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Module – 2

Theodolite traverse

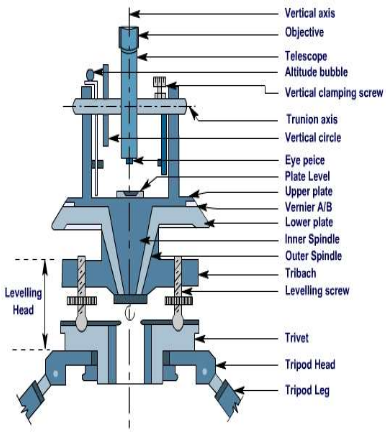

Figure 20.4 Sectional view of a Theodolite

Subject:- Surveying Code:-3140601	Prepared by: Asst.Prof. Nutan Patel (Civil Department,ACET)	AMIRAJ COLLEGE OF ENGINEERING & TECHNOLOGY

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.

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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.
- Ranging curves
- Tacheometric Survey

CLASSIFICATION OF THEODOLITES

Theodolites may be classified as ;

A. Base on Movement of the telescope on horizontal axis in a vertical plane

i) Transit Theodolite.

ii) Non Transit Theodolite.

B. Based on an arrangement to measure an angle

i) Vernier Theodolites.

ii) Micrometer Theodolites.

CLASSIFICATION OF THEODOLITES

Base on Movement of the telescope on horizontal axis in a vertical plane

i **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.

ii **Non-Transit type:-** The telescope cannot be transited. The telescope can not be revolved round the horizontal axis in a vertical plane completely.

CLASSIFICATION OF THEODOLITES

Based on an arrangement to measure an angle

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

ii **Micrometer 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 .

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Difference

Transit Theodolite

- Telescope can be rotate about horizontal axis in a vertical plane through 180^0 .
- The position of the theodolite can be changed from face left to face right.
- Ranging of line can be done by back sighting.

Non-Transit Theodolite

- Telescope can be rotate about horizontal axis in a vertical plane through some limited angle.
- The position of the theodolite can not be changed from face left to face right.
- Ranging of line can not be done by back sighting.

Transit Theodolite

- Deflection of angle can be measured easily.
- These are the theodolite widely used in surveying.

Non-Transit Theodolite

- Deflection of angle can not be measured easily.
- These type of the theodolites have now become obsolete.

SIZE OF THEODOLITE

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

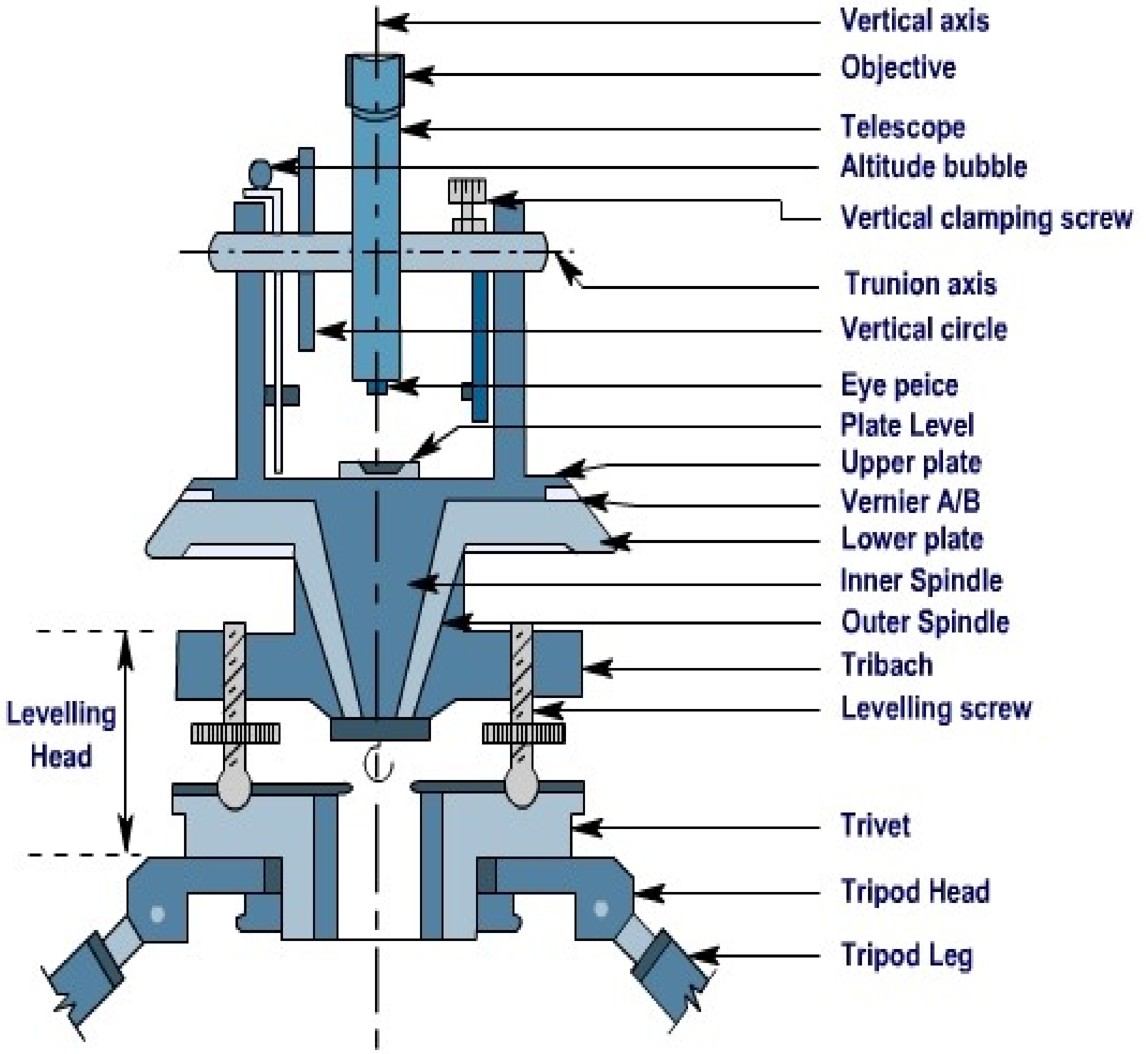
The common sizes are *8cm to 12 cm* while *14 cm to 25 cm* instrument are used for *triangulation work*.

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.

USE OF THEODOLITE

- To measure the horizontal angle.
- To measure the vertical angle.
- To decide true north by astronomical method.
- To know difference in elevation of two point.
- To measure the height and depth.
- To measure the distance between two point.
- To measure the slope.
- To measure the deflection angle between two line.

TRANSIT VERNIER THEODOLITE



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TRANSIT VERNIER THEODOLITE

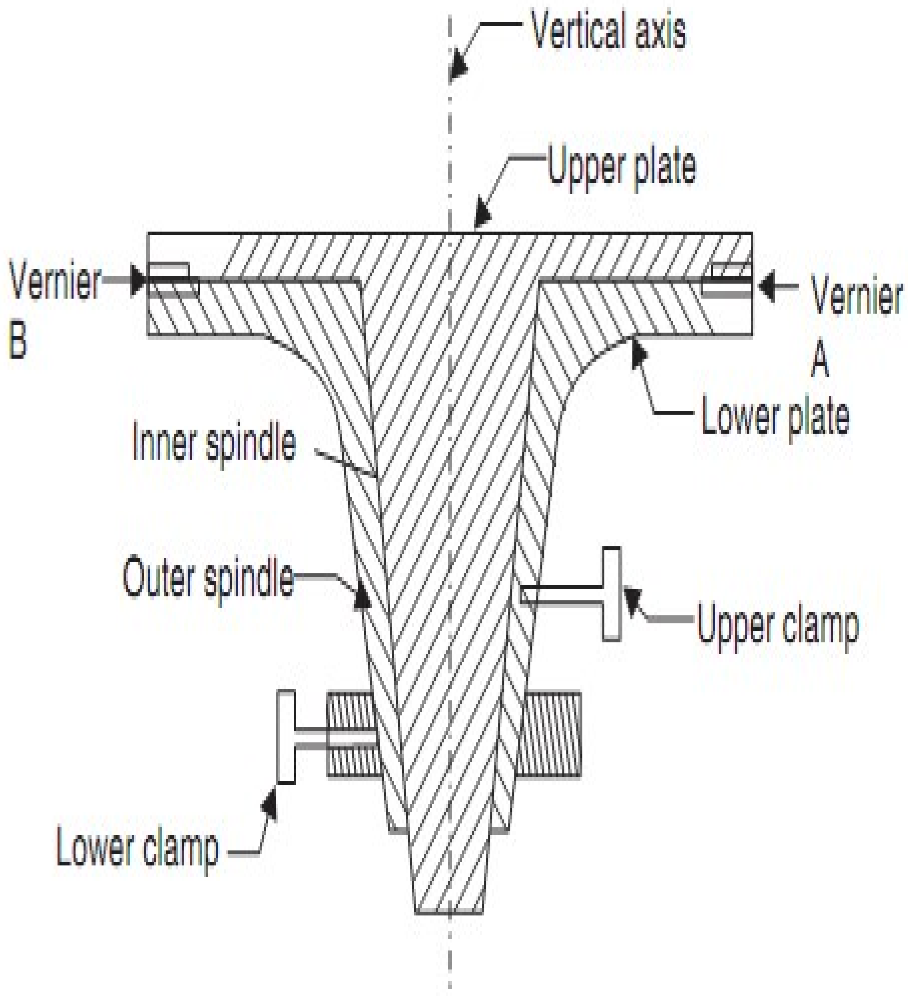
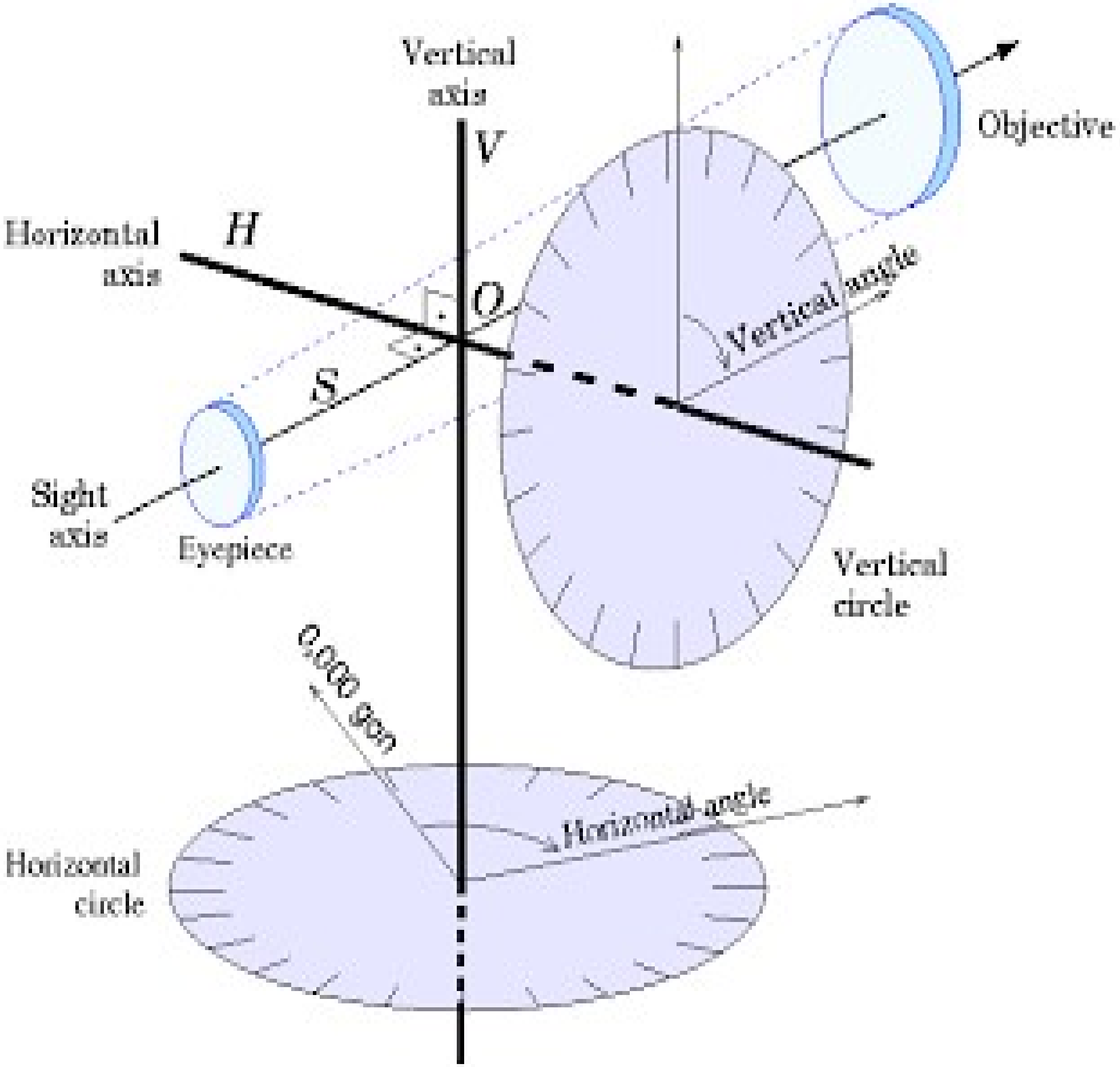


Fig. Details if Upper & Lower Plates.

TRANSIT VERNIER THEODOLITE



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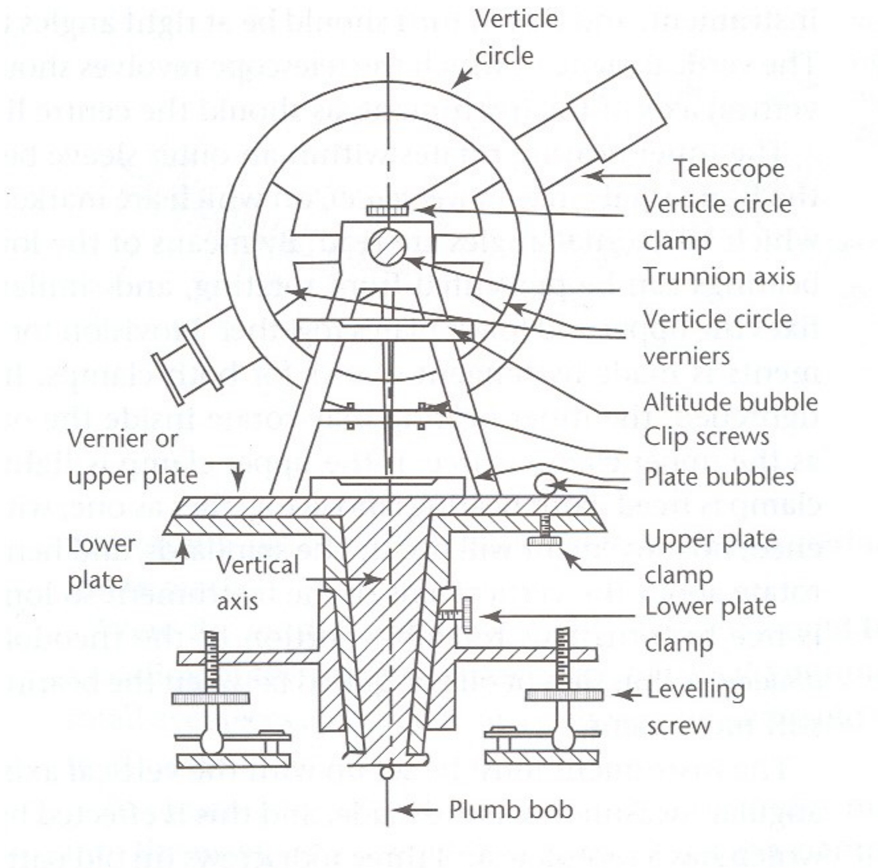
A TRANSIT CONSIST OF THE FOLLOWING ESSENTIAL PARTS

1. Telescope
2. Vertical circle
3. A-frame
4. Leveling head
5. Axes (Two spindles)
6. Lower plate
7. Upper plate
8. Upper and Lower Clamp screw
9. Level tube
10. Plum bob
11. Compass
12. Shifting head
13. Altitude level tube
14. Clip screw

1. Telescope

- The essential parts of the telescopes are eye-piece, diaphragm with cross hairs, object lens and arrangements to focus the telescope.



