THEODOLITE SURVEYING

INTRODUCTION

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.

CLASSIFICATION OF THEODOLITES

Theodolites may be classified as ;

A. Primary

i) Transit Theodolite.

ii) Non Transit Theodolite.

B. Secondary

i) Vernier Theodolites.

ii) Micrometer Theodolites.

iii) Modern Theodolite

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.

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

Transit Theodolite & Non-Transit

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

Micrometer Theodolite - If a *micrometer* is provided to read the graduated circle the same is called as a Micrometer Theodolite.

Vernier type theodolites are commonly used .

C. Modern Theodolite- It is compact, light in weight , simple in design and can be used easily, Virtually dust and moisture proof.

COMPONENTS OF TRANSIT OR VERNIER THEODOLITE

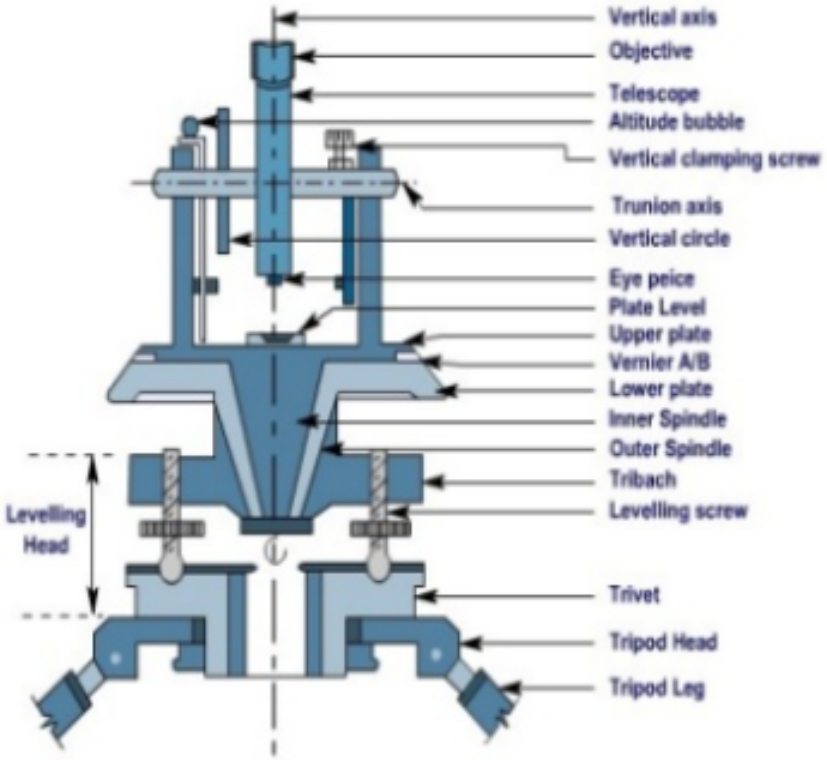


Figure 20.4 Sectional view of a Thedolite

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. Plate level
5. Compass
6. Diaphragm.
7. T- Frame.
8. Plumb –bob.
9. Tripod Stand.
10. Telescope.

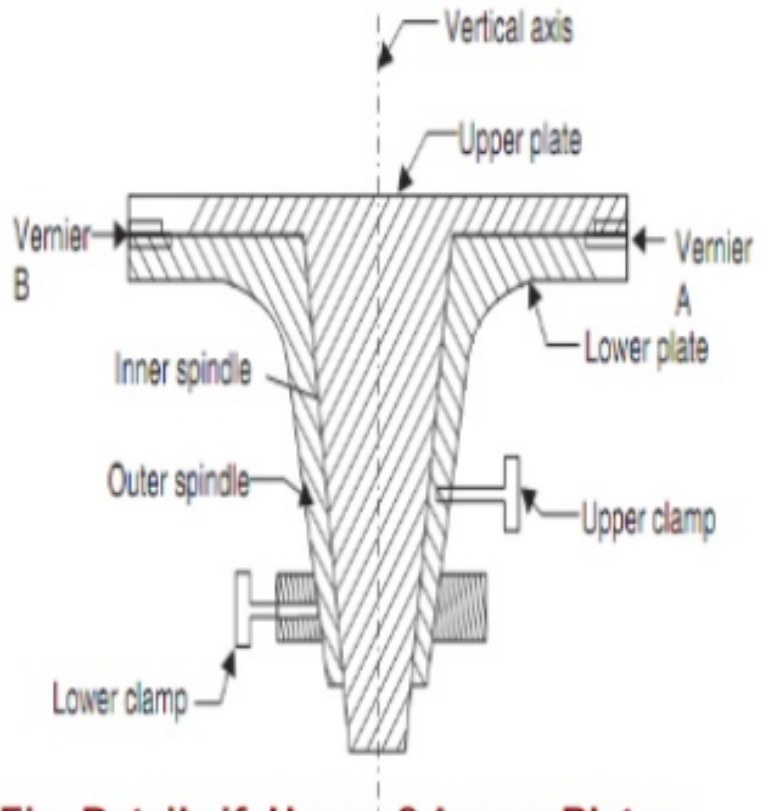
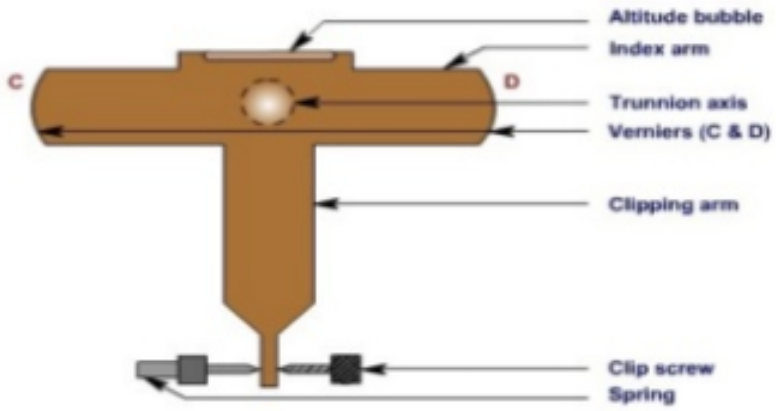


