THEODOLITE SURVEYING

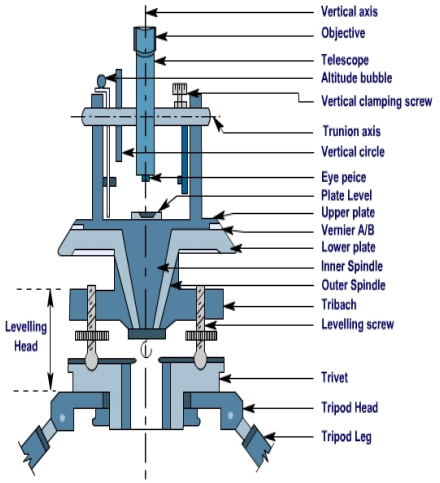
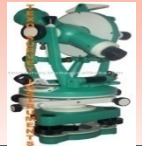


Figure 20.4 Sectional view of a Thedolite

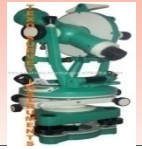
So far we have been measuring horizontal angles by using a *Compass* with respect to *meridian*, which is *less accurate* and also it is not possible to measure vertical angles with a Compass.

So when the objects are at a considerable distance or situated at a considerable elevation or depression ,it becomes necessary to measure horizontal and vertical angles more precisely. So these measurements are taken by an instrument known as a *theodolite*.



THEODOLITE SURVEYING

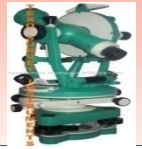
The system of surveying in which the angles are measured with the help of a theodolite, is called Theodolite surveying.



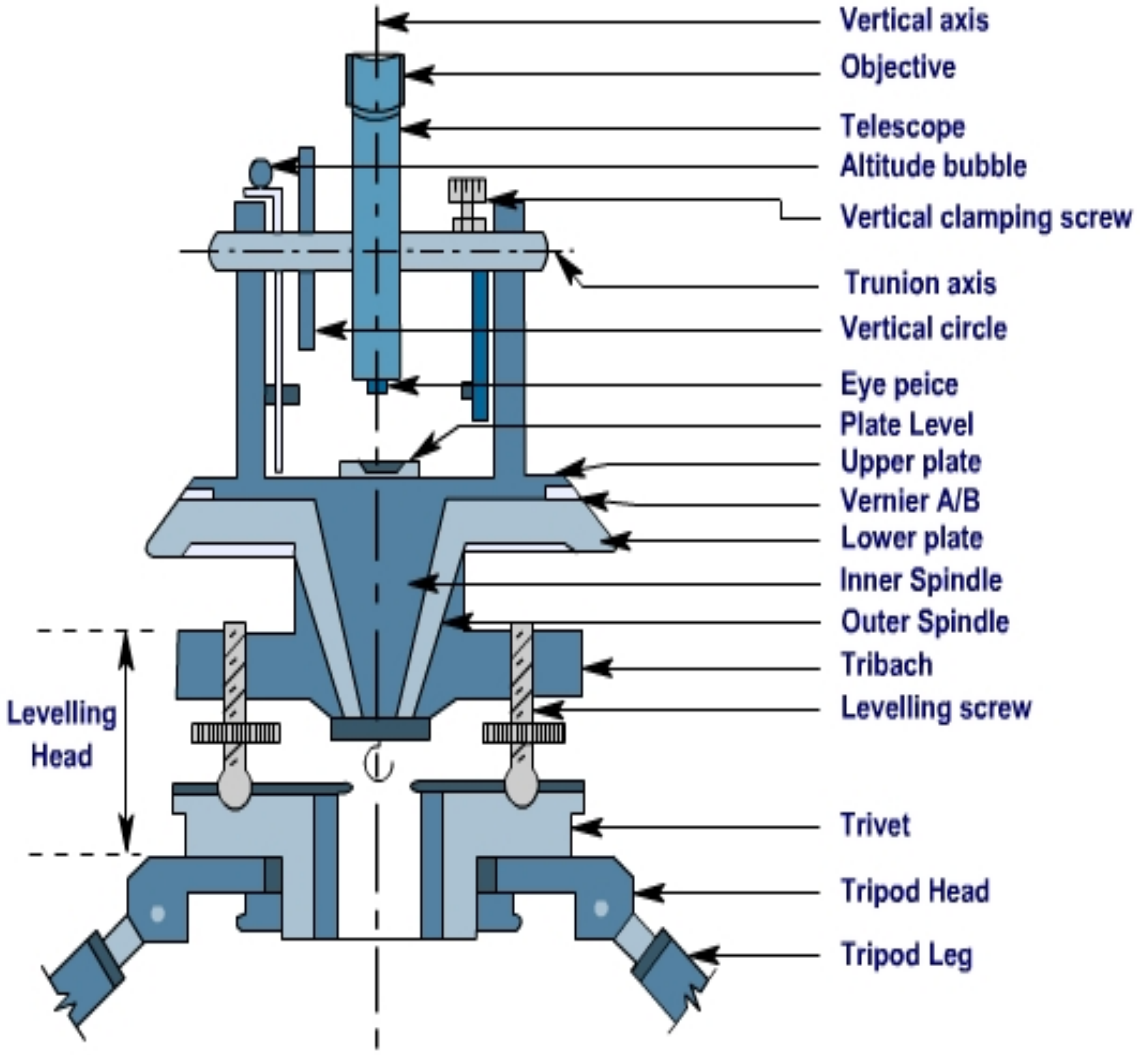
THEODOLITE

The Theodolite is a most accurate surveying instrument mainly used for :

- **Measuring horizontal and vertical angles.**
- **Locating points on a line.**
- **Prolonging survey lines.**
- **Finding difference of level.**
- **Setting out grades**
- **Ranging curves**
- **Tacheometric Survey**