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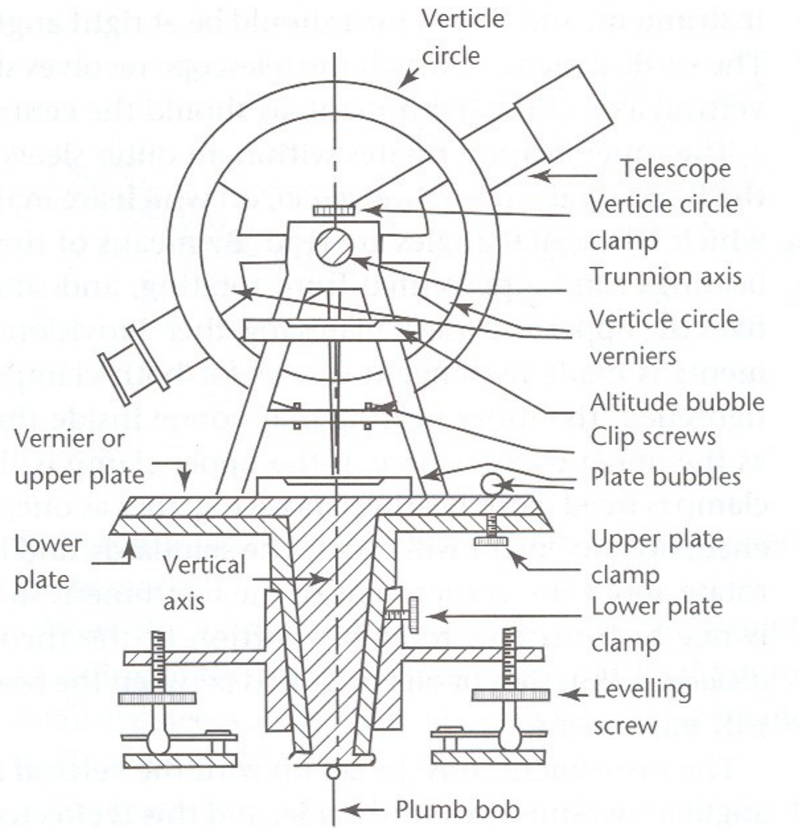
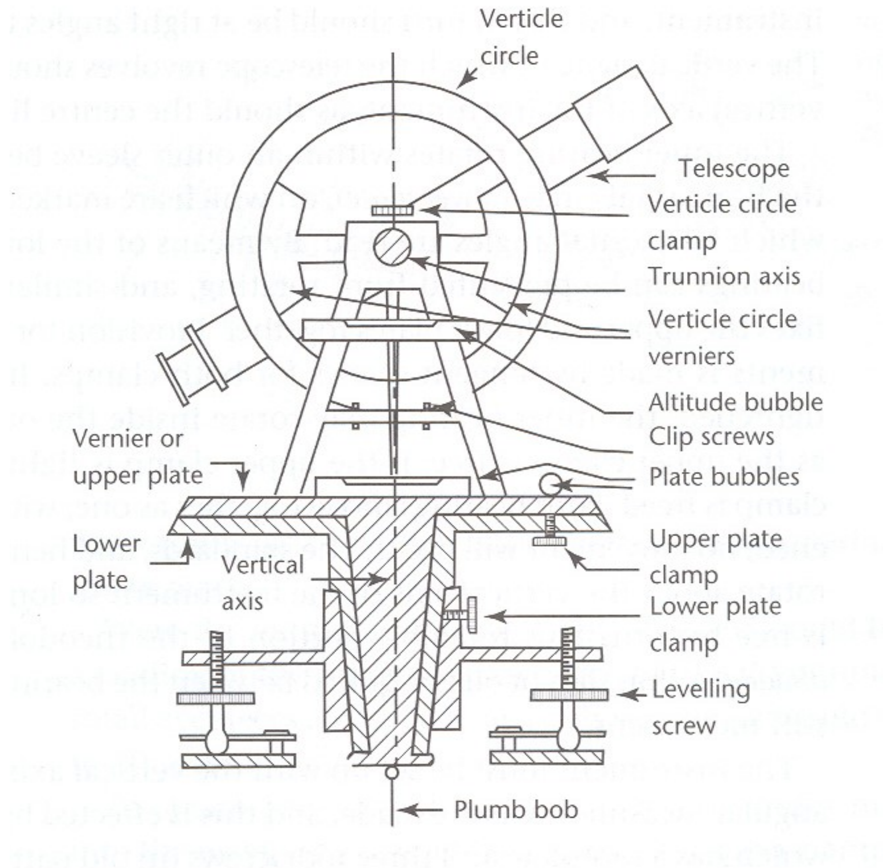
2. Vertical circle

- circular plate supported on horizontal axis of the instrument between the A-frames. Vertical circle has graduation 0-90 in four quadrants. Vertical circle moves with the telescope when it is rotated in the vertical plane.



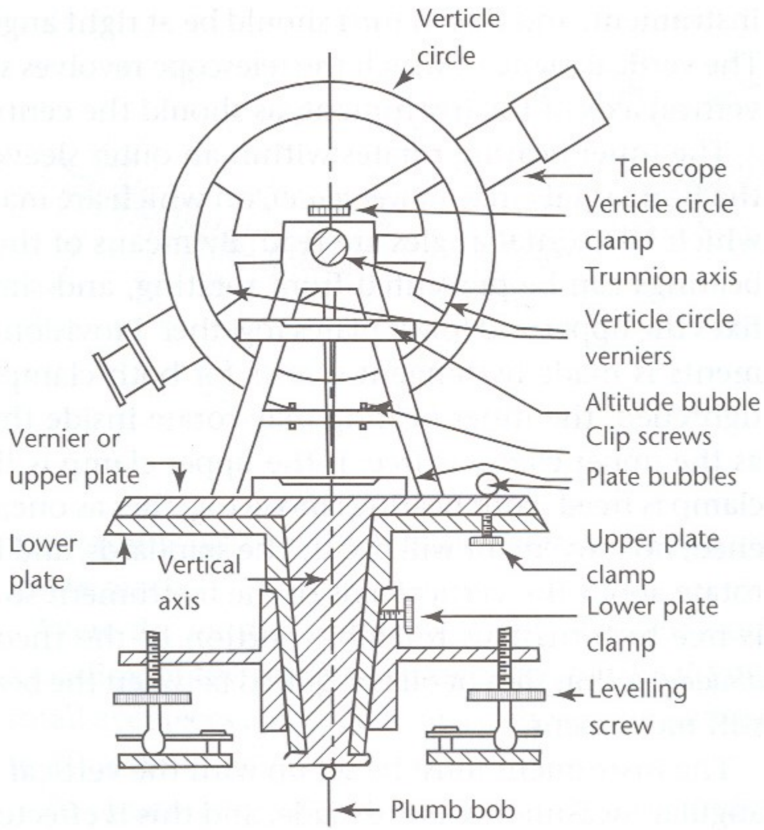
3. A-frame

- Two standard resembling the letter (A) are mounted on upper plate.
- The trunnion axis of the telescope is supported on A frame.



4. Leveling head

- Leveling head is used to attach the instrument to tripod and attach the plumb bob along the vertical axis of the instrument.
- The leveling head consist of two parallel plate known as tribrach plates.



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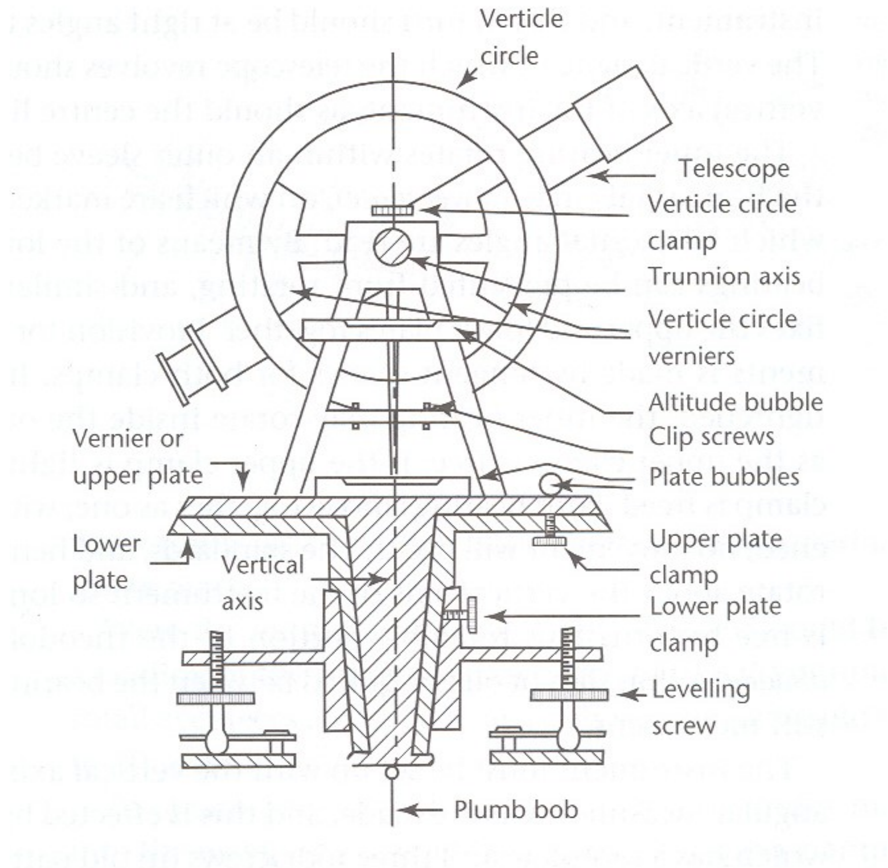
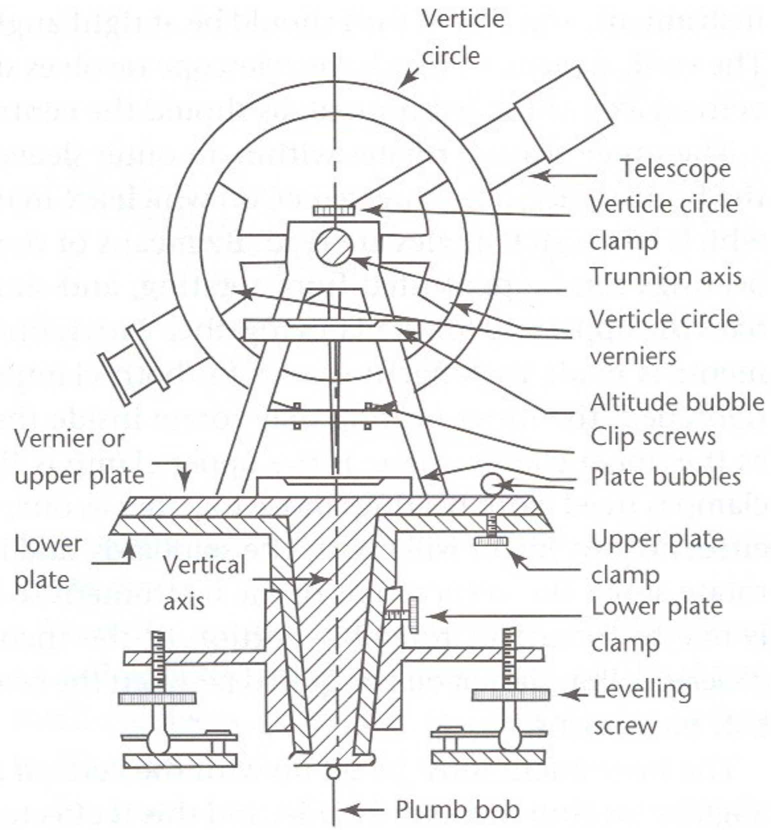
5. Axes (Two spindles)

- The inner spindle or axis is solid and conical. The outer spindle or axis is hollow.
- The inner spindle is also called the upper axis since it carries the venire or upper plate.
- The outer spindle caries the scale or lower plate.



6. Lower plate

- 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 min.

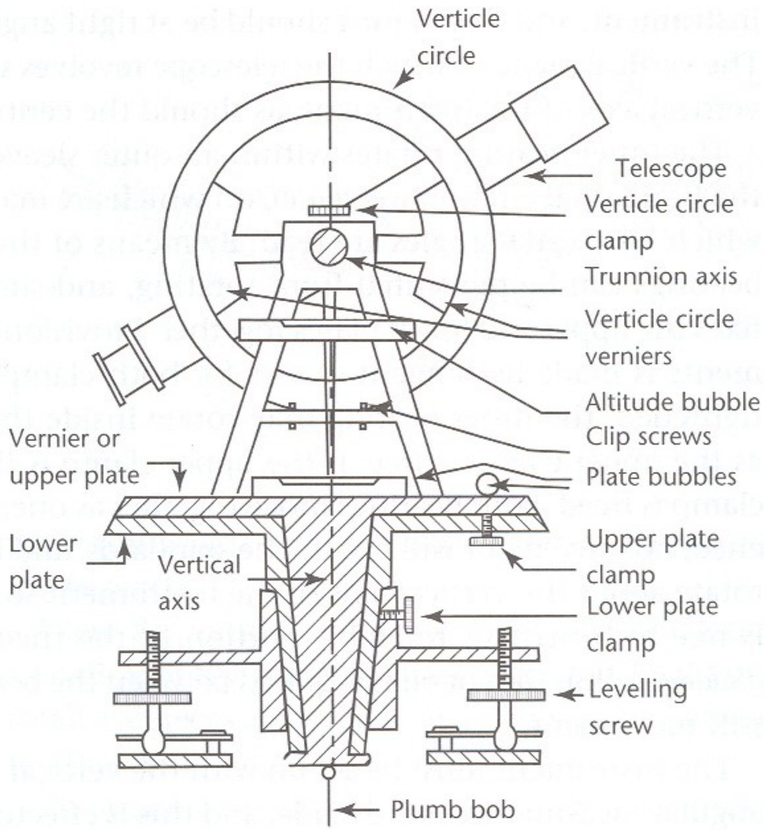


- Horizontal angles are measured with this plate.

- The size of the theodolite is defined by the diameter of horizontal circle.

7. Upper plate

- 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”.



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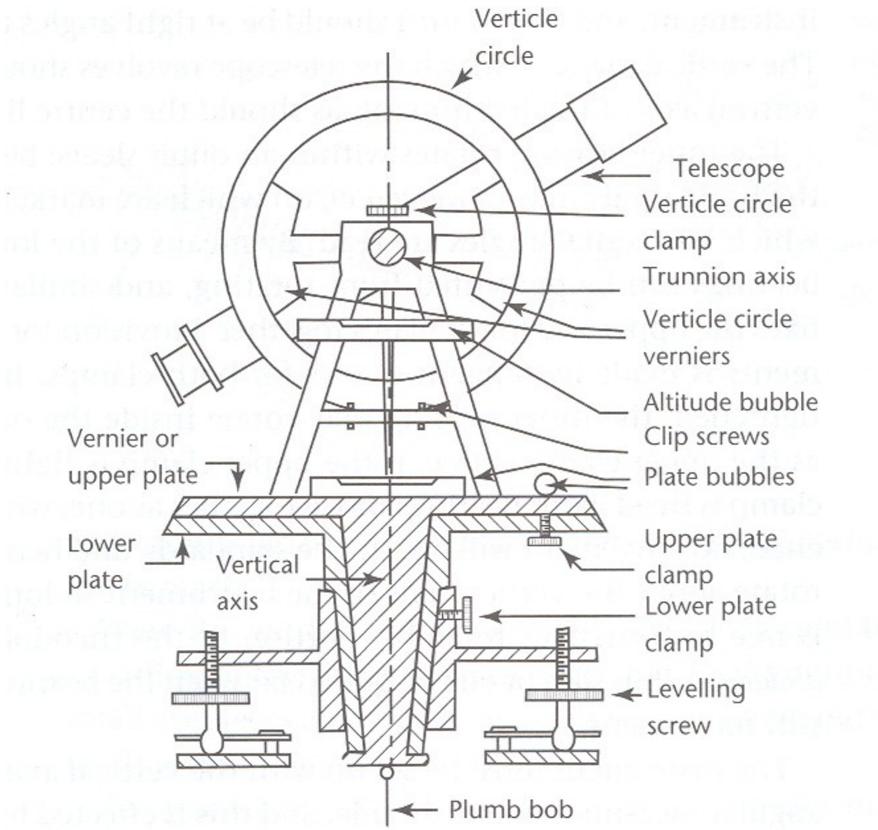
8. Upper and Lower Clamp screw

- There are two clamps and associated tangent screws with the plate. These screws facilitate the motion of the instruments in horizontal plane.



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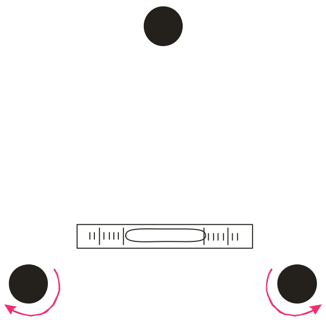
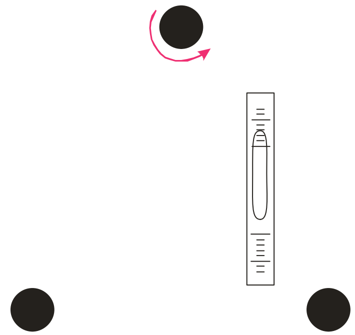
- Lower clamp screw locks or releases the lower plate. When this screw is unlocked both upper and lower plates move together. The associated lower tangent screw allows small motion of the plate in locked position.

