★ Theodolite

★ **Theodolite:** A modern theodolite is Compact, light in weight Simple in design and Can be used rough. All the moviable parts and Scales are fully enclosed and virtually dust and moisture proof. The size of a theodolite is defined by its lower graduated circle.

- A 20cm theodolite means the diameter of the ~~lower~~ graduated Circle of the lower plate is 20 cm. (⇒ Dia = length)
- The Size of theodolite varies from 8 to 25 cm.
- The primary function of a theodolite is to measures Horizontal & Vertical angle accurately.

★ Purpose of Theodolite:

(i) To measure horizontal & Vertical angle precisely
(ii) To measure horizontal & Vertical distance indirectly.
(iii) Ranging or layout of Curve.

▶ Horizontal Plane: Distance b/w left & Right.
▶ Vertical Plane: Distance b/w Top & Bottom.

★ Types of Theodolite (Based on Transition):-

① **Transit theodolite:** In this telescope (line of sight / eye vane & objective vane) Can be rotate or reversed by revolving the telescope through 180° in vertical plane about horizontal axis / tournion axis / transverse axis.

② **Non-Transit Theodolite:** line of sight / telescope Can't be revolve by revolving the telescope 180° in the vertical plane.
- It is plain theodolite.

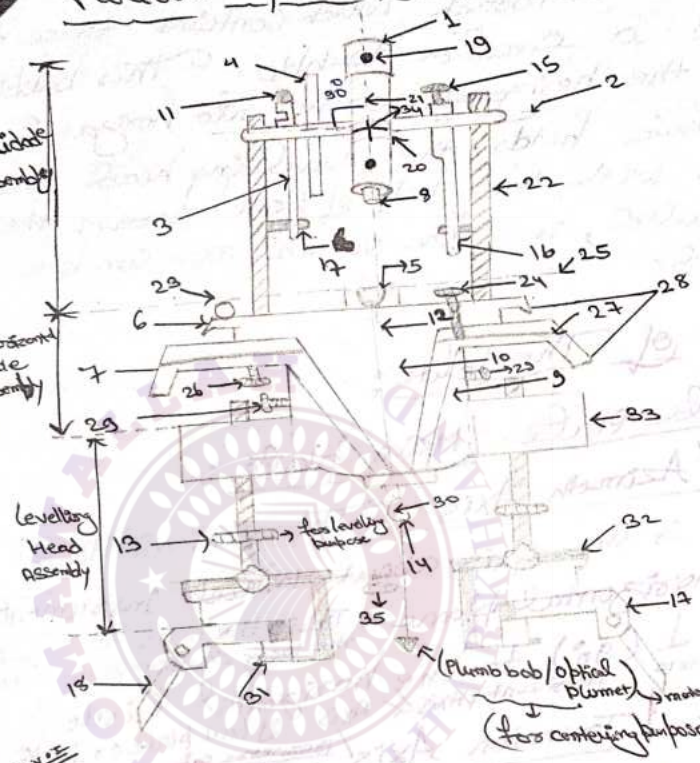
Ex: Y-Theodolite, Everest theodolite.

★ Transit Theodolite:

A theodolite is said to be a transit one when its telescope can be revolved through 180° in a vertical plane about its horizontal axis, thus directing the telescope in exactly opposite direction.

• The Vertical Circle is rigidly fixed to the telescope and rotates with the telescope.

Various parts of Theodolite:



1. Telescope
2. Trunnion axis / Horizontal Axis
3. Vernier frame / Vernier arm
4. Vertical circle
5. Plate level
6. Upper plate / Vernier plate
7. Lower plate (main plate) / Scale plate
8. Eye piece (Eye vane)
9. Outer spindle (for movement of lower & upper plate)
10. Inner spindle
11. Altitude bubble
12. Inner axis
13. Levelling screw / Foot screw (for levelling purpose)
14. Hook (for centering purpose)
15. Vertical clamp screw
16. Vertical tangent screw
17. Tripod head
18. Tripod leg
19. Target sight
20. Diaphragm.
21. Line of sight (from eye piece to object)
22. Standard (A-shape)
23. Plate bubble / Bubble tube / Level bubble
24. Upper plate clamping screw
25. Axis of plate bubble / Level tube
26. Lower plate clamping screw
27. Graduated disc
28. Horizontal Circle Assembly (Setup of upper & lower plate)
29. Tangent screw / Slow moving screw
30. Vertical axis
31. clamping nut
32. Trivet (It is the bottom most lower portion)
33. Tribrach
34. Cross hair, 35. clamping nut

Note:

→ The size of theodolite is represented by the size of lower (main scale) plate.
→ Greater the size of plate represent greater accuracy.
→ Vertical Circle rigidly fixed to the telescope.
→ Lower plate attached with outer spindle & upper plate is attached with inner spindle.