TRANSIT VERNIER THEODOLITE



TRANSIT VERNIER THEODOLITE

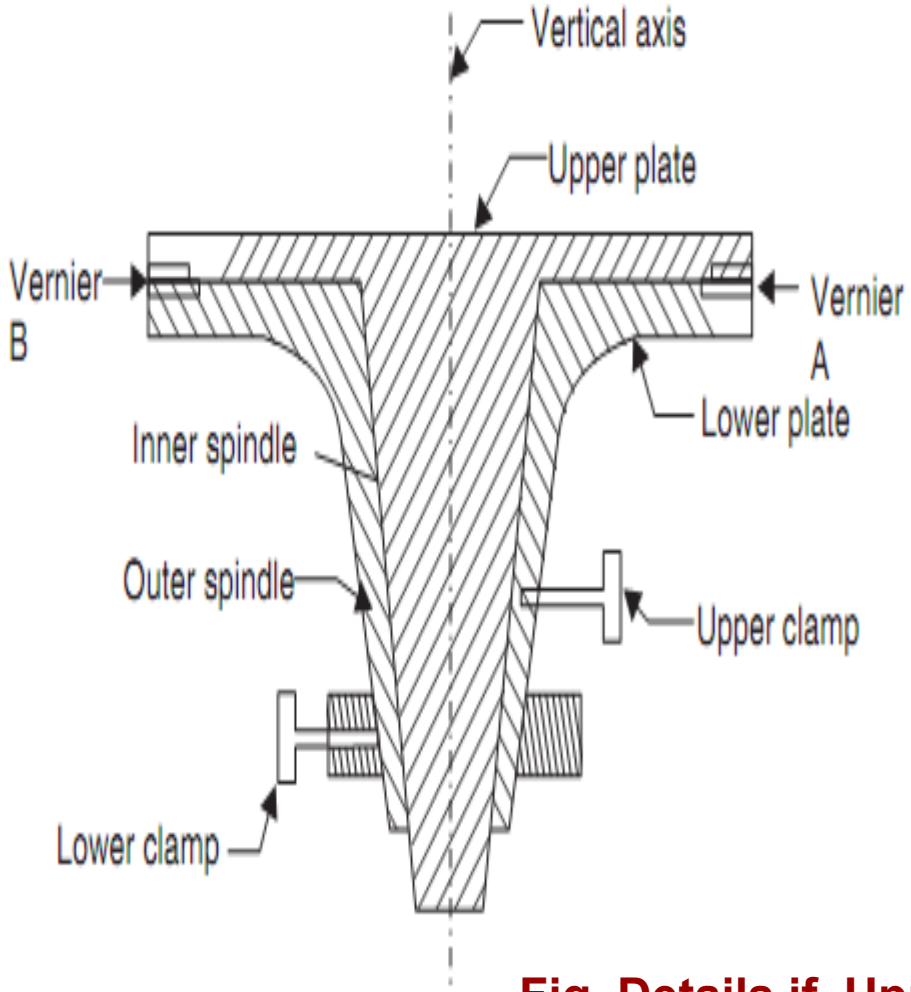
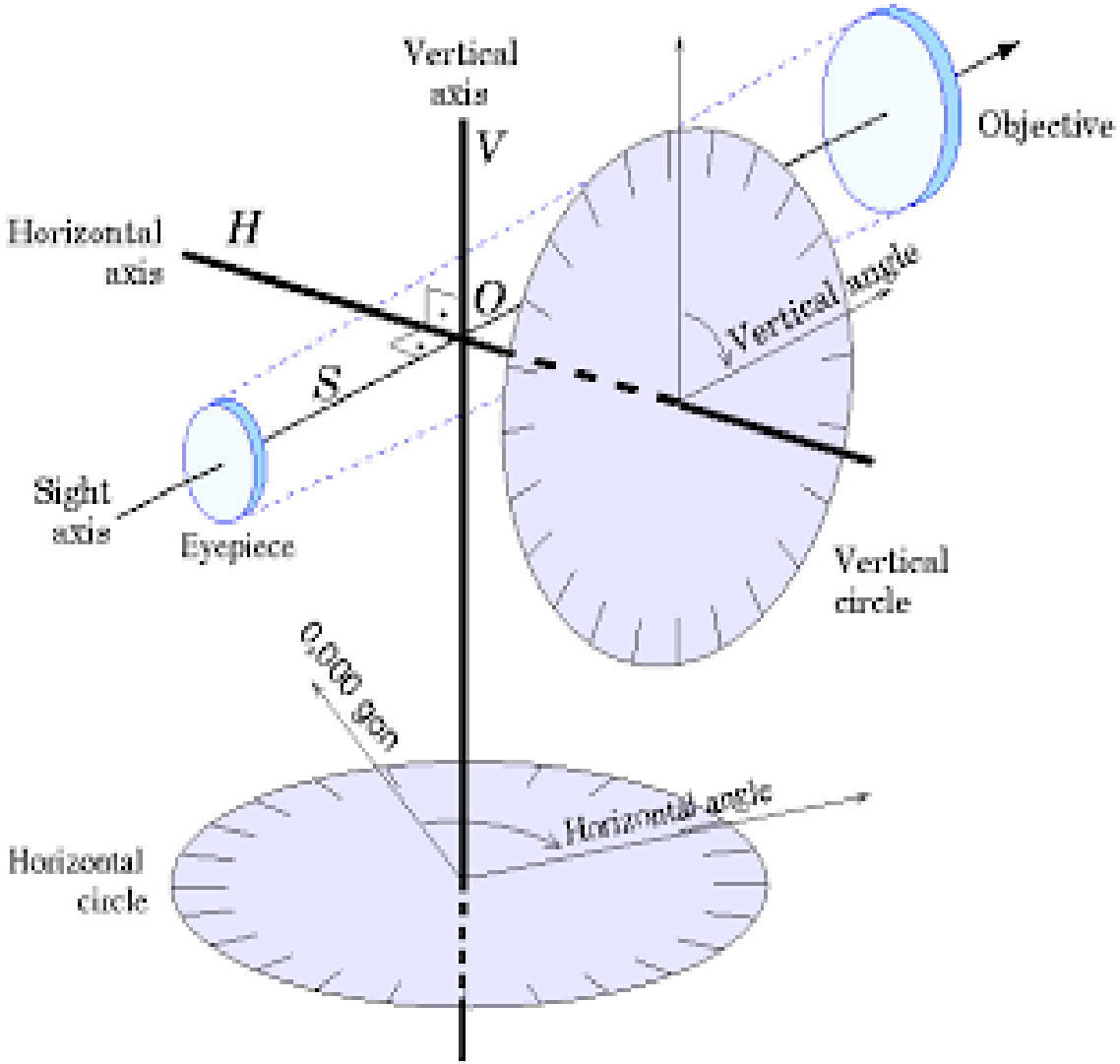


Fig. Details if Upper & Lower Plates.

TRANSIT VERNIER THEODOLITE



CLASSIFICATION OF THEODOLITES

Theodolites may be classified as ;

A.

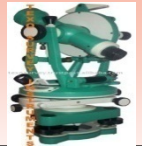
i) Transit Theodolite.

ii) Non Transit Theodolite.

B.

i) Vernier Theodolites.

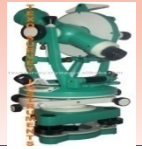
ii) Micrometer Theodolites.



CLASSIFICATION OF THEODOLITES

A. Transit Theodolite: A theodolite is called a transit theodolite when its telescope can be transited i.e revolved through a complete revolution about its horizontal axis in the vertical plane, whereas in a-

Non-Transit type, the telescope cannot be transited. They are inferior in utility and have now become *obsolete*.

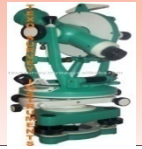


CLASSIFICATION OF THEODOLITES

B. Vernier Theodolite: For reading the graduated circle if verniers are used ,the theodolite is called as a Vernier Theodolite.

Whereas, if a *micrometer* is provided to read the graduated circle the same is called as a Micrometer Theodolite.

Vernier type theodolites are commonly used .

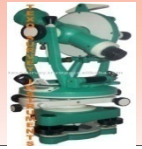


SIZE OF THEODOLITE

A theodolite is designated by diameter of the graduated circle on the lower plate.

The common sizes are *8cm to 12 cm* while *14 cm to 25 cm* instrument are used for *triangulation work*.

Greater accuracy is achieved with larger theodolites as they have bigger graduated circle with larger divisions hence used where the survey works require high degree of accuracy.

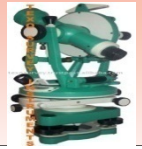


DESCRIPTION OF A

TRANSIT VERNIER THEODOLITE

A Transit vernier theodolite essentially consist of the following :

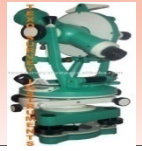
1. Levelling Head.
2. Lower Circular Plate.
3. Upper Plate.
4. Telescope.
5. Vernier Scale.
6. T- Frame.
7. Plumb –bob.
8. Tripod Stand.



TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

1. **Centering** : Centering means setting the theodolite exactly over an instrument- station so that its vertical axis lies immediately above the station- mark. It can be done by means of plumb bob suspended from a small hook attached to the vertical axis of the theodolite.

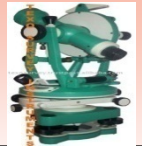
   The centre shifting arrangement if provided with the instrument helps in easy and rapid performance of the centring.



TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

2. Transiting :

Transiting is also known as *plunging* or *reversing*. It is the process of turning the telescope about its horizontal axis through 180^0 in the vertical plane thus bringing it upside down and making it point , exactly in opposite direction.

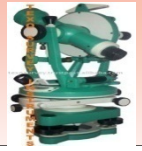


TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

3. Swinging the telescope

It means turning the telescope about its vertical axis in the horizontal plane.

A swing is called *right* or *left* according as the telescope is rotated clockwise or counter clockwise.