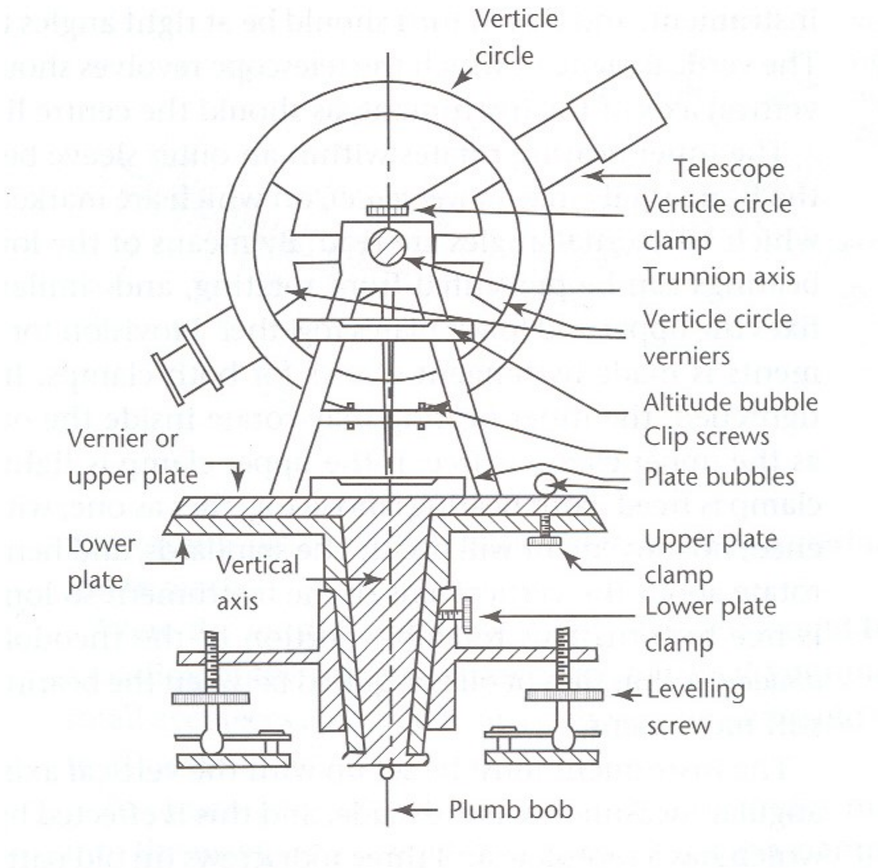
- The upper clamp screw locks or releases the upper vernier plate. When this clamp is released the lower plate does not move but the upper vernier plate moves with the instrument. This causes the change in the reading. The upper tangent screw allows the fine adjustment



9. Level tube

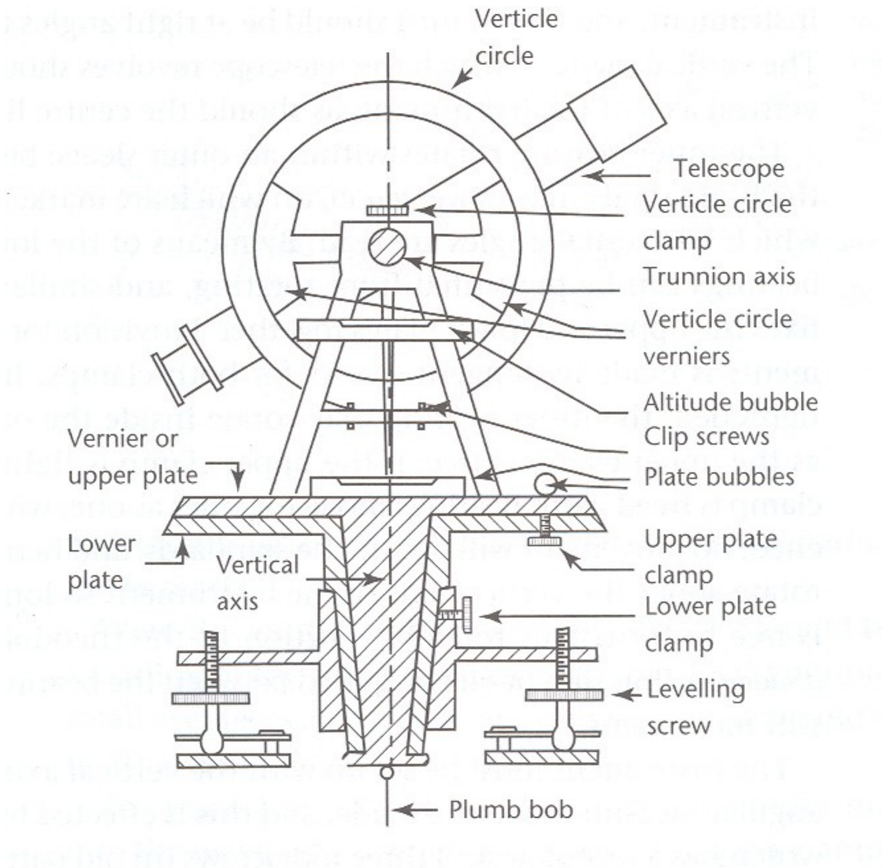


- Spirit level with the bubble and graduation on glass cover.
- A single level or two levels fixed in perpendicular direction may be provided.
- The spirit level can be adjusted with the foot screw of the levelling head .



10. Plum bob

- A plum bob is suspended from the hook fitted to the bottom of the inner axis.
- It is used to center the instrument exactly over the instrument station.



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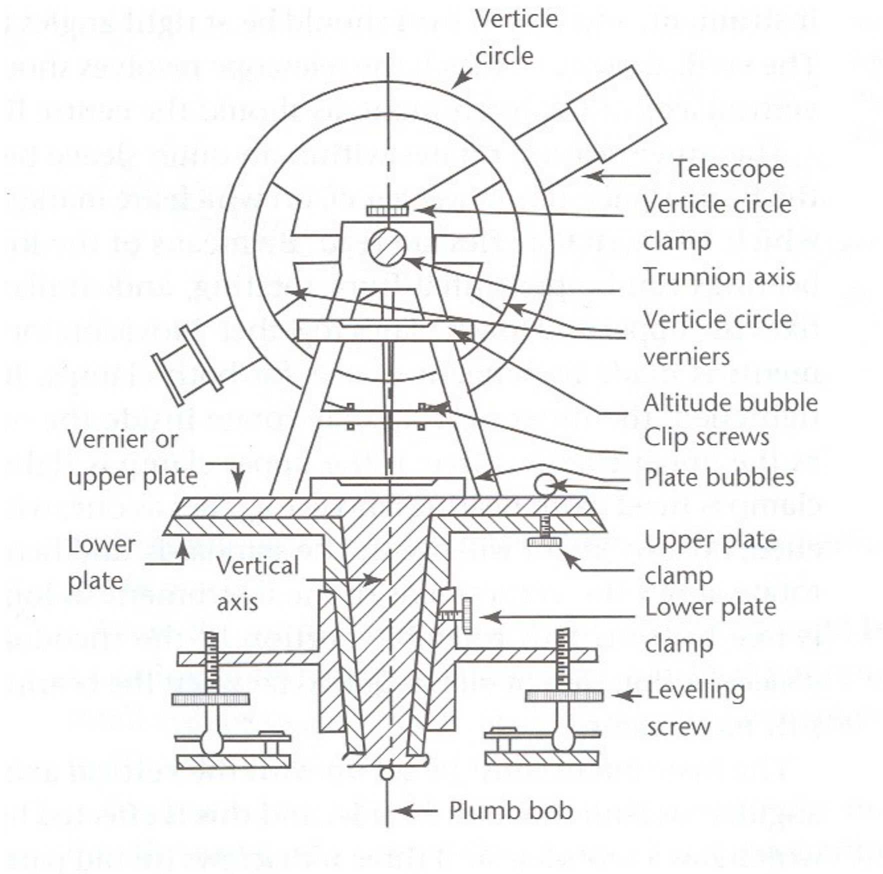
11. Compass

- Some theodolite are provided with compass.
- Bearings are taken from this compass.
- It is fitted to the A Frame.



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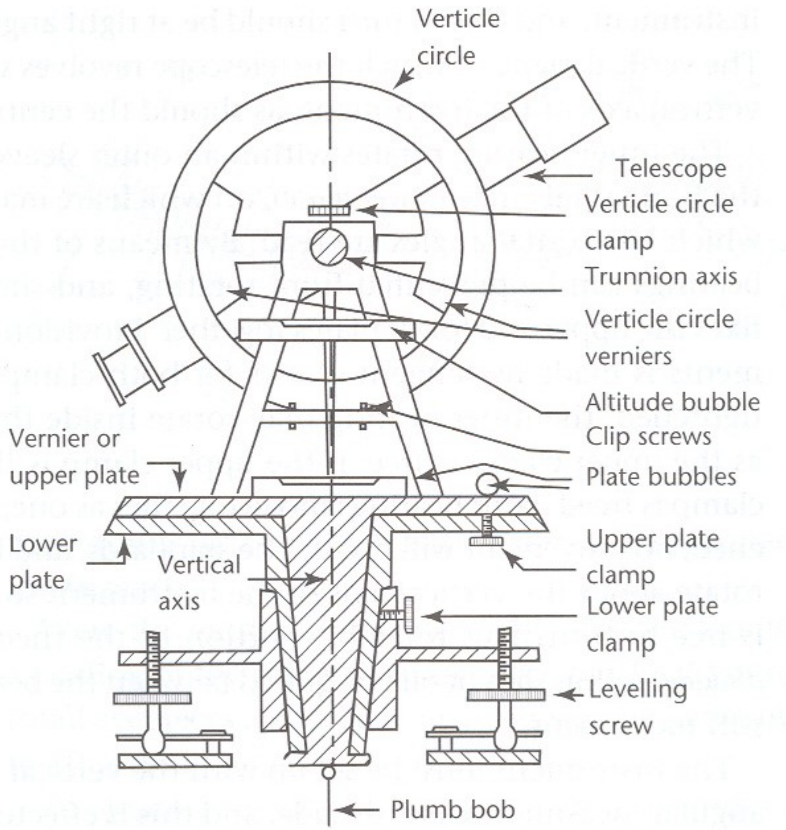
12. Shifting Head

- An arrangement of shifting head is made for quick and accurate centering of the theodolite.
- By this arrangement, the theodolite can be shifted in horizontal plane with respect to the tripod head.



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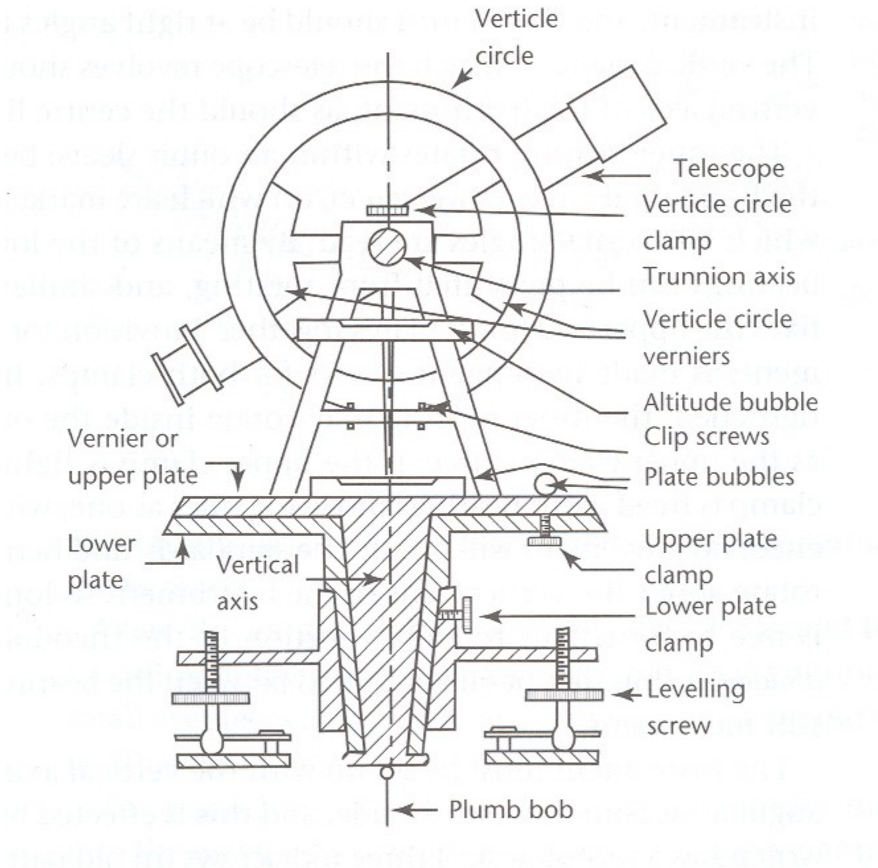
13. Altitude level tube

- A highly sensitive bubble is used for levelling particularly when taking the vertical angle observations.



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Definitions and Technical Terms

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.*

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TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

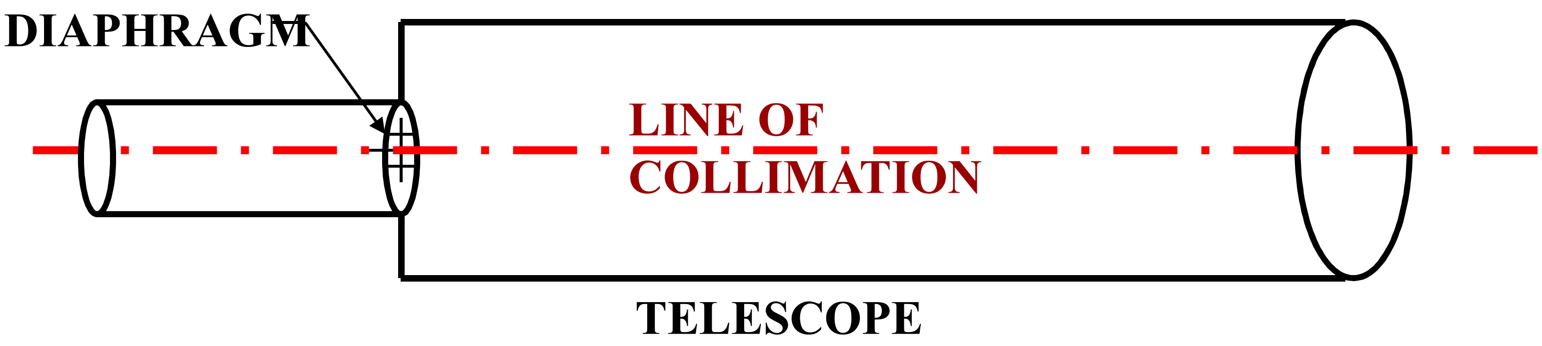
6. Changing Face

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.

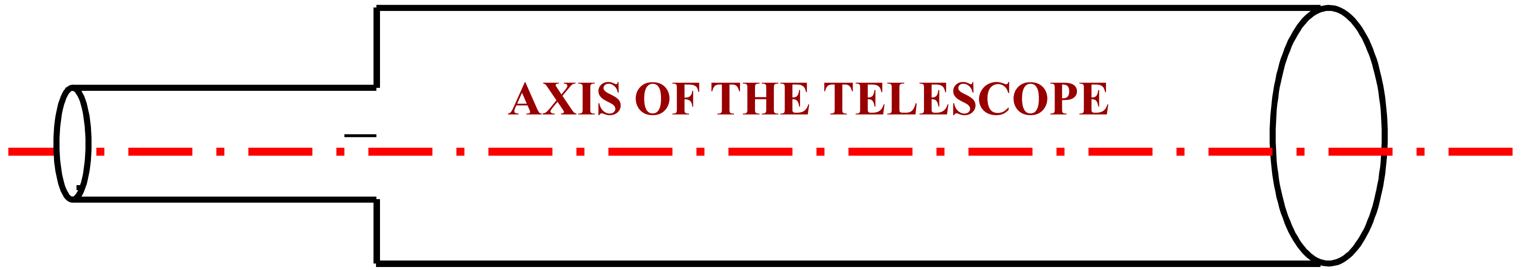
7. Line of Collimation



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.

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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.

1. Centering

- Place the tripod over station.
- The legs of the tripod should be spread.
- Take out the instrument from the box.
- Adjust the height of the instrument.
- Suspended a plum bob from the hook.
- Approximately centering is done by means of the tripod legs.
- Tripod legs are moved for centering.

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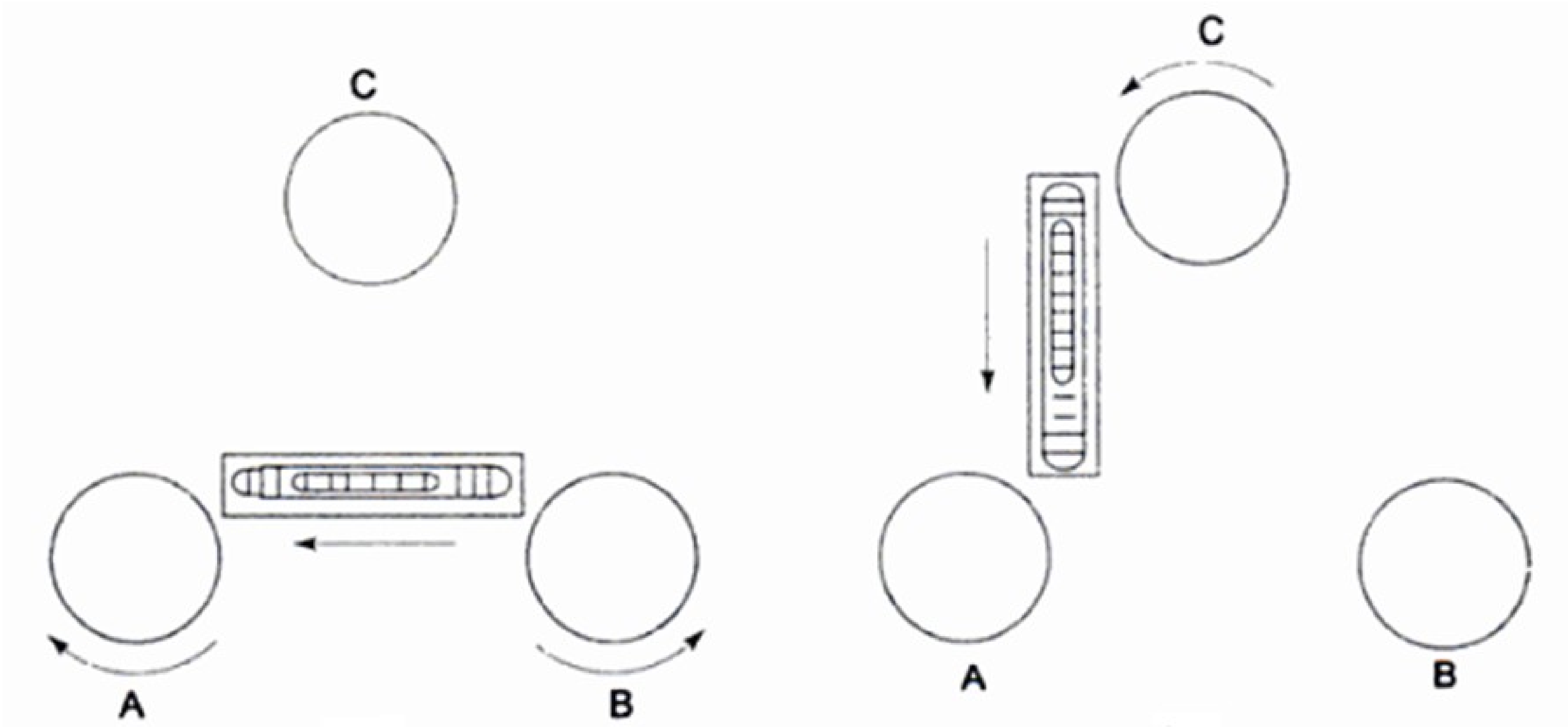
2. Leveling

- Turn the upper plate until the longitudinal axis (or bubble tube) is parallel to the two foot screw.
- Turn both the foot screw in clock wise or anti clock wise direction.
- Centre the bubble in tube.
- Turn the upper plate (or bubble tube) is perpendicular to the two foot screw.
- Turn both the foot screw in clock wise or anti clock wise direction.
- Repeat the above step, till the bubble is center in both the position.


