Surveying-II
CE-205 (T)

Lecture 4
THEODOLITE TRAVERSING

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THEODOLITE TRAVERSING
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.
- These measurements are taken by an instrument known as a Theodolite.

THEODOLITE TRAVERSING

- The system of surveying in which the angles are measured with the help of a theodolite, is called Theodolite surveying.
- Theodolites are telescopic instruments used basically for measuring both vertical and horizontal angles.
- Theodolites are precision instruments used extensively in construction work for measuring angles in the horizontal and vertical planes.
- Many different theodolites are available for measuring angles.

THEODOLITE TRAVERSING

- **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.

THEODOLITE TRAVERSING

CLASSIFICATION OF THEODOLITES

Theodolites may be classified as ;

A.

i) Transit Theodolite.

ii) Non Transit Theodolite.

B.

i) Vernier Theodolites.

ii) Micrometer Theodolites.

THEODOLITE TRAVERSING

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.

Non-Transit type: The telescope cannot be transited. They are inferior in utility and have now become obsolete.

THEODOLITE TRAVERSING

CLASSIFICATION OF THEODOLITES

B.

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

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 .

THEODOLITE TRAVERSING

SIZE OF THEODOLITE

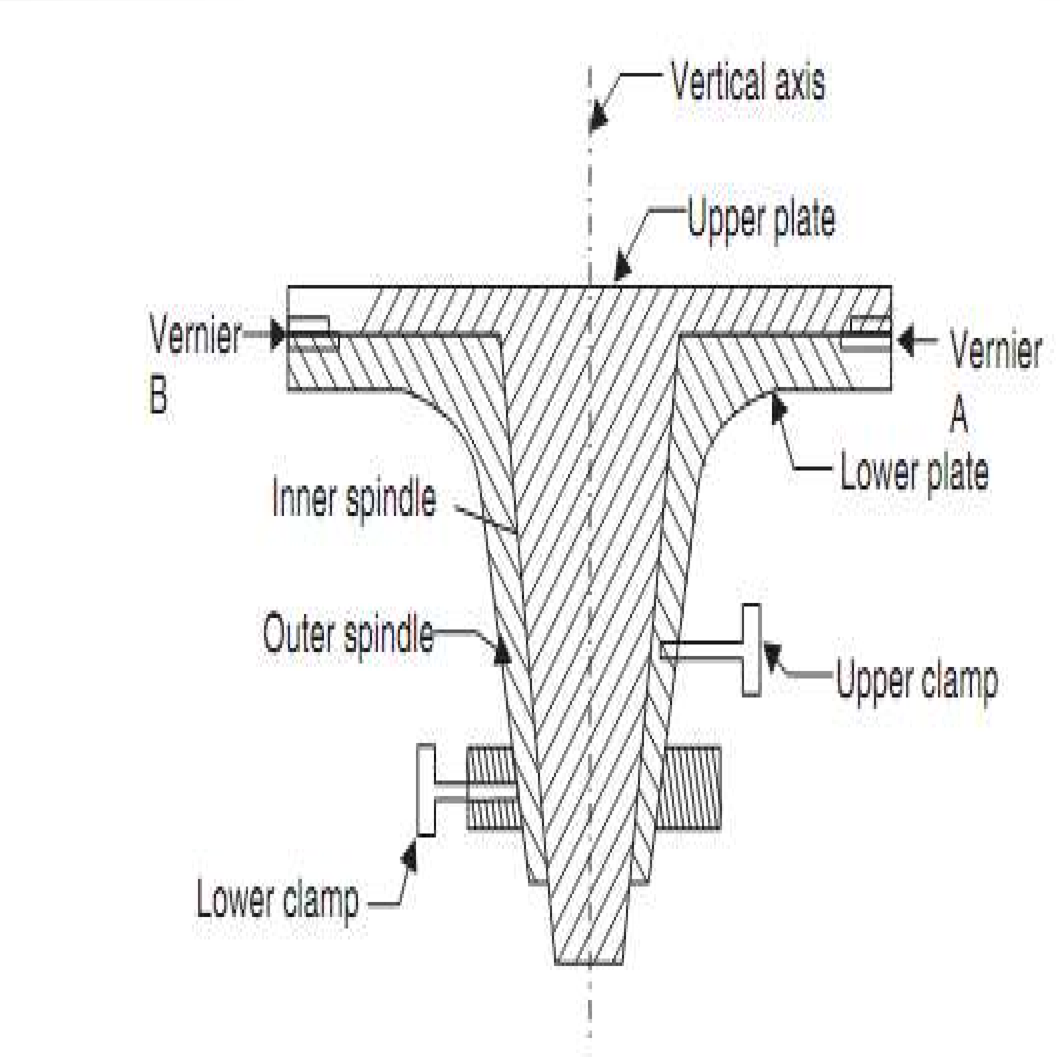
- A theodolite is designated by diameter of the graduated circle on the lower plate.
- The common sizes are 8cm to 12 cm while 14 cm to 25 cm instrument are used for triangulation work.
- Greater accuracy is achieved with larger theodolites as they have bigger graduated circle with larger divisions hence used where the survey works require high degree of accuracy.

THEODOLITE TRAVERSING

TYPE OF THEODOLITE

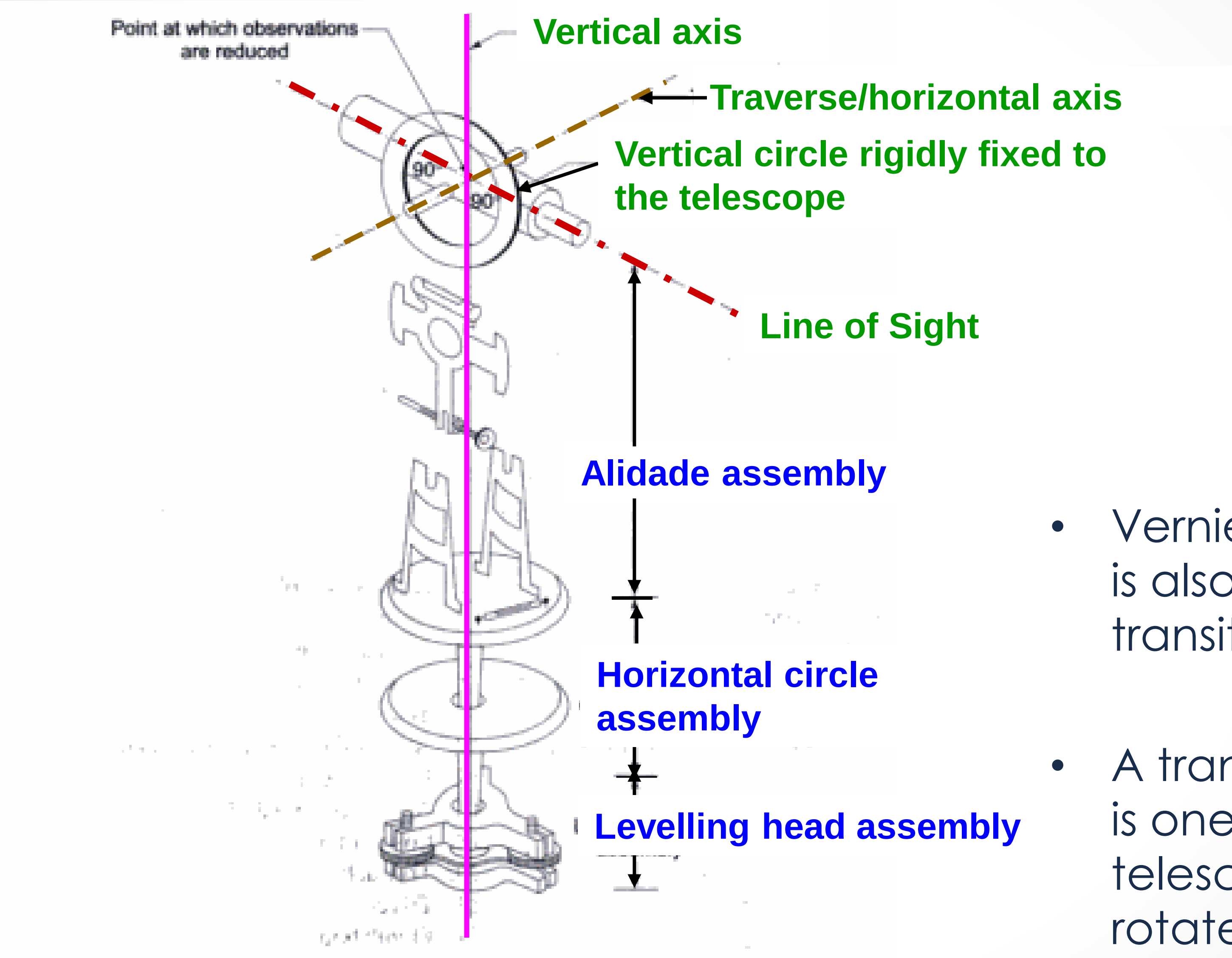
THEODOLITE TRAVERSING

TRANSIT VERNIER THEODOLITE



Details if Upper & Lower Plates.