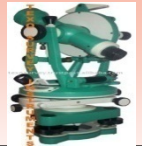


TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

4. Face Left

If the vertical circle of the instrument is on the left side of the observer while taking a reading ,the position is called the *face left* and

the observation taken on the horizontal or vertical circle in this position, is known as the *face left observation*

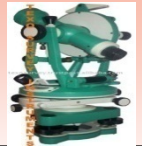


TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

5. Face Right

If the vertical circle of the instrument is on the right side of the observer while taking a reading ,the position is called the *face right* and

the observation taken on the horizontal or vertical circle in this position, is known as the *face right observation.*

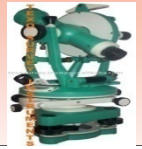


TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

6. Changing Face

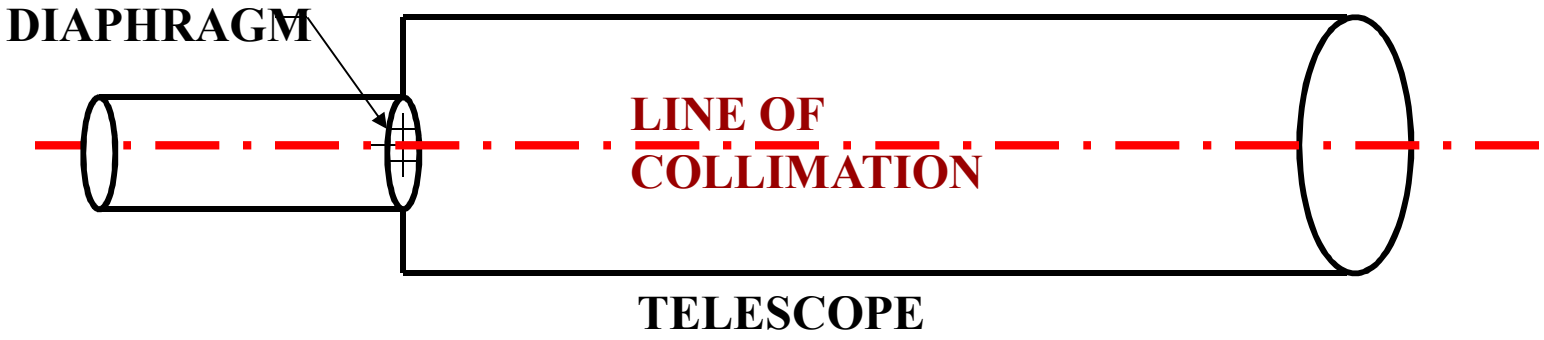
It is the operation of bringing the vertical circle to the right of the observer ,if originally it is to the left , and vice – versa.

It is done in two steps; Firstly revolve the telescope through 180^0 in a vertical plane and then rotate it through 180^0 in the horizontal plane i.e first transit the telescope and then swing it through 180^0.

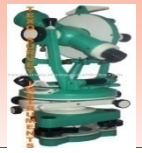


TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

7. Line of Collimation

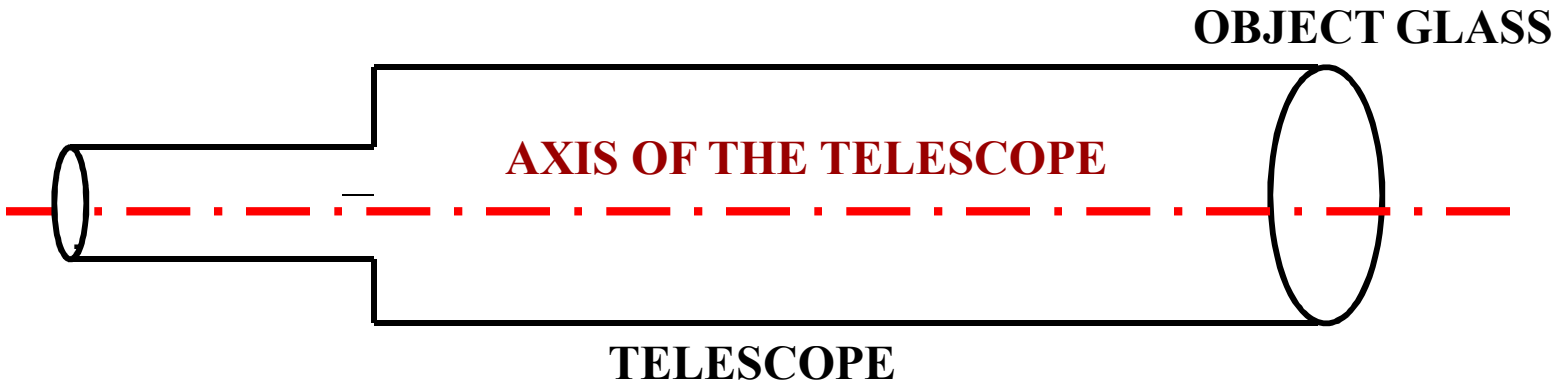


It is also known as the line of sight .It is an imaginary line joining the intersection of the cross- hairs of the diaphragm to the optical centre of the object- glass and its continuation.

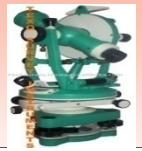


TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

8. Axis of the telescope



It is also known an imaginary line joining the optical centre of the object- glass to the centre of eye piece.

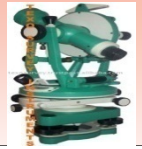


TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

9. Axis of the Level Tube

It is also called the bubble line.

It is a *straight* line *tangential* to the *longitudinal curve* of the level tube at the centre of the tube. It is horizontal when the bubble is in the centre.



TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

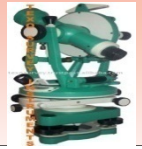
10. Vertical Axis

It is the axis about which the telescope can be rotated in the horizontal plane.

11. Horizontal Axis

It is the axis about which the telescope can be rotated in the vertical plane.

It is also called the *trunion axis.*

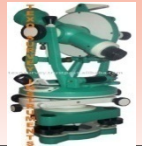


ADJUSTMENT OF A THEODOLITE

The adjustments of a theodolite are of two kinds :-

1. **Permanent Adjustments.**
2. **Temporary Adjustments.**

1) Permanent adjustments: The permanent adjustments are made to establish the relationship between the *fundamental lines* of the theodolite and , once made , they last for a long time. They are essential for the accuracy of observations.



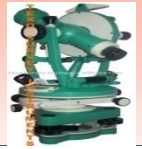
ADJUSTMENT OF A THEODOLITE

1. **Permanent adjustments:** The permanent adjustments in case of a transit theodolites are :-

i) **Adjustment of Horizontal Plate Levels.** The axis of the plate levels must be perpendicular to the vertical axis.

ii) **Collimation Adjustment.** The line of collimation should coincide with the axis of the telescope and the axis of the objective slide and should be at right angles to the horizontal axis.

iii) **Horizontal axis adjustment.** The horizontal axis must be perpendicular to the vertical axis.

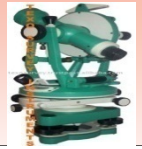


ADJUSTMENT OF A THEODOLITE

1. Permanent adjustments (contd.):

iv) Adjustment of Telescope Level or the Altitude Level Plate Levels. The axis of the telescope levels or the altitude level must be parallel to the line of collimation.

v) Vertical Circle Index Adjustment. The vertical circle vernier must read zero when the line of collimation is horizontal.



ADJUSTMENT OF A THEODOLITE

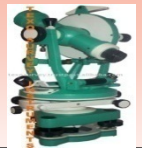
2. Temporary Adjustment

The temporary adjustments are made at each set up of the instrument before we start taking observations with the instrument. There are three temporary adjustments of a theodolite:-

i) Centering.

ii) Levelling.

iii) Focussing.



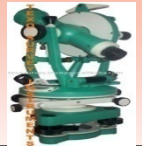
MEASUREMENT OF HORIZONTAL ANGLES:

There are three methods of measuring horizontal angles:-

i) Ordinary Method.

ii) Repetition Method.

iii) Reiteration Method.



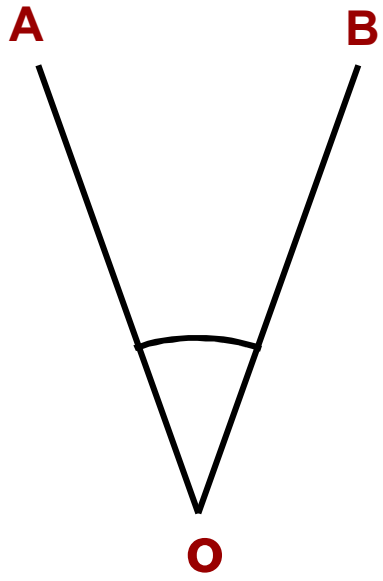
MEASUREMENT OF HORIZONTAL ANGLES:

i) Ordinary Method. To measure horizontal angle AOB:-

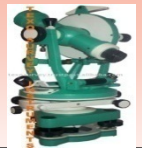
i) Set up the theodolite at station point O and level it accurately.

ii) Set the vernier A to the zero or 360^0 of the horizontal circle. Tighten the upper clamp.

iii) Loosen the lower clamp. Turn the instrument and direct the telescope towards A to bisect it accurately with the use of tangent screw. After bisecting accurately check the reading which must still read zero. Read the vernier B and record both the readings.