C
A
B
C
A
B

3. Focusing

- Focusing is divided another two part

1. Focusing of eye-piece
2. Focusing of object

1. Focusing of eye-piece

- Point the telescope toward the sky or hold a white paper in front of the objective.
- Move the eye piece in or out by rotating it gradually until the cross hair seen quite sharp and clear.

2. Focusing of object :-

- Direct the telescope toward the object.
- Turn the focusing screw until the image of the object appear clear and sharp.
- When the distance of the object is change so focusing has to be done again.

MEASUREMENT OF HORIZONTAL ANGLES:

There are three methods of measuring horizontal angles:-

i) **General (Ordinary) Method.**

ii) **Repetition Method.**

iii) **Reiteration Method.**

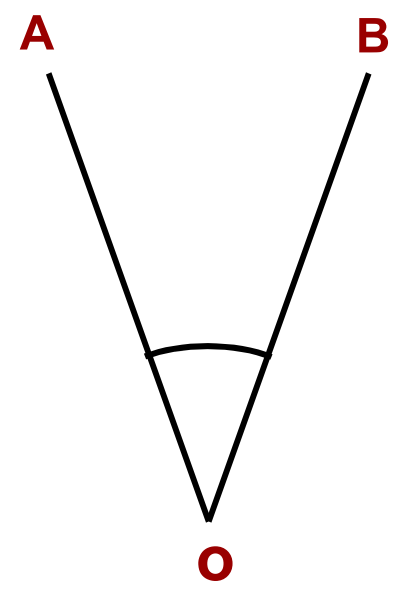
MEASUREMENT OF HORIZONTAL ANGLES:

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.

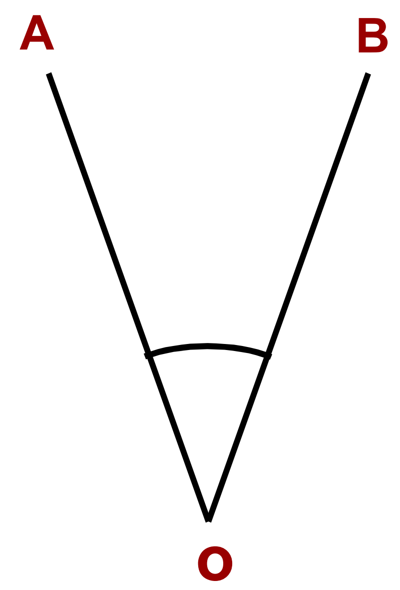


HORIZONTAL ANGLE AOB

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.



HORIZONTAL ANGLE AOB

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.

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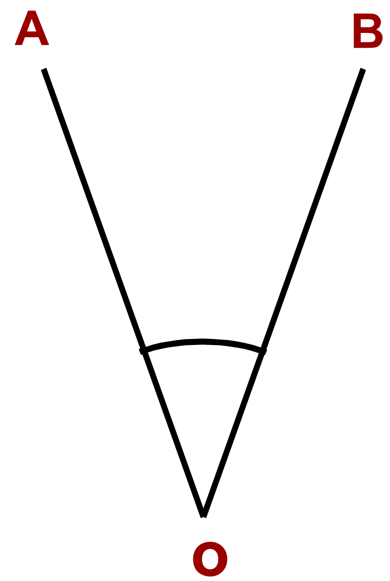
MEASUREMENT OF HORIZONTAL ANGLES:

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

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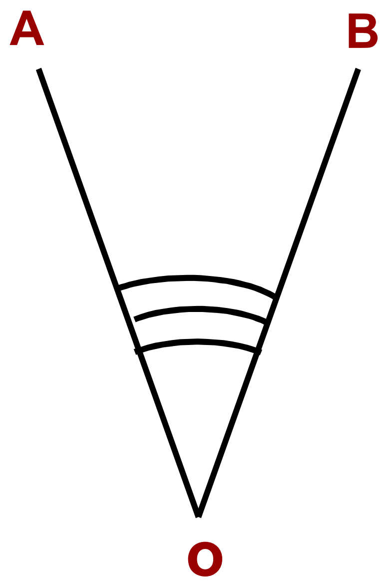
MEASUREMENT OF HORIZONTAL ANGLES:

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:

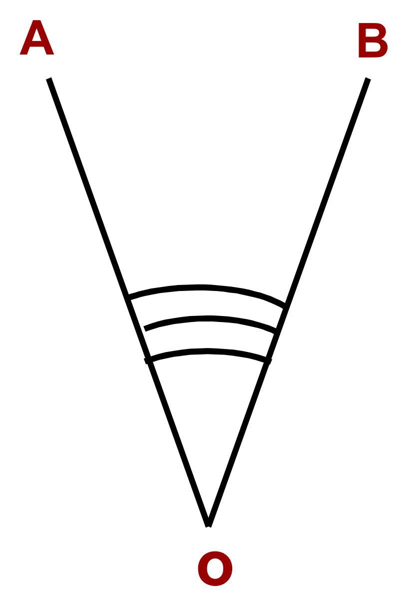
ii) Repetition Method.

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.**

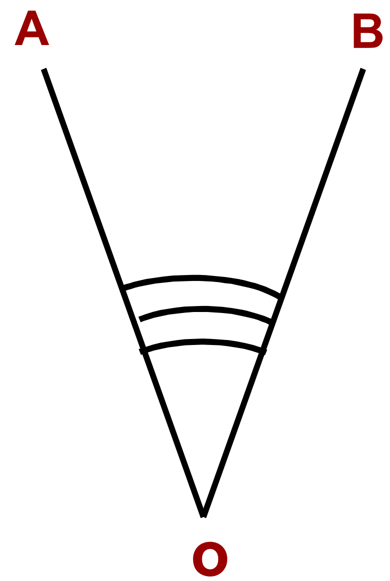


HORIZONTAL ANGLE AOB

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.

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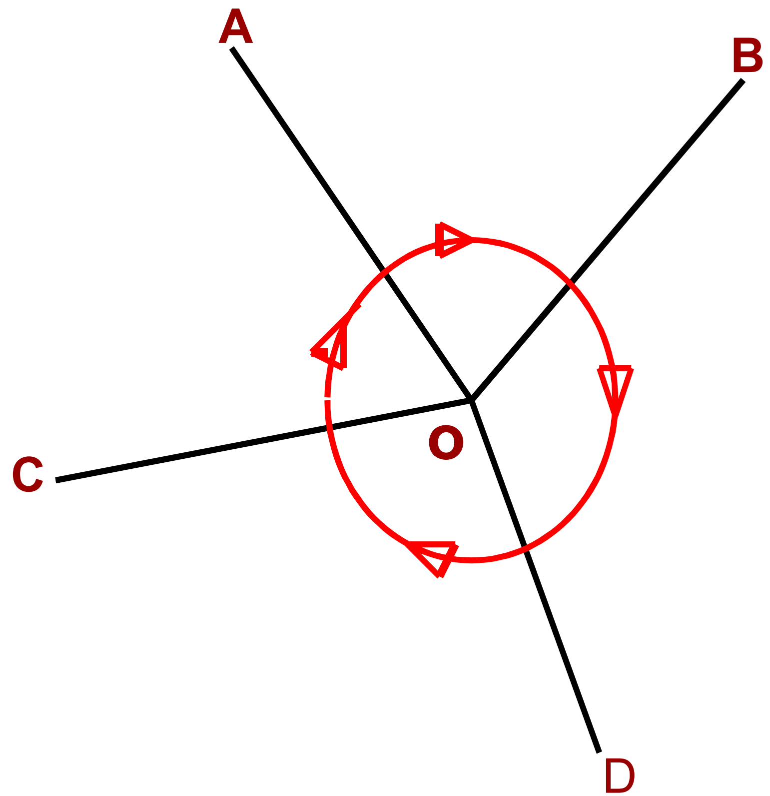
MEASUREMENT OF HORIZONTAL ANGLES:

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

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MEASUREMENT OF HORIZONTAL ANGLES:

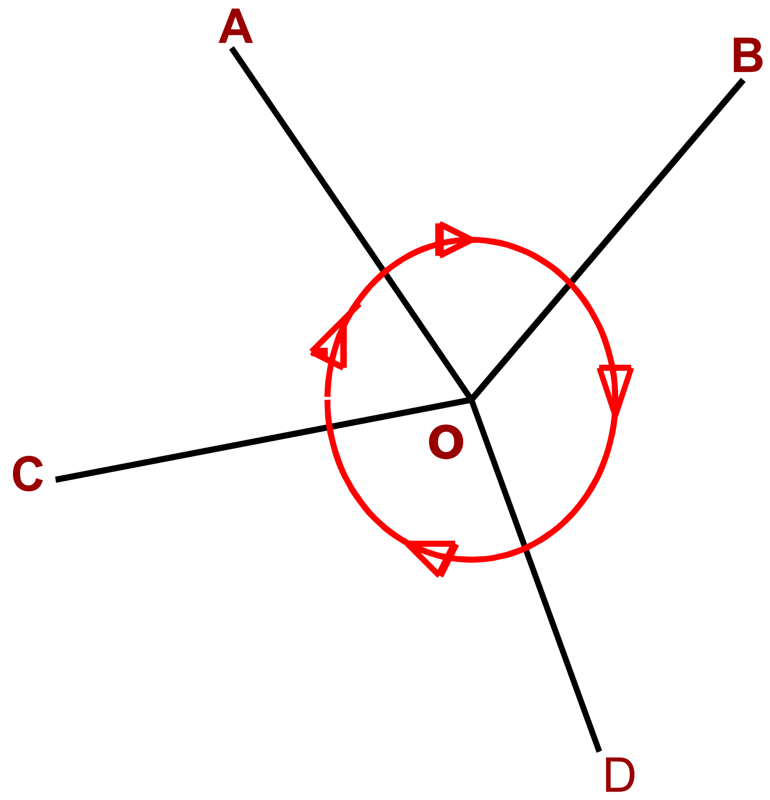
iii) Reiteration Method.

…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

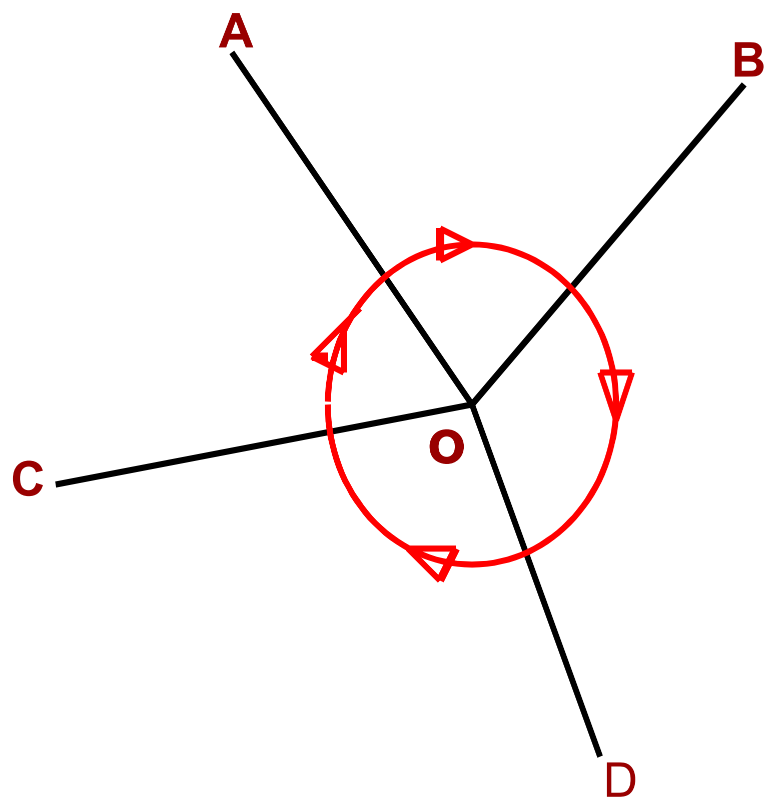
MEASUREMENT OF HORIZONTAL ANGLES:

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

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MEASUREMENT OF HORIZONTAL ANGLES:

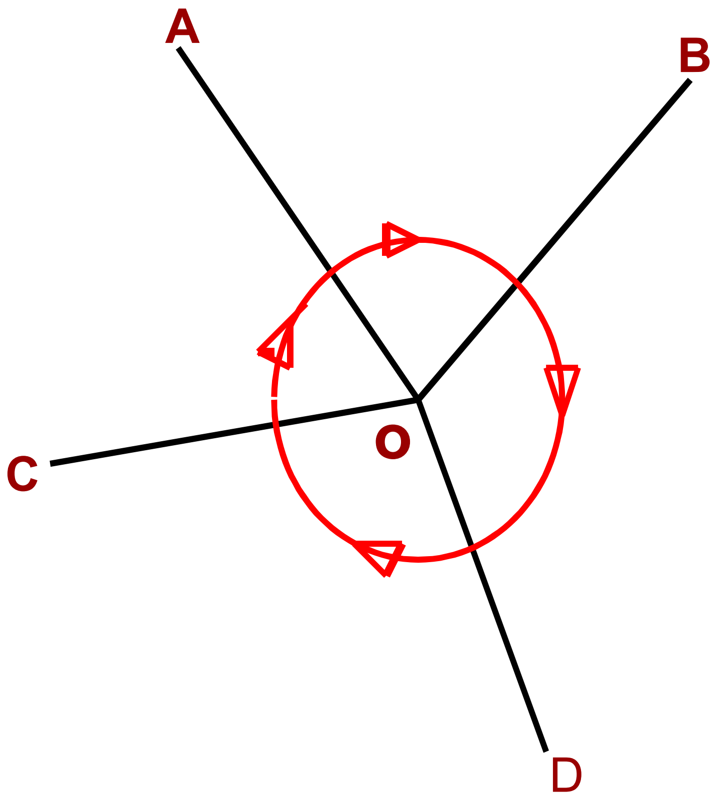
iii) Reiteration Method (contd.).

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

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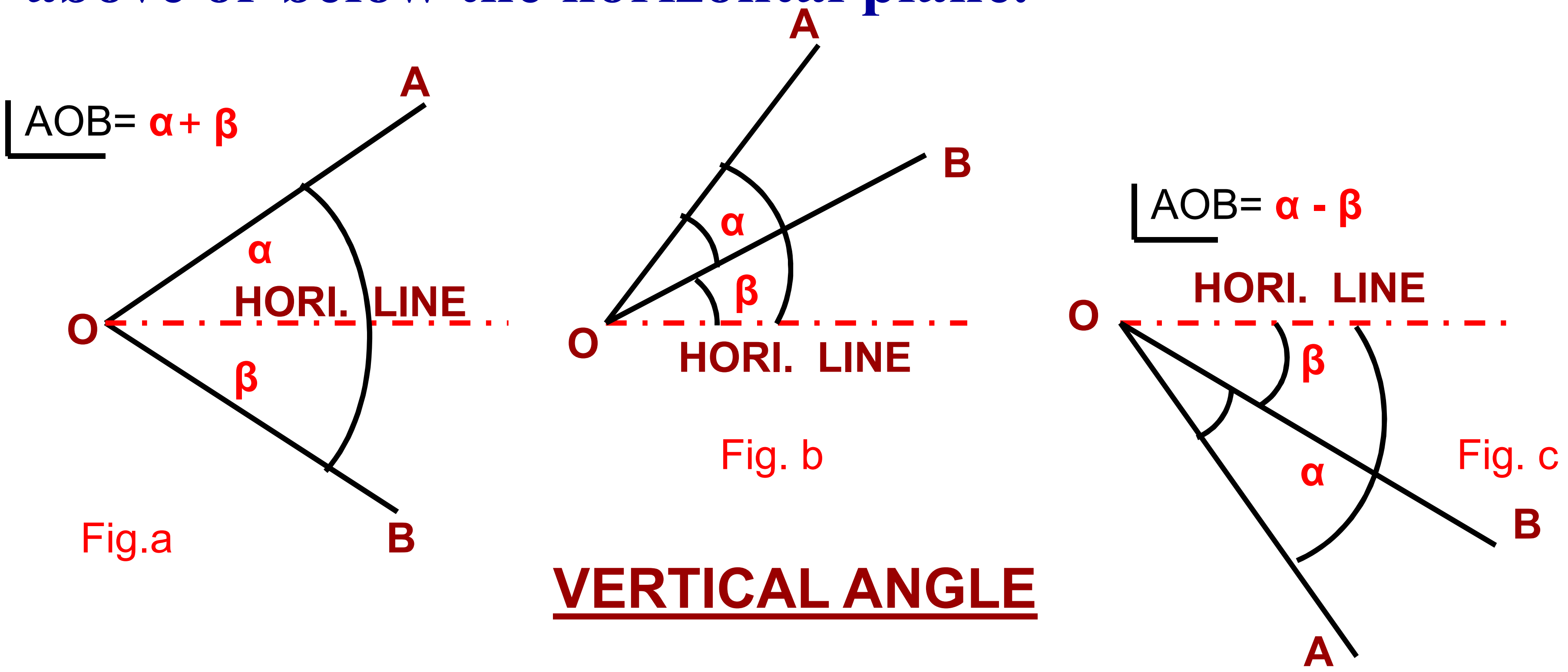
MEASUREMENT OF VERTICAL ANGLES:

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.



