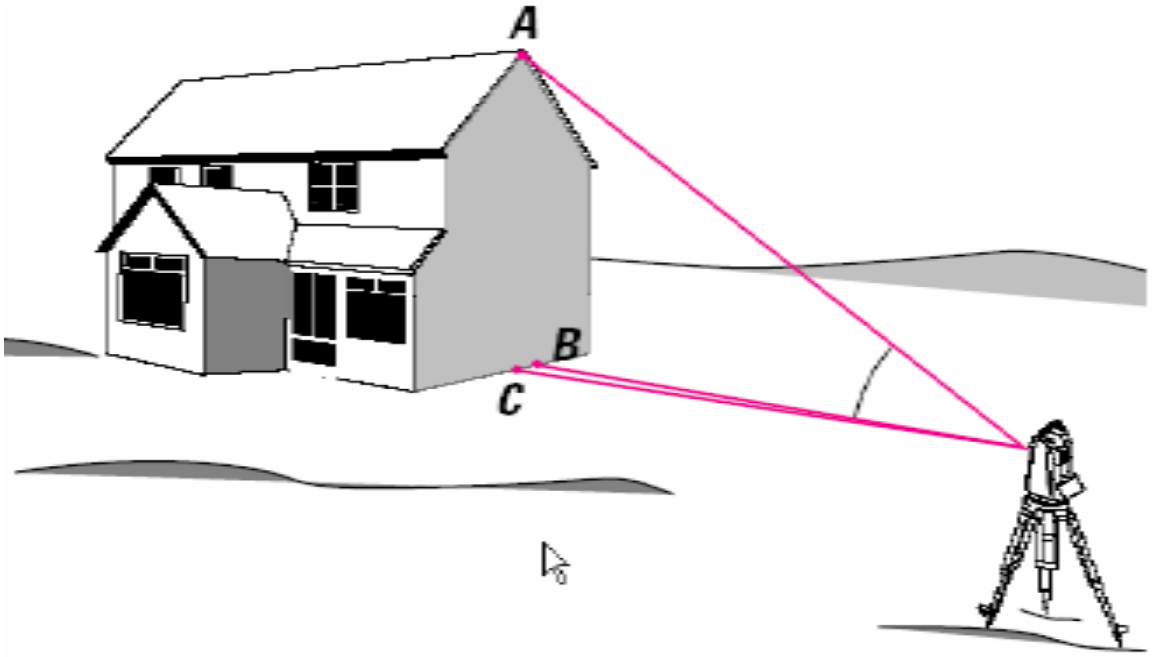
THEODOLITE – AN INTRODUCTION



Introduction:

- Theodolite is used to measure horizontal and vertical angles.
- It is more precise than magnetic compass.
- It is used for various other purposes like prolonging a line, leveling and even for measuring the distances indirectly. Therefore is also called as Universal Instrument.
- Using verniers, angles can be read accurately up to 20″. Precise theodolites are available which can read angles up to even 1″ accuracy.
- Now a days electronic theodolites are also available which display the required angles.

Types of Theodolites:

- There are different types of theodolite available. It may be classified into three broad categories.

1. Vernier or Transit Theodolite
2. Digital Theodolite
3. Total Station

1. Vernier or Transit Theodolite:

- This is most commonly used. In this type of instrument, observations are taken by using the principle of vernier caliper. The precision of this type of instrument varies in the order of **10" to 20".**

2. Digital Theodolite:

- This type of theodolite provides the value of observation directly in viewing panel. The precision of this type of instrument varies in the order of **1" to 10".**

3. Total Station:

- This is an electronic instrument. In this instrument, all the parameters required to be observed during surveying can be obtained. The value of observation gets displayed in a viewing panel. The precision of this type of instrument varies in the order of **0.1" to 10".**