HORIZONTAL ANGLE AOB

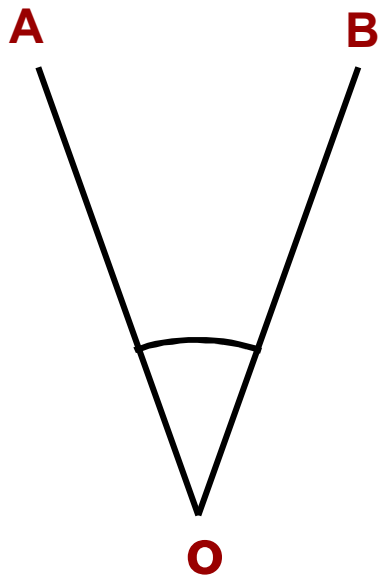


MEASUREMENT OF HORIZONTAL ANGLES:

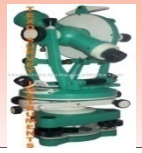
i) Ordinary Method. To measure horizontal angle AOB:-

iv) Loosen the upper clamp and turn the telescope clockwise until line of sight bisects point B on the right hand side. Then tighten the upper clamp and bisect it accurately by turning its tangent screw.

v) Read both verniers. The reading of the vernier a which was initially set at zero gives the value of the angle AOB directly and that of the other vernier B by deducting 180^0 .The mean of the two vernier readings gives the value of the required angle AOB.



HORIZONTAL ANGLE AOB

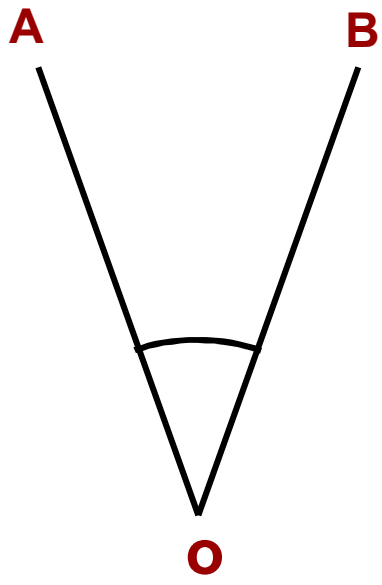


MEASUREMENT OF HORIZONTAL ANGLES:

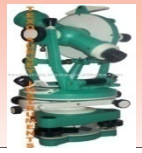
i) Ordinary Method. To measure horizontal angle AOB:-

vi) Change the face of the instrument and repeat the whole process. The mean of the two vernier readings gives the second value of the angle AOB which should be approximately or exactly equal to the previous value.

vii) The mean of the two values of the angle AOB ,one with face left and the other with face right ,gives the required angle free from all instrumental errors.



HORIZONTAL ANGLE AOB

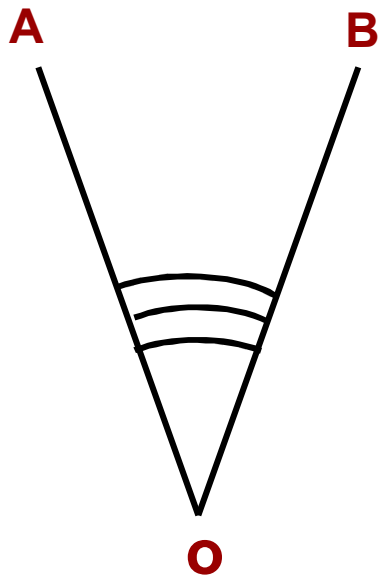


MEASUREMENT OF HORIZONTAL ANGLES:

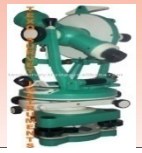
ii) Repetition Method.

This method is used for very accurate work. In this method ,the same angle is added several times mechanically and the correct value of the angle is obtained by dividing the accumulated reading by the no. of repetitions.

The No. of repetitions made usually in this method is six, three with the face left and three with the face right .In this way ,angles can be measured to a finer degree of accuracy than that obtainable with the least count of the vernier.



HORIZONTAL ANGLE AOB



MEASUREMENT OF HORIZONTAL ANGLES:

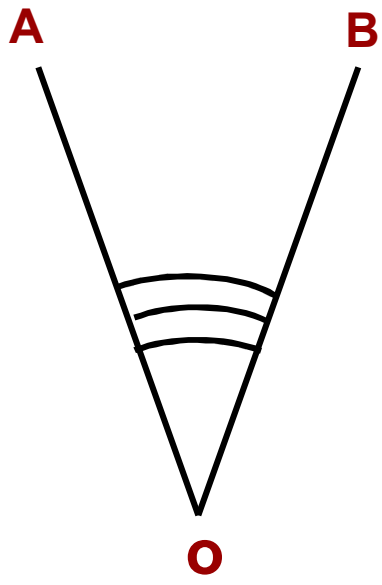
ii) Repetition Method.

To measure horizontal angle by repetitions:-

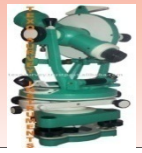
i) Set up the theodolite at starting point O and level it accurately.

ii) Measure The horizontal angle AOB.

iii) Loosen the lower clamp and turn the telescope clock – wise until the object (A) is sighted again. Bisect B accurately by using the upper tangent screw. The verniers will now read the *twice* the value of the angle now.



HORIZONTAL ANGLE AOB

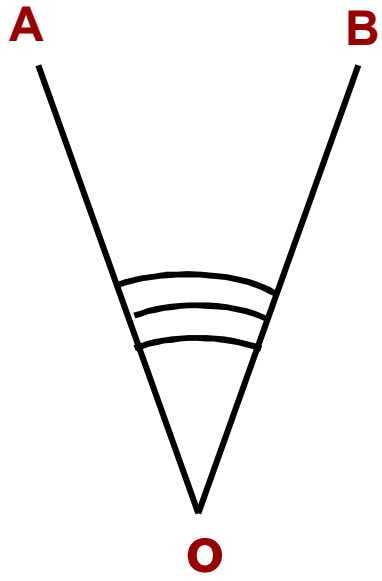


MEASUREMENT OF HORIZONTAL ANGLES:

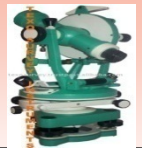
ii) Repetition Method contd...

iv) Repeat the process until the angle is repeated the required number of times (usually 3). Read again both verniers . The final reading after *n repetitions* should be approximately n X (angle). *Divide* the *sum* by the *number of repetitions* and the result thus obtained gives the *correct value of the angle* AOB.

v) Change the face of the instrument. Repeat exactly in the same manner and find another value of the angle AOB. The *average* of two readings gives the required precise value of the angle AOB.



HORIZONTAL ANGLE AOB



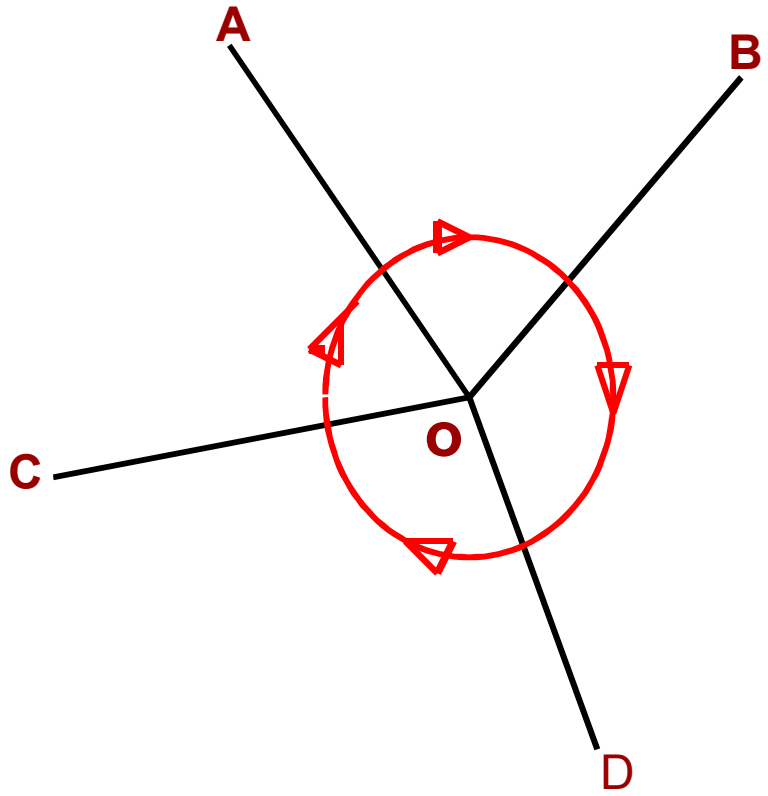
MEASUREMENT OF HORIZONTAL ANGLES:

iii) Reiteration Method.