① **Alidade Assembly:** It is the top most assembly which includes a telescope by two standard of the shape of letter A, forming a U-frame (which rest on the horizontal circle upper plate), and the vertical circle. The altitude bubble is attached to the standards.

② Horizontal Circle Assembly: It Consists of two plates the lower and the upper. The lower plate or main plate carries the main scale and the upper plate carries vernier scale. Normally two plates level are attached to this assembly.

③ Levelling Head Assembly: It is the bottom-most assembly which is screwed on to the top of the tribrach. At its base is the tribrach which contains three or four screws and a circular bubble. This bubble is used to put the horizontal circle into horizontal plane. A locking device holds the levelling head and tribrach together. With the help of foot screws the instruments can be levelled, i.e. the vertical axis can be made truly vertical.

* Important term of Theodolite:

~~① Lower plate / Scale plate / Main plate~~:

① Vertical Axis / Azimuth Axis: The vertical Axis of the theodolite is the axis about which instrument rotate in the horizontal plane. This is the axis about which the lower & upper plate rotate

▶ Vertical axis is ⊥ (90°) to the horizontal Circle & parallel to which axis — those ⊥ to Horizontal axis

② Horizontal Axis / Trunnion Axis / Transverse Axis: The horizontal Axis of the theodolite is the axis about which instrument rotate in vertical plane. Horizontal Axis & Axis of level plate or plate bubble.

▶ Horizontal axis is ⊥ (90°) to the Vertical axis and vertical circle & line of Collimation (or line of sight)

V.V.I Note: ① Line of Collimation must be parallel to Axis of Altitude level.
② Axis of Striding level parallel to horizontal axis

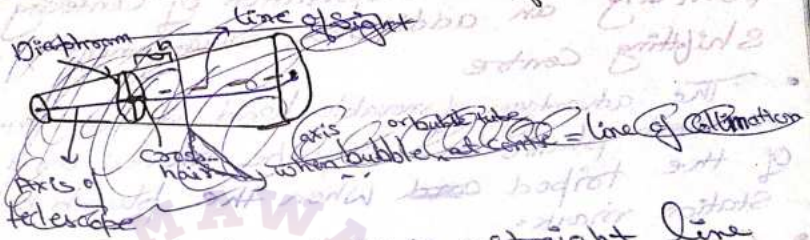
1.) Horizontal Circle must be (⊥) to Vertical Axis
② Vertical circle mus be (⊥) to horizontal Axis
③ Axis of plate level must be (⊥) to Vertical Axis
④ Line of ~~Sight~~ collimation always be (⊥) to horizontal Axis
⑤ for horizontal position of telescope and Los is horizontal and for altitude bubble at the centre readers and vertical Circle must be zero.

⑥ Line of Sight, Trunnion Axis (Horizontal Axis) & vertical axis must meet at common point (termed as centre of instrument)

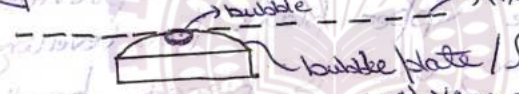
~~③ Line of sight~~

③ Line of Sight : It is an imaginary line passing through intersection of cross hairs of diaphram & optical centre of objective (or object vane).

→ When line of Sight in horizontal plane (or when Axis of level plate) are at centre is called "Line of Collimation"



④ Axis of level tube / Plate bubble : It is a straight line tangential to the longitudinal curves of level tube as it is at Center. Axis of level tube is horizontal when bubble at centre.

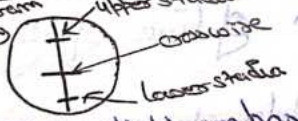


mean telescope at straight (means horizontal)

When Axis of level tube or bubble at centre it is called line of Collimation

Its line is passing through eye piece & cross hair.

