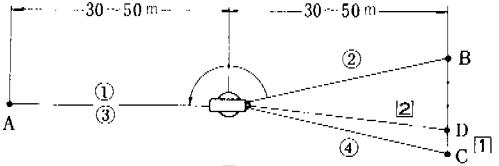


Fig. 39

2) Adjustment

1. If points B and C do not coincide, set up a point D located 1/4 of the length BC from the point C toward B. (Fig. 39)

2. Turn the two cross hairs adjusting screws opposed horizontally by first loosening one, then tightening the other (see Fig. 38) with the adjusting pin. Move the cross hair so that point D is set on the line of sight.

3. Repeat the inspection and check that the adjustment is correct.

5. Reading Vertical Angle with Line of Sight Horizontal

1) Inspection

1. Set and level the instrument at a place of 30 to 50m away from a wall.

2. Point the telescope at the wall by setting it in the reverse position. Set the vertical angle reading to 270° 0′ 0″. Mark a point on the line of sight, and call it point A.
3. Reverse the telescope, and point it at the wall (The telescope has now returned to the normal position.)

4. Set the vertical angle reading to 90° 0′ 0″. Mark a point on the line of sight, and call it point B.

5. No adjustment is necessary if points A and B coincide. To determine the vertical angle in procedures 2 and 4, first set the micrometer reading to 00′00″, then set the telescope horizontal and set 270° or 90° by adjusting the telescope tangent screw. (This is not done on the TH-60S and TH-60E.)

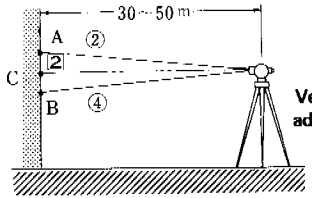


Fig. 40

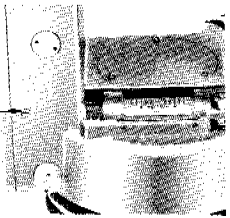


Fig. 41

2) Adjustment

1. If points A and B do not coincide, set up a point C midway between points A and B.

2. Set point C on the line of sight by adjusting the telescope tangent screw.

3. Adjust the micrometer knob and set the micrometer reading to 00′ 00″. (This is not done on the TH-60S and TH-60E.)

4. Turn the vertical axis adjusting screw located on the opposite side of the telescope tangent screw so that the 90° graduation line moves to the center between the index lines. (In the case of TH-60S, let the 90° graduation line coincide with the scale graduation line.)

6. Parallel of Telescope Vial with Line of Sight (TH-20DC)

1) Inspection

1. Prepare two identical targets, and set up the instrument on fairly level ground and in the center of two walls spaced 50 to 100m apart. (Fig. 42)

2. Center the bubble in the telescope vial by adjusting the telescope tagent screw.

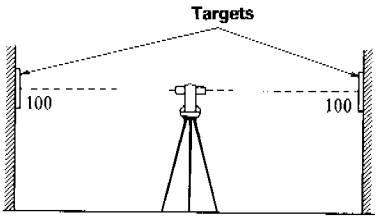


Fig. 42

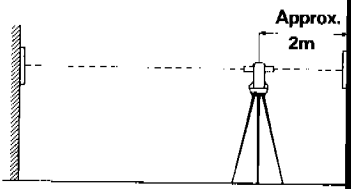


Fig. 43

3. Set the targets on each wall so that reading of each target is at the same level, and fix the target there.

4. Move the instrument to a position 2m away from one target, and level the instrument. (Fig. 43)

5. Center the bubble in the telescope vial by adjusting the telescope tangent screw. Read both targets.

6. If the readings on both targets are the same, no adjustment is necessary.

2) Adjustment

1. If the readings of both targets are not the same, point the telescope to the farthest target.

2. Adjust the telescope tangent screw so that the reading of the farthest target becomes the same as that of the nearest target.

3. Return the bubble of the telescope vial to the center by adjusting the bubble adjusting nut (Fig. 44) with the adjusting pin.

4. Repeat the inspection procedures starting with number 5, and check that the adjustment is correct.

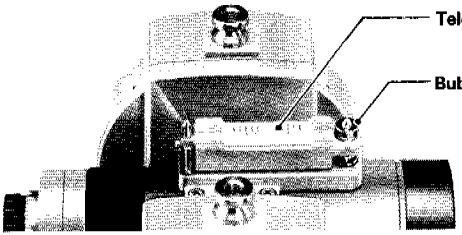


Fig. 44

7. Coincidence of Line of Sight of Optical Plummet with Vertical Axis

1) Inspection

1. Set the instrument on the tripod, and place a piece of white paper with a cross drawn on it immediately under the instrument.

2. Look through the optical plummet, and move the paper so that the intersecting point of the cross comes to the center of the field of view.

3. Adjust the leveling screw so that the center mark of the optical plummet coincides with the intersection point of the cross.