Fig. Details if Upper & Lower Plates.

- **Compass**- Some theodolites are provided with a compass which can be either tubular type or trough type.
- **Diaphragm**- Diaphragm with cross hair is provided in telescope to give a definite line of sight.
- **Vernier Frame** Also called T -frame or index frame, consists of a vertical leg known as clipping arm and a horizontal bar called the index arm engraved with verniers C and D at its ends.



- **Telescope –** the function of telescope is to provide line of sight. The length of telescope varies from 100mm to 175mm.
- **Plumb bob –** To center the instrument exactly over a station mark, a plumb bob is suspended from the hook fitted to the bottom of the central vertical axis.
- **Tripod Stand -** The theodolite is mounted on a strong tripod when being used in the field. The legs of the tripod are solid or framed.

- **Others parts**

1. Level tube
2. Standard Frame
3. Turnnion Axis
4. Vernier Frame
5. Inner Axis
6. Outer Axis
7. Altitude Level
8. Levelling Screw
9. Clamp Screw
10. Tangent Screw
11. Foot Plate
12. Upper Clamp
13. Lower Clamp

Difinitions

Least Count of the vernier

- This is the difference between the value of the smallest division of the main scale and that of the smallest division of the vernier scale. It is the smallest value that can be measured by a theodolite.
- $$V = \frac{d}{n}$$

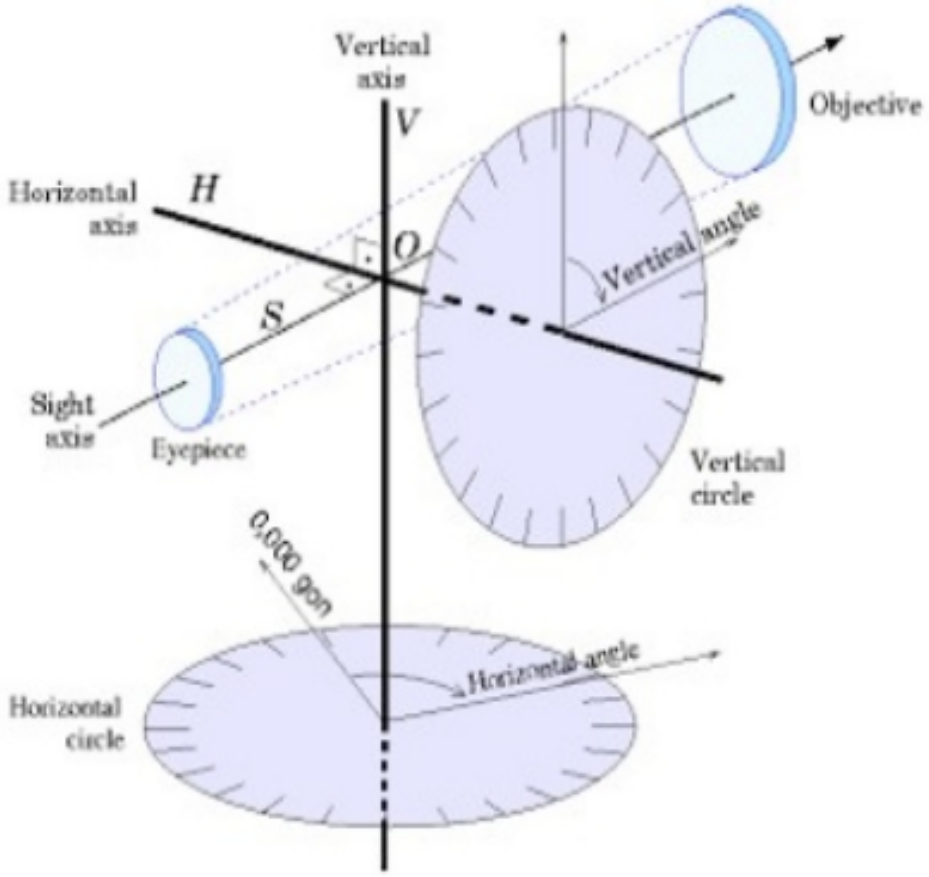
Where, **v= Value of smallest division of vernier Scale**