*Stadia diaphram



The Stadia diaphram has three horizontal cross wire (hair) on the diaphram cross in additional to the horizontal wire two parallel cross wire, one upper and one lower are called stadia. Stadia is used to calculate the horizontal distance from the level tool to the Yard.

(line of sight is may be inclined (that is it is in upward & downward

But line of Collimation not be inclined it is exist only when telescope is straight. (ie- telescope is horizontal)

⑤ Levelling Screws / foot Screws :
The levelling head is provided with three or four levelling screw. Generally three levelling screws is more prefer because theodolite it's done very fast levelling. It is assemble b/w tribrach & trivet.

⑥ Plumb Bob or Optical Plumet and Shifting Centre :
A plumb bob is suspended from the vertical axis of the theodolite, to be centred over the station, from where the measurement are made. The operation of centering is facilitated by providing an additional arrangement, a movable head or shifting centre

- The advantages of movable head is that the theodolite and the attached plumb line may be moved and clamped independent of the tripod when the plumb bob is exactly over the station mark.
- Centering should always be accurate within 2 mm.

⑦ Level tube : Two level tube are provided on the horizontal circle upper plate for levelling the theodolite quickly. Of the two, one is placed parallel and the other at right angles to the line of sight. The level tube parallel to the line of sight should be more sensitive. Since, it is controls the horizontal axis and therefore the verticality of the plane of rotation of line of sight.

⑧ Circle: The size of theodolite is defined by the diameter (b/w the reading edges of the graduations) of the horizontal circle which varies from 8 to 25 cm. It is graduated from 0° to 360° in clockwise direction. The graduation on it are from 0° to 90°. The vertical circle is usually of the same diameter as the horizontal circle. The two verniers are provided on each circle and two power magnifiers are attached for reading the observed values.

★ Striding level : Some theodolite are fitted with striding level & is use to measure horizontaly of transit or trunnion axis / Horizontal axis

⑨ Clamp & tangent screw: Two sets of clamp and tangent screws are provided on the horizontal circle to control the motion of the telescope about the vertical axis. one set of clamp and tangent screw is ~~podpite~~ provided to control the movement of telescope about the horizontal axis of theodolite.

- The tangent screws makes possible slow movement for accurate setting after the clamp have been tightened.
- When both clamp screw are tightened, the lower and upper plates along with the telescope and the vertical circle are fixed with reference to the vertical axis and levelling base.
- Fine motion are possible with tangent screws.
- If the lower tangent screw is turned, both the lower & upper plates rotate together as a single unit about the vertical axis with reference to the levelling head.
- If the upper tangent screw is turned, the upper plate rotates about the vertical axis relative to the lower plate
- When the lower plate is clamped and the upper clamp screw is loosened, the upper plate with the telescope and vertical circle can be rotate about the vertical axis relative to the lower plate. If the lower tangent screw is operated the lower plate turns slowly relative to the levelling head, even though the upper and lower plates are clamped together.
- When the upper plate is clamped and the lower clamp screw is loosened, the upper plates rotate as a single unit about the vertical axis with reference to the levelling head. If the upper tangent screw is operated, the upper plate can be made to run slowly even though the lower plate remains clamped to the levelling head.
- When both the clamps are loosened both the plates becomes free and can be rotate independently about the vertical axis. There is no point in operating either tangent screw

Note:- No tangent screw will function until the corresponding clamp screw has been set.

1) Telescope: A telescope of either internal or external focusing type is provided.

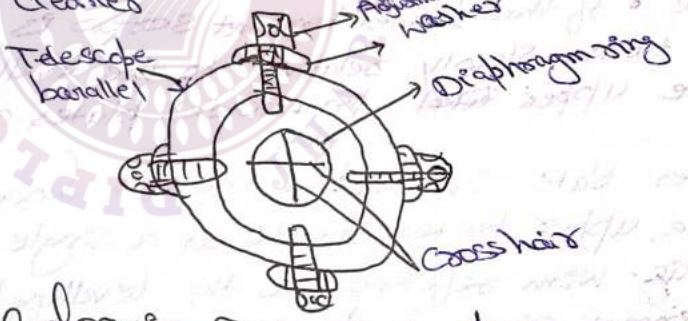
• To facilitate transiting it is convenient to provide an internal focusing rather than the external focusing in telescope.