4. Rotate the instrument around the vertical axis. Look through the optical plummet each step of 90° rotation, and observe the center mark position against the intersection point of the cross.

5. If the center mark always coincides with the intersecting point, no adjustment is necessary.

2) Adjustment

1. If the center mark does not coincide with the intersection point, mark the points set on the line of sight at each step of 90° rotation on the paper, and call them points A, B, C and D (see Fig. 45).

2. Join the opposed points (A, C and B, D) with a straight line, and set intersecting point 0.

3. Turn three optical plummet adjusting screws with a screwdriver so that the center mark coincides with intersecting point 0 (see Fig. 46).

4. Repeat the inspection procedures starting with number 4, and check that the adjustment is correct.

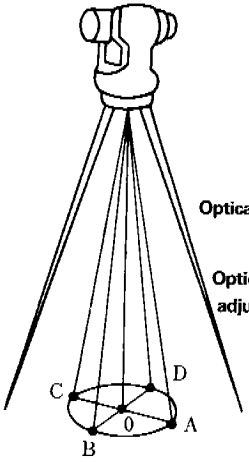


Fig. 45

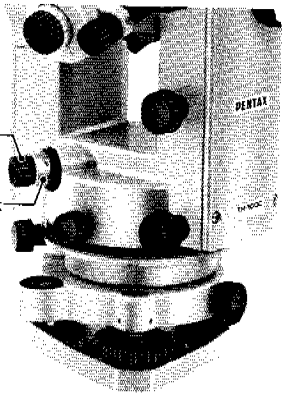


Fig. 46

9. Applications and Specifications of Optional Accessories

1) Tripods

Use of a high quality tripod is one of the essential conditions for obtaining highly accurate measurement values in surveying. Only use tripods that carry the PENTAX trademark.

TS-2 Tripod

The TS-2 is a large precision tripod made of high quality wood, and used with the TH-06D, TH-10D, TH-20D, TH-60S and TH-60E.

TC-2 Tripod

The TC-2 is a large precision tripod made of high quality wood, and used with the TH-10DC and TH-20DC.

TS-3 Tripod

The TS-3 is an aluminum tripod, and used with the TH-06D, TH-10D, TH-20D, TH-60S and TH-60E.

TC-3 Tripod

The TC-3 is an aluminum tripod, and used with the TH-10DC and TH-20DC.

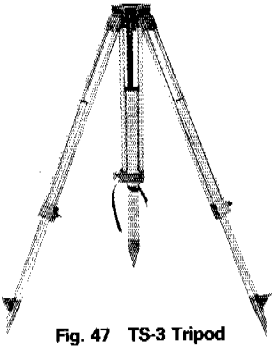


Fig. 47 TS-3 Tripod

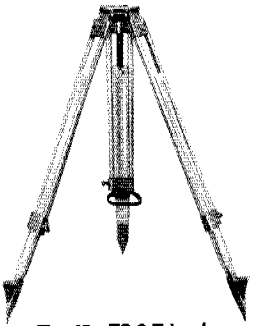


Fig. 48 TS-2 Tripod

2) Target Set

Theodolites TH-06D, TH-10D, TH-20D and TH-60S have a detachable tribrach, allowing a target to be used for efficient measurement in various types of surveying.

Target (with optical plummet) 2
Tribrach 2
Lighting device set 2
Plumb bob set 2
Storage case 1

Fig. 49

3) Diagonal Eyepiece

The diagonal eyepiece can be attached to the telescope eyepiece or circle reading eyepiece for convenience in observing the zenith or surveying in confined spaces.
To attach the diagonal eyepiece to the telescope, turn the telescope eyepiece ring counterclockwise to remove the eyepiece, and attach the diagonal eyepiece by turning its ring clockwise.
To attach the eyepiece to the circle reading eyepiece, turn the knurled rubber knob of the circle reading eyepiece counterclockwise to remove it.
The eyepiece can be rotated through 360°.
When sighting is made through the telescope with the diagonal eyepiece attached, the reticle may be seen deflected vertically or horizontally, but this has no influence upon accuracy. It can be corrected with three adjusting screws if necessary.

4) Eyepiece Filter

The eyepiece filter can be attached to the telescope eyepiece or diagonal eyepiece for sun observation, etc.

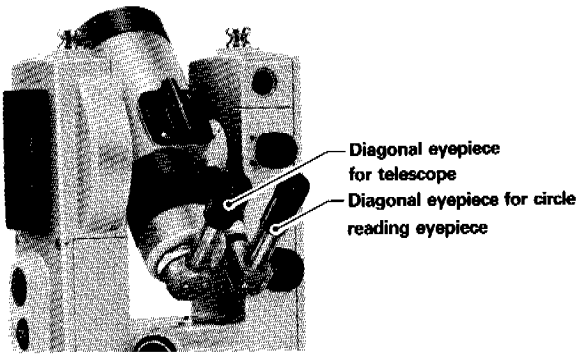


Fig. 50

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