TRANSIT VERNIER THEODOLITE



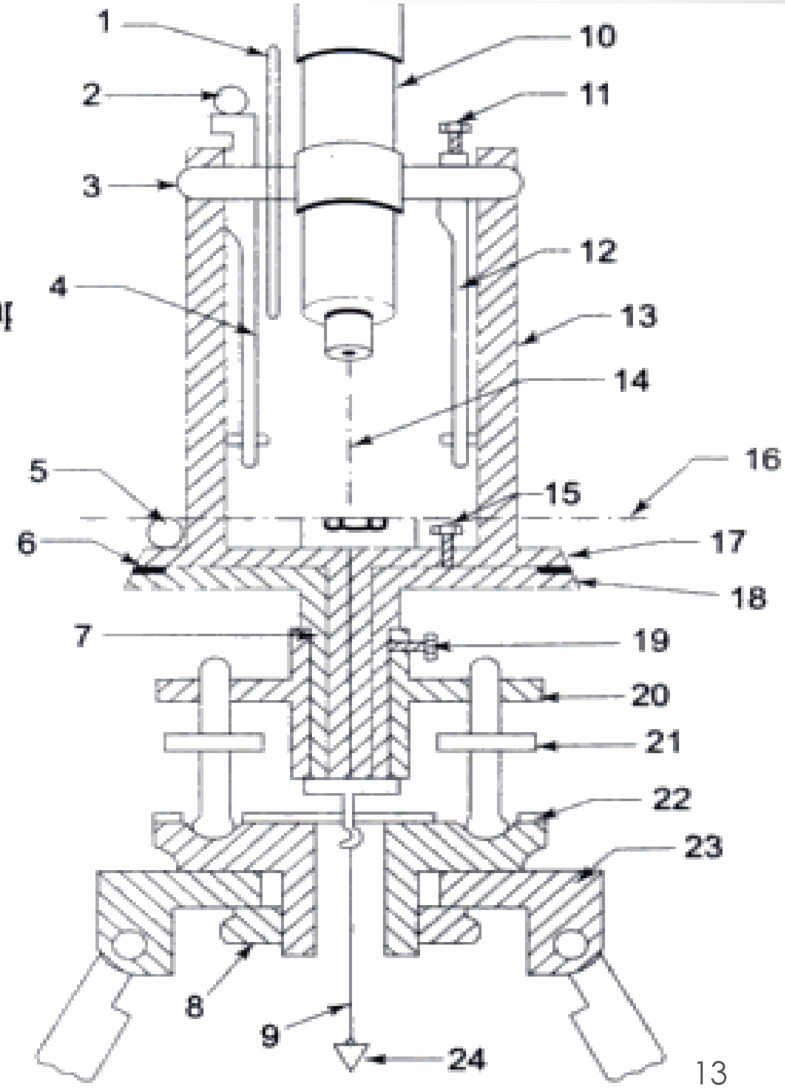
Three assemblies of Theodolite

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

TRANSIT VERNIER THEODOLITE

MAIN PARTS

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

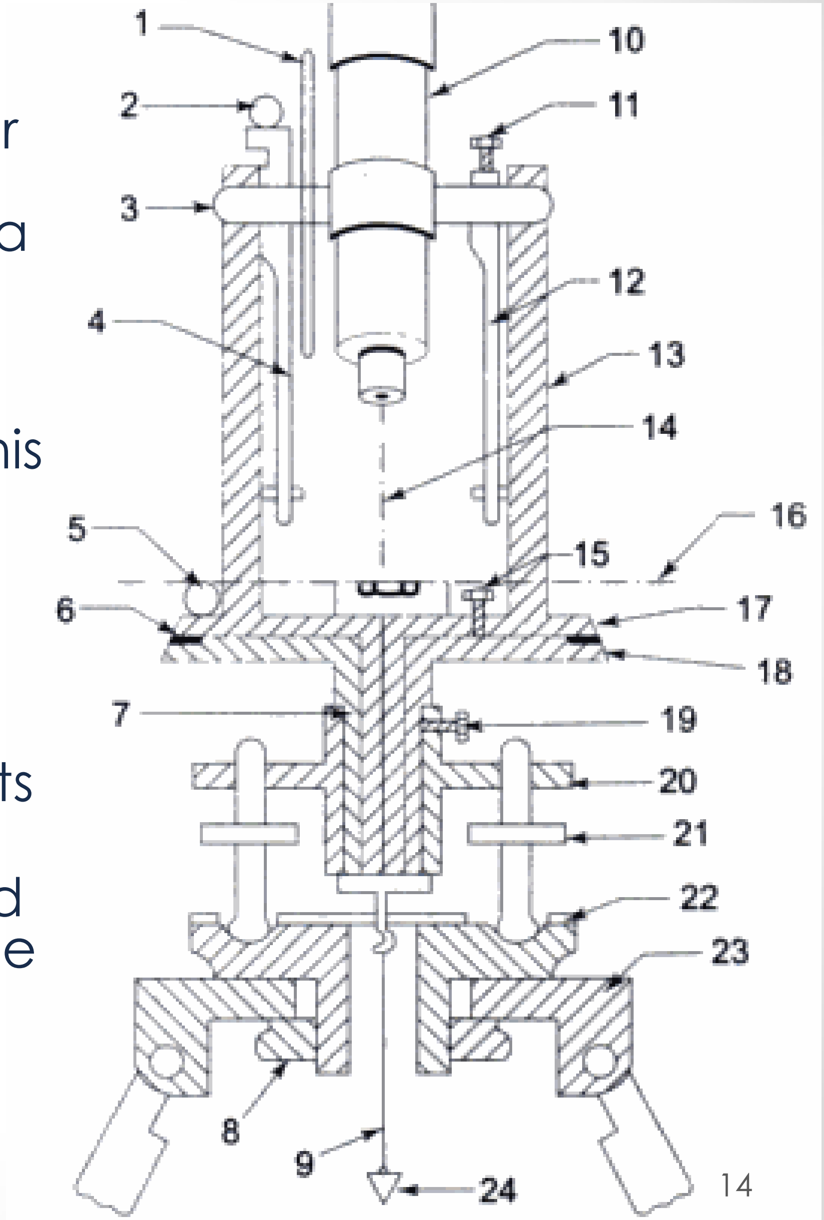


- **Levelling head (7):** Levelling head is used to attach the instrument to tripod and attach the plumb bob along the vertical axis of the instrument.

TRANSIT VERNIER THEODOLITE

MAIN PARTS

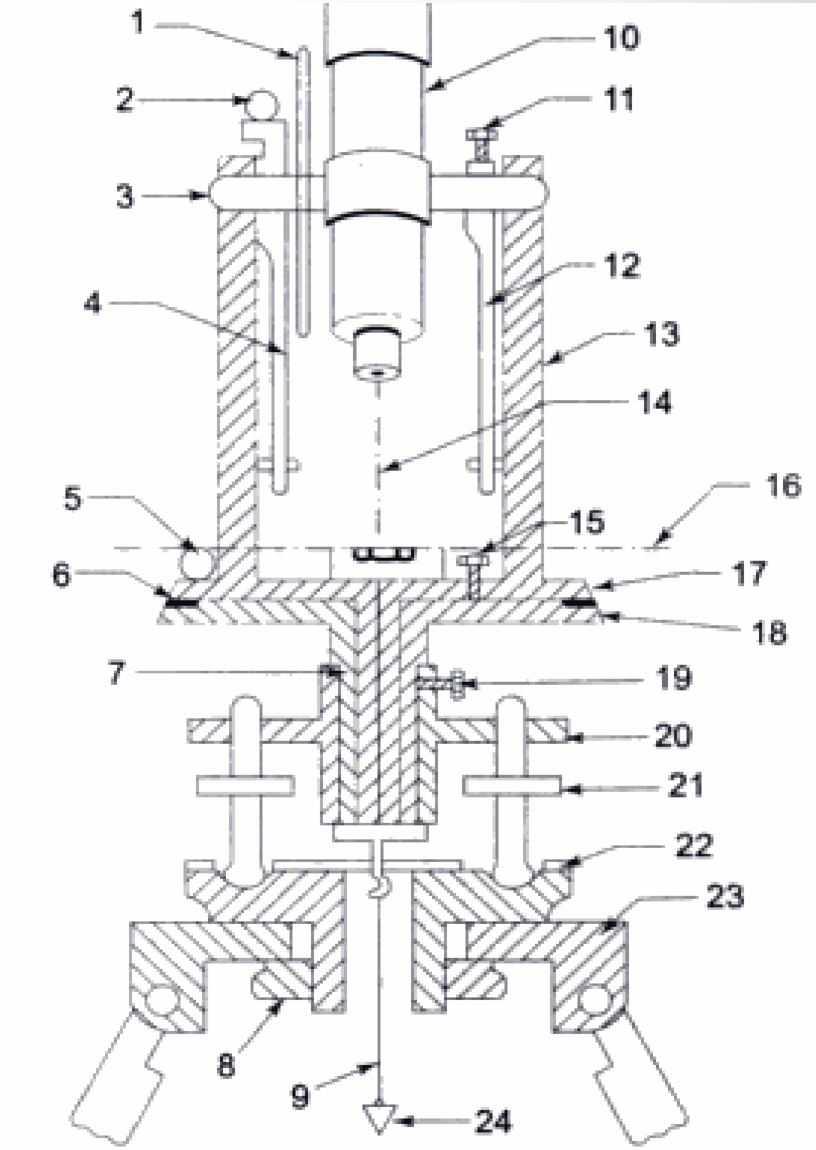
- **Lower plate/circle plate (18):** An annular horizontal plate with the graduations provided all around, from 0 to 360°, in a clockwise direction. The graduations are in degree divided in to 3 parts so that each division equals to 20 min.
- Horizontal angles are measured with this plate.
- The size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