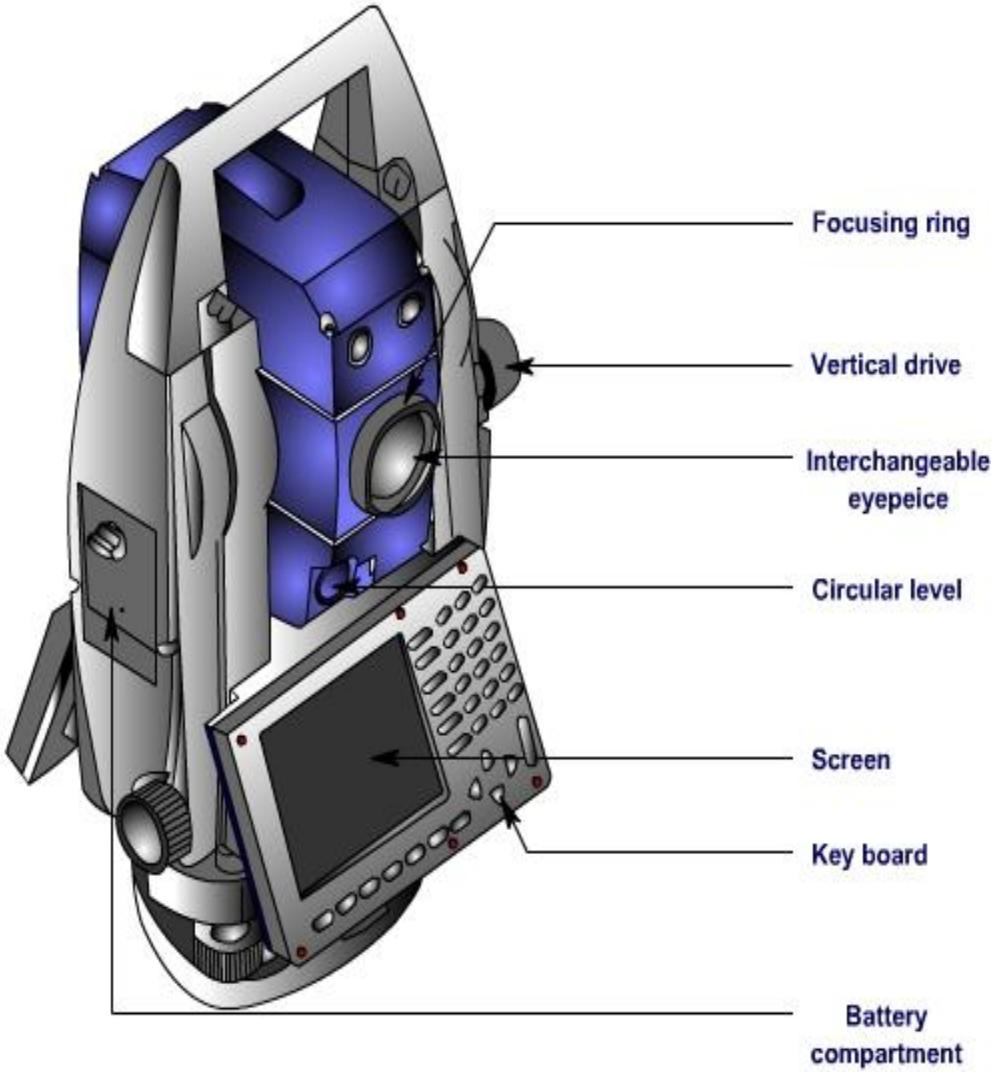
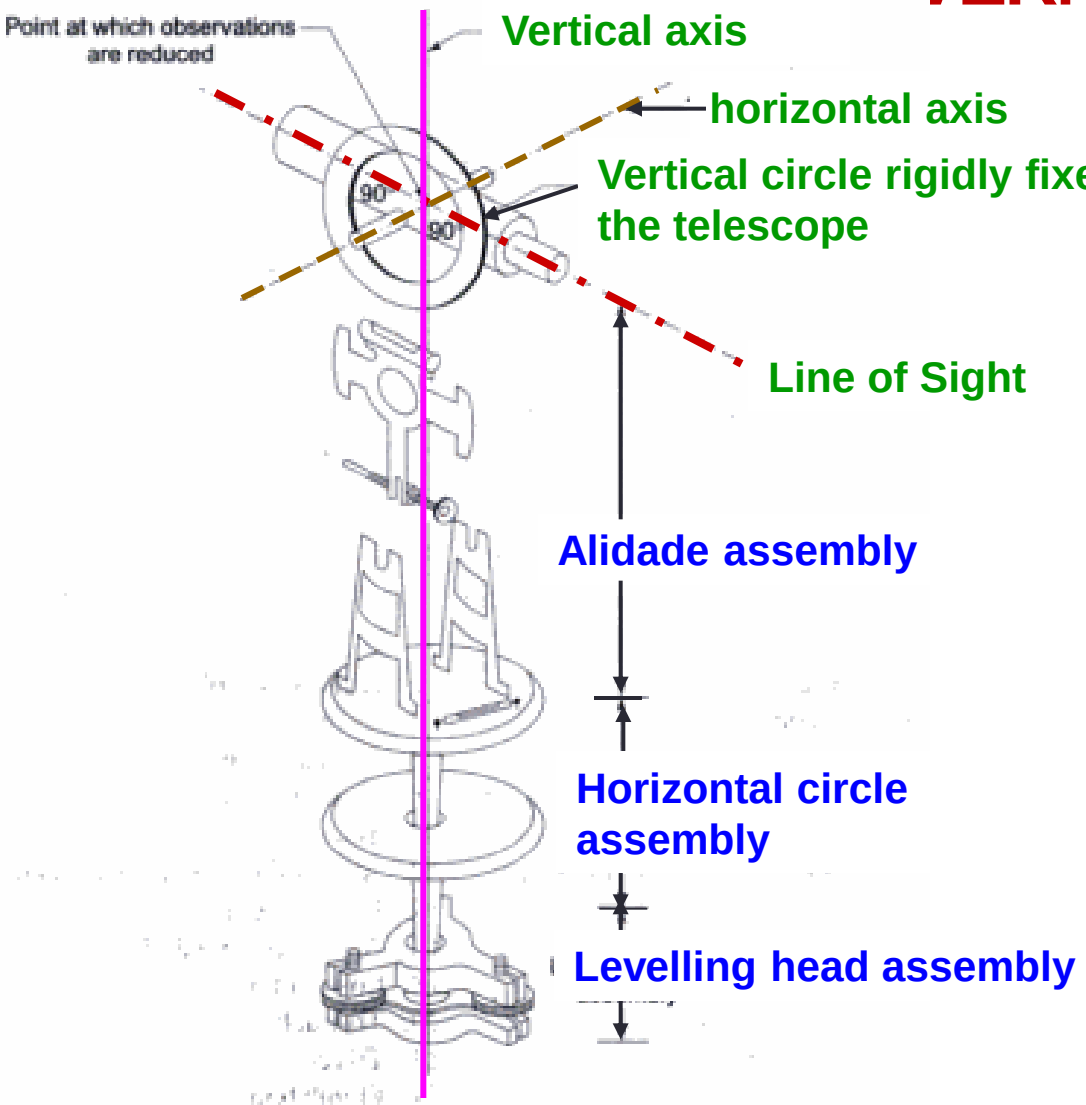


Figure 20.3 Total Station

Types:

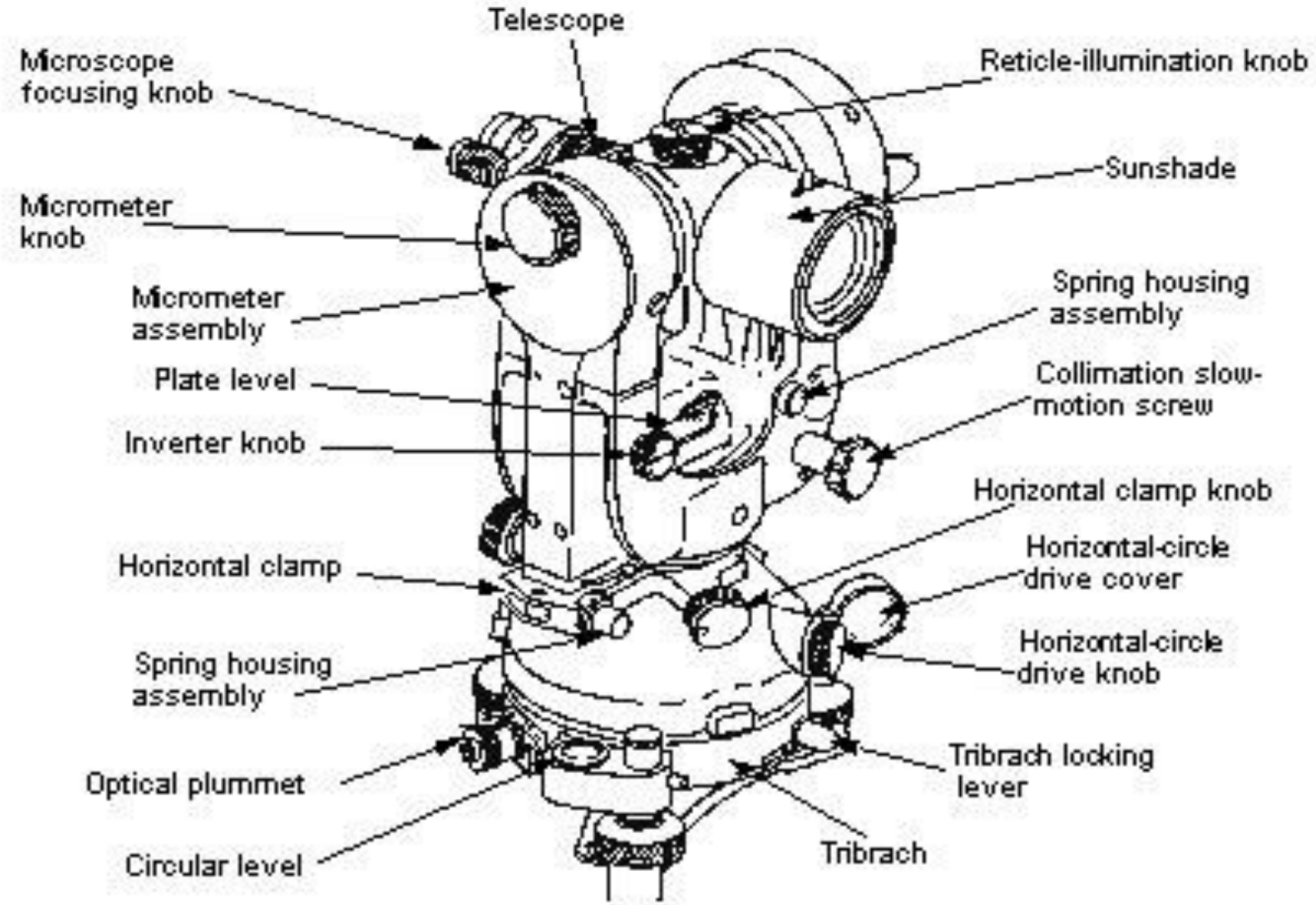
VERNIER THEODOLITE

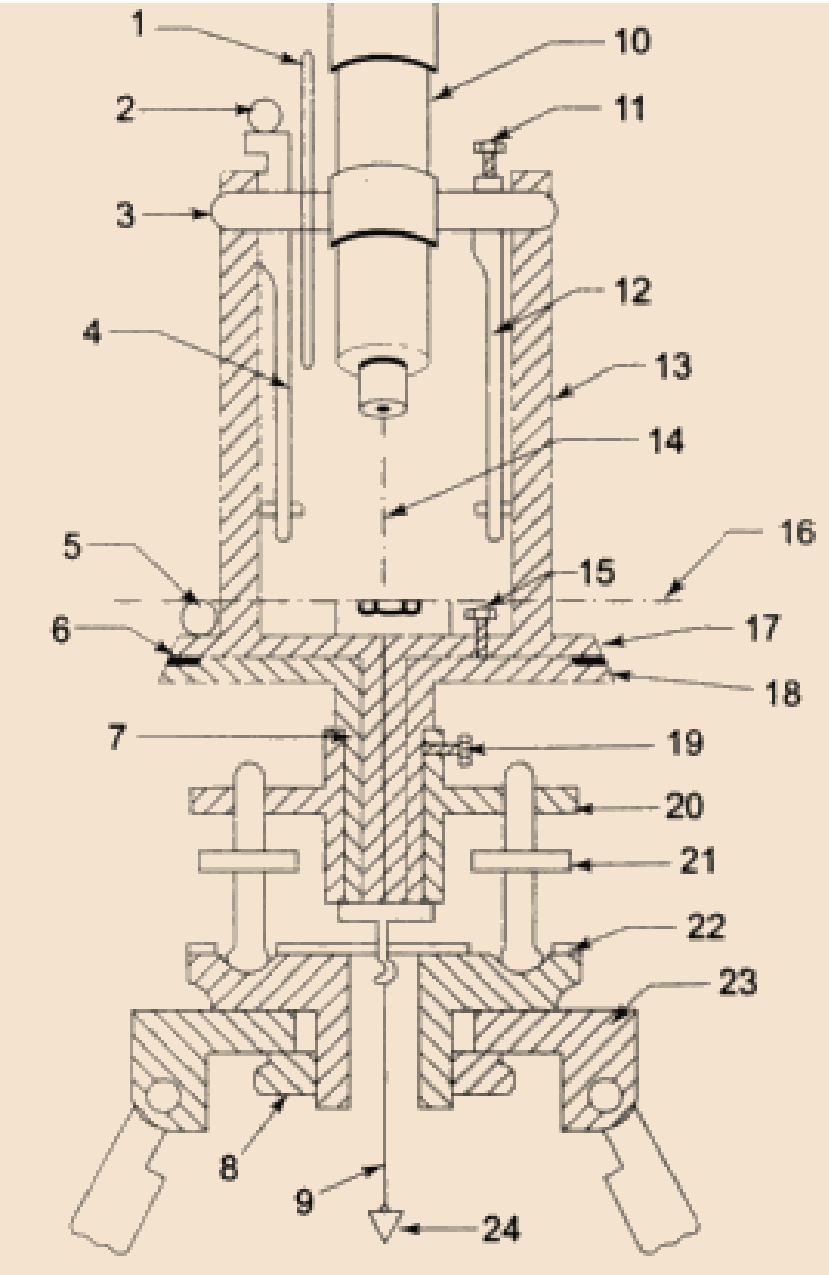


Three assemblies of Theodolite

- Vernier theodolite is also known as transit.
- A transit theodolite is one in which the telescope can be rotated in a vertical plane.

MAIN PARTS


Telescope
Microscope focusing knob
Reticle-illumination knob
Sunshade
Micrometer knob
Micrometer assembly
Spring housing assembly
Plate level
Collimation slow-motion screw
Inverter knob
Horizontal clamp knob
Horizontal clamp
Horizontal-circle drive cover
Spring housing assembly
Horizontal-circle drive knob
Tribrach locking lever
Optical plummet
Circular level
Tribrach