• The magnification range from 15 to 30 diameter.

(i) External focusing Telescope: An external focusing telescope involves adjustment made to the outer barrel or housing of the telescope.

• A telescope in which focussing is achieved by the external movement of the objective tube is known as an external focusing telescope. The movement is done with the help of a focussing screw.

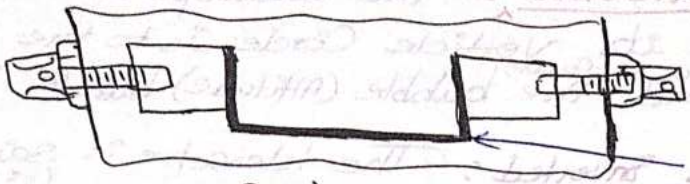
→ The external focusing telescope is like the Camera: You turn a ring on the outside to make faraway things look sharper, just like when you twist the lens on a Camera to make a picture clearer



(ii) Internal focusing Telescope: An internal focusing telescope, the adjustments for focusing occurs within the main body of the telescope itself.

• A telescope in which focussing is achieved internally with a negative lens is called an internal focusing telescope. The objective (objective lens) and the eyepiece are kept at a fixed distance and focussing is achieved by double Concave lens mounted in a short tube capable of sliding axially to and fro b/w the eyepiece and the objective. Focussing is achieved by moving the negative lens with a focusing screw.

→ The internal focusing telescope is more like binocular. You don't have to twist anything outside, instead, you adjust something inside to make things look clearer, just like when you adjust the little wheen in middle of binocular (दूरबीन) to see things better.



Diaphroam of telescope

★ Important Terminology in theodolite:

- **Centering:** The process of setting the theodolite exactly over the ground station mark is known as centering.
  - → A plumb bob is used for precise centering.
  - → Optical plummet used in windy condition to centering theodolite. (In this a stone is freely fall from centering hall).
- **Transiting:** This is the operation of revolving the telescope through 180° in vertical plane about its horizontal Axis/ transverse axis / tunion axis. is called Transiting.
  - → It is also known as Plunging and Reversing.
- **Right face (Observation):** When the vertical circle of a theodolite is on the right hand side of the observer, the position is called face right and the observation made is called face right observation.
  - Right face observation :- anti-clockwise
- **Left face (Observation):** When the vertical circle of a theodolite is on the left hand side of the observer, the position is called left face and the observation made is called left face observation.
  - Left face observation → Clockwise
  - → By taking the mean of both face reading, the collimation error (line of Collimation error) is eliminated.

$$\text{error} = \frac{\text{face left} - \text{face right}}{2}$$

- **Slewing:** It is the process of turning or revolving the telescope in the horizontal plane about its vertical axis is called slewing
  - → Right swing :- when the telescope rotate in clockwise direction.
  - → left swing :- when the telescope rotate about anti-clockwise direction.

→ By taking the mean of the right swing and the left swing observation, the effect of error due to friction or backlash in the moving part is eliminated.

- **Telescope Normal (Direct)**: The telescope is said to be normal or direct when its Vertical Circle is to the left of the observer (i.e face left condition) and the bubble (Altitude) bubble is up.
- **Telescope inverted**: The telescope is said to be inverted (i.e face right condition) when its vertical circle is to the right side of the observer and the bubble is downward (it is occur when theodolite is transit).
- **Axis of telescope**: It is the line joining the optical centre of the object glass to the centre of the eyepiece
- **Ranging in**: It is the process of establishing intermediate points with theodolite on a given straight line whose ends are intervisible (i.e it is case of direct ranging).
- **Balancing In**: It is the process of establishing intermediate points with theodolite on given straight line whose ends are not intervisible. (i.e it is the case of indirect ranging)
- **Changing face**: Changing face means the operation of bringing the telescope from face left to face right or face right to face left.

→ The face is changed by transisting and swinging the telescope.

The errors that are eliminated by changing the face or Double sighting are:

(i) Error due to line of Collimation not being perpendicular to the horizontal axis.

(ii) Error due to horizontal axis not being perpendicular to the vertical axis.