VERTICAL ANGLE

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MEASUREMENT OF VERTICAL ANGLES:

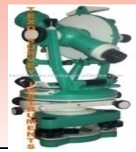
To Measure the Vertical Angle of an object A at a station O:

(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.

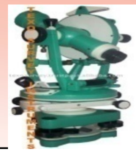


MEASUREMENT OF VERTICAL ANGLES:

(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.



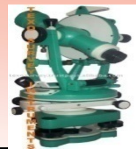
MEASUREMENT OF VERTICAL ANGLES:

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

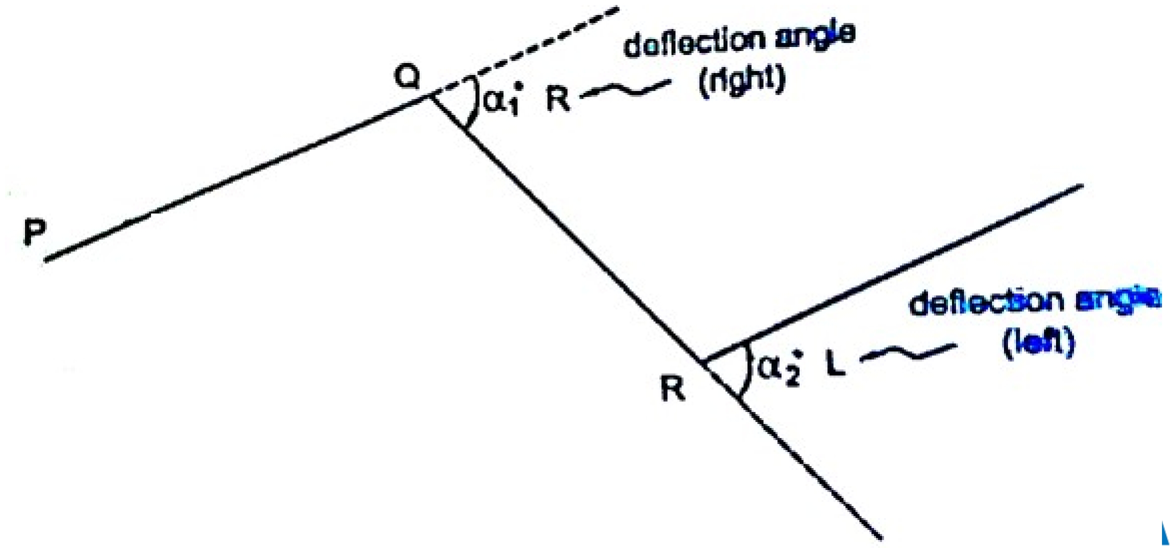
ii) Similarly, sight B and take the mean of the two vernier readings at the vertical circle. Let it be β

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



MEASUREMENT OF DEFLECTION ANGLE

- A deflection angle is the angle in which the survey line makes with the prolongation of the preceding line.
- The deflection angle is designated as right (R) when it is measured clock wise or to ward right side of the prolongation of the preceding line.
- It is designed as left (L) when it is measured anti-clock wise from the prolongation of the preceding line.



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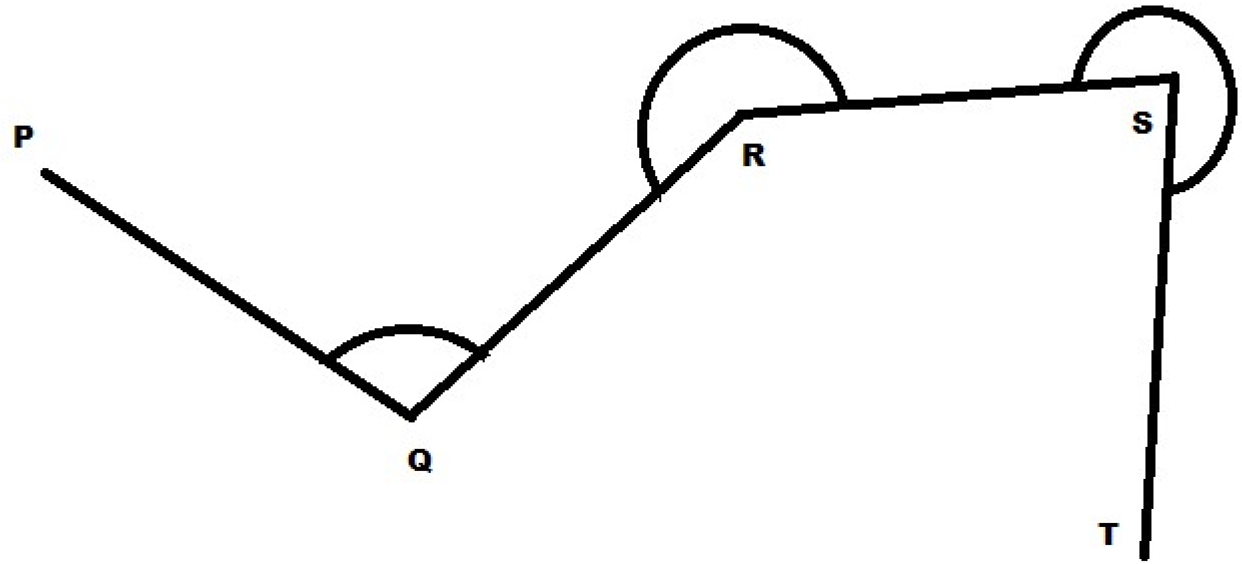
MEASUREMENT OF DEFLECTION ANGLE

- **Procedure :-**

1. **Set the instrument at Q and level it.**
2. **Set a vernier A to Zero. Clamp the upper plate.**
3. **Take a back sight on P. Clamp the lower plate. Bisect P accurately using the lower tangent screw.**
4. **Plunge the telescope. Now the line of sight is along the prolongation of PQ (Dotted line) and the reading on the vernier A is zero.**
5. **Unclamp the upper plate. Turn the telescope clock wise (Right side) bisect R accurately using upper tangent screw.**
6. **Read both the verniers A and B.**
7. **The mean of the two vernier reading is equall to the deflection angle $\alpha 1$**

MEASUREMENT OF DIRECT ANGLE

- Direct angle are the horizontal angle measured in clock wise direction from the previous line to the following line (next line)



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MEASUREMENT OF DIRECT ANGLE

- **Procedure :-**

1. Set the instrument at Q and level it accurately with face left, set the reading on vernier A at 0^0, fix both the plate by upper clamp screw.
2. Unclamp the lower plate and direct the telescope to P. Bisect accurately using lower tangent screw.
3. Unclamp the upper clamp and swing the telescope clock wise and sight R. Bisect the R accurately using the upper tangent screw. Read both the readings.
4. Repeat the above step.

MEASUREMENT OF 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.

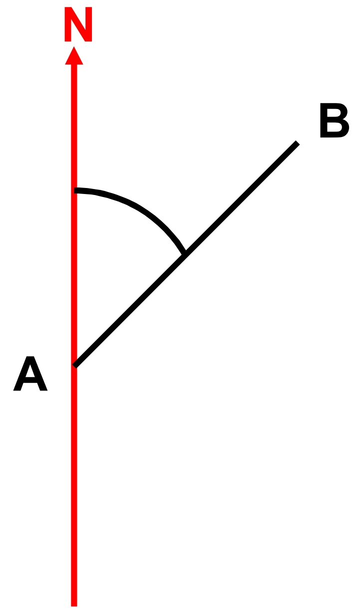

Fig.
Magnetic Bearing of a Line

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.

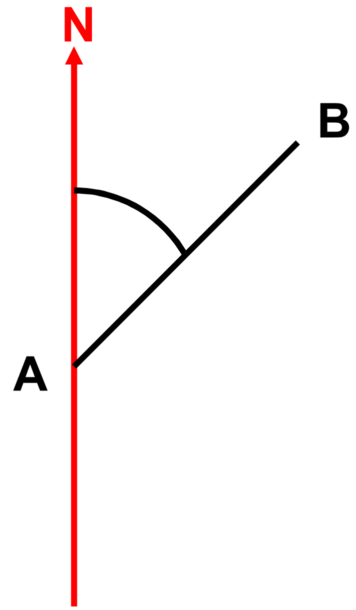

Fig.

Magnetic Bearing of a Line

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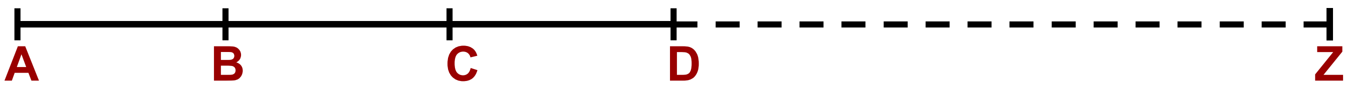
PROLONGING A STRAIGHT A LINE

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



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.

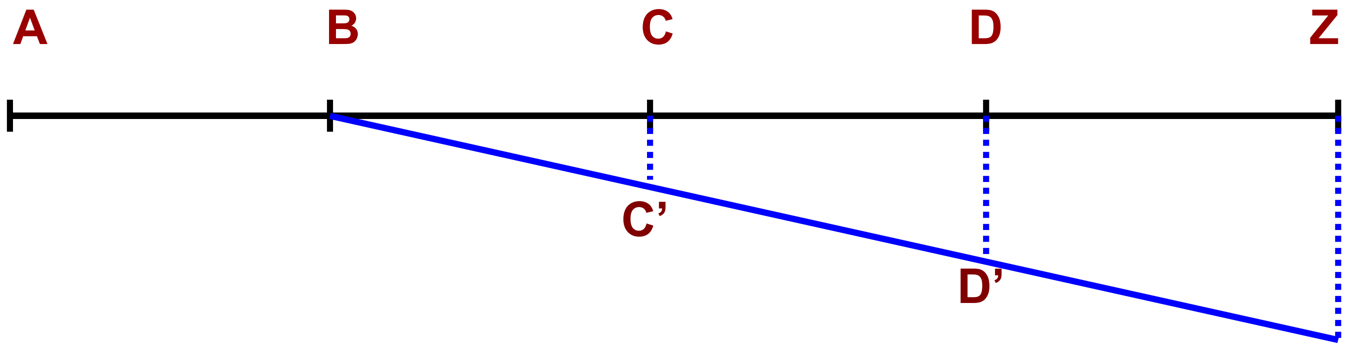
ii) Shift the instrument to B ,take a fore sight on C and establish a point D in line beyond C.

Fig.

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 .**

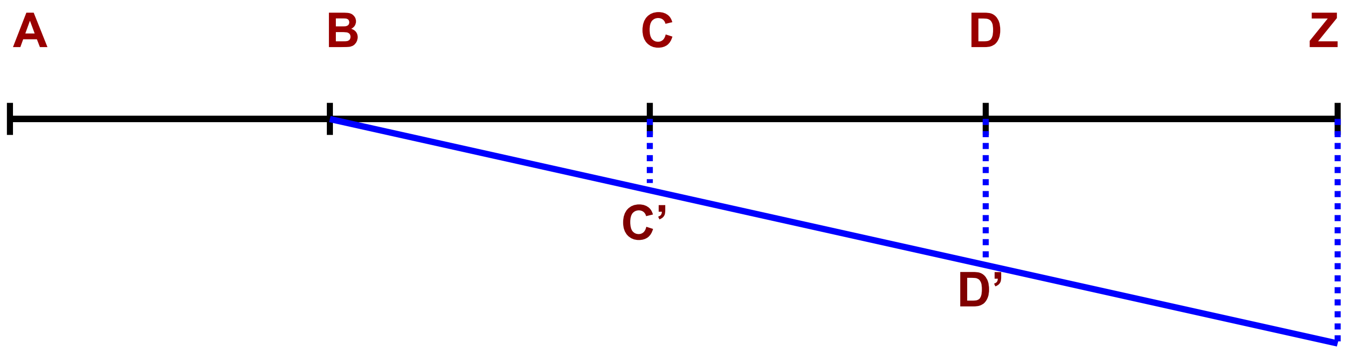
ii) **Take a back sight on A.**

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.

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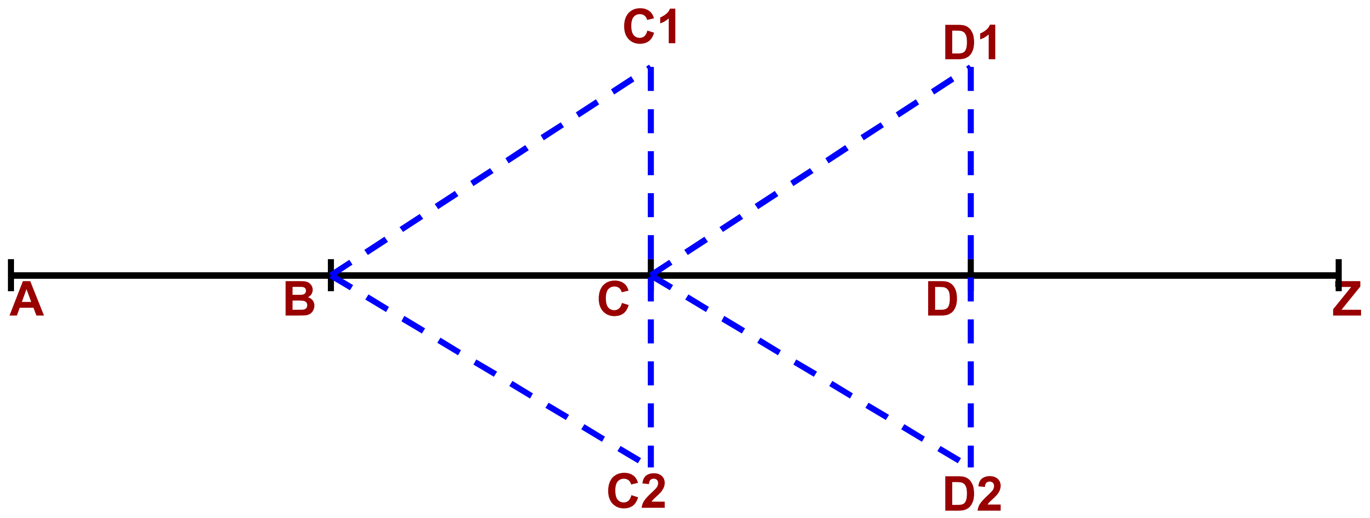
PROLONGING A STRAIGHT A LINE

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

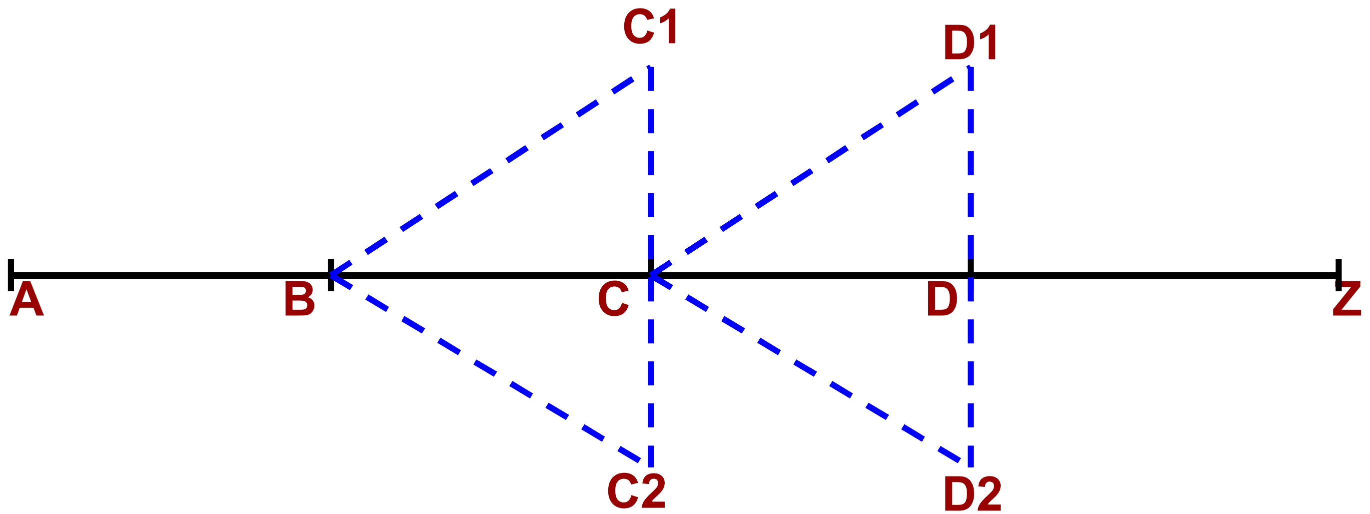
PROLONGING A STRAIGHT A LINE

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.