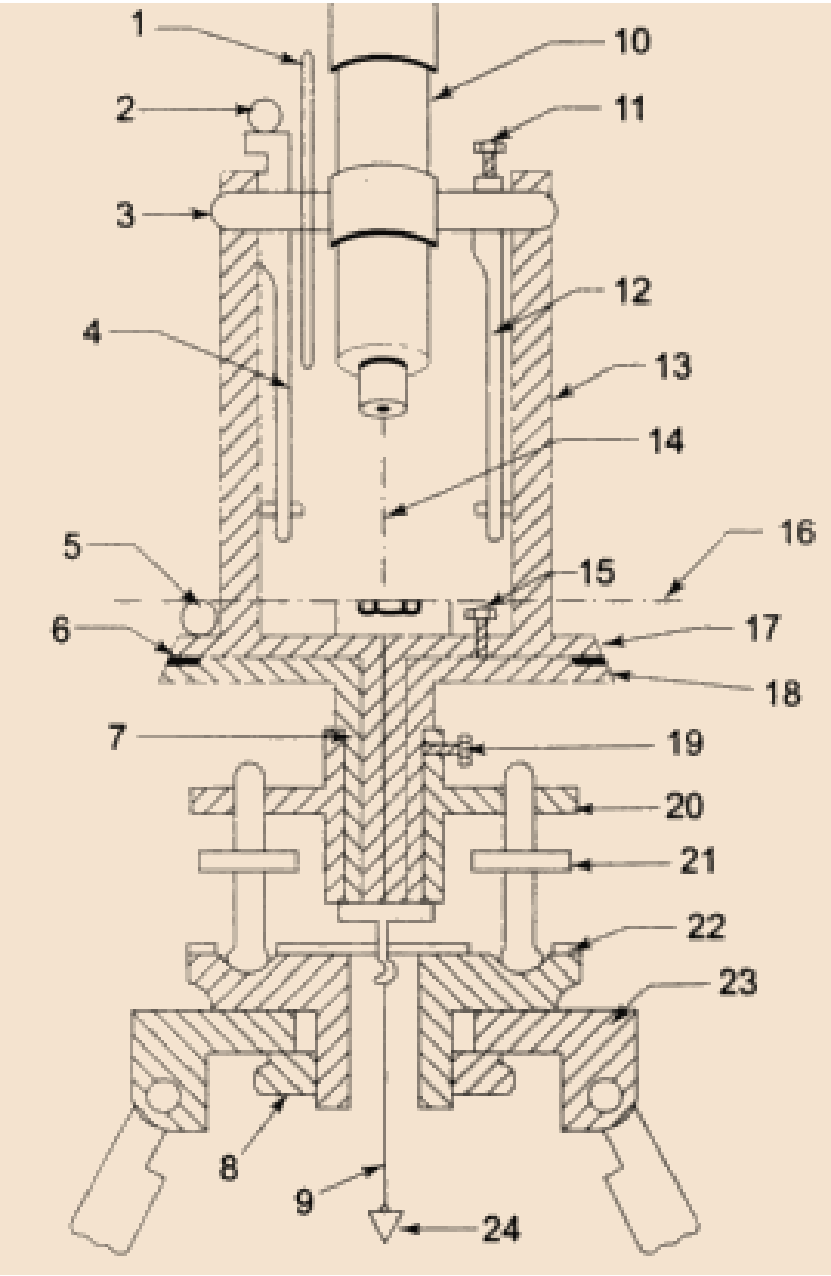
MAIN PARTS

- **Levelling head (7):** Levelling head is used to attach the instrument to tripod and attach the plumb bob along the vertical axis of the instrument.

1. Vertical circle
2. Altitude bubble
3. Horizontal axes
4. Vernier arm
5. Plate bubble
6. Graduated arc
7. Levelling head
8. Clamping nut
9. Vertical axis
10. Telescope
11. Vertical circle clamping screw
12. Arm of the vertical circle clamp
13. Standard
14. Line of sight
15. Upper plate clamping screw
16. Axis of plate bubble
17. Upper plate
18. Lower plate
19. Lower plate clamping screw
20. Tribrach
21. Foot screw
22. Trivet
23. Tripod top
24. Plumb bob

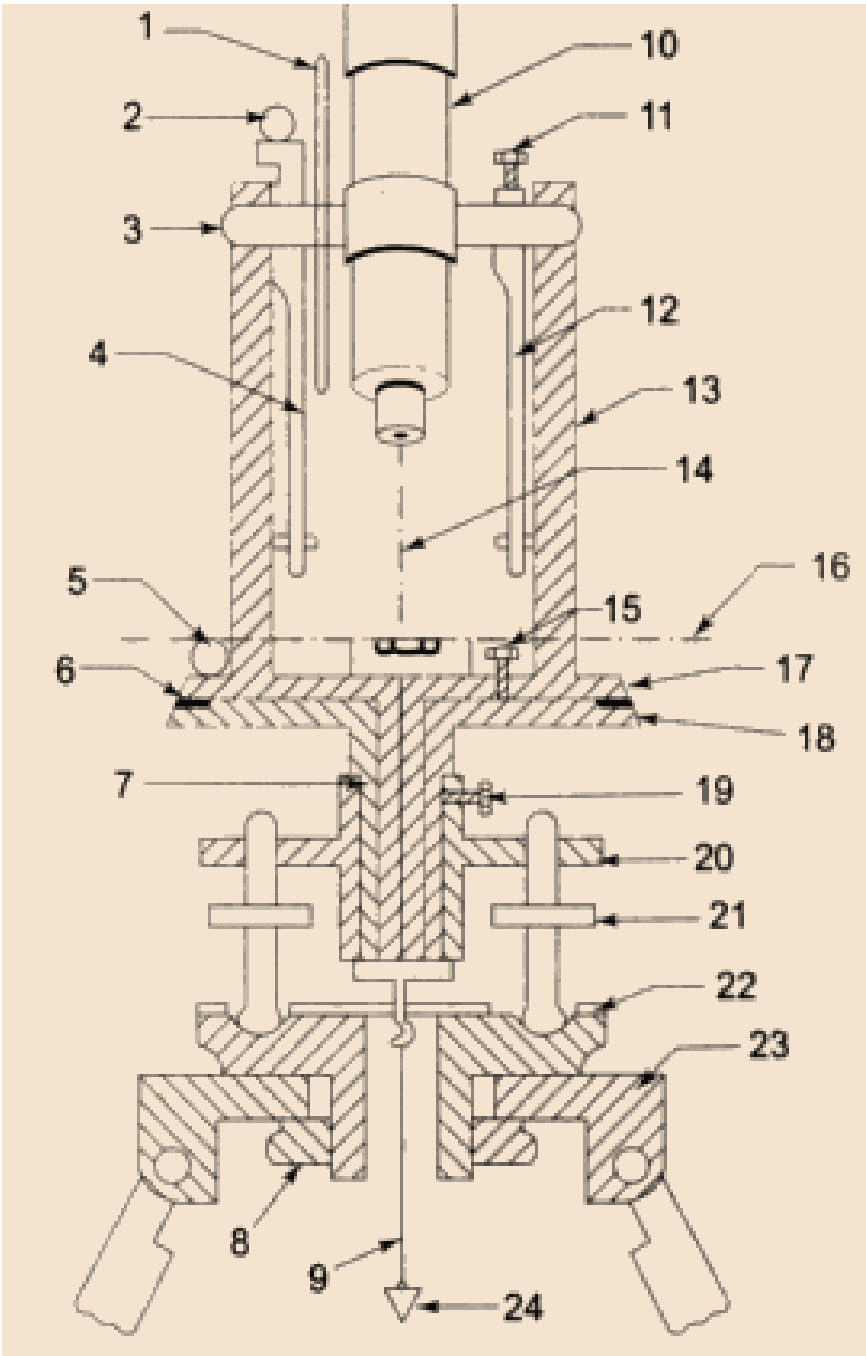
MAIN PARTS

- **Lower plate/circle plate (18):** an annular horizontal plate with the graduations provided all around, from 0 to 360°, in a clockwise direction. The graduations are in degree divided in to 3 parts so that each division equals to 20 minutes.
- Horizontal angles are measured with this plate.
- The size of the theodolite is defined by the diameter of horizontal circle.
- **Upper plate (17):** Horizontal plate of smaller diameter provided with two verniers. on diametrically opposite parts of its circumference. These verniers are designated as A and B. They are used to read fractions of the horizontal circle plate graduations. The verniers are graduated in 20 min and each minute is divided in 3 to 5 parts making least count 20” or 10”.