TRANSIT VERNIER THEODOLITE

MAIN PARTS

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

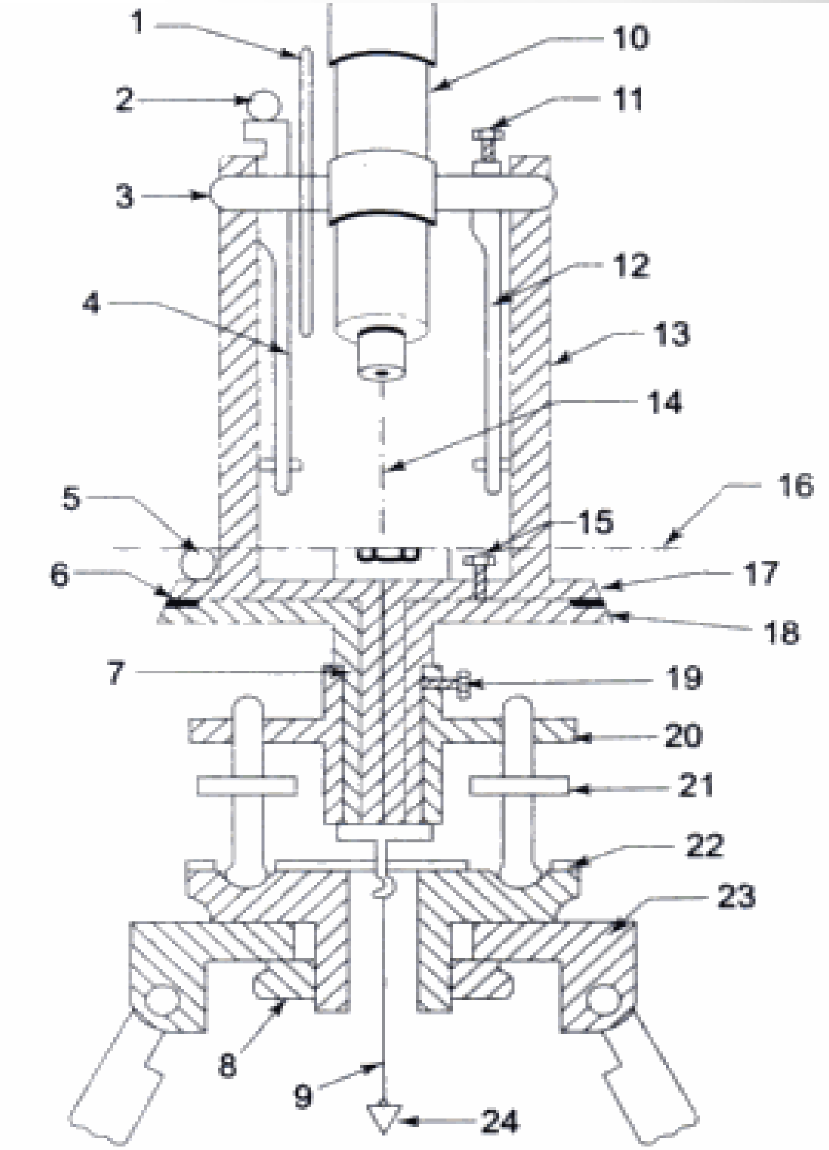


TRANSIT VERNIER THEODOLITE

MAIN PARTS

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

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



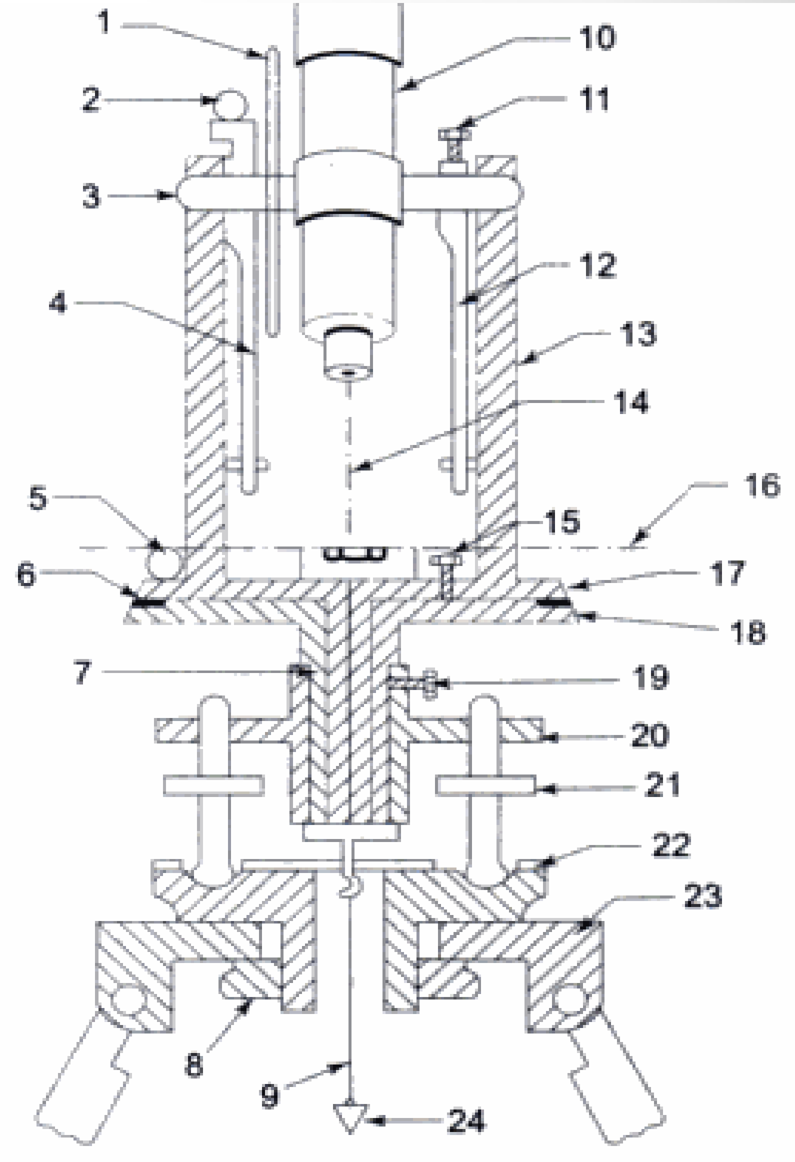
TRANSIT VERNIER THEODOLITE

MAIN PARTS

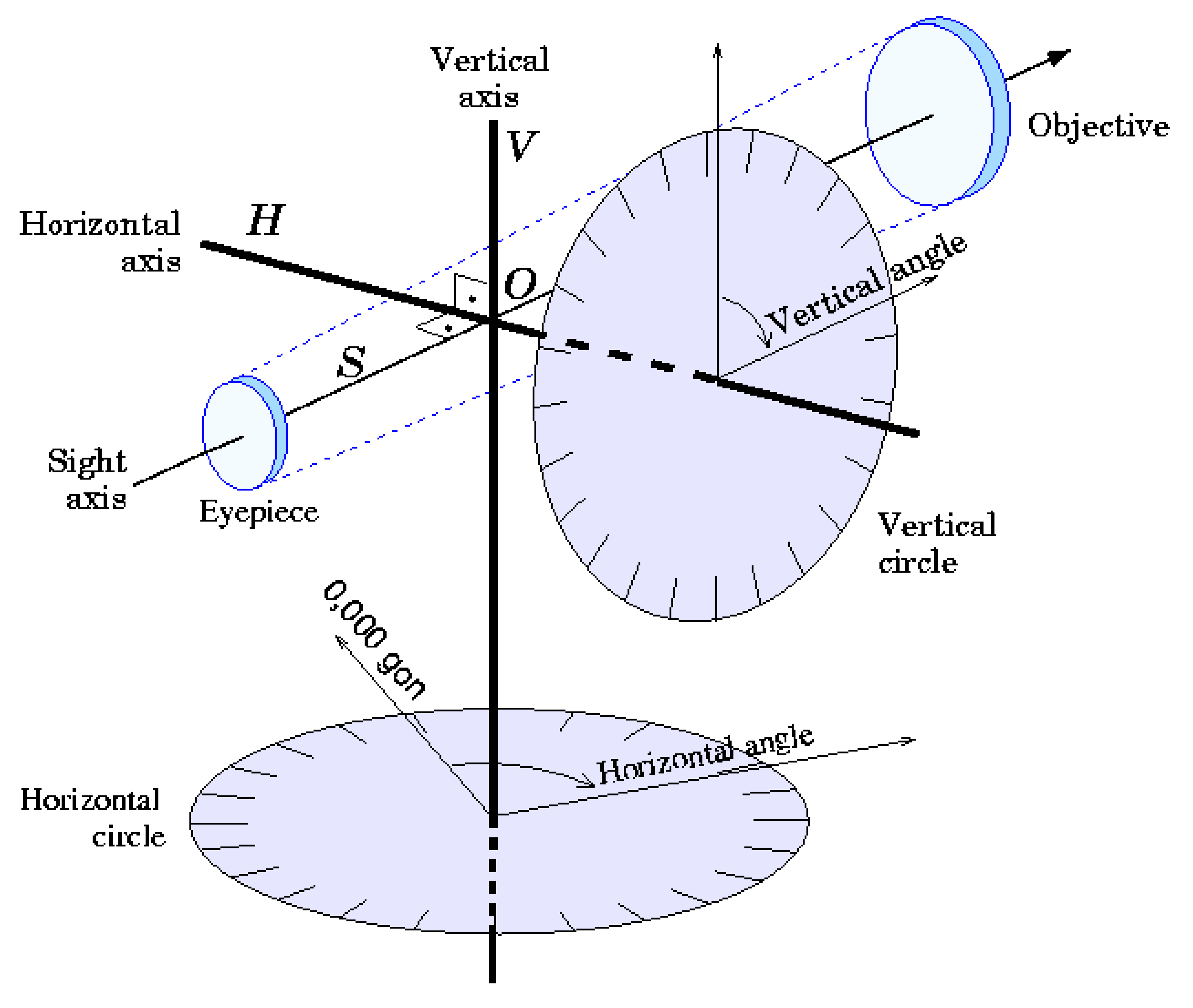
- **Vertical circle (1): C**ircular plate supported on horizontal axis of the instrument between the A-frames. Vertical circle has graduation 0-90 in four quadrants. Vertical circle moves with the telescope when it is rotated in the vertical plane.

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

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

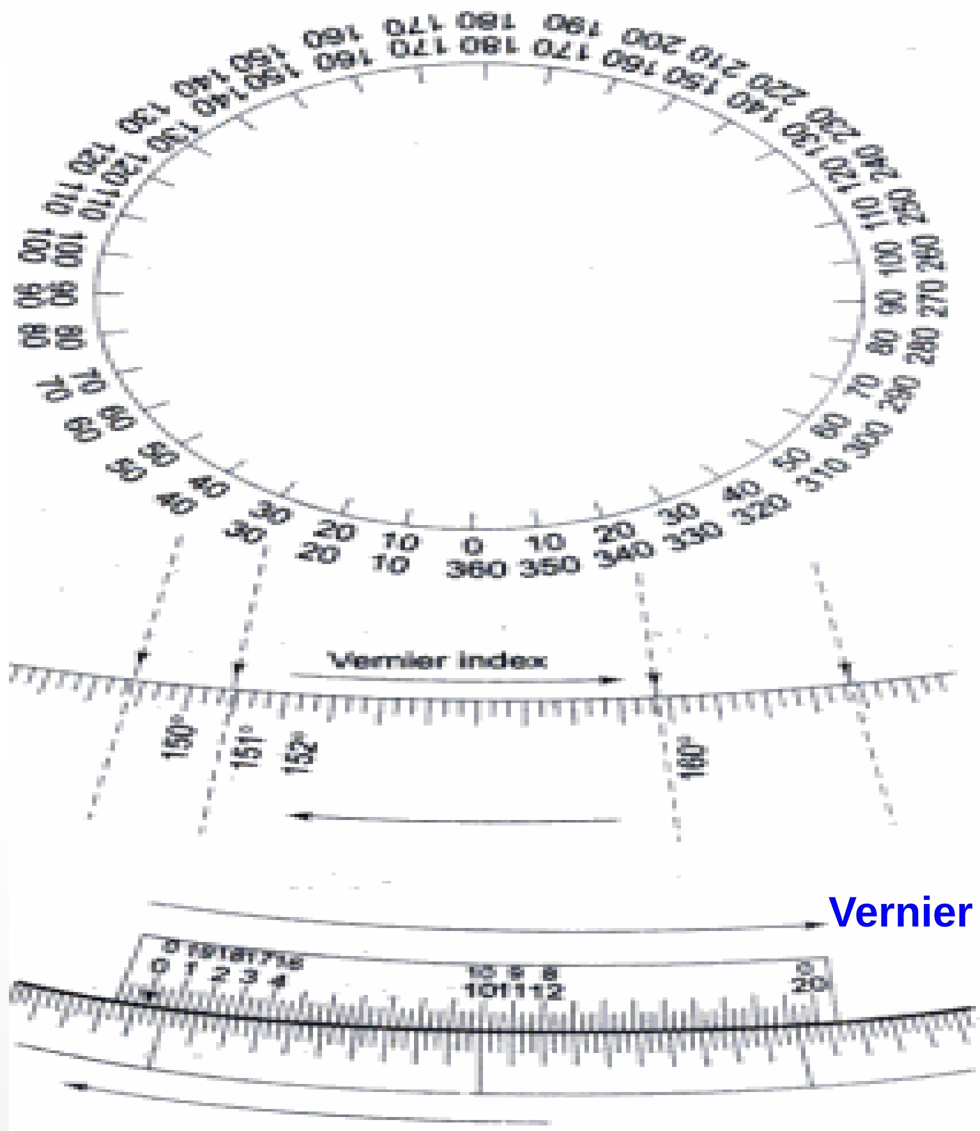


TRANSIT VERNIER THEODOLITE



TRANSIT VERNIER THEODOLITE

Reading a Theodolite



Vernier scale graduation

THEODOLITE TRAVERSING

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.

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.

THEODOLITE TRAVERSING

TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE

3. 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.

4. 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.

THEODOLITE TRAVERSING

TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE

5. 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.

6. Changing Face

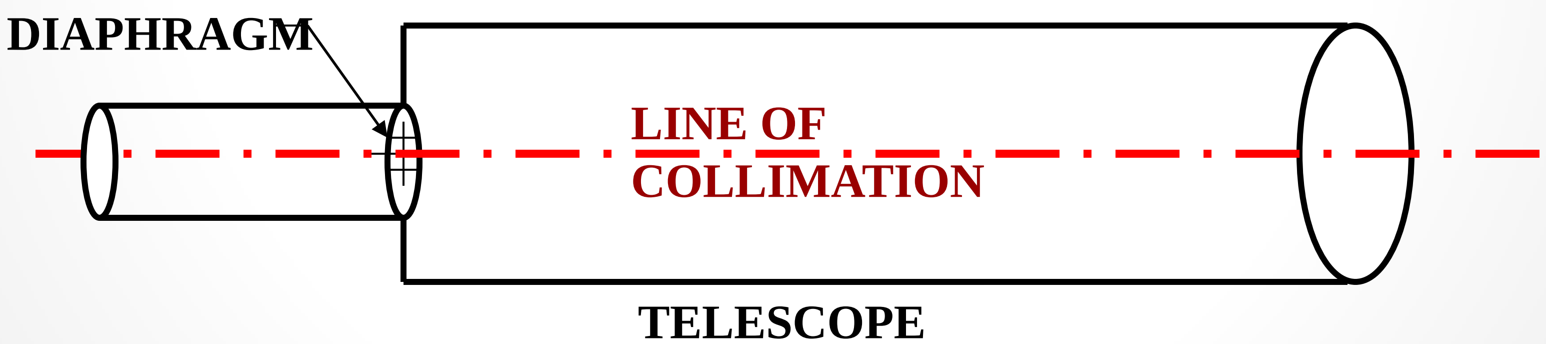
- It is the operation of bringing the vertical circle to the right of the observer ,if originally it is to the left , and vice – versa.
- It is done in two steps; Firstly revolve the telescope through 180^0 in a vertical plane and then rotate it through 180^0 in the horizontal plane i.e first transit the telescope and then swing it through 180^0.