d= Value of the smallest division of main scale

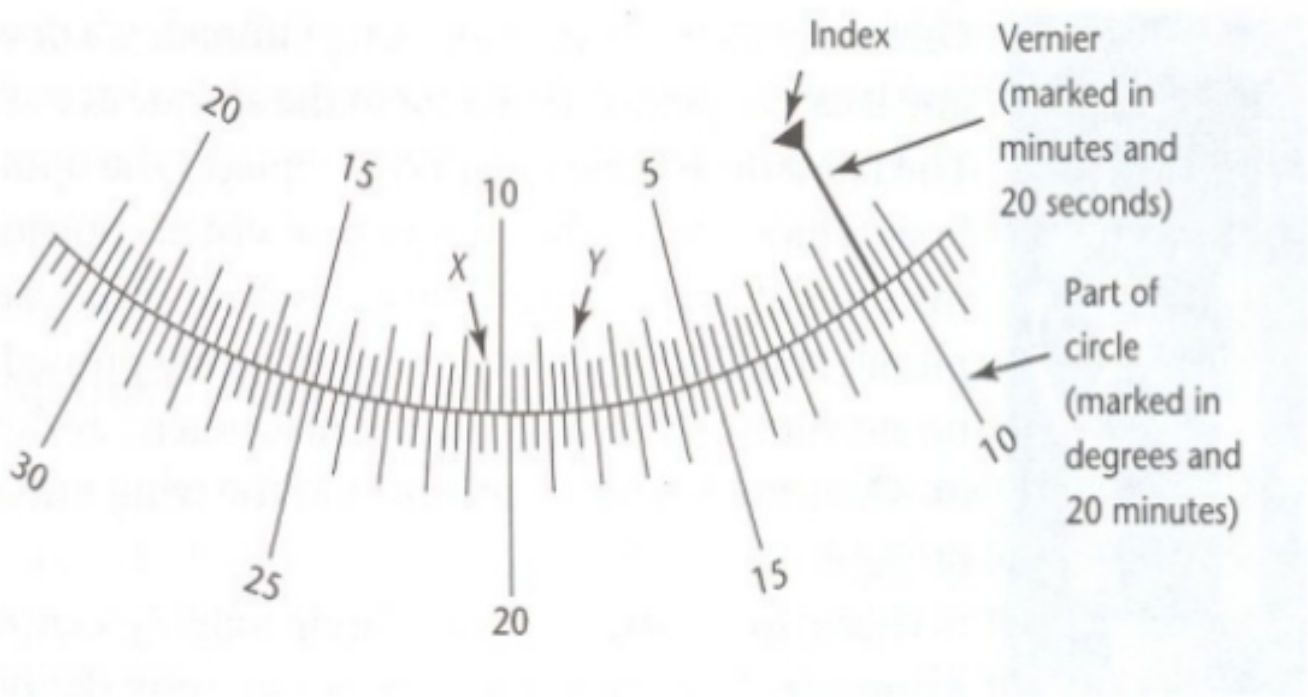
n= no of small divisions on vernier scale.

Least count of theodolites are generally 20" and 15" and so on.

AXIS OF VERNIER THEODOLITE



METHOD OF READING VERNIER



TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

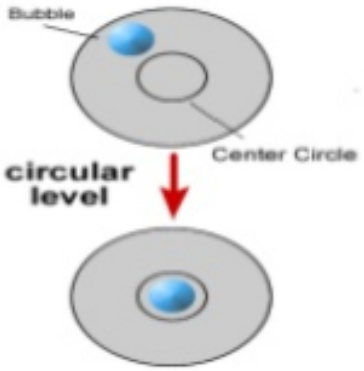
1. **Centering** : Centering means setting the theodolite exactly over an instrument. It can be done by means of plumb bob suspended from a small hook attached to the vertical axis of the theodolite.

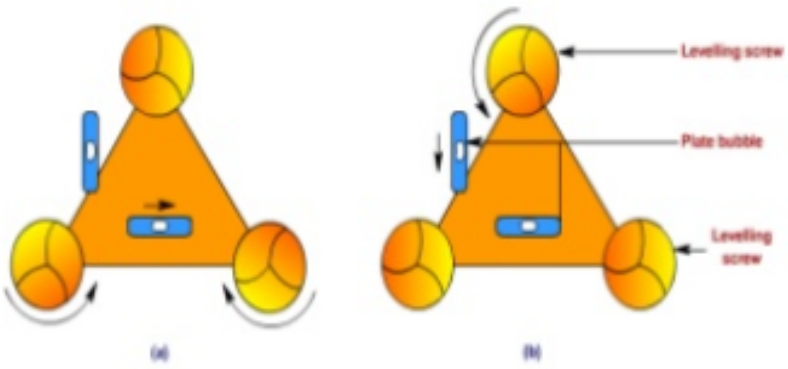
2. **Transiting** : Transiting is also known as *plunging* or *reversing*. It is the process of turning the telescope about its horizontal axis through 180^0 in the vertical plane.