MAIN PARTS

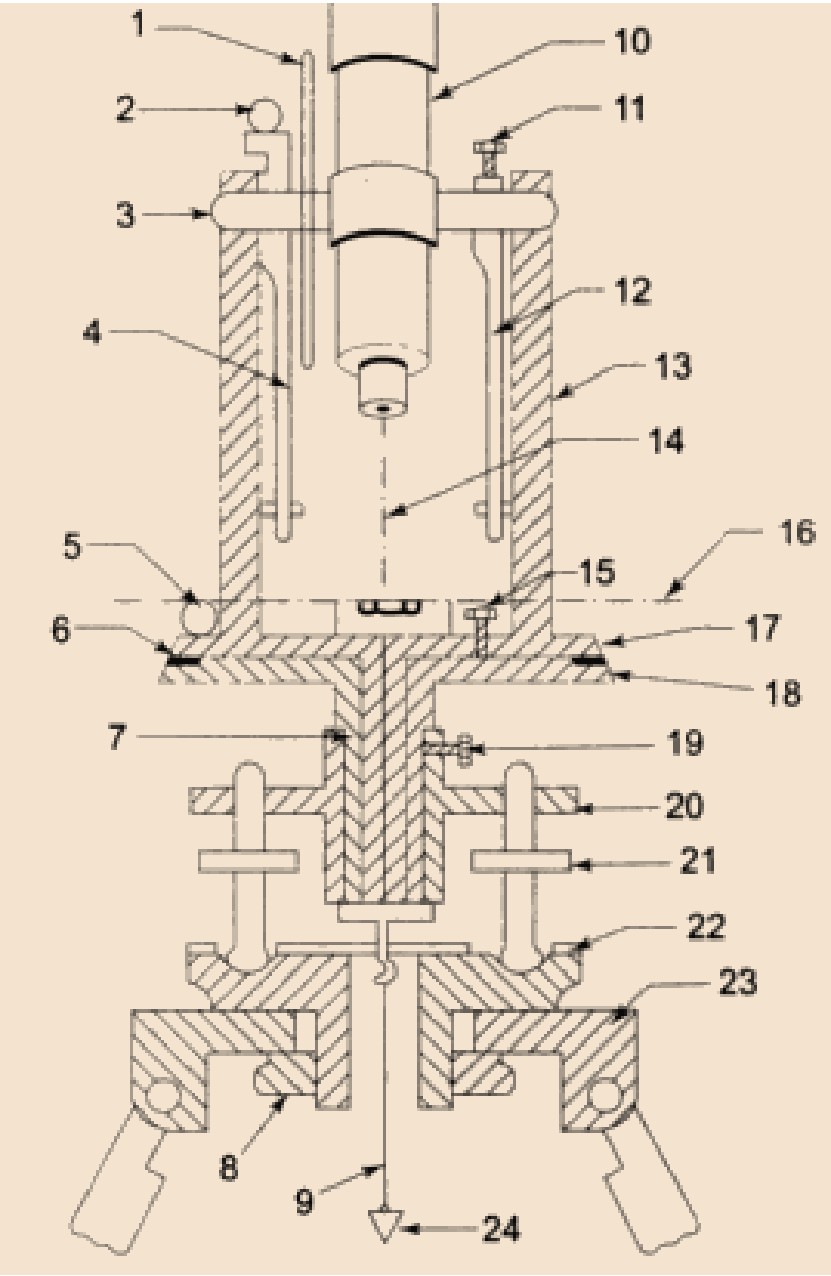
- **Clamps and Tangent Screws/ Slow Motion (15, 19):**
  - There are two clamps and associated tangent screws (Slow Motion) with the plate. These screws facilitate the motion of the instruments in horizontal plane.
  - Lower clamp screw locks or releases the lower plate. When this screw is unlocked both upper and lower plates move together. The associated lower tangent screw allows small motion of the plate in locked position.
  - The upper clamp screw locks or releases the upper vernier plate. When this clamp is released the lower plate does not move but the upper vernier plate moves with the instrument. This causes the change in the reading. The upper tangent screw allows the fine adjustment.



MAIN PARTS

- **Plate level (5):**
  - Spirit level with the bubble and graduation on glass cover.
  - A single level or two levels fixed in perpendicular direction may be provided.
  - The spirit level can be adjusted with the foot screw **(21)** of the levelling head **(7)**.

- **Telescope (10):** The essential parts of the telescopes are eye-piece, cross hairs, object lens and arrangements to focus the telescope.