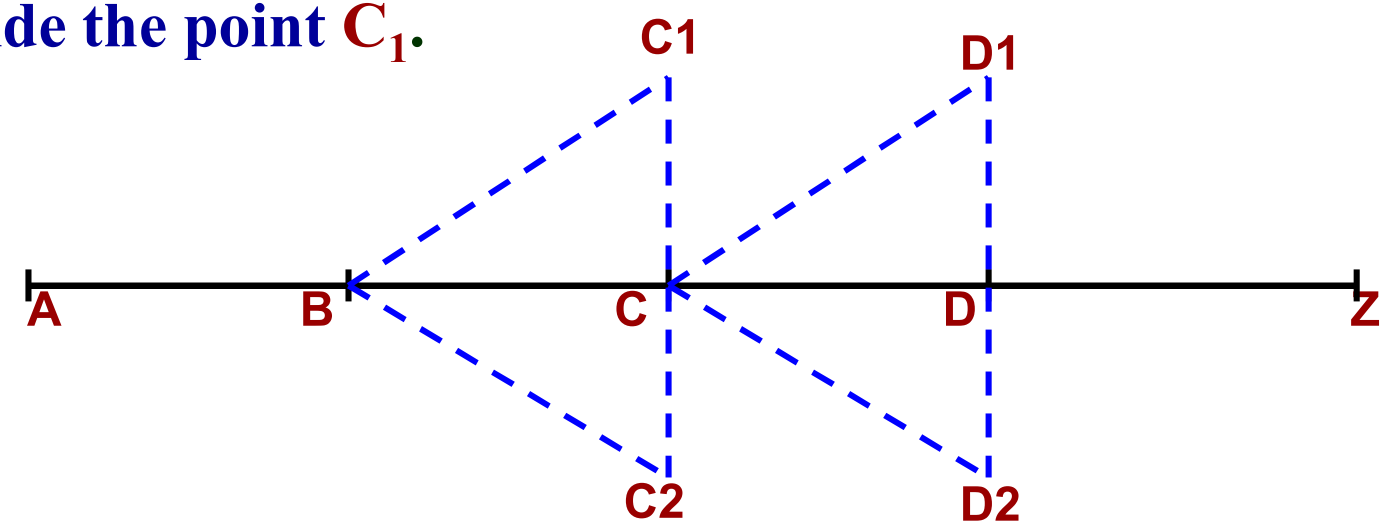
Double Sighting / Reversing Method

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.

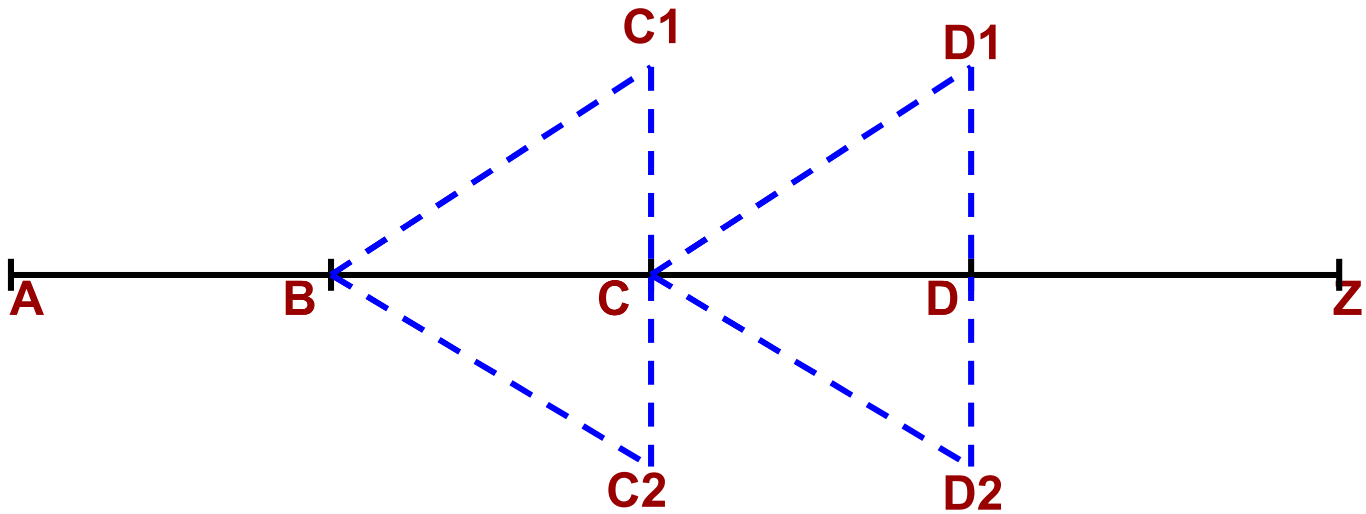


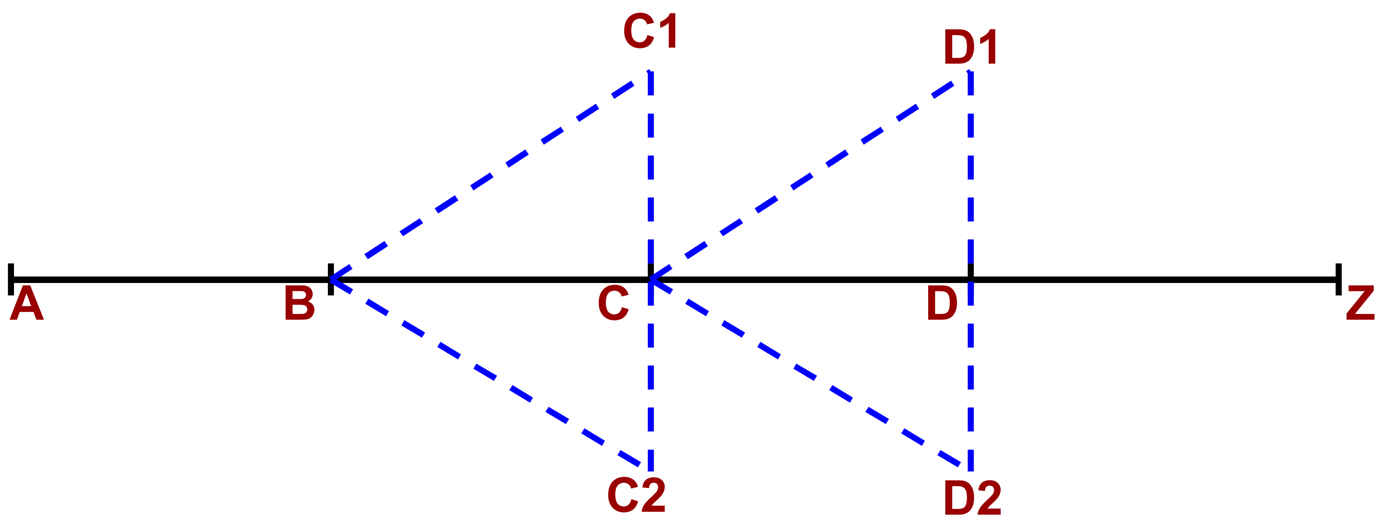
Fig. Double Sighting / Reversing Method

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

Errors in Theodolite work

- There are main three type of the error in the theodolite work

1. Instrumental error
2. Personal error
3. Natural error

1. Instrumental Error

- Error due to imperfect adjustment of plate level.
- Error due to line of collimation not being perpendicular to the horizontal axis.
- Errors due to horizontal axis not being perpendicular to the vertical axis.
- Errors due to line of collimation and axis of telescope not being parallel.
- Errors due to eccentricity of inner and outer axis.
- Error due to imperfect graduation.

2. Personal Error

- Inaccurate centering.
- Inaccurate leveling
- Manipulating wrong tangent screw
- Inaccurate sighting
- Ranging rod is not vertical.
- Parallax (bisection is not possible)

3. Natural Error

- Unequal expansion of part of telescope and circle due to temperature change.
- Unequal atmospheric refraction due to high temperature.
- Strong wind causing vibration.
- Unequal settlement of tripod.

Theodolite Traversing

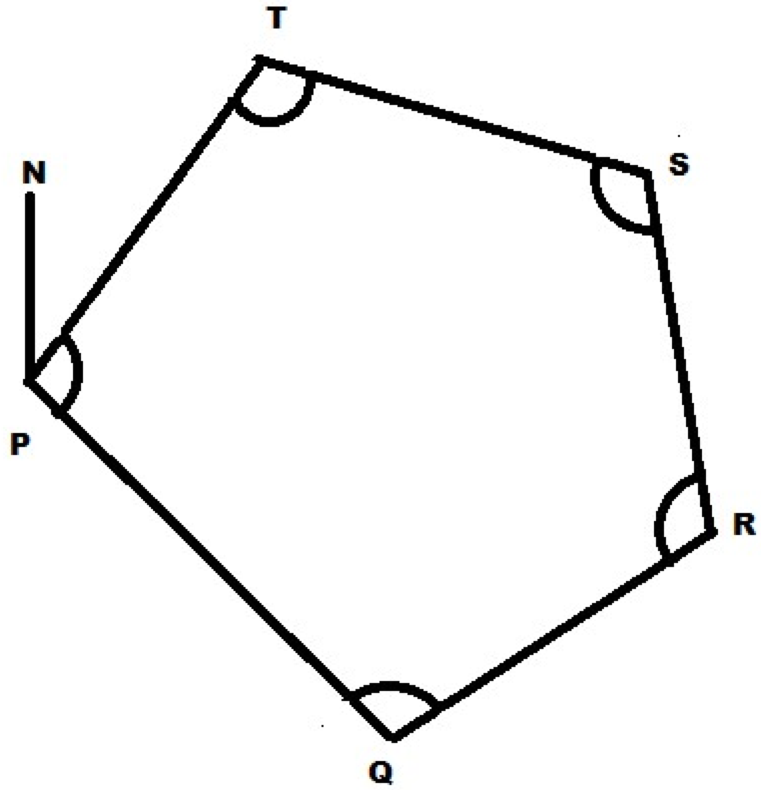
- In this method a frame work of a survey line is prepared in area to be surveyed.
- There are main two type of the traverse

1. Open Traverse
2. Closed Traverse

- There are main two type of the method apply for making a traverse

1. Traversing by included angle
2. Traversing by deflection angle

1. Traversing by included angle



- In this method the magnetic bearing of the line is measured with theodolite.
- all the included angle are also measured.
- The following procedure adopted for traversing in antilock wise direction.

1. Select the survey station like P, Q, R, S, T and insert a peg at each station.
2. Set up the instrument over the station P and level it.

3. Orient the telescope in the magnetic meridian and determine the bearing of the initial line PQ.
4. Set the vernier A to zero.
5. Take a back sight on station T.
6. Loose the upper plate. Turn the telescope in clock wise direction and take a fore sight to station Q.
7. The vernier reading will give the interior angle TPQ.
8. Similarly set the theodolite at another station like Q, R, S, T……
9. Follow the same procedure.

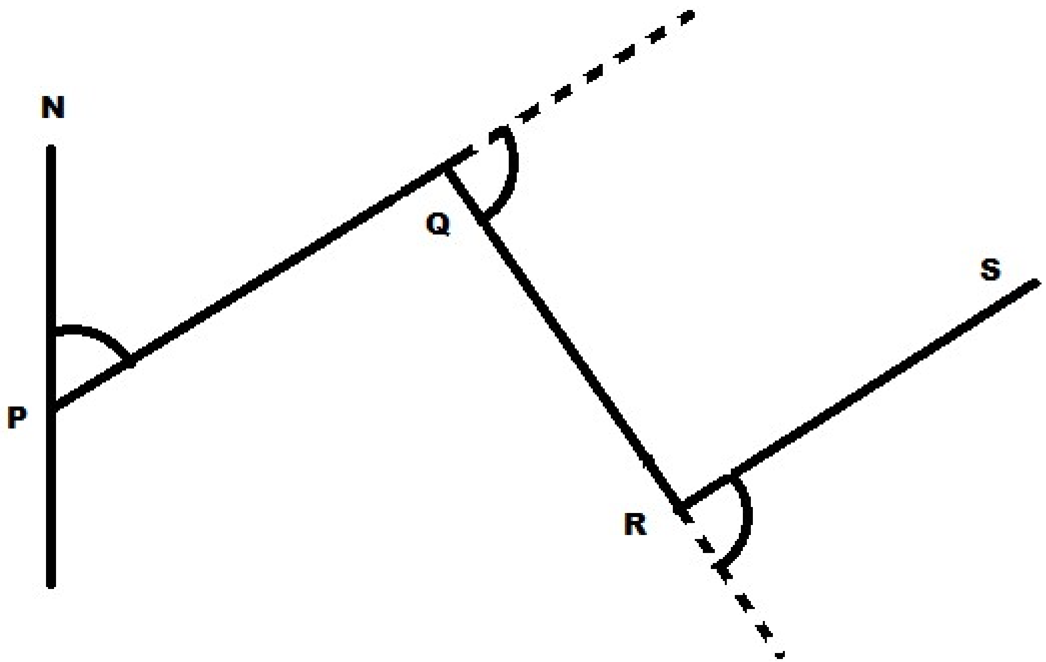
2. Traversing by deflected angle

- This method is generally used in an open traverse.
- It is suitable for traversing roads, railway, canal, pipe line.
- The procedure are as under

1. Set up the instrument at the starting station P.
2. Level it accurately, measure the bearing line PQ.
3. Shift the instrument to the station Q. Set up an level it accurately.

4. Unclamp the lower plate and take a back sight on station P. Bisect the P exactly using lower tangent screw.
5. Plunge the telescope.
6. The line of sight will be in the direction of the PQ.
7. Take a reading on vernier A will be zero.
8. Release the upper clamp and turn the telescope in clock wise direction.

9. Bisect the station R.
10. Similarly set the instrument at R.
11. Apply the same procedure.



Traverse Computation

1. Latitude (L) :-

- The latitude of the survey line any be defined as co-ordinate length measure parallel to an assumed meridian direction.
- l = Length of the line AB
- θ = Angle of line AB with north south line .
- Latitude = L = l Cosθ

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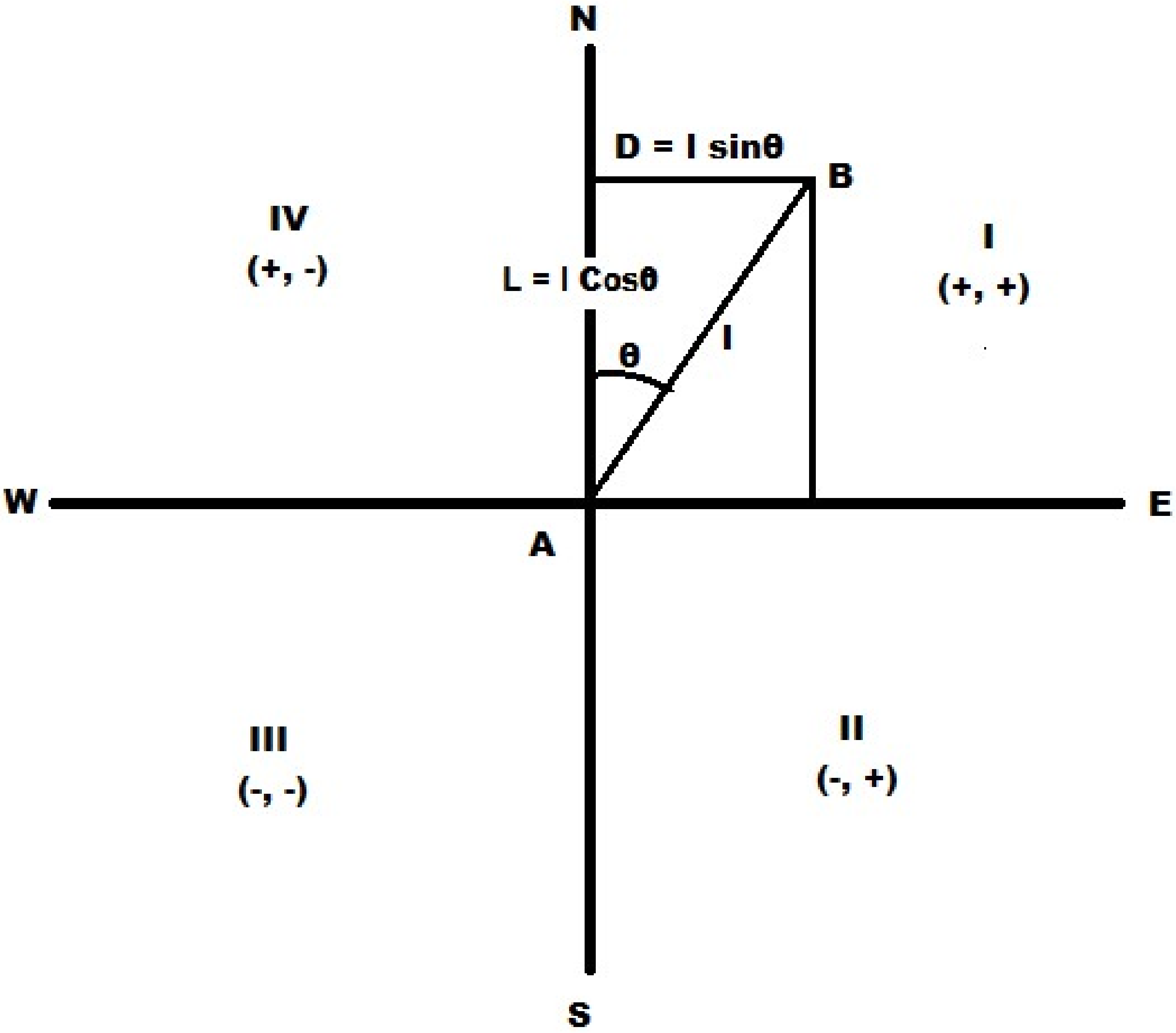
- When latitude (L) of a line is measured toward north, it is termed as northing.
- It is taken +ve
- When latitude (L) of a line is measured toward south. It is termed as southing.
- It is taken as -ve