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.*

5. **Leveling** - Leveling of an instrument is done to make the vertical axis of the instrument truly vertical. Generally, there are three leveling screws and two plate levels are present in a theodolite instrument.

CENTERING





LEVELLING

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*

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.

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.

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.

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.**

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.**

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.**

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.**

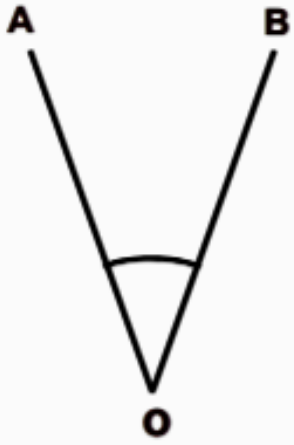
MEASUREMENT OF HORIZONTAL ANGLES:

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.



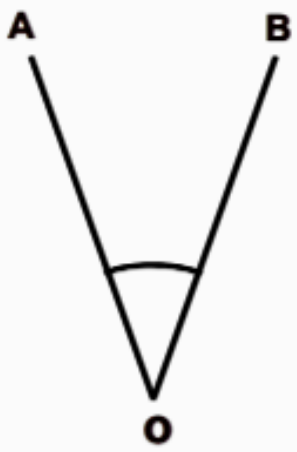
HORIZONTAL ANGLE AOB

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.



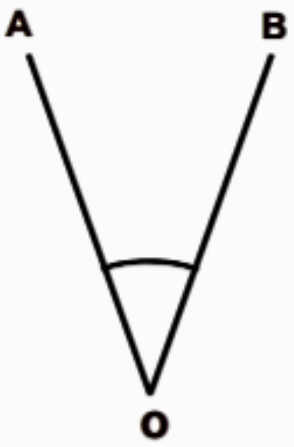
HORIZONTAL ANGLE AOB

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.



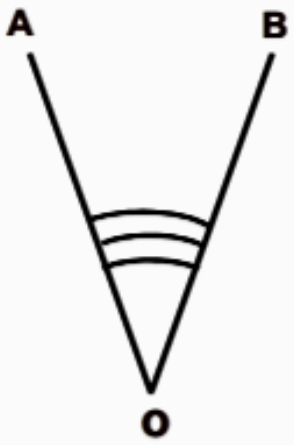
HORIZONTAL ANGLE AOB

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:

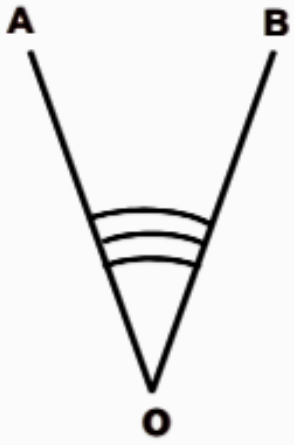
ii) Repetition Method.

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.

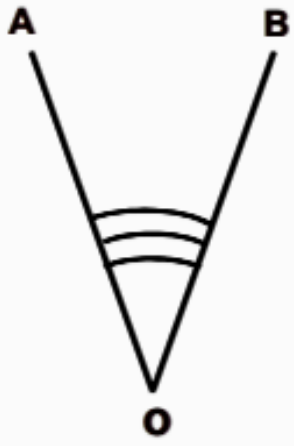


HORIZONTAL ANGLE AOB

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.



HORIZONTAL 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.

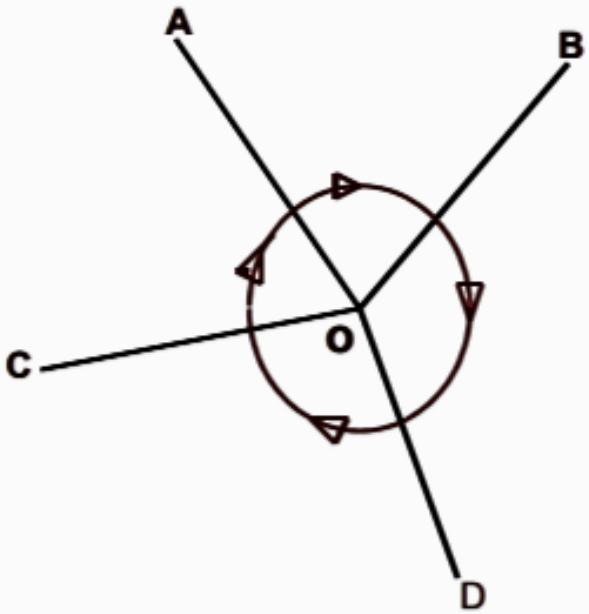
MEASUREMENT OF HORIZONTAL ANGLES:

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:

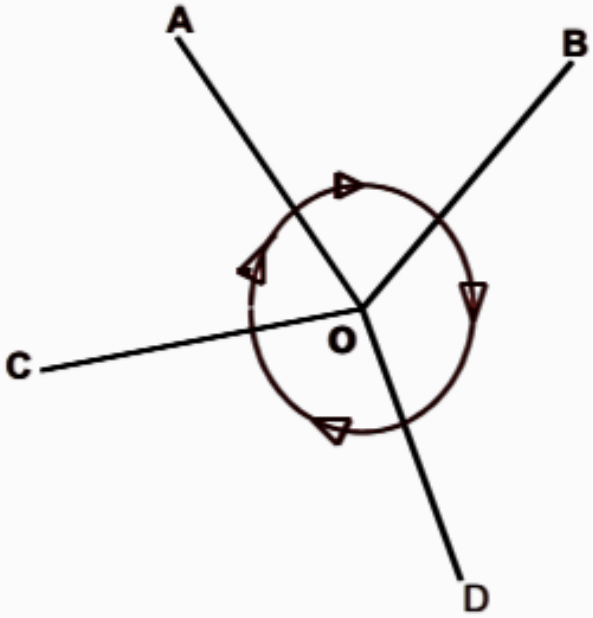
iii) Reiteration Method.

…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

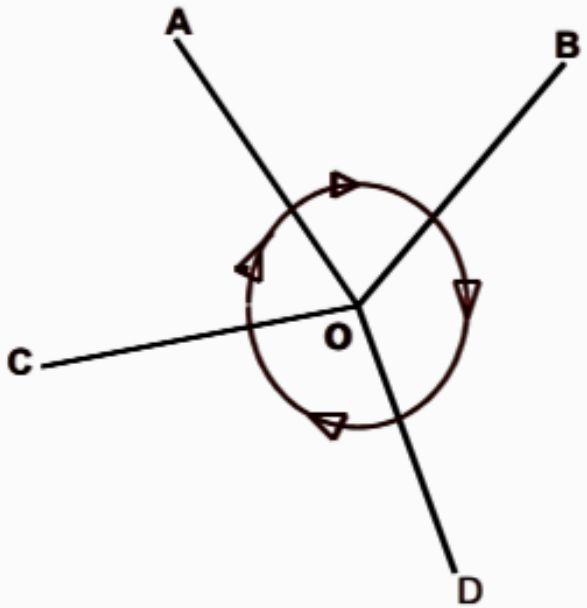
MEASUREMENT OF HORIZONTAL ANGLES:

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:

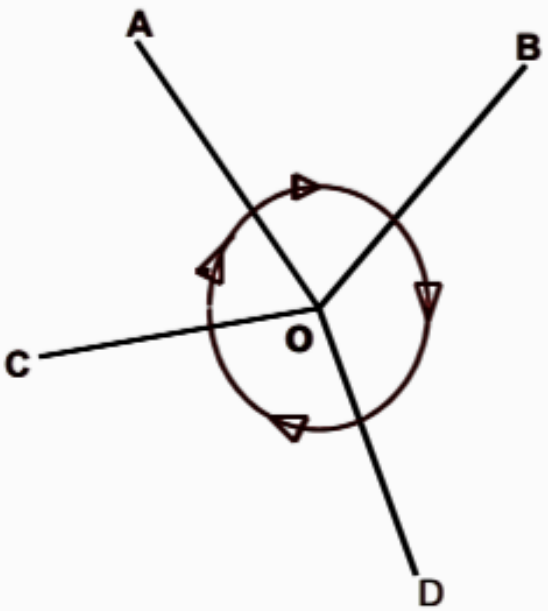
iii) Reiteration Method (contd.).

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.