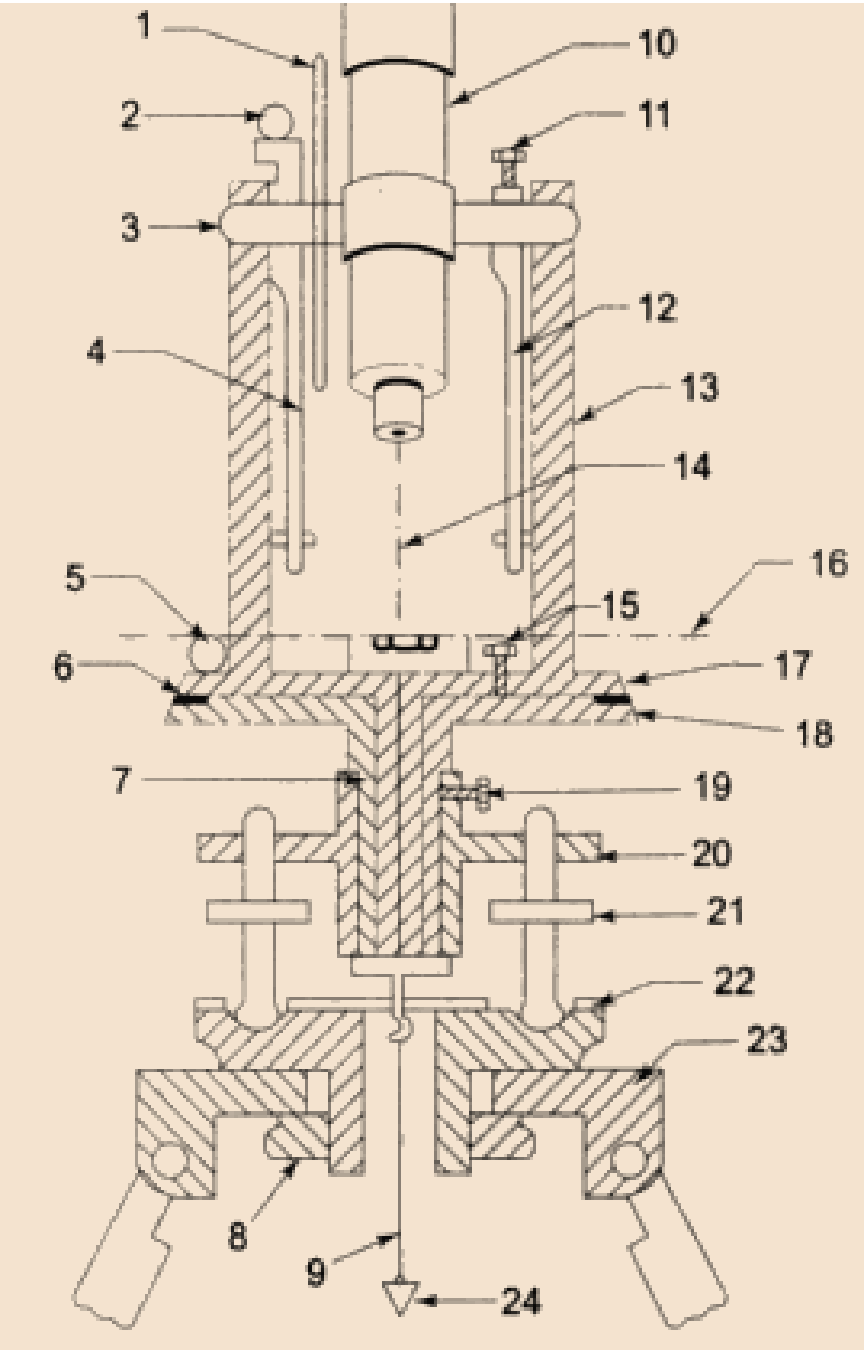


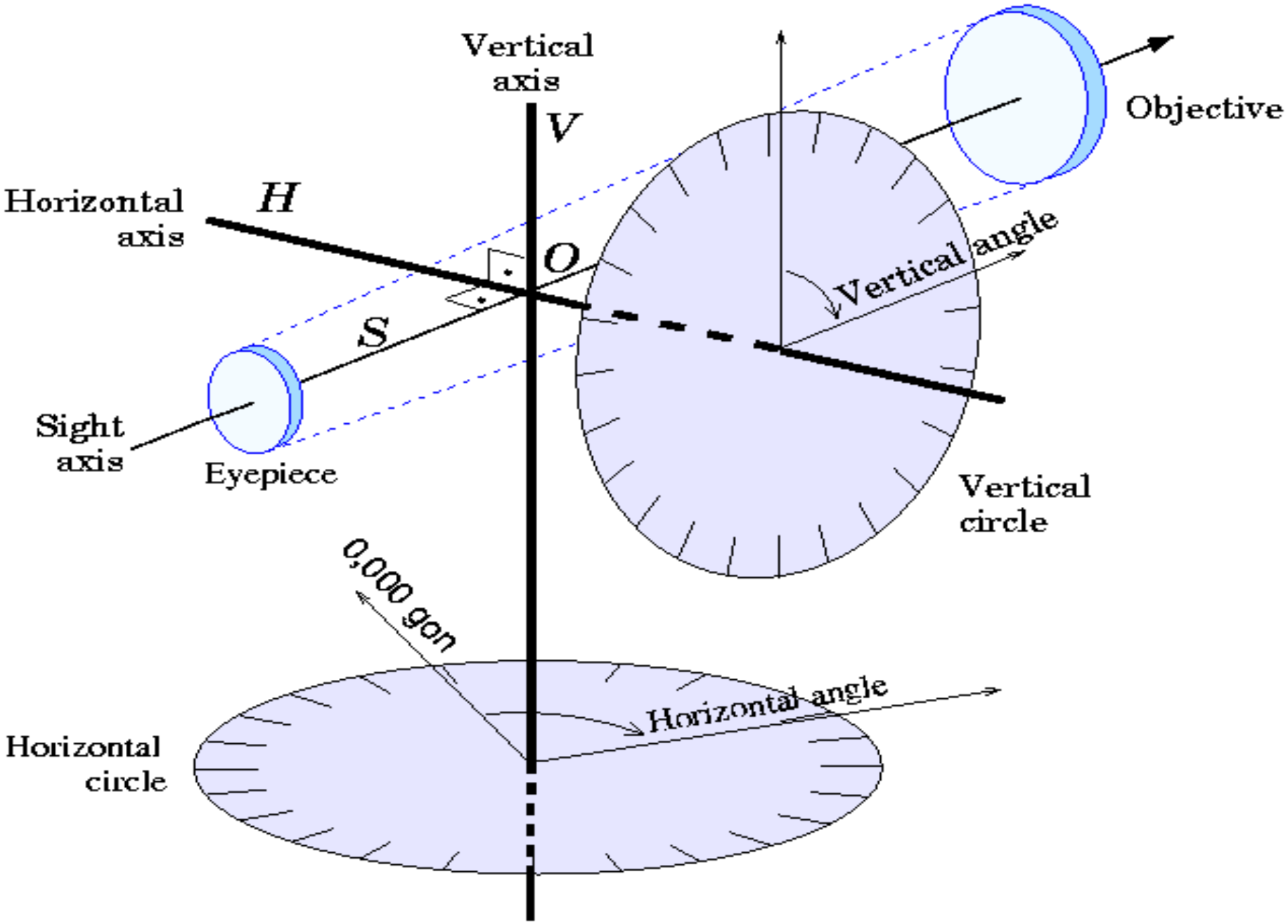
MAIN PARTS

- **Vertical circle (1):** Circular plate supported on horizontal axis of the instrument. Vertical circle has graduation 0-90 in four quadrants. Vertical circle moves with the telescope when it is rotated in the vertical plane.

- **Vertical circle clamp and tangent screw (11):** Clamping the vertical circle restrict the movement of telescope in vertical plane.

- **Altitude level (2):** A highly sensitive bubble is used for leveling particularly when taking the vertical angle observations.




Vertical
axis
V
Objective
Horizontal
axis
H
O
Vertical angle
S
Sight
axis
Eyepiece
Vertical
circle
0,000 gon
Horizontal angle
Horizontal
circle

Important Definitions:

Face Right:

- When the vertical circle of theodolite is on the right of observer, the position is called face right and the observation made is called face right observation.

Face Left:

- When the vertical circle of theodolite is on the left of observer, the position is called face left and the observation made is called face left observation.

Telescope Normal:

- The telescope is said to be normal or direct when its vertical circle is to the left of the observer & the bubble is on the upper side.

Telescope Inverted:

- The telescope is said to be *inverted* when its vertical circle is to the right of the observer & the bubble is on the lower side.