(iii) Error due to line of Collimation not being parallel to the axis of the altitude level or plate level.

$$\Rightarrow \text{Error} = \frac{\text{face right observation} - \text{face left observation}}{2}$$

- **Double Sighting**: It is the process of measuring the horizontal or vertical angle twice, one with telescope in normal condition and another with telescope in inverted condition.
- **Levelling head**: It consists of two parallel plates that are separated by three levelling screw. Upper parallel plate is known as ~~tribrach~~ and lower parallel plate is known as ~~trivet~~.
  - → Levelling head provided a balanced level to the instrument.
  - → It support the upper part of the instrument.
- **Shifting head**: Shifting head allowed slight movement of instrument in horizontal direction over the tripod station.
  - → After completion of levelling, it is used to exact centering of the instrument.
- **Index frame**: It is the T-shaped frame carrying the vernier of the vertical circle. It is also known as vertical frame & vertical arm.
  - → It is also known as clipping arm and horizontal arm in index or vernier arm.
- **Altitude bubble**: It is placed on the vernier frame and used to make the horizontal axis truly horizontal.
- **Vertical Circle**: Vertical circle is attached to the trunnion axis.
  - → It provided the main scale reading for the vertical angles
  - → Slow motion screw is used to accurate target of an object.

★ **Horizontal Angle measurements**:

- If the lower plate is clamp (fix) & upper is unclamped (loosened) we can measure horizontal angle as there is relative motion b/w main scale & vernier scale.
- Upper clamped screw is clamped but lower clamped screw is unclamped then both plates moves together in same direction for that condition it measure horizontal angle.
  - → Both upper & lower plate screw is clamped then there is no movement b/w plates.

★ **Lower Plate**: Lower plate monolithically constructed with outer spindle.

- It provide main scale reading of a horizontal angle.
- It is also known as scale plate, main plate or horizontal plate.
- It is graduated (the main scale) from 0° to 360° in clockwise direction degree and minutes.
- Each degree part is divided into three equal parts.
- Hence, the minimum reading that can be read from the main scale is 20'. (20 minute)

Main scale / Lower plate → Least Count (L.C) = 20'

- For control the lower plate, a lower clamp screw and slow motion screw or tangent screw are used.

★ **Upper Plate**: Upper plate monolithically constructed with inner spindle.

- At upper plate two Vernier Scale is attached in opposite direction.
- Upper plate also known as Vernier plate
- The Vernier scale is graduated into minute & second in clockwise & anti clock wise direction.
- Each minute division is divided into three equal parts.
- Hence, the minimum reading that can be read from the Vernier scale is 20". (20 second)

Vernier scale / Upper plate → least Count (L.C) = 20".

- We arrange Upper plate & lower plate in this type in which Vernier A 0' is lies on the main scale in 0° from lower plate.

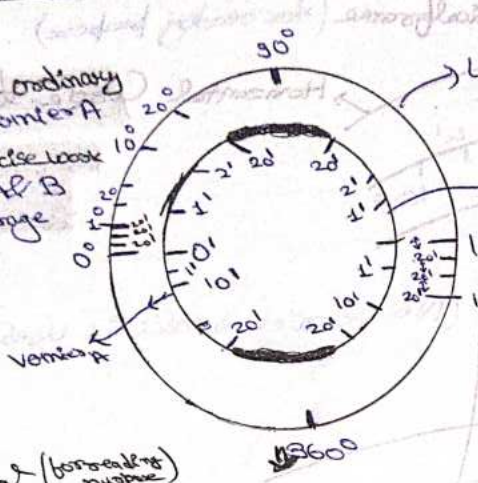
&

In upper plate Vernier B 0' lies on the main scale in 180° from lower plate.