THEODOLITE TRAVERSING

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.

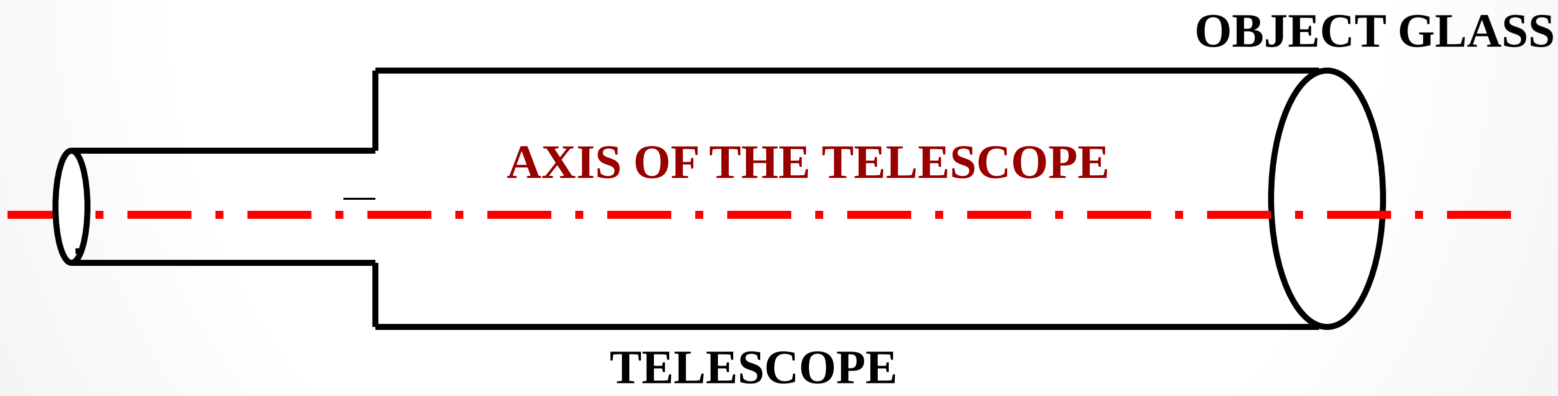


THEODOLITE TRAVERSING

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.



THEODOLITE TRAVERSING

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.

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.

THEODOLITE TRAVERSING

ADJUSTMENT OF A THEODOLITE

- The adjustments of a theodolite are of two kinds :-
    1. Temporary Adjustments.
    2. Permanent Adjustments.
- The Temporary adjustments , which have to be made at every setup of the instrument and preparatory to taking observations with the instrument.
- 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.

THEODOLITE TRAVERSING

ADJUSTMENT OF A THEODOLITE

1. 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) **Setting up the theodolite over the station**

a) Centering **b)** Approx. Levelling it by legs

ii) **Levelling.**

Accurately levelled by leveling or foot Screws

iii) **Focusing.**

For Elimination of Parallax

a) Focusing the Eye Piece **b)** Focusing the Objective

THEODOLITE TRAVERSING

ADJUSTMENT OF A THEODOLITE

2) 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.

THEODOLITE TRAVERSING

MEASUREMENT OF ANGLES

MEASUREMENT OF HORIZONTAL ANGLES:

- There are three methods of measuring horizontal angles:-

    i) Ordinary Method.

    ii) Repetition Method.

    iii) Reiteration Method.

THEODOLITE TRAVERSING

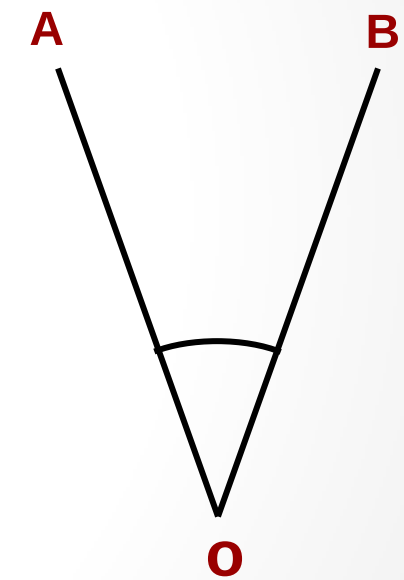
MEASUREMENT OF HORIZONTAL ANGLES:

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 point 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

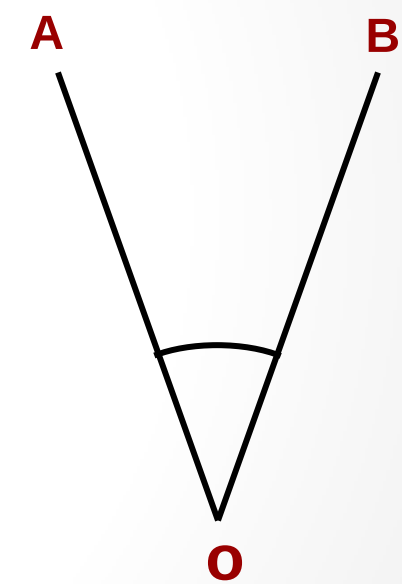
THEODOLITE TRAVERSING

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

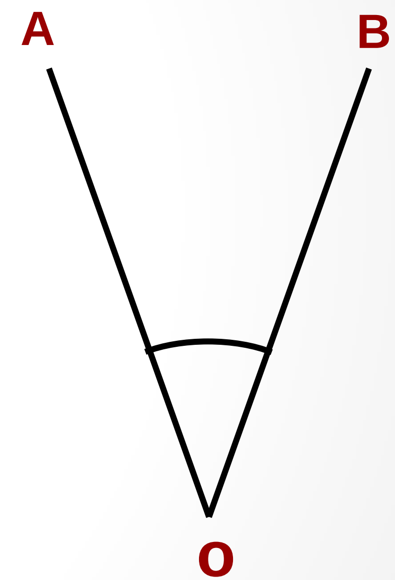
THEODOLITE TRAVERSING

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.



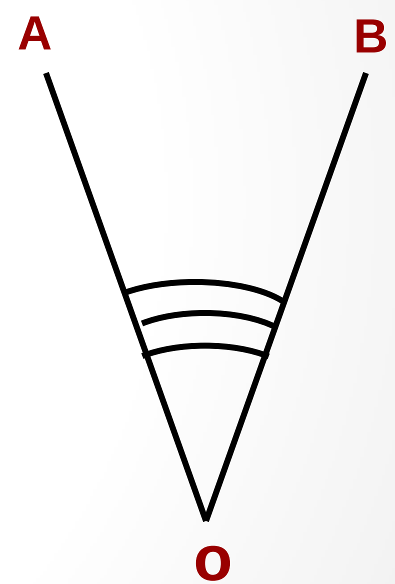
HORIZONTAL ANGLE AOB

THEODOLITE TRAVERSING

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

THEODOLITE TRAVERSING

MEASUREMENT OF HORIZONTAL ANGLES:

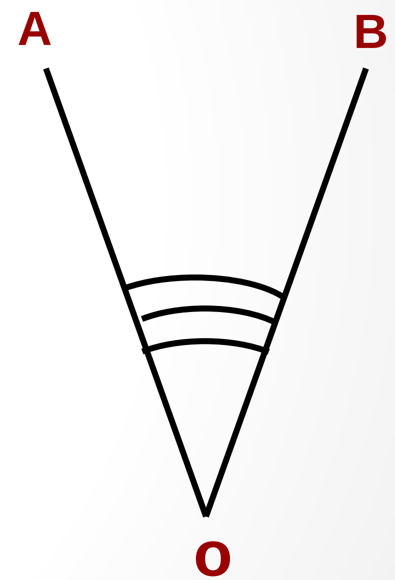
ii) Repetition Method.

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

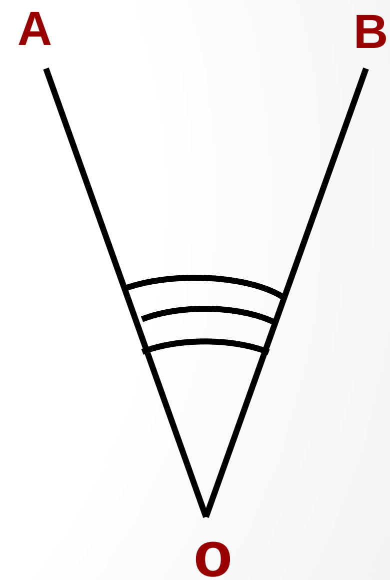
THEODOLITE TRAVERSING

MEASUREMENT OF HORIZONTAL ANGLES:

ii) Repetition Method.

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.



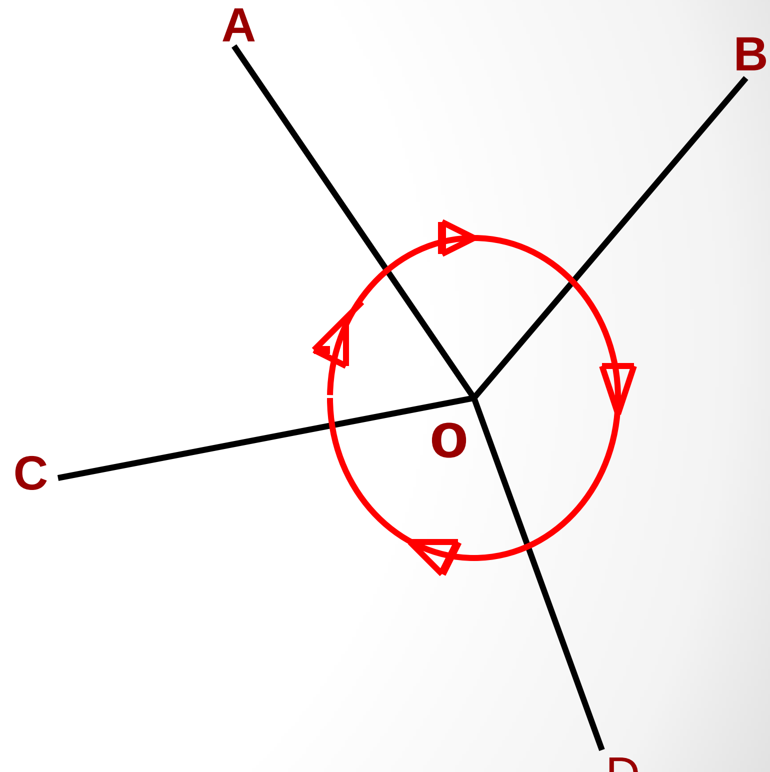
HORIZONTAL ANGLE AOB

THEODOLITE TRAVERSING

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

THEODOLITE TRAVERSING

MEASUREMENT OF HORIZONTAL ANGLES:

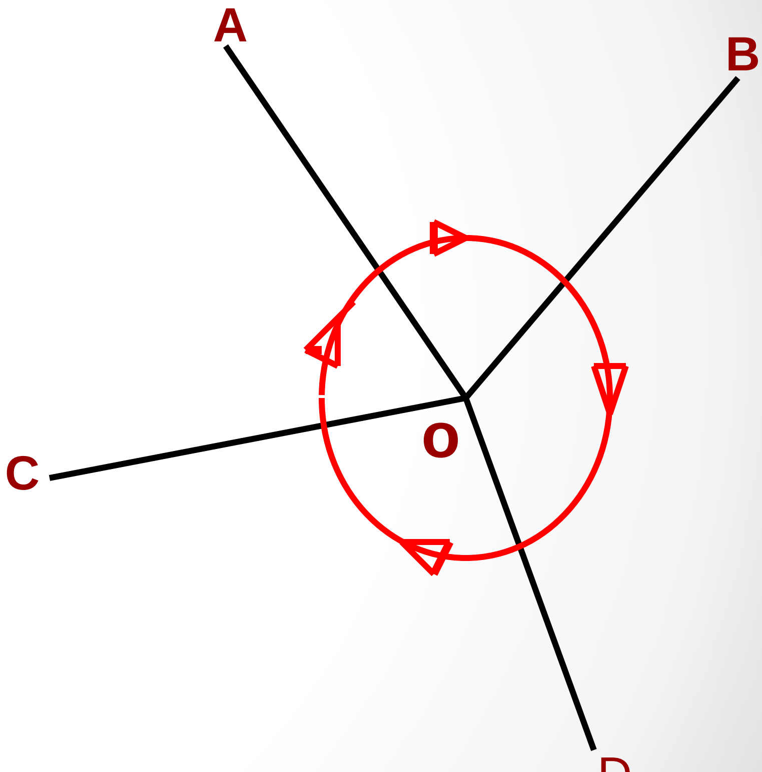
iii) Reiteration Method.