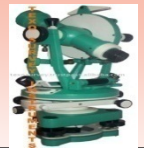
This method is another *precise* and comparatively *less tedious* method of measuring the horizontal angles.

It is generally preferred when *several angles* are to be measured at a particular station.

This method consists in measuring several angles successively and finally closing the horizon at the starting point. The *final reading* of the vernier A should be *same* as its *initial reading*.



Reiteration Method



MEASUREMENT OF HORIZONTAL ANGLES:

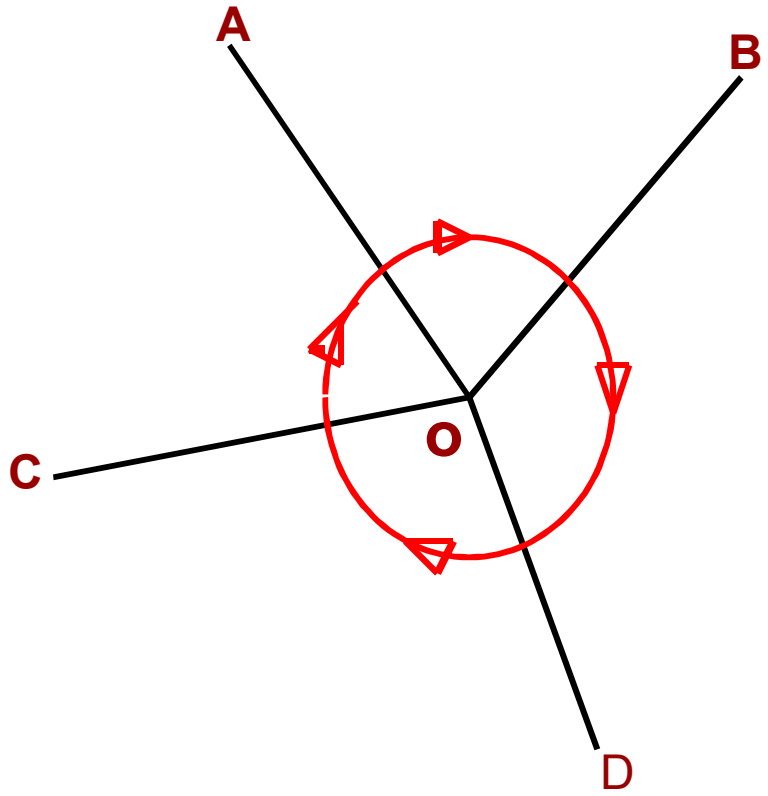
iii) Reiteration Method.

…If not ,the discrepancy is equally distributed among all the measured angles.

Procedure

Suppose it is required to measure the angles AOB,BOC and COD. Then to measure these angles by repetition method :

i) Set up the instrument over station point O and level it accurately.



Reiteration Method

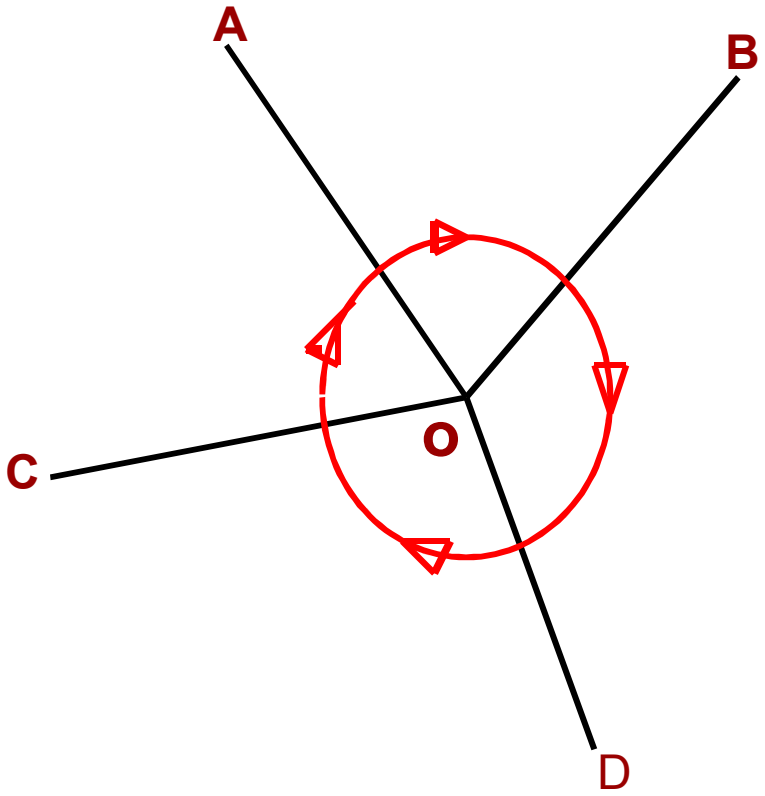
MEASUREMENT OF HORIZONTAL ANGLES:

iii) Reiteration Method.

Procedure

ii) Direct the telescope towards point A which is known as referring object. Bisect it accurately and check the reading of vernier as 0 or 360^0. Loosen the lower clamp and turn the telescope clockwise to sight point B exactly. Read the verniers again and The mean reading will give the value of angle AOB.

iii) Similarly bisect C & D successively, read both verniers at-



Reiteration Method

MEASUREMENT OF HORIZONTAL ANGLES:

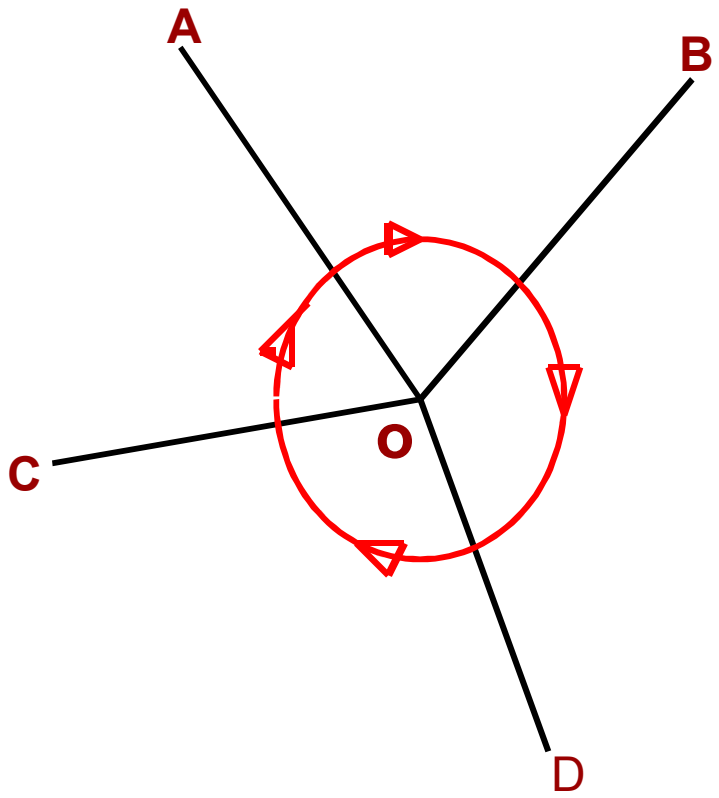
iii) Reiteration Method (contd.).

Procedure. each bisection, find the value of the angle BOC and COD.

iv) Finally close the horizon by sighting towards the referring object (point A).

v) The vernier A should now read 360^0. If not note down the error .This error occurs due to *slip* etc.

vi) If the error is small, it is *equally distributed* among the several angles .If *large* the readings should be *discarded* and a new set of readings be taken.



Reiteration Method

MEASUREMENT OF VERTICAL ANGLES:

Vertical Angle : A vertical angle is an angle between the *inclined line of sight* and the *horizontal*. It may be an angle of *elevation* or *depression* according as the object is above or below the horizontal plane.