Note:-

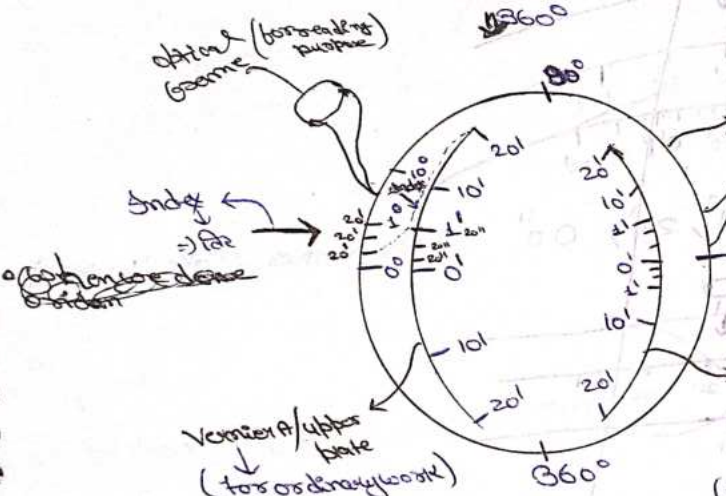
(i) When we done ordinary work we use vernier A

(ii) When we done precise work we use vernier A & B & take average



$1^\circ = 60'$

$\Rightarrow 20' + 20' + 20' = 60' = 1^\circ$



$1^\circ = 60'$

$\Rightarrow 20' + 20' + 20' = 60' \Rightarrow 1^\circ$

$1' = 60''$

$\Rightarrow 20'' + 20'' + 20'' = 60'' = 1'$

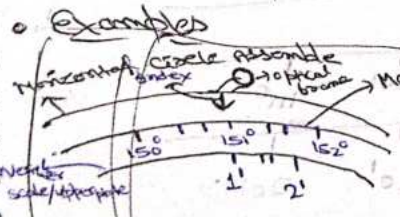
Vernier scale $\Rightarrow$ L.C = 20''

(i.e minimum reading that can be taken)

Note: Hence, Overall least count of horizontal Circle Assemble (Combination of lower plate & upper plate) $\Rightarrow$ L.C = 20''.

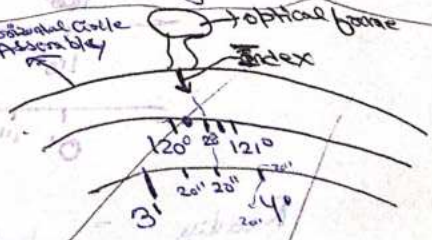
- To read an observation, first determine the value of scale reading in degrees & minutes up to the last scale division passed by the vernier zero (index). Add to this the vernier reading. A vernier reading is obtained by locating the vernier line, which coincides with the main scale. The number of that vernier line is then multiplied by the least count of the vernier to get the reading

- Examples



In this case reading is

151°, 1'



In this case Reading is

120°, 20', 40''

★ 5 fundamental Axes of theodolite: refers to the primary lines or axes around which the instrument operates. These axis are essential for accurate measurement and determining angular position

(i) Vertical Axis
(ii) Horizontal Axis
(iii) line of collimation
(iv) Bubble lines (or Axis of altitude level/bubble. Axes of level tube or plate bubble and Altitude level Axis (Altitude bubble axis)
(v) Plate level Axis (or Axis of plate level/bubble.): it is perpendicular to the vertical axis when the bubble is at the centre.
(vi) Axis of Stroking level.

★ Adjustment in Theodolite:

~~These are the adjustment which are done before making the observation at every~~

- Theodolite has two types of adjustment – temporary & permanent
- Temporary adjustment are to be done at every station where the instrument is set up.
- Permanent adjustment deals with the fundamental lines and their relationships and should be done once in a while to ensure that the instrument is properly adjusted.

★ Temporary Adjustment of Theodolite:

These are the adjustments which are done before making the observation at every setup of the instrument. They consist of setting up the theodolite, levelling it, and focussing the eyepiece & objectives

Step 1: Setting up the theodolite:

It consist of centering the theodolite over the station and its approximate levelling by tripod legs and adjust height

step-2

(2) Centering:- This involves setting the theodolite exactly over the station mark on the ground by the station peg. or we find center point of instrument & transfer it to ground

- Approximate levelling: This involves levelling the instrument with the legs of the tripod i.e by bringing the small circular bubble provided on the tribrach in the centre.

Notes: • When the leg is moved ~~radi~~ radially, the plumb bob is shifted in the direction of the leg without affecting the plate level appreciably.

• When the leg is moved Circumferentially, the instrument tilts and the plate levels are affected but the plumb bob position is not affected appreciabely.

Step 3: Levelling up:

This mean making the vertical axis truly vertical. This is done with the help of foot screw.

Step 4: focusing: or Elimination of Parallax:-

It Consist of focusing the eyepiece & the objective.