- ...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

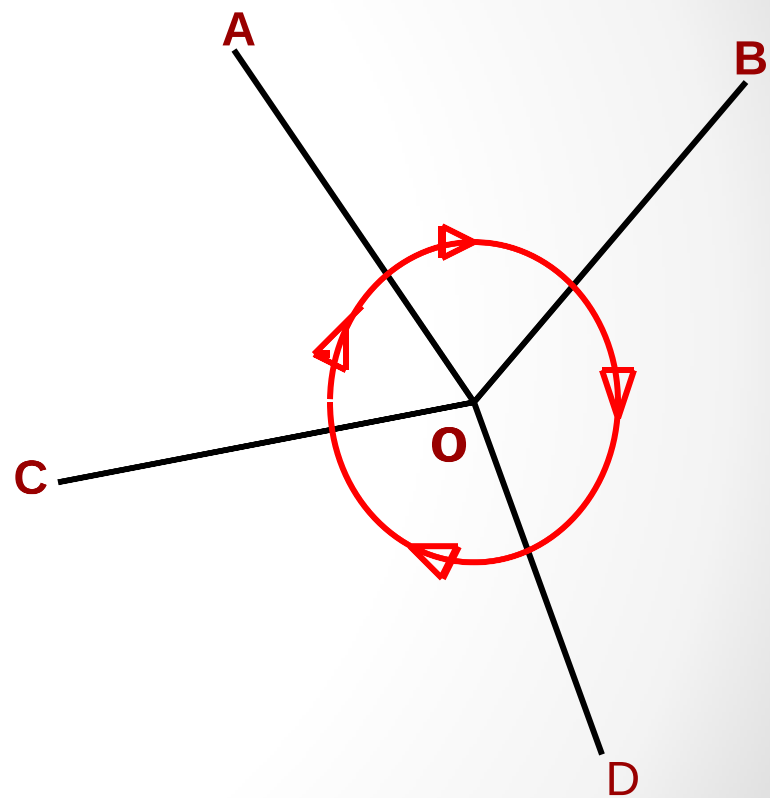
THEODOLITE TRAVERSING

MEASUREMENT OF HORIZONTAL ANGLES:

iii) Reiteration Method.

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 3600 . 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 each bisection, find the value of the angle BOC and COD.



Reiteration Method

THEODOLITE TRAVERSING

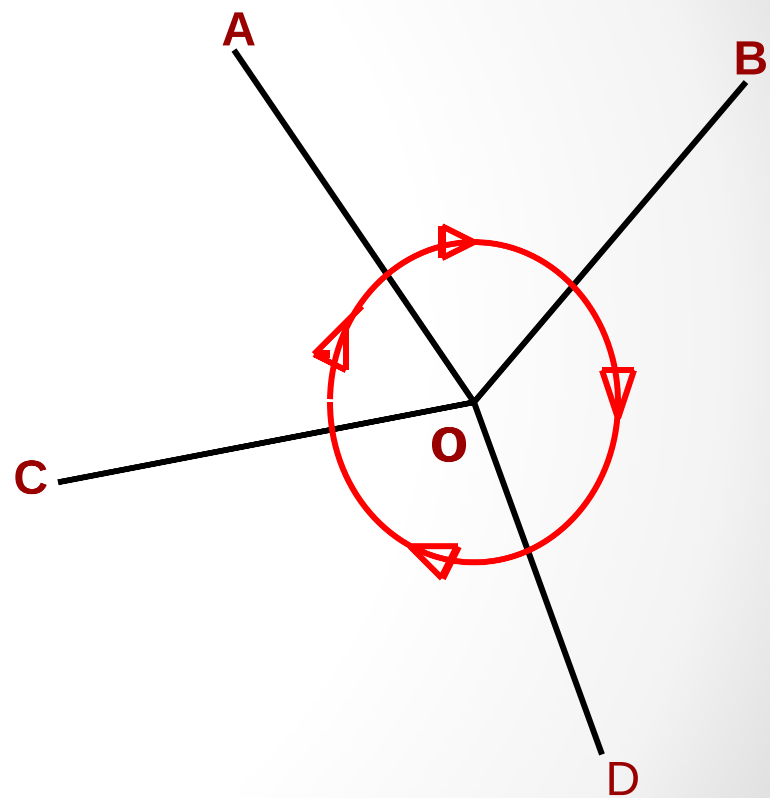
MEASUREMENT OF HORIZONTAL ANGLES:

iii) Reiteration Method.

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

v) The vernier A should now read 3600. 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.

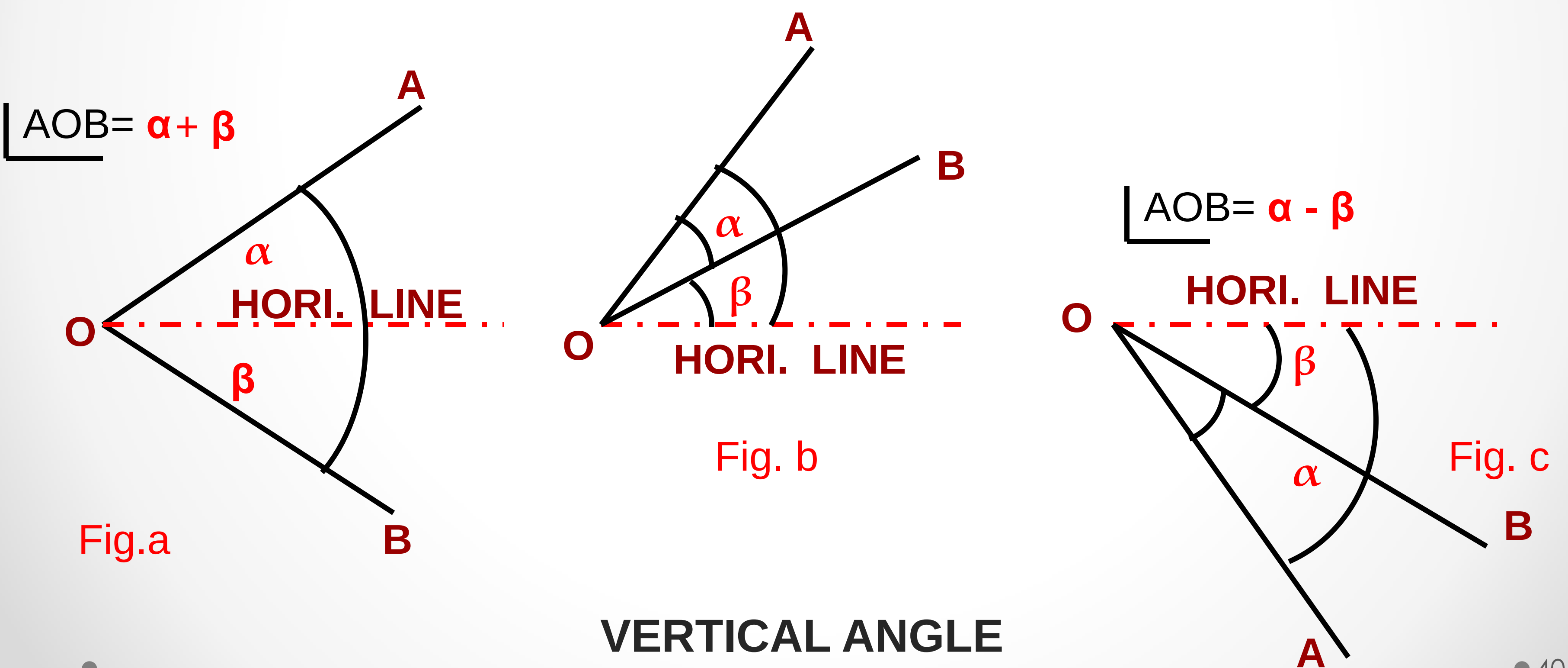


Reiteration Method

THEODOLITE TRAVERSING

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

THEODOLITE TRAVERSING

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.

THEODOLITE TRAVERSING

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 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.

THEODOLITE TRAVERSING

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.

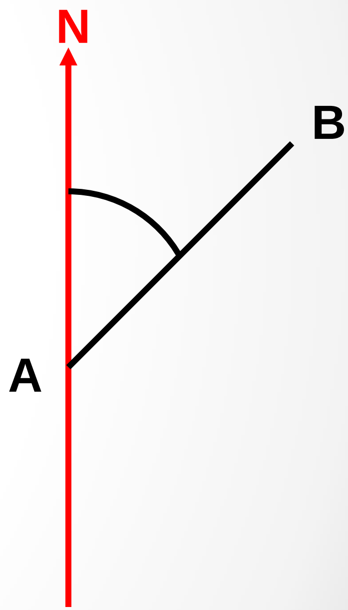


Fig.

Magnetic Bearing of a Line

THEODOLITE TRAVERSING

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.

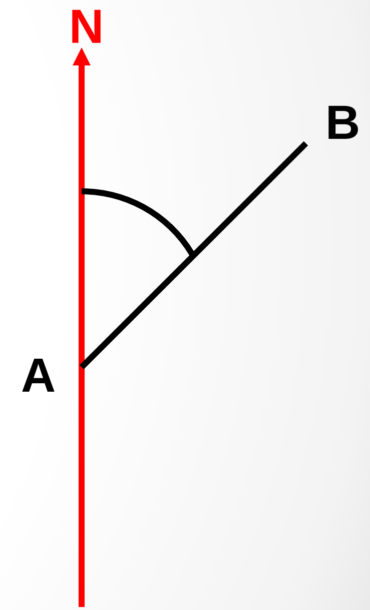


Fig.

Magnetic Bearing of a Line

THEODOLITE TRAVERSING

- Prolonging a Straight
- To Measure Direct Angle
- To Measure Deflection Angle
- Balancing In
- Random Line
- Intersection of two Straight Lines
- To Lay off Horizontal Angle

Read

THEODOLITE TRAVERSING

Traverse Survey with Theodolite

In Theodolite Traversing, the field work consisting of :

- Reconnaissance.
- Selection , Marking and Referencing of station.
- Running of survey lines.
- Picking up of details.
- Booking of field notes.

In Traverse surveying , the direction of survey line are fixed by angular measurements and not by forming network of triangles as done in chain surveying.

A traverse survey is one in which framework consist of a series of connected lines, the length and directions of which are measured with a chain or tape and angular instruments respectively.