Important Definitions

Changing face:

- Revolving the telescope by 180° in vertical plane about horizontal axis.


face left
face right

Temporary Adjustments:

- At each station point, before taking any observation, it is required to carry out some operations in sequence. The set of operations those are required to be done on an instrument in order to make it ready for taking observation is known as temporary adjustment.
- Temporary adjustment of a vernier theodolite consists of following operations:

1. Setting
2. Centering
3. Approximate Leveling
4. Focusing

Temporary Adjustment of the theodolite

Setting

1. The levelling screws are at the centre of their run.
2. The shifting head of the theodolite is at its centre so that equal movement is possible in all the directions.
3. The wing nuts on the tripod legs are tight enough so that when raised, the tripod legs do not fall under their own weight.

Centring This involves setting the theodolite exactly over the station mark or on the station peg. It is done by the following steps:

1. The plumb bob is suspended from a small hook attached to the vertical axis of the theodolite.
2. The instrument is placed over the station mark with the telescope at a convenient height and with the tripod legs set well apart.
3. Two legs of the tripod are set firmly into the ground and the third leg is moved radially to bring the plumb bob exactly over the station mark. Then the third leg is also pushed into the ground.

Temporary Adjustment of the theodolite

Approximate levelling This implies levelling the instrument with the legs of the tripod, i.e. by bringing the small circular bubble provided on the tribrach in the centre. To achieve this, two of the tripod legs are pushed firmly into the ground and the third leg of the tripod is moved to the right or to the left, i.e. in the circumferential direction until the bubble is centred. This leg is then pushed into the ground.

4.9.2 Levelling up

This means making the vertical axis truly vertical. This is done with the help of the foot screws. The procedure is as follows:

1. The longer plate level is brought parallel to any two foot screws.

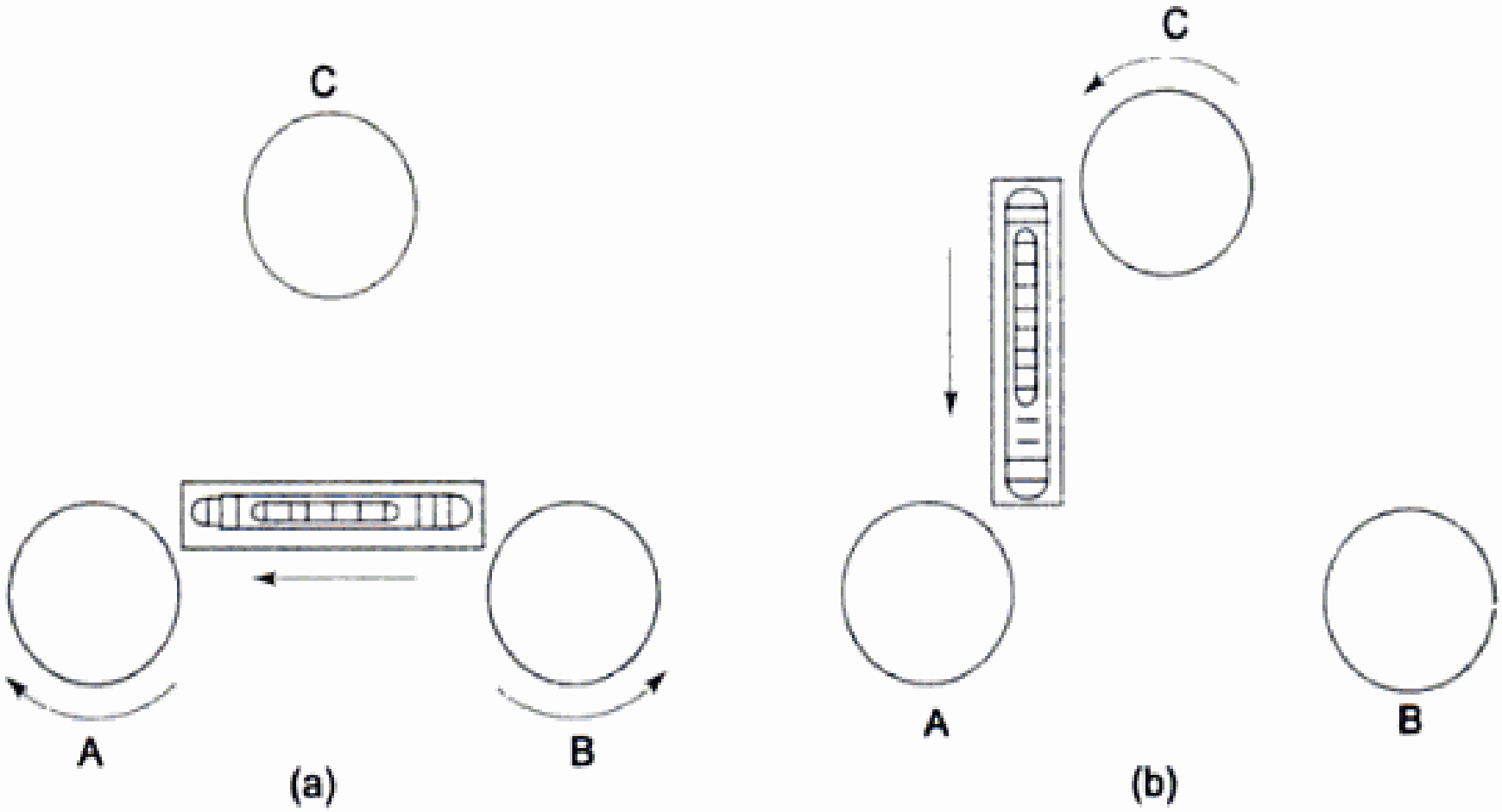


Fig. 4.4 Levelling with three foot screws

2. Bring the bubble of the longer plate level to the centre of its run by moving the two foot screws, say A and B, uniformly either inwards or outwards (Fig. 4.4(a)). It may be noted that the bubble always moves in the direction of the left thumb as the surveyor turns the screw.
3. Move the third foot screw C so that the bubble in the other plate level is centred (Fig. 4.4(b)).

4.9.3 Focussing

It consists of focussing the eyepiece and the objective.

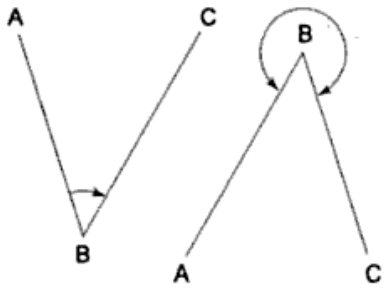
Focussing the eyepiece This operation is done to make the cross-hairs appear clearly visible. The following steps are involved:

1. The telescope is directed towards the sky or a sheet of white paper held in front of the objective.
2. The eyepiece is moved in or out until the cross-hairs appear clear and distinct.

Focussing the objective This operation is done to bring the image of the object in the plane of the cross-hairs. The following steps are involved:

1. The telescope is directed towards the object.
2. The focussing screw is turned until the image appears clear and sharp.