→ focusing the eyepiece: This operation is done to make the cross-hair appear clearly visible. The following steps are-

(i) The telescope is directed toward the sky or a sheet of white paper held in front of the objective.

(ii) The eyepiece is mpved in or out until the cross hair appear clearly and distinct.

→ Focusing the objective: This operation is done to bring the image of the object in the plane of the cross hair. The following steps are-

(i) The telescope is directly toward the object.

(ii) The focusing the screw is turned until the image appear clear and sharp.

• (focusing of eyepiece & focusing of objective also known as Elimination of parallax.

⇒ Temporary adjustment of theodolite Steps are

(i) Initial Setting (Not madoratory) Not Count in adjustment

(ii) Centering

(iii) Levelling (Done with the help of levelling or foot screw)

(iv) focusing of eye piece

(v) focusing of objective lens.

(Overall ⇒ (Setting over the Station) Centering → Levelling → focusing (or Elimanation of parallex).)

• Parallex:- It is an error occured when image formed by objective lens is not in the same plane with cross hair of telescope.

Or, It is the apparent movement of the image relative to the cross-hair when the image formed by the objective doesn't fall in the plane of the diaphragm.

✱ Permanent Adjustment of Theodolite:

- Aim → To establish or determine relation b/w fundamental lines of theodolite.
- The permanent adjustment of a theodolite are so arranged in sequence that the next adjustment does not disturb the result obtained from the previous adjustments.

→ Order of permanent adjustment:

(i) Make the plate bubble central to their run when the vertical axis of the theodolite is truly vertical. (Plate level test)
↳ vertical axis should be ⊥ to axis of level tube

(ii) (Cross-hair ring Test) - Make the vertical cross hair lies in a plane perpendicular to the horizontal axis.

(iii) (Collimation in Azimuth test) - Make the line of sight ⊥ to the horizontal axis. or (Line of Collimation parallel to horizontal axis)

(iv) (Spire test): Make the horizontal axis ⊥ to the vertical axis.

(v) Make the telescope bubble central when the line of sight is horizontal. (Bubble tube adjustment) → (Adjustment of Altitude level)

(vi) (Vertical arc test) - Make the vertical circle indicates zero when the line of sight is ⊥ to the vertical axis.
(Axis of level tube (bubble tube) should be parallel to line of Collimation)

⇒ Order of permanent Adjustment.

(i) Plate level test → (first test)
(ii) Cross hair ring Test
(iii) Collimation in Azimuth test
(iv) Spire Test
(v) Bubble tube Adjustment test
(vi) Vertical Arc Test → (Last test)

★ Measurement of Horizontal Angle :-

(1) By repetition method :- This method is used to measure a horizontal angle to a finer degree of accuracy. The average horizontal angle is obtained by taking average of two angle obtain with face left and face right.
key point
- More accurate & less error but more time consuming

(2) By Reiteration method :- It generally preferred when several angle are to be measured at a particular station. All the angles are measured successively and finally horizon is closed. face left observation are done in clockwise direction while face right should be made in anti-clockwise direction
key point of this
- Closing the horizon are used in reiteration method
- Start angle is 0° and final / last angle is 360°
- It is used when several angle measured

$$\frac{\text{face left} + \text{face right}}{2}$$

(3) Measurement of Direct angle / included angle :- An angle measured clockwise from preceding line to next line is called direct angle.

(4) Measurement of Deflecting Angle :- A deflection angle is made b/w prolongation of preceding line and following line. When angle is measured clockwise is called right deflection angle & when measured anticlockwise it is called left deflection angle.

★ Measurement of Horizontal Angles

- While taking the observation, both the verniers are read. It eliminates the error due to the axis of vernier plate not coinciding with the axis of the main plate.
- The vernier A is initally set to zero of the circle for convenience only. It may be set to any other reading e.g. 30°, 60°, 90° etc. In each case the initial reading on the starting station is called initial zero.
- If the lower plate is clamp (fix) & upper plate is unclamped (loosened) we can measure horizontal angle.

→ A horizontal angle is measured either by the method of repetition or by reiteration method.