THEODOLITE TRAVERSING

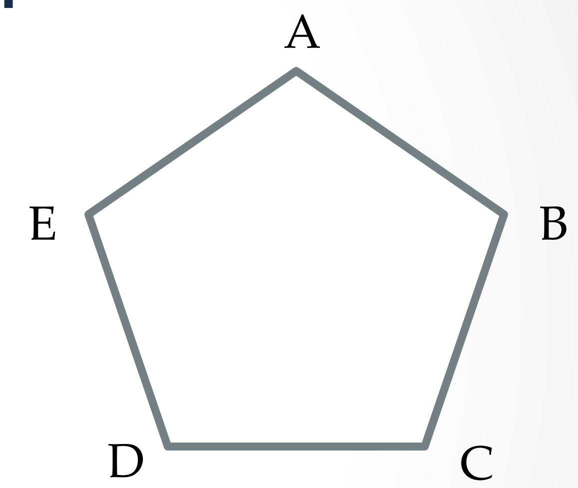
Traverse Survey with Theodolite

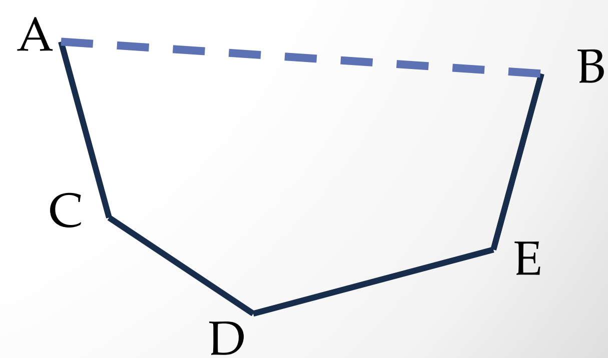
- There are generally two types of Traverse:

1) Closed traverse **2) Open traverse**

1) Closed traverse

- A traverse is said to be closed when a complete circuit is made i.e when it returns to the starting point forming a closed polygon OR when it begins and ends at points whose positions on plan are known.
- The work may be checked or "balanced".
- Suitable for locating bounders of lakes, woods etc and for the survey of moderately large area.





THEODOLITE TRAVERSING

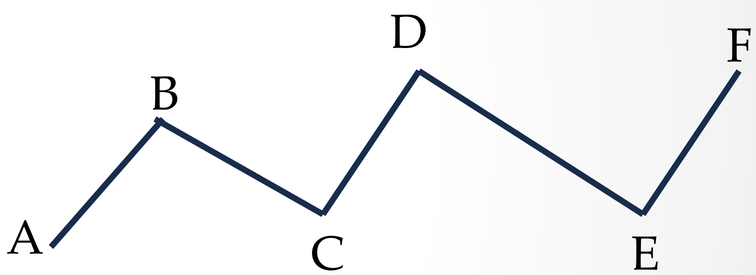
Traverse Survey with Theodolite

- There are generally two types of Traverse:

  1) Closed Traverse 2) Open Traverse

2) Open Traverse

- A traverse is said to be open or unclosed when it does not form a closed polygon.
- It consist of connecting lines extending in the same general direction and not returning to the starting point.
- Similarly it does not start and end as points whose positions on plan are known.
- It is suitable for the survey of long narrow strip eg River, coast line, road, railway etc.



THEODOLITE TRAVERSING

Methods of Measuring Traverse angles and Direction

- The methods by which the relative directions of lines of a traverse may be determined are:

  A) By the measurement of angles between successive lines

  - It is used for long traversing or where greater precision is required.

  B) By the direct observation of bearings of the lines.

  - It is used for short traversing or where greater precision is not required and for topographical survey.

THEODOLITE TRAVERSING

Methods of Measuring Traverse angles and Direction

A) Direct Observation of Angles

- The angles between successive lines are measured and the bearing of initial line is observed. The bearing of remaining lines are then calculated from he observed bearing and the measured angles.

- The angles measured at the different stations may be
  1) Included angles
  2) Direct angles or angles to the right
  3) Deflection angles

THEODOLITE TRAVERSING

Methods of Measuring Traverse angles and Direction

A) Direct Observation of Angles

1) Traversing by the Method of Included angles

- It is chiefly used inland surveying and where grater accuracy is required. In this method the bearing of initial line and the included angles of a traverse are measured.
- In closed traverse the angles measured or either interior angle or exterior according as the traverse is run in CCW direction as shown in fig 1 OR in a CW direction as shown in fig 2.
- It is customary to run a closed traverse in CCW direction.

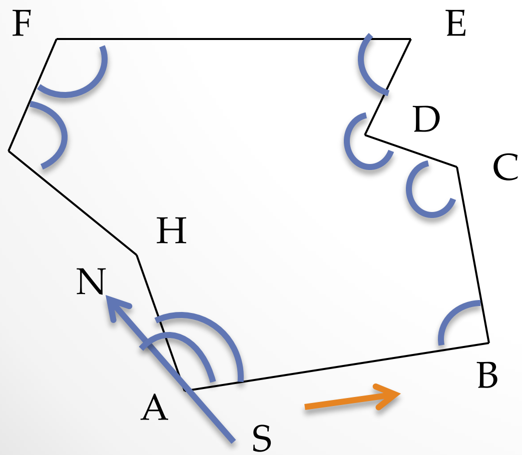


Fig 1

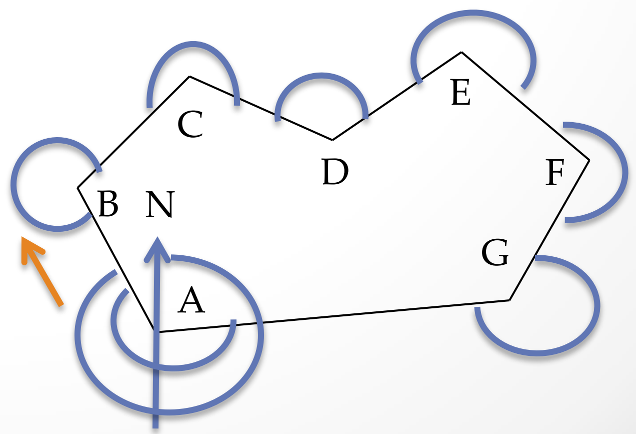


Fig 2

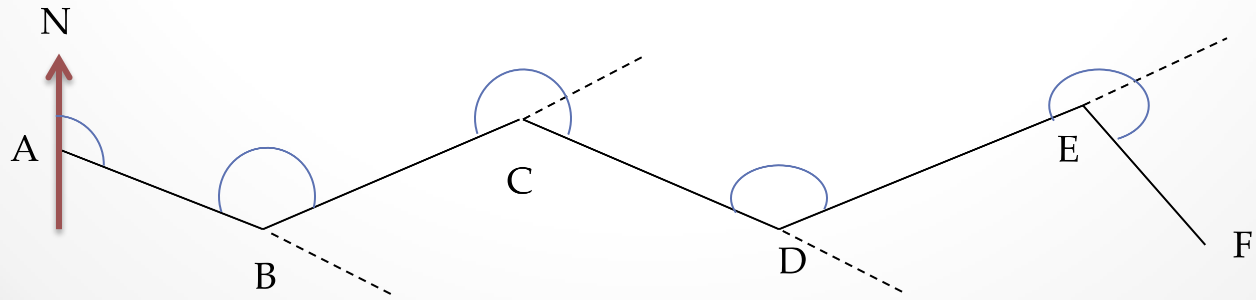
THEODOLITE TRAVERSING

Methods of Measuring Traverse angles and Direction

A) Direct Observation of Angles

2) Traversing by the Method of Direct angles

- This method is mostly used in open traverse. To run an open traverse as shown in fig, the theodolite is set up at the starting station A and bearing of line AB is observed. The theodolite is shifted to B. with vernier at A is zero, a backsight is taken on the preceding station A and a foresight is taken on the following station C. the other angles are measured in a like manner.
- **Direct angles-** angles measured CW from preceding line to the following line are called Direct Angles or Angle to the sight. It may vary from 0 to 360°.



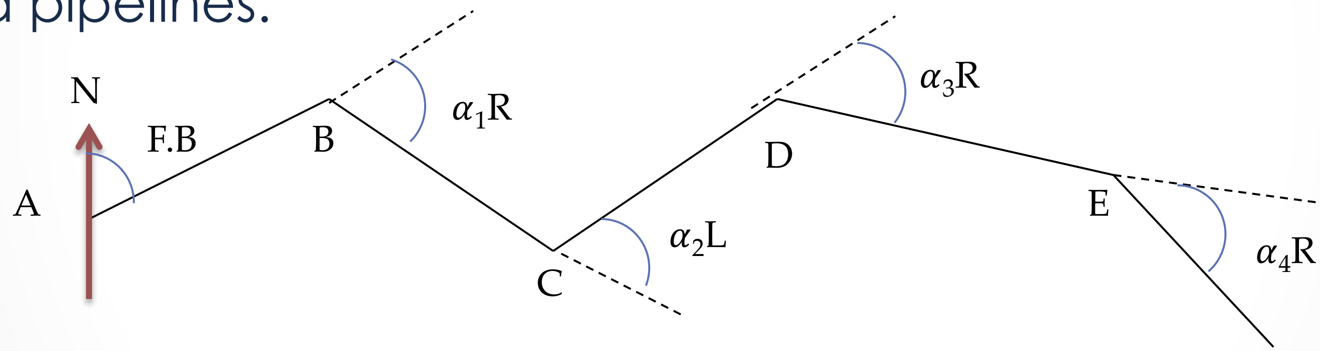
THEODOLITE TRAVERSING

Methods of Measuring Traverse angles and Direction

A) Direct Observation of Angles

3) Traversing by the Method of Deflection angles

- This method id chiefly employed on open traverse. This method is commonly used in railway, highway works, canals and pipelines.



- **Deflection angle-** An angle which a survey line makes with the prolongation of preceding line and is equal to the difference between the included angle and 180°. It may vary from 0° to 180° but is usually employed for angles less than 90°. Deflections are designated as Right (R) or Left (L) according to as they are measured to the right or left from the prolongation of the preceding line.

THEODOLITE TRAVERSING

Methods of Measuring Traverse angles and Direction

B) By Direct Observation of Bearings

Traversing by Fast Needle method

There are three methods of observing bearings directly in the field

1) Direct method in which the telescope is transited
2) Direct method in which the telescope is Not transited
3) Back bearing method

Assignment

THEODOLITE TRAVERSING

Checks in Closed Traverse

1) Check on Angular Measurement

A)Traverse by Included angles:

a) The sum of measured interior angles should equal to (2N – 4) x right angle

b) The sum of exterior angles should be equal to (2N+4) x right angle

Where N is the number of the sides of the traverse

- Angular error of closure should not exceeds least count of the instrument x $\sqrt{N}$

B) Traverse of deflection angle:

Algebraic sum of deflection angles = 360°

- Considering right-hand deflection angles as +ve and left-hand deflection angles as –ve

C) Traverse by direct observation of bearings:

- The work is checked by comparing fore bearing of last line with its back bearing observed at the initial station.

(B.B)any line – (F.B)same line = 180°

THEODOLITE TRAVERSING

Checks in Closed Traverse

2) Check on Linear Measurement

- Each line should be measured twice with same accuracy and on different days and in opposite direction.