Measurement of Horizontal Angle:



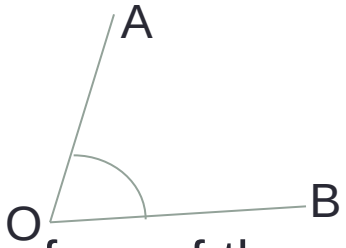
- **Measurement of Angle ABC**
  - The instrument is set over B.
  - The lower clamp is kept fixed and upper clamp is loosened.
  - Set vernier A to 0° and vernier B to approximately 180° by turning the theodolite.
  - Upper clamp is tightened and using the upper slow motion screw the vernier A and B are exactly set to 0° and 180°.
  - Upper clamp is tightly fixed, lower one is loosened and telescope is directed towards A and bisect the ranging rod at A.
  - Tightened the lower clamp and turn the lower motion screw to perfectly bisect ranging rod at A.
  - Loose the upper clamp and turn the telescope clockwise to bisect the ranging rod at C tightened the upper clamp and do the fine adjustment with upper motion screw.
  - The reading on vernier A and B are noted. Vernier A gives the angle directly and vernier B gives the reading by subtracting the initial reading (180°) from final reading.

Two Methods of Measuring Horizontal Angle:

1. Repetition method
2. Reiteration method

Repetition Method:

- This method is recommended when a **single horizontal angle** is required to be measured because horizontal angle AOB to be measured by the method of repetition proceeds at follow.



1. Setup the instrument over O and level it accurately (the face of the instrument should be left and telescope in normal position)
2. Set the vernier A to 0 degree (Usually marked as 360^{o}). Loosen the lower clamp, direct the telescope to the left hand station (A), and bisect A exactly by using lower clamp and lower slow motion screw.
3. Check the reading of the vernier A to see that no slip has occurred and read the other vernier B.
4. Un-clamp the upper plate, turn the telescope clockwise and bisect the right hand station (B) exactly by using the upper clamp and upper slow motion screw.

Repetition Method

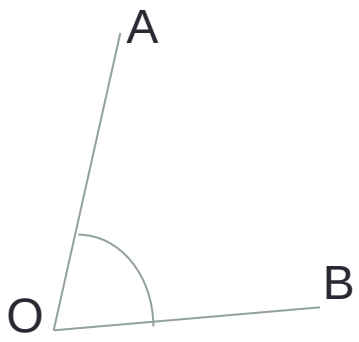
5. Read both the verniers. The object reading the verniers is to obtain the approximate value of the angle. Suppose the mean reading is 60 degree and 2 minutes.
6. Leaving the verniers, unchanged, un-clamp the lower screw. Transit telescope, face will be right and turn the telescope clockwise until the station A is again bisected accurately, using the lower clamp and lower slow motion screw. Check the vernier reading which must be same as before.
7. Release the upper clamping screw, turn the telescope clockwise and again bisect the station B exactly, using the upper clamp and its slow motion screw. The vernier will now read the twice the value of the angle.

Repetition Method

8. Repeat the process until the angle is repeated the required number of times(usually 4 times).
9. Read both the verniers, the final reading after n repetitions should be n(60 degree and 2 minutes). Add 360 degree for every complete revolution to the final reading and (divide the sum by the no of repetitions. The result give the correct value of the angle, AOB)

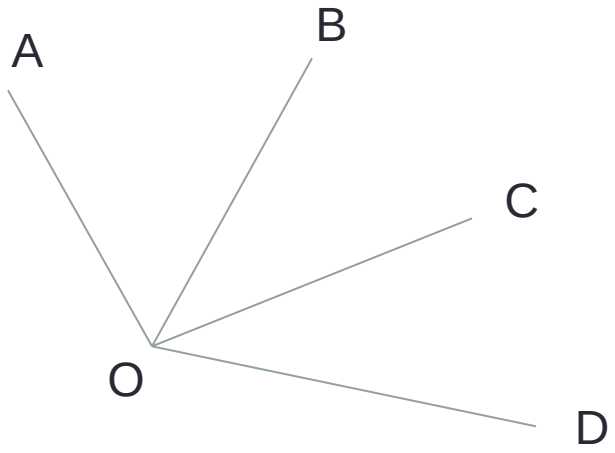
Table:

Instrument Station	Repetition No.	Vernier Reading		Mean of Vernier	Angle	Remarks
		A	B			
O	0					
	1					
	4					



Reiteration Method:

- This method generally preferred when more than one angles are to be measured at a station.



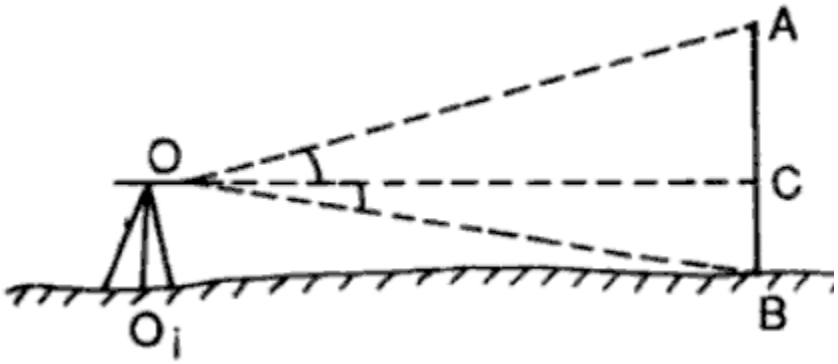
- Suppose it required to measure the angle AOB, BOC and COD.

1. Setup the instrument at O, and face should be left.
2. Set the vernier at 0 degrees 0 minutes and 0 seconds.
3. Direct the telescope the station A, bisect it accurately by lower clamp and lower slow motion screw. Note the vernier reading.

Reiteration Method

4. Similarly, bisect C and D successively, reading both verniers at each bisection.
5. Reaching at D, clamp upper screw, transit the telescope and bisect the station D by using lower clamp and lower slow motion screw.
6. Un-clamp the upper screw and bisect the station C by using upper slow motion screw, and read both the verniers.
7. Similarly bisect station B and A and read both verniers and put this reading in the table drawn for reiteration method and calculate the angle values.

Vertical Angle Measurement



1. The theodolite is set up at O. It is centred and levelled properly. The zeros of the verniers (generally C and D) are set at the 0°–0° mark of the vertical circle (which is fixed to the telescope). The telescope is then clamped.
2. The plate bubble is brought to the centre with the help of foot screws (in the usual manner). Then the altitude bubble is brought to the centre by means of a clip screw. At this position the line of collimation is exactly horizontal.
3. To measure the angle of elevation, the telescope is raised slowly to bisect the point A accurately. The readings on both the verniers are noted, and the angle of elevation recorded.

Vertical Angle Measurement

4. The face of the instrument is changed and the point A is again bisected. The readings on the verniers are noted. The mean of the angles of the observed is assumed to be the correct angle of elevation.
5. To measure the angle of depression, the telescope is lowered slowly and the point B is bisected. The readings on the verniers are noted for the two observations (face left and face right). The mean angle of the observation is taken to be the correct angle of depression.