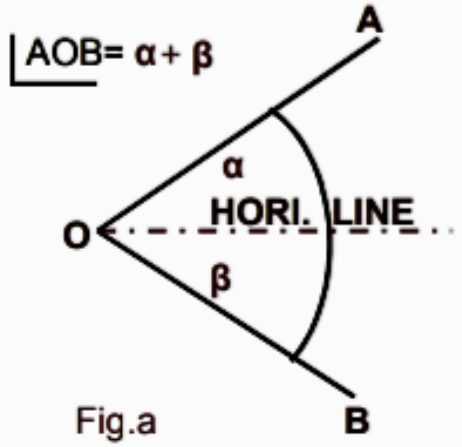


Fig.a

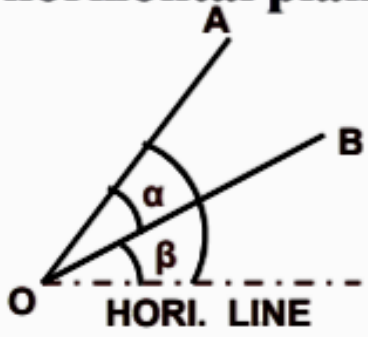


Fig. b

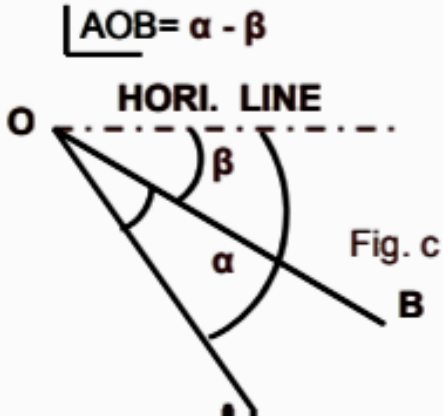


Fig. c

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.

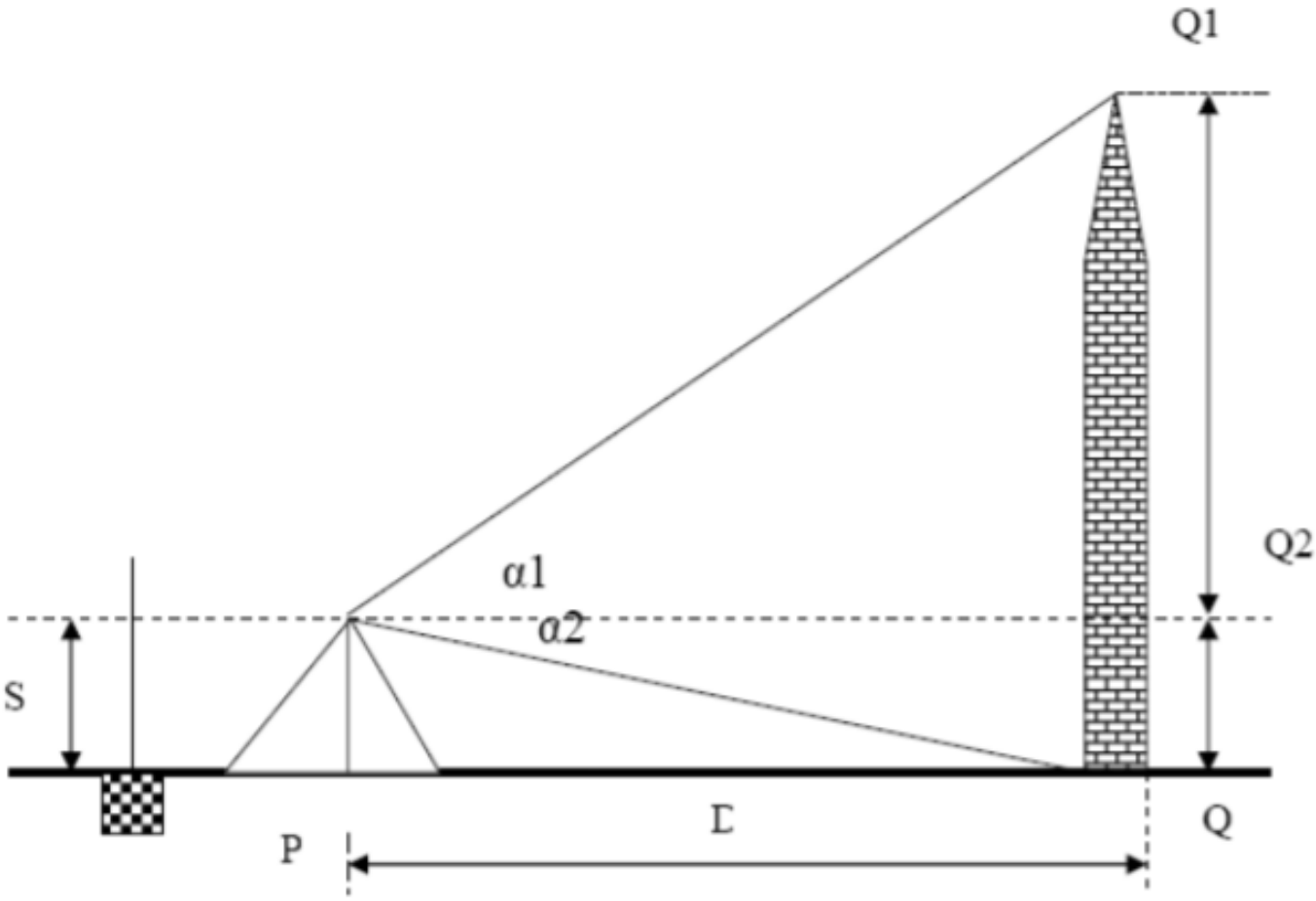
(vi) Change the face of the instrument and repeat the process. The mean of of the two vernier readings gives the second value of the required angle.