- The sum of northing(distances measured north) should be equal to the sum of southing (distances measured south).

$$\sum N = \sum S$$

- Similarly the sum of easting should be equal to the sum of westings

$$\sum E = \sum W$$

THEODOLITE TRAVERSING

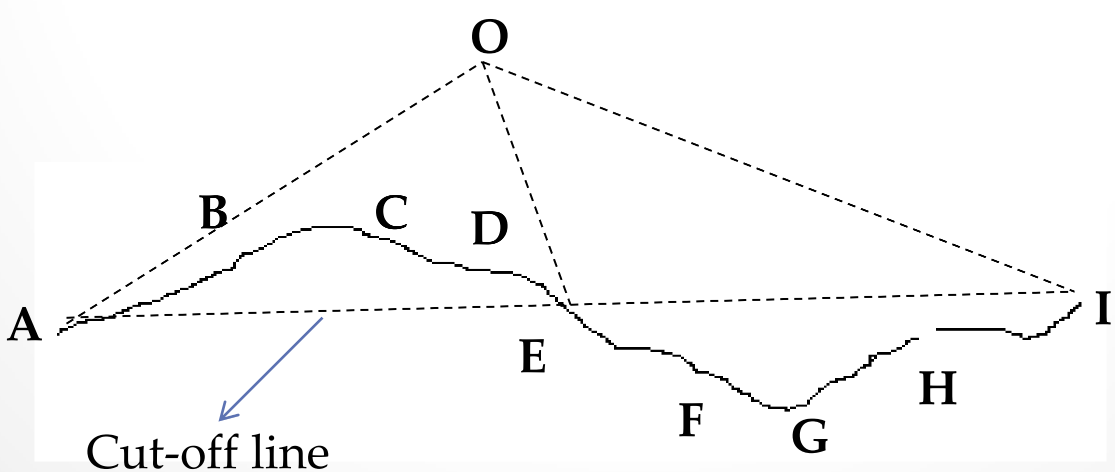
Checks in Open Traverse

In open traverse the measurement as a whole cannot be checked however the field measurement can be checked approximately.

a)By astronomical observation for azimuth at regular interval during progress of work.

b) By Cut-off lines between certain intermediate stations

c) By observing the bearing of a well defined permanent object at regular interval.



THEODOLITE TRAVERSING

Calculations of Bearing from Angles

a) Included Angles

A traverse run by the method of included angles , the W.C.B of the initial lines is observed C.W and various included angles between the successive lines are measured C.W. The Angles measured can be exterior or Interior angles.

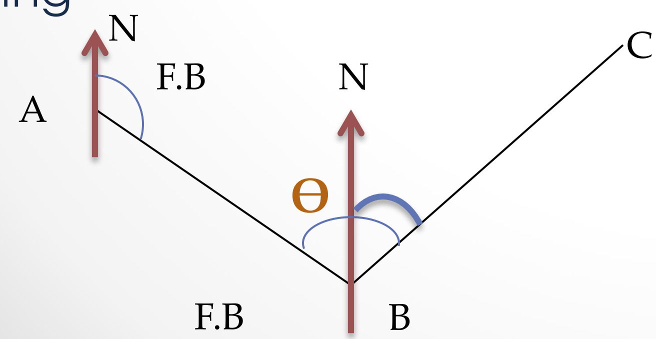
In general

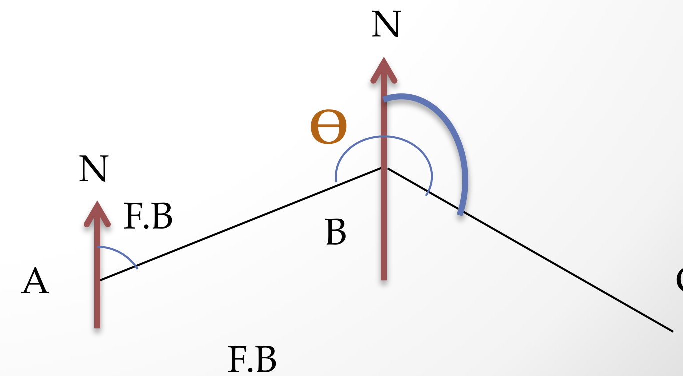
(F.Baearing)any line = (F.Bearing) previous line + Included angle $\mp 180^{\circ}$

In some cases the sum of the bearing and included angle is greater than 360°, in such case subtract from 180°. The result as usual greater than ?

Check of calculation work:

Calculated bearing of the initial line should be equal to its observed bearing





THEODOLITE TRAVERSING

Calculations of Bearing from Angles

a) Included Angles

Example 1: following are interior angles of closed traverse ABCDE

LA, 87°50'20" LB, 114°55'40" LC, 94°38'50" LD, 129°40'40"

LE, 112°54'30" . The observed bearing of AB is 221°18'40", calculate the bearing of reaming sides of the traverse.

Solution:

Bearing of AB = 221°18'40"

Add LB = 114°55'40"

=336°14'20"

Minus =180°0'0"

Bearing of BC = 156°14'20"

Add LC = 94°38'50"

=250°53'10"

Minus =180°0'0"

Bearing of CD =70°53'10"

Add LD = 129°40'40"

=200°33'50"

Minus =180°0'0"

Bearing of DE = 20°33'50"

Add LE = 112°54'30"

=133°28'20"

Add =180°0'0"

Bearing of EA =313°28'20"

Add LA = 87°50'20"

=401°18'40"

Minus =180°0'0"

Bearing AB = 221°18'40"

THEODOLITE TRAVERSING

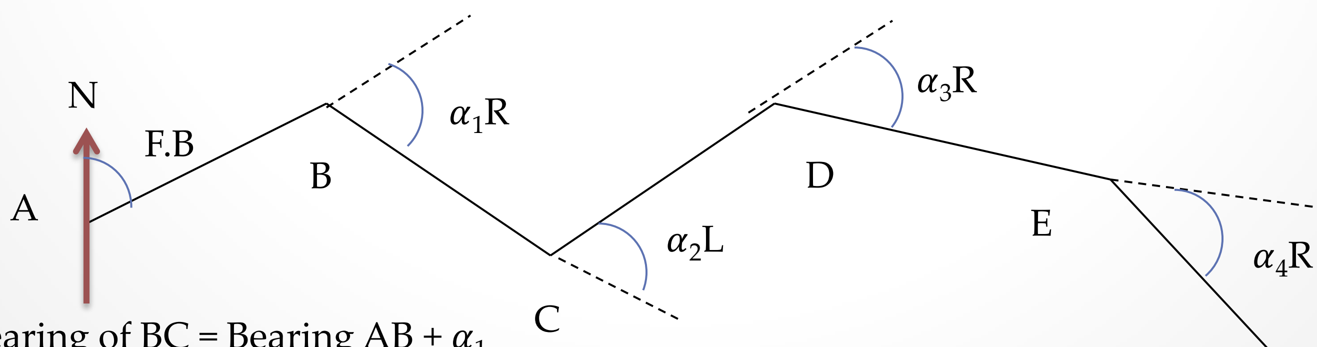
Calculations of Bearing from Angles

b) Deflection Angles:

- From the W.C.B of initial line and the deflection angles , the W.C.B of the remaining lines of the traverse can calculated as follows:

(W.C.B)any line = (W.C.B) preceding line $\mp$ d

- Where d is deflection angle
- +ve when deflection angle is C.W and –ve when C.C.W.
- Add 360° if result is –ve and subtract 360° if it is greater than 360°



Bearing of BC = Bearing AB + α_1
Bearing of CD = Bearing BC - α_2

THEODOLITE TRAVERSING

Calculations of Bearing from Angles

b) Deflection Angles:

Check on calculation work:

- Considering the right-hand deflection angles as +ve and left-hand deflection angles as –ve, the computation can be checked as

Bearing of last line = F.B of initial line + sum of +ve d.angles – sum of –ve d.angles

THEODOLITE TRAVERSING

Calculations of Bearing from Angles

Assignment

a) Included Angles

Example 2 and 3 Page 230,231

b) Deflection Angles

Example 1 and 2 page 232,233

THEODOLITE TRAVERSING

Calculations of deflection Angles from Included Angles

- The deflection angles may be calculated from the included angles measured C.W from back station by following rules:

a) If the included angle is greater than 180°, the deflection angle is right-hand or positive and is given by

$$d = \theta - 180^\circ$$

b) If the included angle is less than 180o, the deflection angle is left-hand or negative and is given by

$$d = 180^\circ - \theta$$

Check:

The algebraic sum of the deflection angles of a closed traverse must be equal to 360°, considering right-hand deflections as +ve and left-hand as -ve.

$$\text{E right d.angles} - \text{E left d.angles} = 360^\circ$$

THEODOLITE TRAVERSING

Calculations of deflection Angles from Included Angles

Assignment

- Example 3, 4 and 5.

THEODOLITE TRAVERSING

Traverse Computations

- Knowing the length and bearing of a line, its projections on the parallel to the meridian and on the line perpendicular to it may be obtained.
- These projections are called latitude and departure of the line respectively.

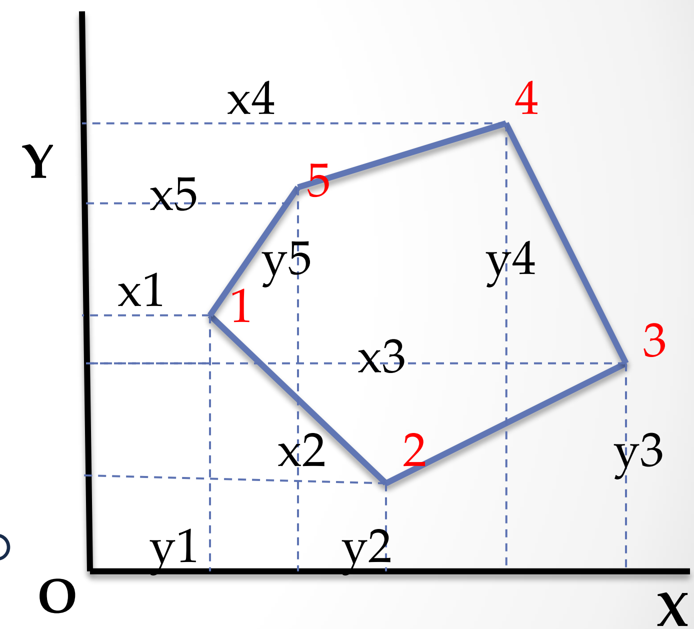
- **The Latitude of a line** , the distance measured parallel to the meridian (N-S Line)
- **The Departure of a line**, the distance measured parallel to the line perpendicular to the meridian (E-W Line).