N
D = l sinθ
B
IV
(+, -)
I
(+, +)
L = l Cosθ
θ
l
W
E
A
III
(-, -)
II
(-, +)
S

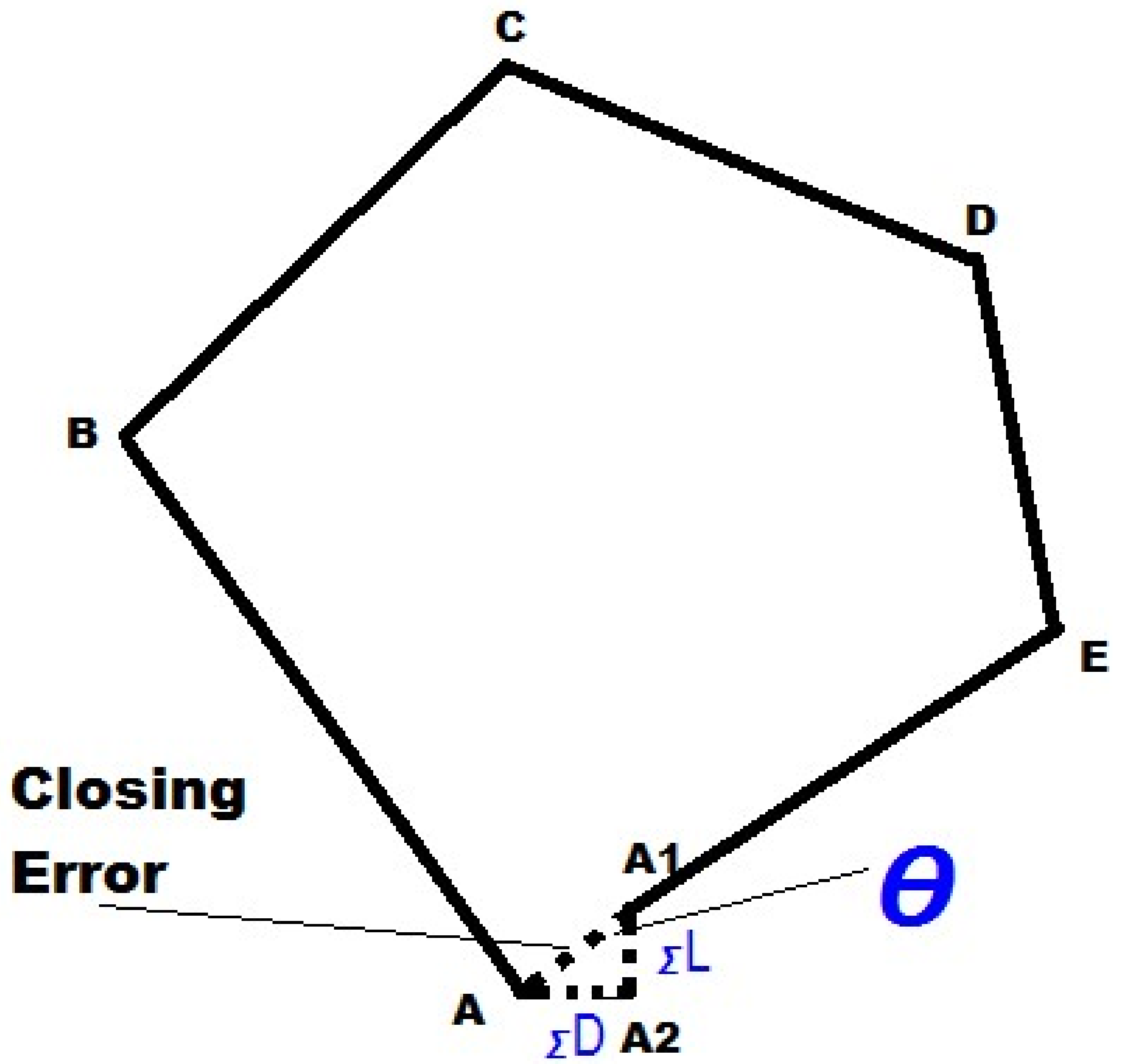
2. Departure (D) :-

- The departure of the survey line may be define as its co-ordinate length measured perpendicular to the meridian direction.
- Departure = D = l Sinθ

- When departure (D) of a line is measured towards east it is termed as easting.
- It is taken +ve
- When departure (D) of a line is measured toward west, it is termed as westing.
- It is taken - ve

Closing Error

- In the closing error algebraic sum of the latitude (**Σ**L) should be zero.
- Similarly algebraic sum of the Departures (**Σ** D) should be zero.
- If closed traverse is plotted according to the field measurements, the end point of the traverse will not coincide exactly with the starting point.
- The error in the field measurement of the angle and distances. Such a error is known as closing error.



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- Closing error = e = AA_1
- $e = \sqrt{(\Sigma L)^2 + (\Sigma D)^2}$

- The direction of the closing error is given
- by $\tan\boldsymbol{\theta} = \frac{\Sigma D}{\Sigma L}$

- The sign of the ΣL and ΣD will thus define

Relative error of closure

- It is convention to express the closing error with the numerator as unity.
- Such an error is called relative error of closure.
- Relative error of closure = $\frac{Closing\ error}{Perimeter\ of\ Traverse}$
- Relative error of closure = $\frac{e}{P}$

Adjustment of angular error

- In closed traverse thee sum of the interior angle = $(2N - 4) \times 90^0$.

- An error is distributed equally to each angle of traverse.

Adjustment of the Bearing

- Correction of the bearing of each line are as under.
- Correction for first line = $\frac{e}{N}$
- Correction for second line = $\frac{2e}{N}$
- Correction for third line = $\frac{3e}{N}$
- Correction for last line = $\frac{Ne}{N}$ = e

e = Closing Error
N = Number of sides of closed traverse

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Balancing the traverse

- The operation of applying correction to latitude and departures in such a way that $\Sigma L = 0$ and $\Sigma D = 0$, is know as balancing the travese.
- The following rules are adopted for balancing the traverse.

1. Bowditch's rule.
2. Transit rule.

1. Bowditch's rule.

- Bowditch's rule is also called the compass rule, is generally used for adjusting a traverse in which the angles and distance are measured with the same precision.
- Correction to latitude or departure of any side

$$= \text{Total error in latitude or departure} \times \frac{Length\ of\ that\ side}{Perimeter\ of\ travese}$$

- $C_L = \Sigma L \times \frac{l}{\Sigma L}$

2. Transit rule.

- This rule is applied to balance the traverse when the angular measurements are more precise than the linear measurement.
- Correction to latitude or departure of any side

$$= \text{Total error in latitude or departure} \times \frac{L \text{ or } D \text{ of that side}}{\text{Arithmatic sum of } L \text{ or } D}$$

- $C_L = \Sigma L \times \frac{L}{L_T}$
- $C_D = \Sigma D \times \frac{D}{D_T}$

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Traverse Area

- There are main five method for traverse area

Traverse Area	Meridian Distance method
	Double Meridian Distance method (DMD)
	Double parallel distance method
	Departure and total Latitude method
	Co-ordinate method

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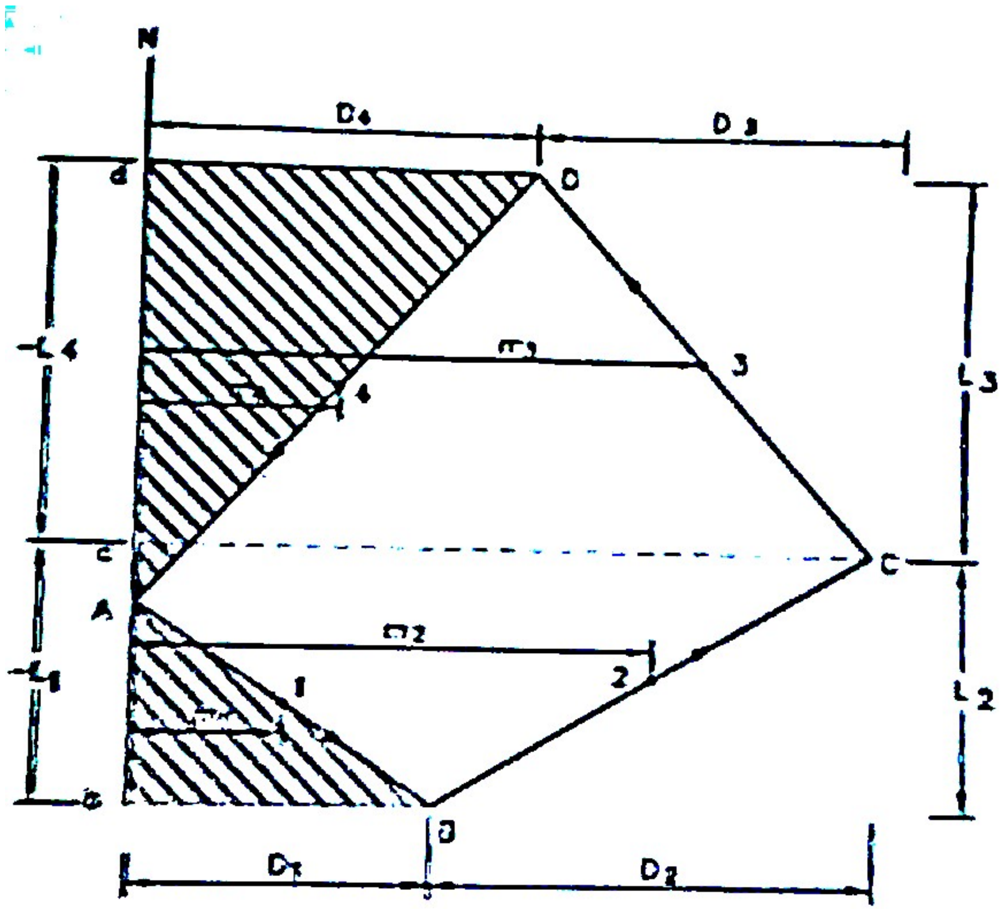
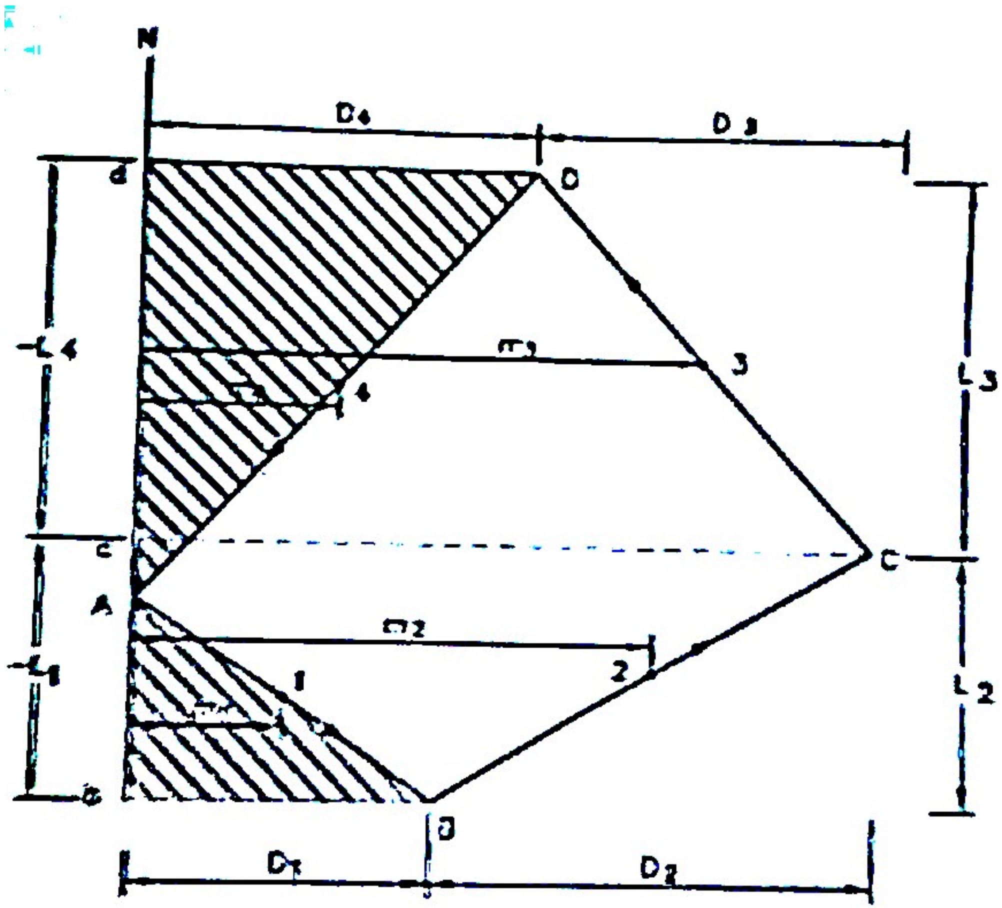
1. Meridian Distance method

- Meridian distance (m) of any point is the perpendicular distance of the point from the reference meridian.
- Meridian distance is also known as longitudinal distance.

- Meridian distance of points 1,2,3,4 are m_1, m_2, m_3, m_4.
- In fig, if the point 1 is the mid point of line AB, the meridian distance of AB will be m_1.
- In fig the lines AB, BC, CD and DA are D_1, D_2, D_3, D_4 respectively.





- $m_1 = \frac{D_1}{2}$
- $m_2 = m_1 + \frac{D_1}{2} + \frac{D_2}{2}$
- $m_3 = m_2 + \frac{D_2}{2} + (-\frac{D_3}{2})$
- $m_4 = m_3 + (-\frac{D_3}{2}) + (-\frac{D_4}{2})$

- Area of ABCD can be written as
- A = Area (CcbB) + Area (CcdD) – Area (Dad) – Area (Bab)
- $A = m_2L_2 + m_3L_3 - m_4L_4 - m_1L_1$

2. Double Meridian Distance method (DMD)

- Double meridian distance is the twice of the meridian distance.
- The DMD is represented by letter M.

- $M_1 = 2m_1 = 2\left(\frac{D_1}{2}\right) = D_1$

- $M_2 = 2m_2 = 2\left(m_1 + \frac{D_1}{2} + \frac{D_2}{2}\right)$

$$= 2\left(\frac{D_1}{2} + \frac{D_1}{2} + \frac{D_2}{2}\right)$$

$$= 2D_1 + D_2$$

$$= M_1 + D_1 + D_2$$

- $M_3 = 2m_3 = 2\left(m_2 + \frac{D_2}{2} + (-\frac{D_3}{2})\right)$

$$= 2\left(m_1 + \frac{D_1}{2} + \frac{D_2}{2} + \frac{D_2}{2} - \frac{D_3}{2}\right)$$

$$= 2\left(\frac{D_1}{2} + \frac{D_1}{2} + \frac{D_2}{2} + \frac{D_2}{2} - \frac{D_3}{2}\right)$$

$$= 2D_1 + D_2 + D_2 - D_3$$

$$= M_2 + D_2 - D_3$$

- $M_4 = 2m_4 = 2\left(m_3 + (-\frac{D_3}{2}) + (-\frac{D_4}{2})\right)$

$$= 2\left(m_2 + \frac{D_2}{2} - \frac{D_3}{2} - \frac{D_3}{2} - \frac{D_4}{2}\right)$$

$$= 2\left(m_1 + \frac{D_1}{2} + \frac{D_2}{2} + \frac{D_2}{2} - \frac{D_3}{2} + \frac{D_2}{2} - \frac{D_3}{2} - \frac{D_3}{2} - \frac{D_4}{2}\right)$$

$$= 2\left(\frac{D_1}{2} + \frac{D_1}{2} + \frac{D_2}{2} + \frac{D_2}{2} - \frac{D_3}{2} + \frac{D_2}{2} - \frac{D_3}{2} - \frac{D_3}{2} - \frac{D_4}{2}\right)$$

$$= (2D_1 + D_2) + D_2 - D_3 - D_3 - D_4)$$

$$= M_3 - D_3 - D_4$$

- Area of traverse ABCD is given by
- $A = \frac{1}{2}(Bb + Cc)\,bc + \frac{1}{2}(Cc + Dd)\,cd - \frac{1}{2}(0 + Dd)\,Ad - \frac{1}{2}(0 + Bb)\,Ab$
- Now $Bb + Cc = D_1 + D_2 + D_3$

$$= M_1 + D_2 + D_3$$

$$= M_2$$

Similarly, $Cc + Dd = M_3$

$$0 + Dd = M_4$$

$$0 + Bb = M_1$$

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- $A = \frac{1}{2}(M_2L_2) + \frac{1}{2}(M_3L_3) - \frac{1}{2}(M_4(-L_4)) - \frac{1}{2}(M_1(-L_1))$
- $A = \frac{1}{2}(M_1L_1 + M_2L_2 + M_3L_3 + M_4L_4)$
- $A = \frac{1}{2}(\Sigma ML)$