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

DETERMINING AN HEIGHT OF OBJECT BY MEASURING VERTICAL ANGLE

OBJECTIVE:

Determining a height of object by measuring vertical angle.



EQUIPMENTS:

1. Theodolite
2. Leveling Stop
3. Tape or Chain
4. Pegs
5. Plumb bob

PROCEDURE:

1. Setup the instrument at station P.
2. Perform all temporary adjustments.
3. Bring the line of collimation horizontal
4. Enter the initial readings in the tabular form.
5. Swing the telescope and take staff reading over the given B.M.
6. Swing the telescope towards the object.

7. Release the vertical clamp screw, sight the top of the object Q1, and clamp the vertical clamp screw.

8. Read C and D verniers and enter the readings.

9. Release the vertical clamp screw, sight the bottom of the object Q, and clamp the screw.

10. Read vernier readings and enter in the tabular form.

11. Measure the Horizontal distance between the instrument station and the object.

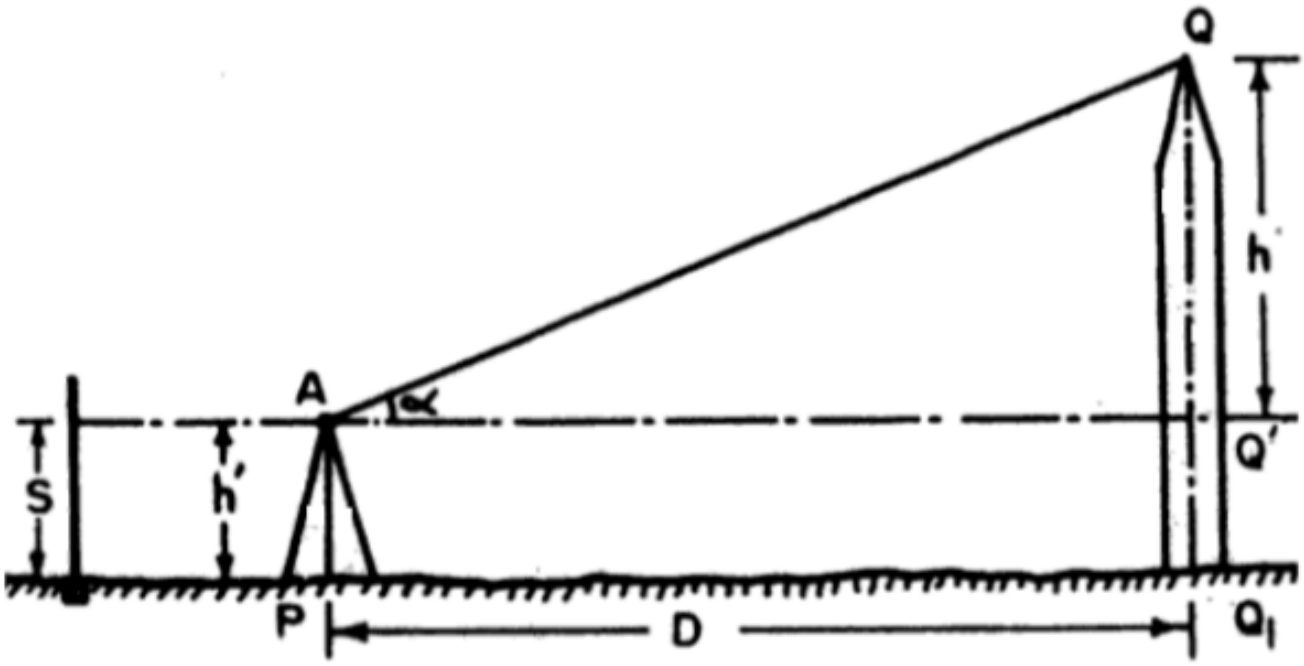
12. The above procedure will be repeated with the face right observation.

13. The average of the two observations by transiting the telescope taken with different faces will be vertical angle.

14. Calculate the height of the top point Q1 from horizontal line (h1) and height of the bottom point Q0 from horizontal line (h2) by using formula h = d tan α

Methods:

1. Measurement of Height of an object when base is accessible (on level ground)



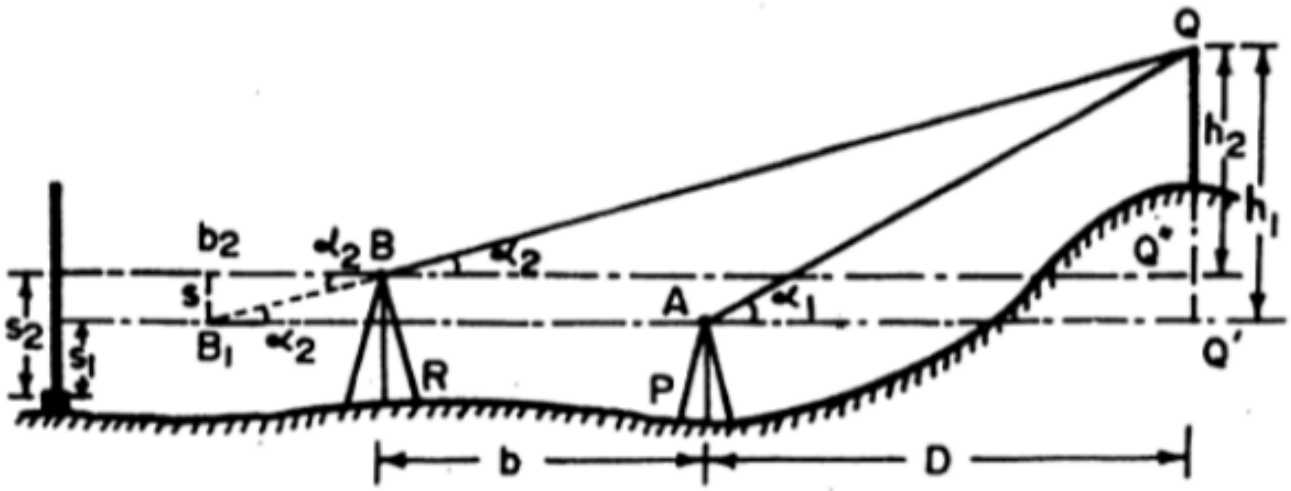
BASE ACCESSIBLE

h = D tan α

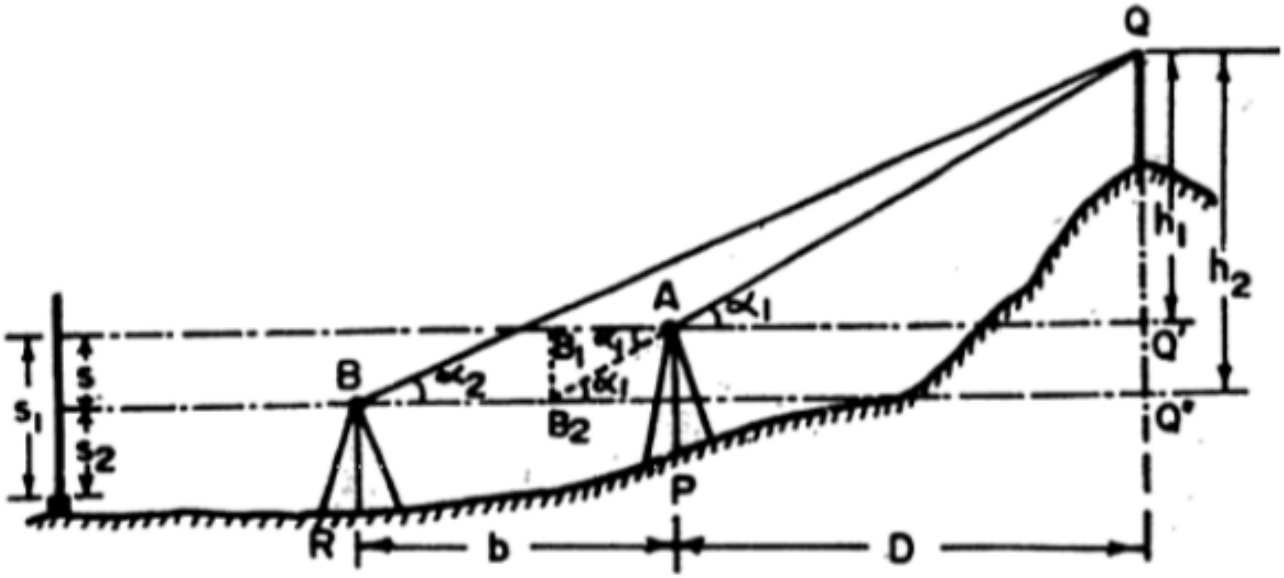
Height of the object = s + h

R.L. of top of the object = R. L. of B.M. + s + h

2. Measurement of Height of an object when base is inaccessible



When P is Lower than R



When P is higher than R

$$D = \frac{(b \pm s \cot \alpha_2) \tan \alpha_2}{\tan \alpha_1 - \tan \alpha_2}$$

Use + sign with $s \cot \alpha_2$ when the instrument axis at A is lower and − sign when it is higher than at B.

$$\text{R.L. of } Q = \text{R.L. of B.M.} + S_1 + h_1$$

$$h_1 = D \tan \alpha_1$$

Sources of Error in Theodolite

1. Instrument Errors

a)Non-adjustment of plate bubble

b) Line of collimation not being perpendicular to horizontal axis .

c) Horizontal axis not being perpendicular to vertical axis.

d) Eccentricity of Inner and Outer axes

e) Graduation not being Uniform.

2.Personal Errors

3. Natural Errors

APPLICATIONS

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

CONCLUSION:

The theodolite surveying helps us a great in surveying work.
This instrument plays a major role in measuring horz angle , vertical angle , bearing etc.