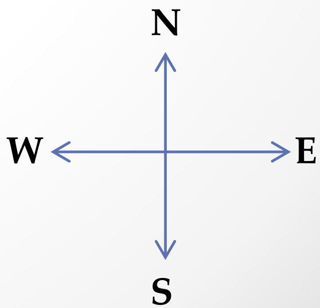
N – latitude = + L = Northing

S – Latitude = - L = Southing

E – latitude = + D = Easting

W– Latitude = - D = westing





THEODOLITE TRAVERSING

Traverse Computations

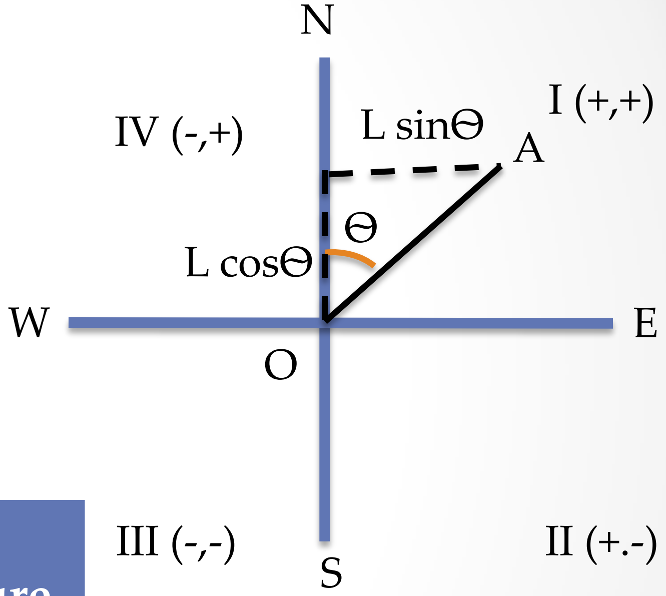
- The latitude and departure of a line can determined by:

Latitude of line = L x cos ϴ

Departure of a line = L x sin ϴ

Where L is length of the line

ϴ is reduced bearing of the line



W.C.B	Quadrant	Sign of Latitude	Sign of Departure
0^o to 90^o	I N.E	+	+
90^o to 180^o	II S.E	-	+
180^o to 270^o	III S.W	-	-
270^o to 360^o	IV N.W	+	-

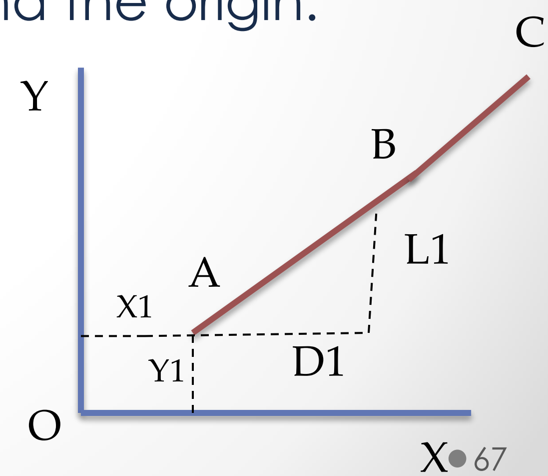
THEODOLITE TRAVERSING

Traverse Computations

- The latitude and departure of any point with reference to the preceding point is called **Consecutive Co-ordinates** of the point.
- While the co-ordinates of any point with respect to a common origin are known as **Independent Co-ordinates** of the point. These are also called Total Latitude and Total Departure.
- The independent Co-ordinates of any point or station may be obtained by adding the algebraically the latitude and departure of the lines between that point and the origin.

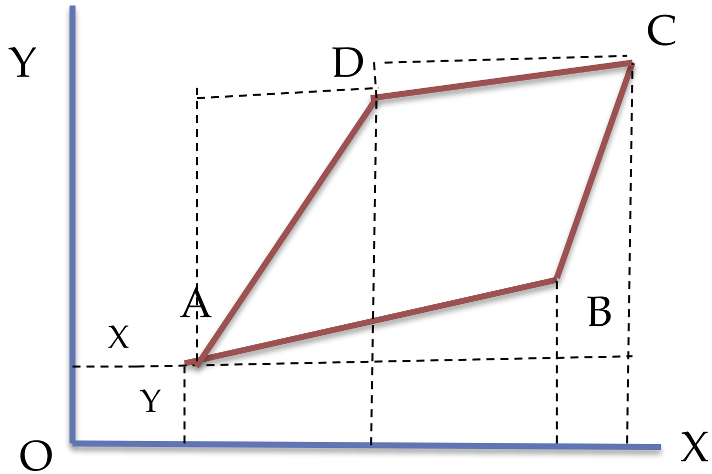
Latitude of B = latitude of A (Y_1) + L_1

Departure of B = departure of A (X_1) + D_1



THEODOLITE TRAVERSING

Traverse Computations



Total Latitude of D = latitude of A (Y) + L_{ab} + L_{bc} + L_{cd}

Total departure of D = departure of A (X)+ D_{ab} + D_{bc} + D_{cd}

- In General :
- X Co- ordinate (Total departure) of last point of the traverse **=** X co-ordinate of 1st point + algebraic sum of all departure
- Y Co- ordinate (Total latitude) of last point of the traverse **=** Y co-ordinate of 1st point + algebraic sum of all latitude

THEODOLITE TRAVERSING

Adjustment of Closed Traverse

Balancing the Traverse

- It is the operation of applying corrections to the latitude and departure.
- The total error in latitude and departure is determined , the latitude and departure are so adjusted that the algebraic sum of latitude and departure should equal to zero i.e

$$\sum L + \sum D = 0$$

$$\sum N = \sum S \quad \text{and} \quad \sum E = \sum W$$

THEODOLITE TRAVERSING

Adjustment of Closed Traverse

Balancing the Traverse

Closing Error

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

where L = latitude

and D = departure

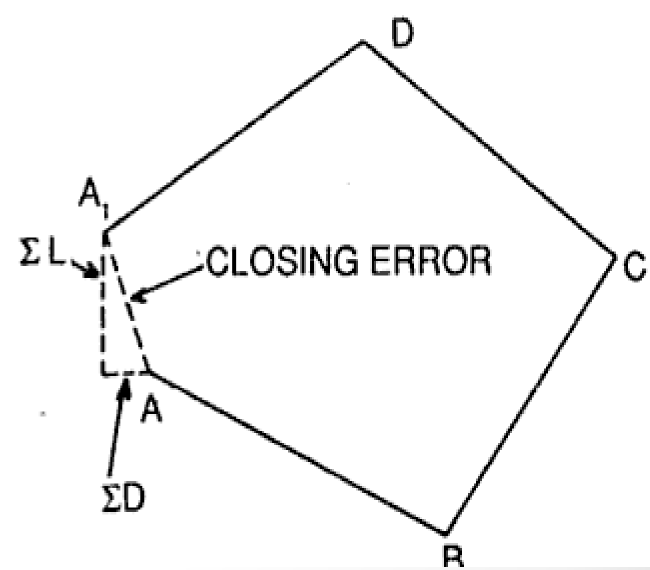
$$\text{Relative closing error} = \frac{\text{closing error}}{\text{perimeter of traverse}}$$

$$\text{Permissible angular error} = \text{least count} \times \sqrt{N}$$

where N = number of sides

$$\tan\theta = \frac{\Sigma D}{\Sigma L}$$

where θ indicates the direction of closing error.



THEODOLITE TRAVERSING

Adjustment of Closed Traverse

Balancing the Traverse

- The following rules may be used to determined the corrections to balance the traverse.
  - A) Bowditch's Rule
  - B) Transit Rule

A) Bowditch's Rule:

- This rule is also term as compass rule, is used to balance traverse when the angular and linear measurement are equally precise.
- By this rule the total error in latitude and in departure is distributed in proportion to the lengths of the sides.

Correction in latitude or departure of any side = Total error in Latitude or departure X

$$\text{Correction in latitude or departure of any side} = \text{Total error in Latitude or departure} \times \left\{ \frac{\text{length of that side}}{\text{Perimeter of Traverse}} \right\}$$

THEODOLITE TRAVERSING

Adjustment of Closed Traverse

Balancing the Traverse

B) Transit Rule:

- The transit rule may be used to balance the traverse when the angular measurement are more precise that the linear measurement.

$$\text{Correction to latitude of any side} = \text{Total error in Latitude or departure} \times \left\{ \frac{\text{latitude of that side}}{\text{Arithmetical sum of all latitude}} \right\}$$

$$\text{Correction to departure of any side} = \text{Total error in departure or departure} \times \left\{ \frac{\text{departure of that side}}{\text{Arithmetical sum of all departure}} \right\}$$

THEODOLITE TRAVERSING

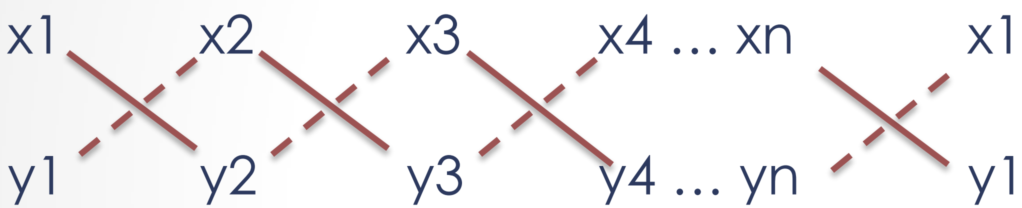
Computation of Area of a closed Traverse

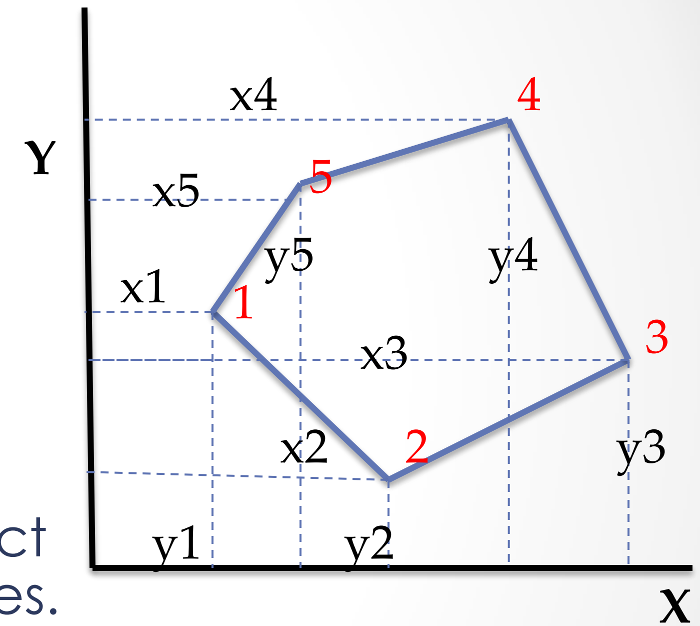
1) Area from Co-ordinates
2) Area from Latitudes and Double Meridian Distance
3) Area Departure and Total Latitudes

THEODOLITE TRAVERSING

Computation of Area of a closed Traverse

1) Area from Co-ordinates





- Find sum of the product of co-ordinates joined By full lines and sum of the product of the co-ordinates joined by broken lines.
- Find their difference , which will give twice the area of traverse.
- Half this difference gives the required area.

THEODOLITE TRAVERSING

Computation of Area of a closed Traverse

Area from Co-ordinates

Example: the folioing tables gives latitude and departure of sides of closed traverse ABCD. Compute Area.

Solution:

Side	Latitude (m)	Departure (m)	Station	Independent Co-ordinates	
				North	Last
AB	+214.8	+124.0	A	200.0	100.0
BC	- 245.4	+205.7	B	414.8	224.0
CD	- 155.9	-90.0	C	169.7	429.7
DA	+186.2	-239.7	D	13.8	339.7
			A	200.0	100.0

THEODOLITE TRAVERSING

Computation of Area of a closed Traverse

Area from Co-ordinates

Example: the folioing tables gives latitude and departure of sides of closed traverse ABCD. Compute Area.

Solution:

200.0	414.8	169.7	13.8	200.0
100.0	224.0	429.7	339.7	100.0

EP = (200.0x 224.0) + (414.8 x 429.7) + (169.7 x 339.7)+ (13.8x100.0)

EQ = (100.0 x 414.8) + (224.0 x 169.7) + (429.7 x 13.8) + (339.7 x 200.0)

Twice area = EP – EQ

2A = 282066.45 – 153362.64

2A=128703.84

A = 64,351.91 sq.m

THEODOLITE TRAVERSING

Assignment

Traversing by Fast Needle method

Calculations of Bearing from Angles

a) Included Angles

Example 2 and 3, Page 230,231

b) Deflection Angles

Example 1 and 2, Page 232,233

Calculations of deflection Angles from Included Angles

Example 3, 4 and 5, Page 234