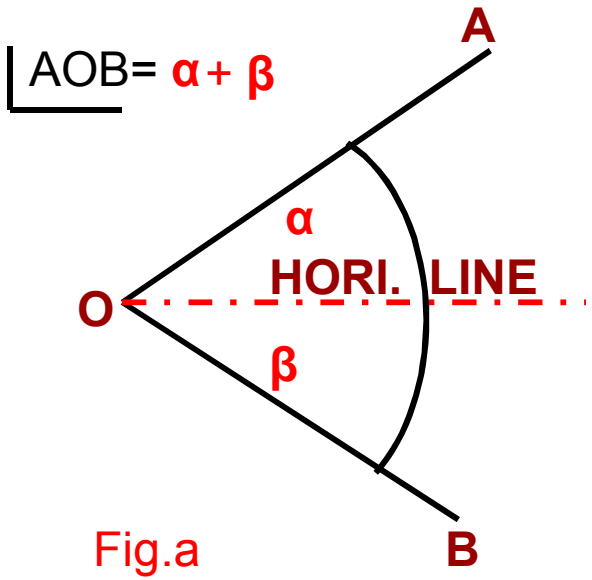


Fig.a

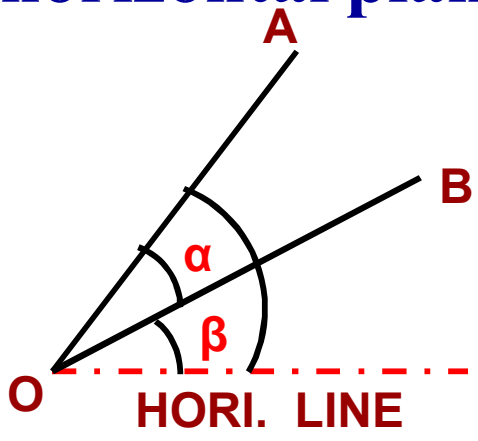


Fig. b

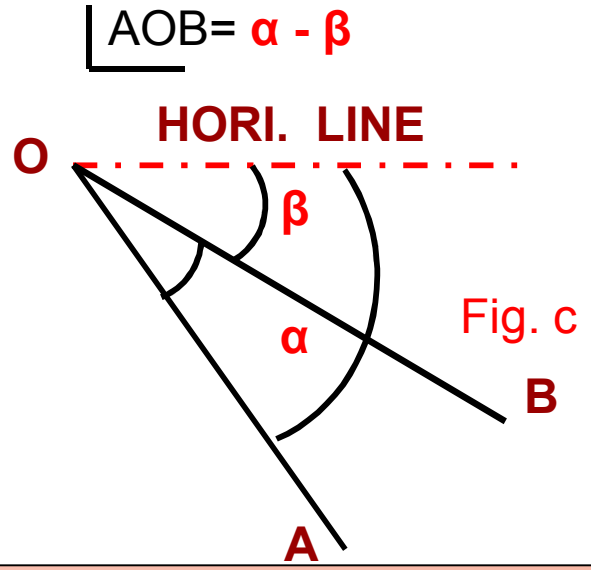
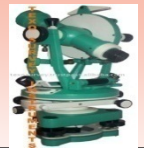


Fig. c

VERTICAL ANGLE



MEASUREMENT OF VERTICAL ANGLES:

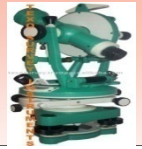
To Measure the Vertical Angle of an object A at a station O:

(i) Set up the theodolite at station point O and level it accurately with reference to the altitude bubble.

(ii) Set the zero of vertical vernier exactly to the zero of the vertical circle clamp and tangent screw.

(iii) Bring the bubble of the altitude level in the central position by using clip screw. The line of sight is thus made horizontal and vernier still reads zero.

(iv) Loosen the vertical circle clamp screw and direct the telescope towards the object A and sight it exactly by using the vertical circle tangent screw.

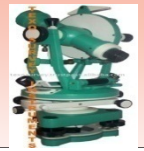


MEASUREMENT OF VERTICAL ANGLES:

(v) Read both verniers on the vertical circle, The mean of the two vernier readings gives the value of the required angle.

(vi) Change the face of the instrument and repeat the process. The mean of of the two vernier readings gives the second value of the required angle.

(vii) The average of the two values of the angles thus obtained, is the required value of the angle free from instrumental errors.



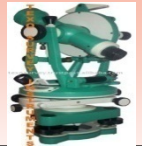
MEASUREMENT OF VERTICAL ANGLES:

For measuring Vertical Angle between two points A &B

i) Sight A as before , and take the mean of the two vernier readings at the vertical circle. Let it be α

ii) Similarly, sight B and take the mean of the two vernier readings at the vertical circle. Let it be β

iii) The sum or difference of these dings will give the value of the vertical angle between A and B according as one of the points is above and the other below the horizontal plane. or both points are on the same side of the horizontal plane Fig b & c



READING MAGNETIC BEARING OF A LINE

To find the bearing of a line AB as shown in fig .below

i) Set up the instrument over A and level it accurately

ii) Set the vernier to the zero of the horizontal circle.

iii) Release the magnetic needle and loosen the lower clamp.

iv) Rotate the instrument till magnetic needle points to North. Now clamp the lower clamp with the help of lower tangent screw .Bring the needle exactly against the mark in order to bring it in magnetic meridian. At this stage the line of sight will also be in magnetic meridian.

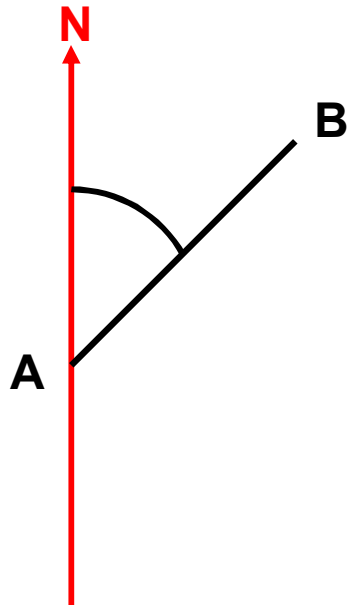
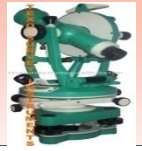


Fig.
Magnetic Bearing of a Line



READING MAGNETIC BEARING OF A LINE

iv) Now loose the upper clamp and point the telescope towards B .With the help of upper tangent screw ,bisect B accurately and read both the verniers .The mean of the two readings will be recorded as magnetic bearing of line.

v) Change the face of the instrument for accurate magnetic bearing of the line and repeat .the mean of the two values will give the correct bearing of the line AB.

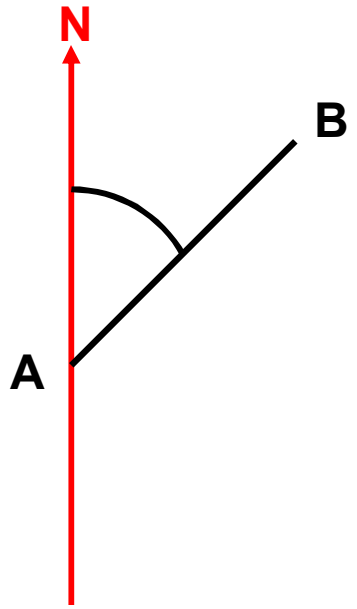


Fig.
Magnetic Bearing of a Line

PROLONGING A STRAIGHT A LINE

There are two methods of prolonging a given line such as AB

(1) Fore sight method ,and (2) Back Sight Method

(1)Fore Sight Method. As shown in the fig. below

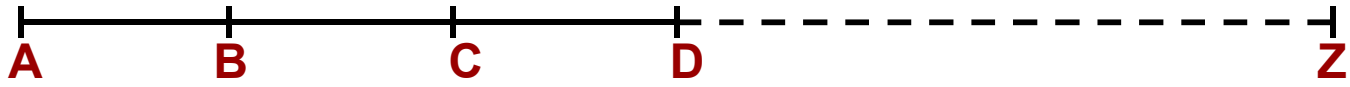


Fig.