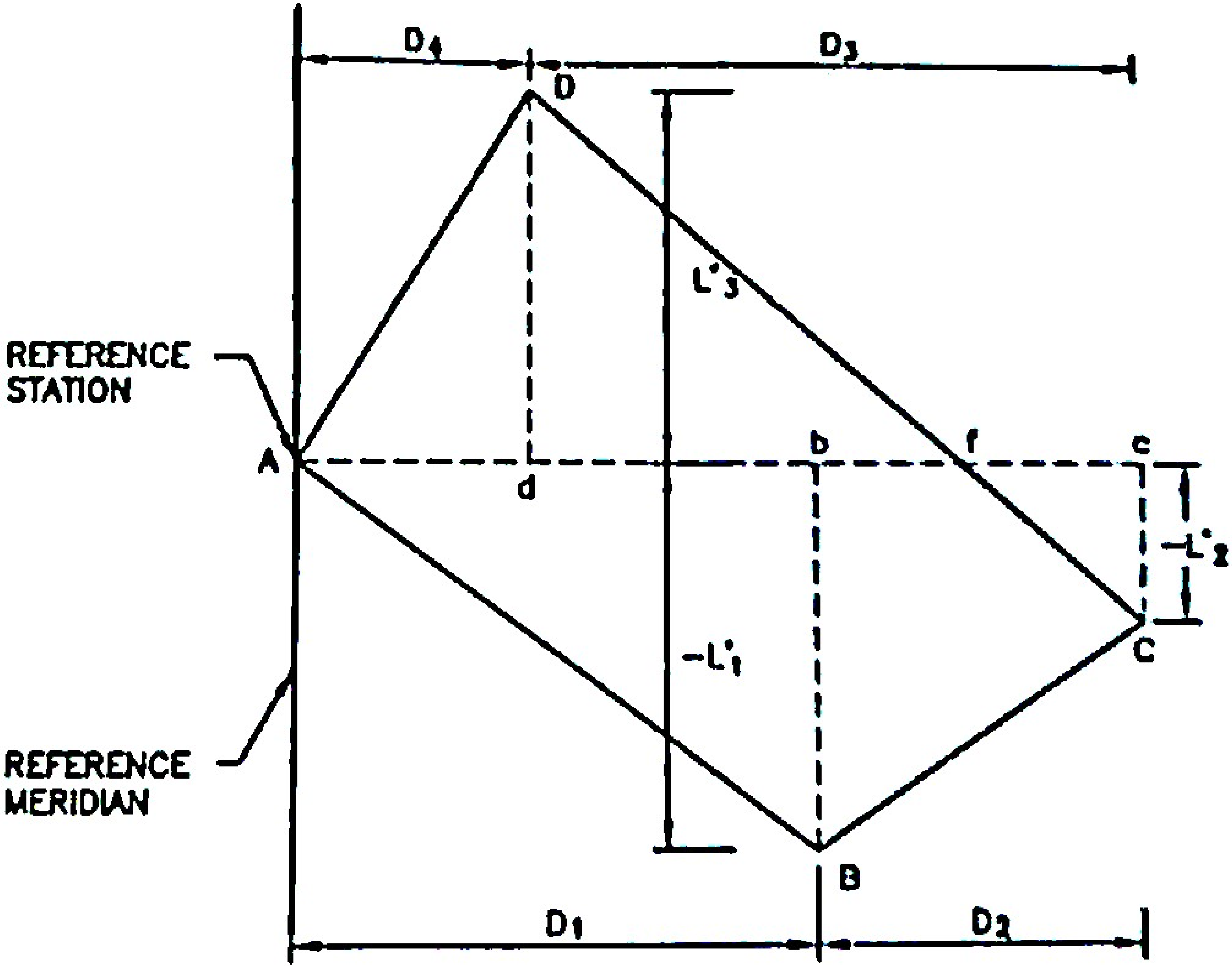
3. Double parallel distance method

- The parallel distance of a line is the distance of its mid point from a reference parallel measured at right angle to the reference parallel.
- DPD twice the parallel distance.
- The area of traverse can be obtained in terms of DPD by replacing M and L by P and D.
- $2A = \boldsymbol{\Sigma}(P \times D)$
- Where p = double parallel distance

  D = departure

4. Departure and total Latitude method

- Rule :- Total latitude of a point is equal to the algebraic sum of the latitude of the preceding station and latitude of the preceding line.
- The total latitude of the station A, B, C, D are L_0', $-L_1'$, $-L_2'$, L_3'



D4
D3
D
L'3
REFERENCE STATION
A
d
b
f
c
$-L'_2$
C
$-L'_1$
REFERENCE MERIDIAN
B
D1
D2

- Area of Traverse ABCD computed as
- A = Area ABb + Area BbcC + Area DdCc + Area DdA
- $A = \frac{1}{2} D_1 (0 – L_1') + \frac{1}{2} D_2 (- L_1' – L_2') + \frac{1}{2} (-D_3) (- L_2' + L_3') + \frac{1}{2} (-D_4) (L_3' – 0)$

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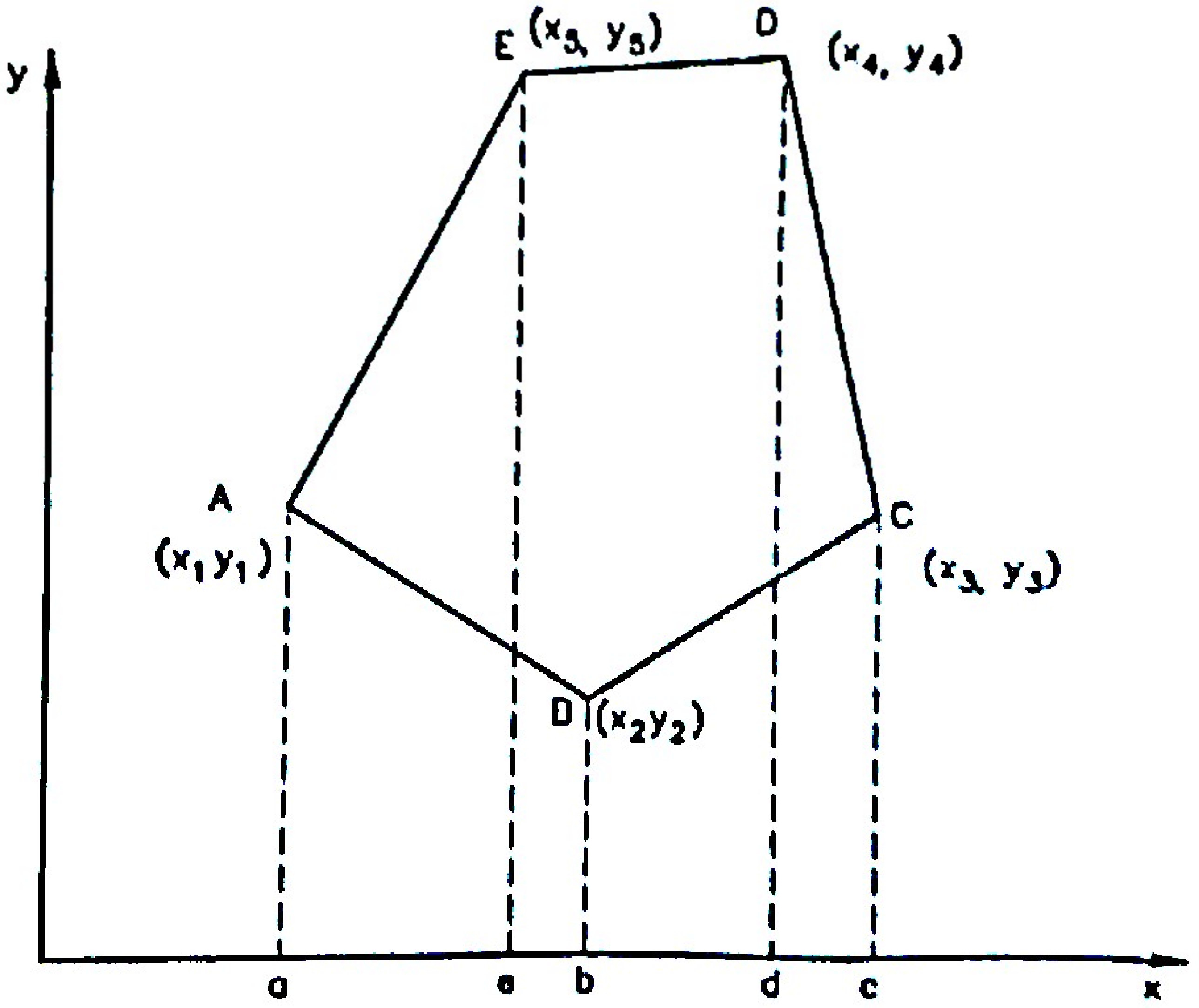
5. Co-ordinate method

- In this method independent co-ordinates of the points are used in the computation of the areas.
- Batter than DMD method.



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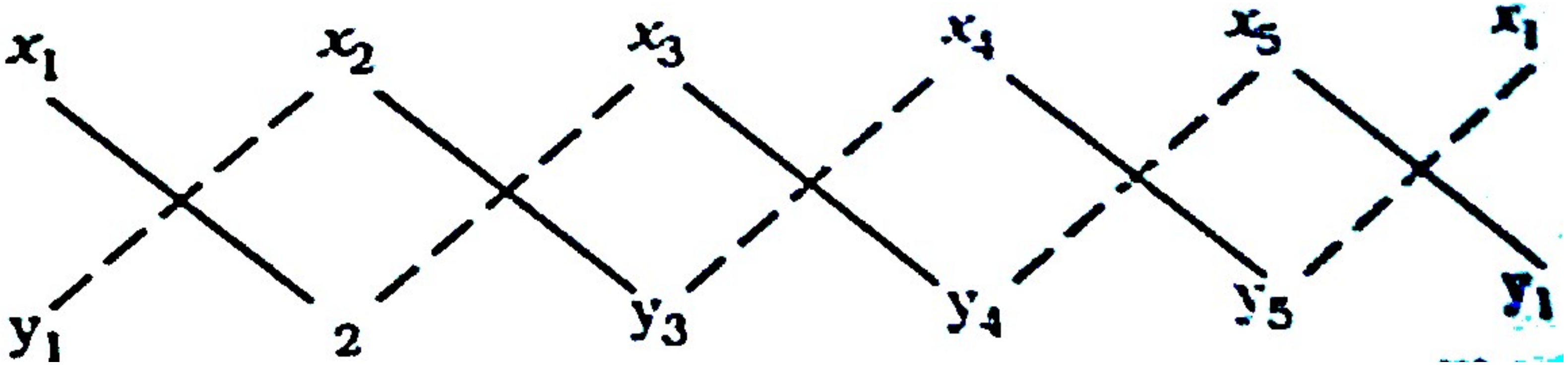
- Area of trapezoid AaeE is = $\frac{1}{2}(x_5 - x_1)(y_5 + y_1)$
- $A = \frac{1}{2}(x_5 - x_1)(y_5 + y_1) + \frac{1}{2}(x_4 - x_5)(y_4 + y_5) + \frac{1}{2}(x_3 - x_4)(y_3 + y_4) - \frac{1}{2}(x_2 - x_1)(y_2 + y_1) - \frac{1}{2}(x_3 - x_2)(y_3 + y_2)$
- $A = \frac{1}{2}\Big[(x_1)(y_2 - y_5) + (x_2)(y_3 - y_1) + (x_3)(y_4 - y_2) + (x_4)(y_5 - y_3) + (x_5)(y_1 - y_4)$
- $A = \frac{1}{2}\Big[(x_1y_2) - (x_1y_5) + (x_2y_3) - (x_2y_1) + (x_3y_4) - (x_3y_2) + (x_4y_5) - (x_4y_3) + (x_5y_1) - (x_5y_4)\Big]$



- $A = \frac{1}{2}\Big[(x_1y_2) + (x_2y_3) + (x_3y_4) + (x_4y_5) + (x_5y_1) - (x_1y_5) - (x_5y_4) - (x_4y_3) - (x_3y_2) - (x_2y_1)\Big]$

Example : 1

- The latitude and departure of the line of a closed traverse are given bellow. Calculate the area of traverse.

Line	Northing	Southing	Easting	Westing
AB	-	157.2	154.8	-
BC	210.5	-	52.5	-
CD	175.4	-	-	98.3
DA	-	228.7	-	109.0

Example : 2

- The latitude and departure of the line of a closed traverse ABCD are given below. Calculate the area of traverse by

1. Co-ordinate method
2. Meridian Distance method
3. Double Meridian Distance method (DMD)
4. Departure and total latitude method

Line	Northing	Southing	Easting	Westing
AB	-	164.5	162.1	-
BC	217.8	-	59.8	-
CD	168.1	-	-	105.6
DA	-	221.4	-	116.3

Omitted Measurement

- All the lengths and all the angles of the closed traverse should be measured in the field, so proper check can be made and traverse can be adjust.
- Sometimes it is not possible to take all the linear and angular measurement in the field due to some obstacles, such a measurement are called omitted measurement.

- This omitted measurements can be determine from the other measurements as explain bellow.

- For a closed traverse, the algebraic sum of latitude is equal to zero.
- $\boldsymbol{\Sigma} \mathrm{L} = 0$
- $l_1 \cos \theta_1 + l_2 \cos \theta_2 + l_3 \cos \theta_3 + \ldots\ldots\ldots = 0$

- For a closed traverse, the algebraic sum of departure is equal to zero.
- $\boldsymbol{\Sigma} \mathrm{L} = 0$
- $l_1 \sin \theta_1 + l_2 \sin \theta_2 + l_3 \sin \theta_3 + \ldots\ldots\ldots = 0$

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- Trigonometric relations given in table bellow may be used for the computation of omitted measurement.

Data given	Required	Formula
l, θ	L	L = l Cos θ
l, θ	D	D = l Sin θ
L, D	tan θ	$\tan\theta = D/L$
L, θ	l	l = L Sec θ
D, θ	l	l = D Cosec θ
L, t	Cos θ	$\cos\theta = L/l$
D, l	Sin θ	$\sin\theta = D/l$
L, D	l	$l = \sqrt{L^2 + D^2}$

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There are main four general cases of omitted measurement

- Case : 1

a) When the length of one side is omitted.

b) When the bearing of one side is omitted.

c) When the length and bearing of one side is omitted.

- Case : 2
- When the length of one side and the bearing of an adjacent side are omitted.

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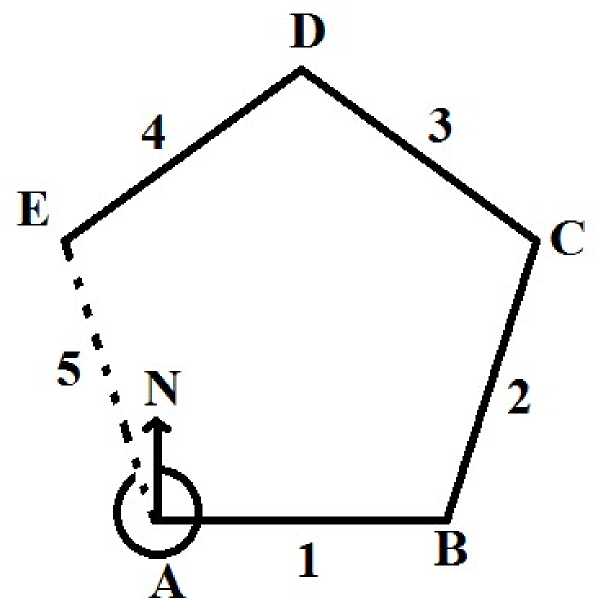
- Case : 3
- When the length of two sides are omitted.

- Case : 4
- When the bearing of two adjacent sides are omitted.

Case : 1 When the length or bearing or length and bearing of one side is omitted.

- Let it is required to calculate either bearing or length or both bearing and length of the line EA of the traverse ABCDEA.
- Calculate ΣL’ and ΣD’ of the four known side AB, BC, CD, DE.



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- ΣL = Latitude of EA + ΣL' = 0
- Latitude of EA = - ΣL'

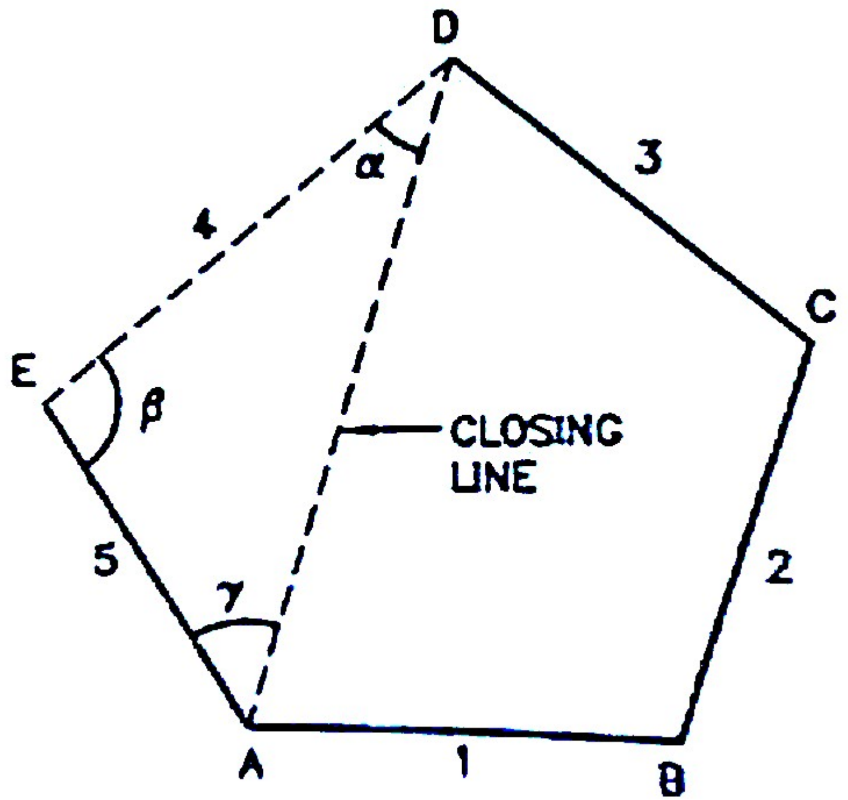
- Similarly
- ΣD = Departure of EA + ΣD' = 0
- Departure of EA = - ΣD'

- Length of line EA = l = $\sqrt{(L_{EA})^2 + (D_{EA})^2}$
- Now using relations,

Case : 2 When the length of one side and the bearing of an adjacent side are omitted.

- Let the length of one side DE and the bearing of an adjacent side EA are omitted.
- Joint point D and A.
- The length and bearing

Of all the line are known.



- In ΔADE, the length of side DA and EA are known, the angle ADE (α) is also known.
- The angle β and length DE can be determine from the sine rule.
- $\frac{EA}{Sin\ \alpha} = \frac{DA}{Sin\ \beta} = \frac{DE}{Sin\ \gamma}$

Case : 3 When the length of two sides are omitted.

- Let the length DE and EA could not be measured in the field.
- Joint point D and A. determine the length and bearing of DA, from the closed traverse ABCD.
- The angle α, β, and γ can be computed by the known bearing.
- The length DE and EA can be computed by the sine law.

- $\frac{EA}{\sin\alpha} = \frac{DA}{\sin\beta} = \frac{DE}{\sin\gamma}$

- $EA = \frac{\sin\alpha}{\sin\beta} DA$

- $DE = \frac{\sin\gamma}{\sin\beta} DA$