★ Comparison of Repetition method Vs Reiteration method

(1) By Repetition method :-

- Measurement of simple angle or (more) least count of instrument
- When accuracy is needed beyond with coarsely graduated circle.
- It is more accurate & less error.
- More time consuming method & chances of personal error
- Generally six time repetitions are done, three time with the telescope normal/face left and three time with the telescope inverted face right.
- Horizontal angles measure several times (generally six times) measurement is add them and divided by number of repetion i.e. mean or average it gives finer degree than least count.

(2) By Reiteration Method :

- This method is used for Triangulation Survey.
- for face left, the observation should be made in clockwise direction, whereas for face right, they should be made in anticlockwise direction.
- Where number of angles may be required at one station by the instrument with finely graduated circle.

V.V.I

★ Note :- Error due to eccentricity of vernier and center are eliminated by taking both vernier reading.

* Types of theodolite

▶ Based on method of obtaining Reading →

(i) (Precise) Optical theodolite: Mostly used for Astronomical work
Or Electronic theodolite
Least Count = 1" (1 second)

(ii) Vernier Theodolite: It Consist of two vernier scale for measuring angle more precisely.
- Upper plate of a transit theodolite has two vernier which are diametrically opposite to each other.
- It is also known as Transit theodolite.

L.C = 20" (20 second).

▶ Based on Size of plates →

(i) 8-12 cm theodolite: Used for ordinary work
- its lower plate dia is 8 to 12 cm

(ii) (8 or) 12 - 25 cm theodolite: used for high precision work like triangulation.
- Its lower plate dia is 8 or 12 to 25 cm.

* Micro-optic theodolite: Or Microscopic theodolite: This is the most accurate theodolite and is used in Geodetic Survey & military survey.
- A micrometer is used to measure the reading in this theodolite
- Micrometer is used to take reading in microscopic or micro-optic theodolite.

L.C = 2". (2 second)

* Error due to eccentricity of inner & outer vertical axes:- If the centre of the graduated circle plate does not coincide with the center of the vernier plate the angle recorded by either of the vernier is incorrect. To eliminate the error due to this source, observe both the verniers and take the mean value.

* Error due to eccentricity of Vernier:- If the line joining the zeros of the horizontal plate verniers do not pass through the center of the vernier plate, an error in the measured horizontal angles is introduced. The error may be eliminated by taking the mean of the two values by reading both the verniers.

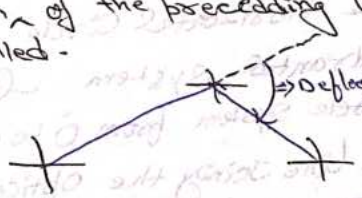
8) The process of turning the telescope in the theodolite in vertical plane through 180° about the trunnion axis is called
(a) Swinging (b) Centering (c) Transiting (d) Levelling

9) For measurement of vertical angles through theodolite, the instrument should be levelled with reference to the _____ bubble and the _____ clamp that is used to rotate the telescope in the vertical plane.
(a) Spindle : vertical plate (b) foot screw : lower plate
(c) Altitude : vertical circle (d) altitude : upper plate.

10) The following statements given pertain to theodolite used in surveying. Identify the incorrect statement
(a) The line of sight should be parallel to the horizontal axis
(b) The horizontal axis should be ⊥ to the vertical axis
(c) The vertical cross hair should be ⊥ to the horizontal axis (tilting axis)
(d) The axis of plate bubble should be in a plane ⊥ to the vertical axis.

11) The L.C of theodolite is
(a) one degree (b) 1'' (c) 2'' (d) 20'' (when no data is given we assume Vernier theodolite)

12) The angle b/w the prolongation of the preceding line and the forward line of traverse is called. or exceed



(a) Direct angle
(b) Excluded angle
(c) Interior angle
(d) Exterior included angle
(e) Deflection angle

13) The most accurate instrument for measuring horizontal & vertical angle
(a) Theodolite (b) Dumpy level (c) Compass (d) Tape & Chain

14) In transit theodolite, the line of sight can be reversed by reversing the telescope through
(a) 90° in horizontal plane (b) 90° in vertical plane
(c) 180° in horizontal plane (d) 180° in vertical plane

15) The trunnion axis or transverse axis is
(a) The axis about which the telescope can be rotate in vertical plane
(b) The axis about which the telescope can be rotate in horizontal plane
(c) The vertical axis
(d) The horizontal axis