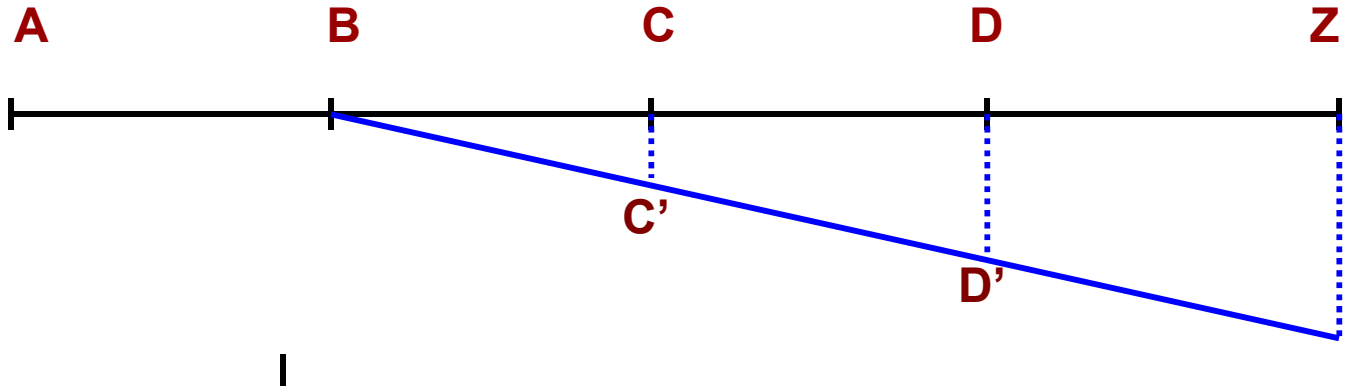
i) Set up the theodolite at A and level it accurately .Bisect the point b correctly. Establish a point C in the line beyond B approximately by looking over the top of the telescope and accurately by sighting through the telescope.

ii) Shift the instrument to B ,take a fore sight on C and establish a point D in line beyond C.

iii) Repeat the process until the last point Z is reached.

PROLONGING A STRAIGHT A LINE

(2) Back Sight Method. As shown in the fig. below

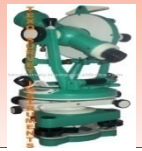


i) Set up the instrument at B and level it accurately .

ii) Take a back sight on A.

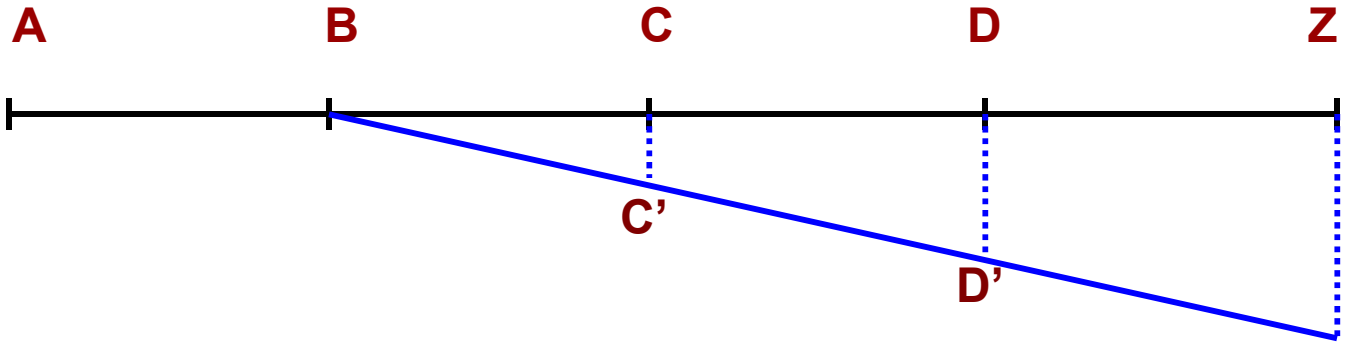
iii) Tighten the upper and lower clamps, transit the telescope and establish a point C in the line beyond B.

iv) Shift the theodolite to C ,back sight on B transit the telescope and establish a point D in line beyond C. Repeat the process until the last point (Z) is established.



PROLONGING A STRAIGHT A LINE

(2) Back Sight Method.(contd.) As shown in the fig. below



Now if the instrument is in adjustment, the points A,B,C,D and Z will be in one line, which is straight but if it is not in adjustment i.e. line of collimation is not perpendicular to the horizontal axis ,then C', D' and Z' will not be in a straight line.

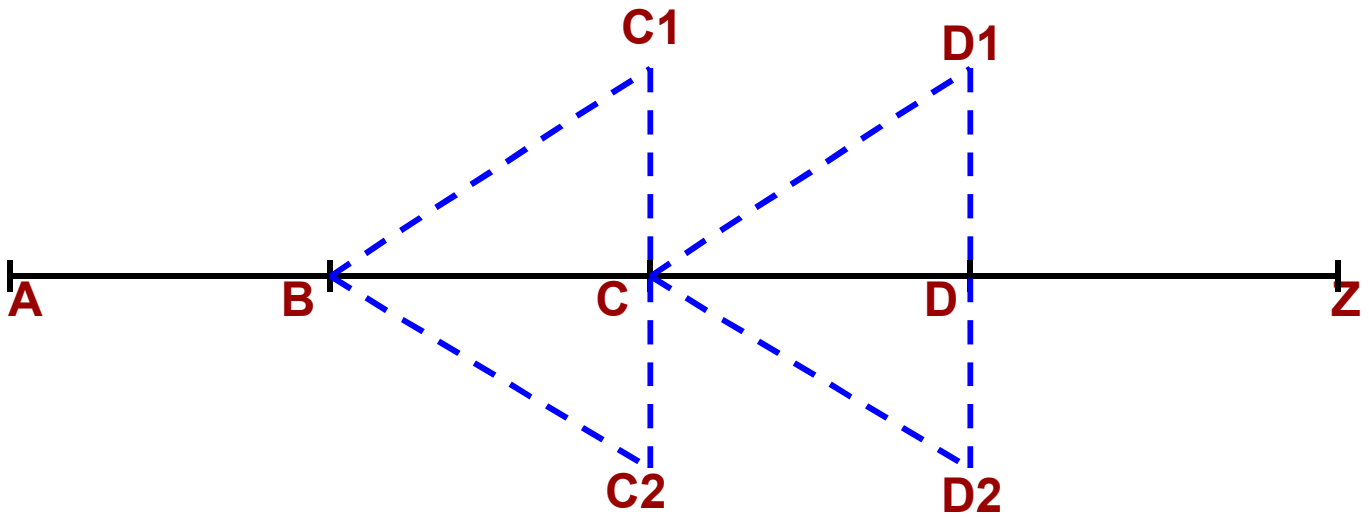
PROLONGING A STRAIGHT A LINE

Double reversing Method

When the line is to be prolonged with *high precision* or when the *instrument* is in *imperfect adjustment*, the process of *double sighting* or *double reversing*, is used.

Suppose the line AB is to be prolonged to a point Z.

Procedure: As shown below:



Double Sighting / Reversing Method

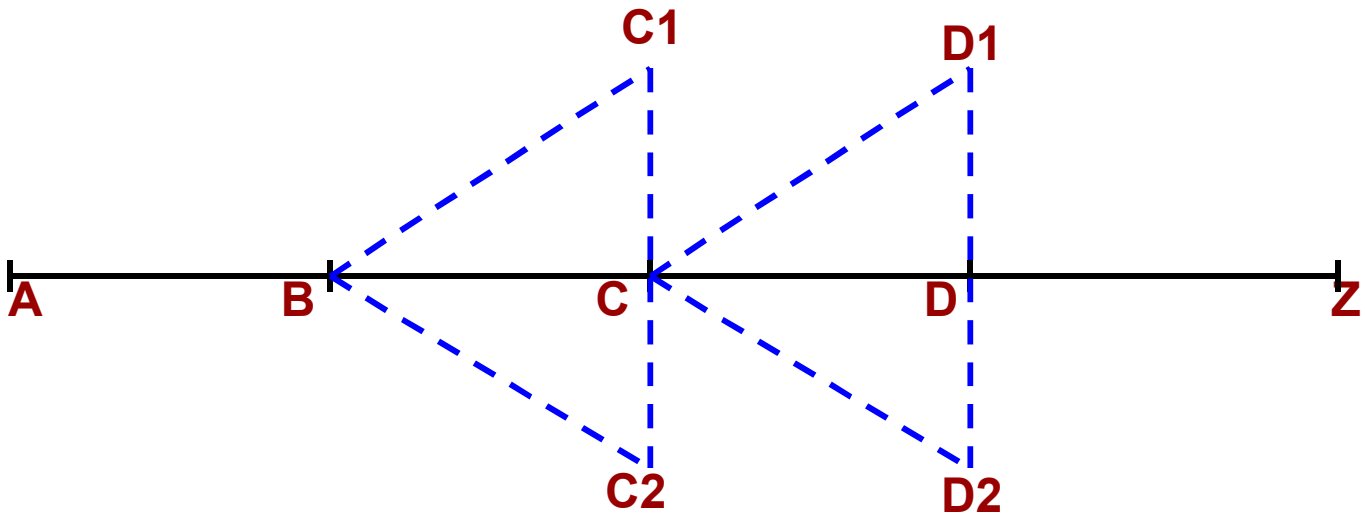
PROLONGING A STRAIGHT A LINE

Double reversing Method

i) Set up the theodolite at B and level it accurately.

ii) With the face of instrument left, back sight on A and clamp both the upper and lower motions.

iii) Transit the telescope and set a point C_1 ahead in line.



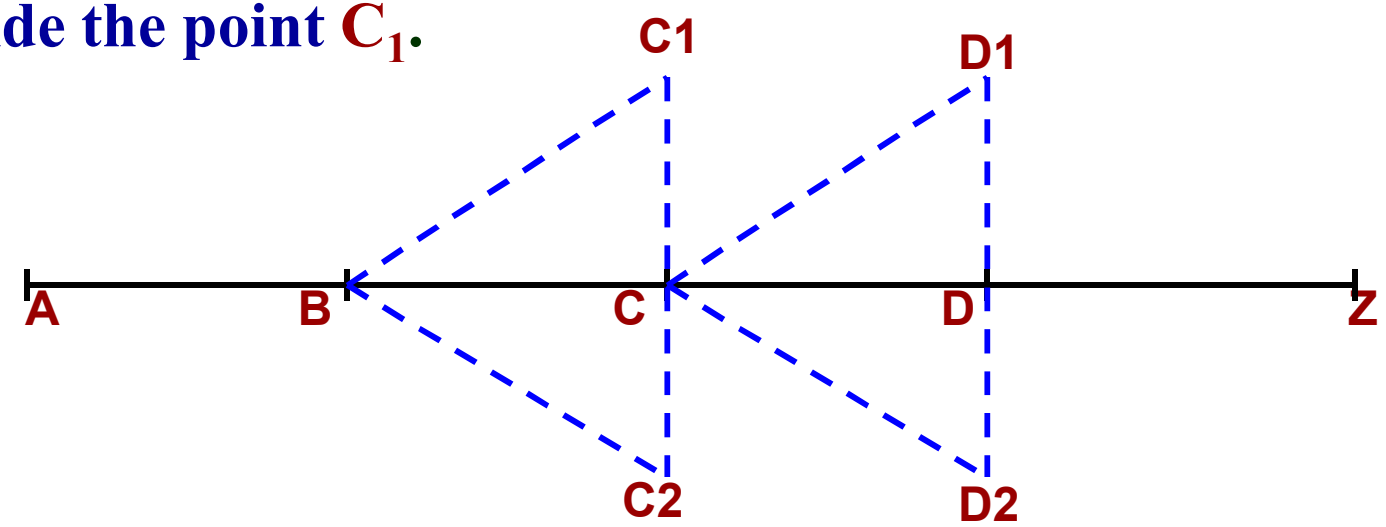
Double Sighting / Reversing Method

PROLONGING A STRAIGHT A LINE

Double reversing Method (contd.)

iv) Loosen the lower clamp ,revolve the telescope in the horizontal plane and back sight on A .Bisect A exactly by using the lower clamp and its tangent screw. Now the face of instrument is right.

v) Transit the telescope and establish a point C_2 in line beside the point C_1.



Double Sighting / Reversing Method

PROLONGING A STRAIGHT A LINE

Double reversing Method (contd.)

vi) The exact position of the true point C must be mid-way between C_1 and C_2 .

vii) Measure C_1 C_2 and establish a point C exactly mid-way, which lies on the true prolongation of AB.

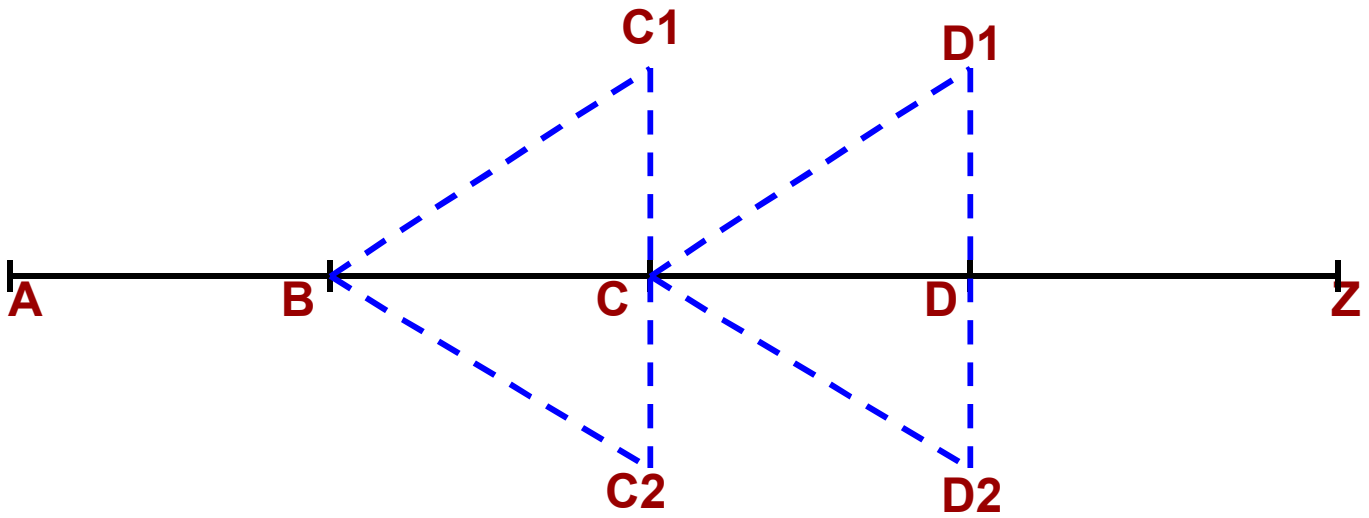
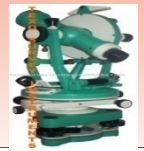


Fig. Double Sighting / Reversing Method

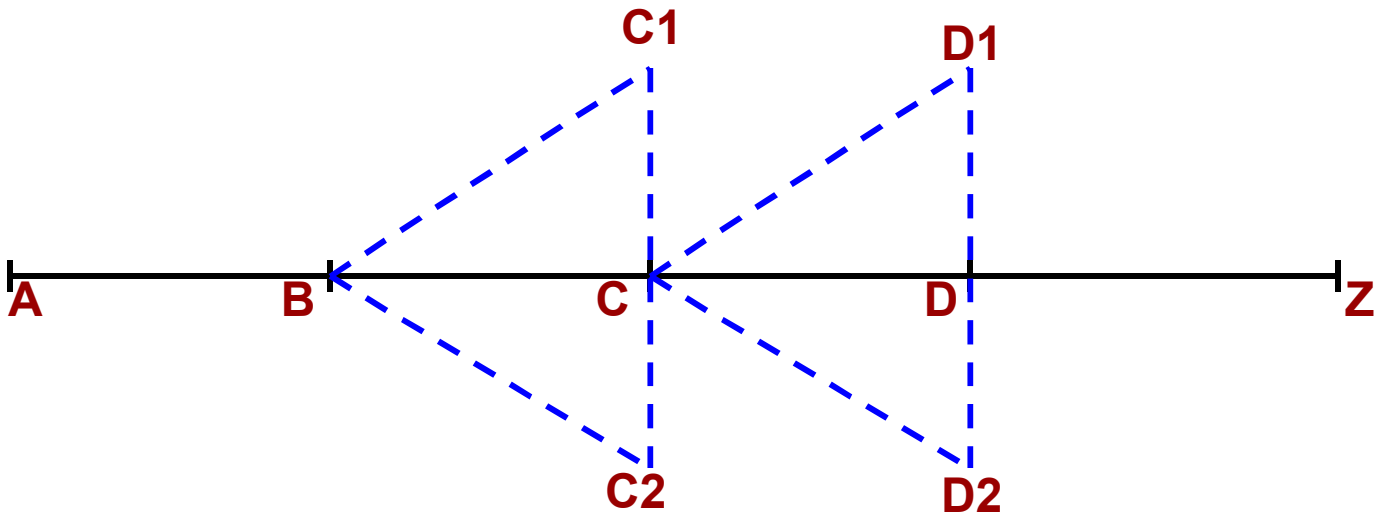


PROLONGING A STRAIGHT A LINE

Double reversing Method (contd.)

viii) Shift the instrument to C, double sight on B ,establish the point D_1 and D_2 and locate the true point D as before .

ix) Continue the process until the last point Z is established.



Double Sighting / Reversing Method