Catalog

## 1.1 INTRODUCTION

### Surveying

Surveying can be defined as an art to determine the relative position of points on above are beneath the surface of the earth with respect to each other by measurement of horizontal and vertical distances, angles and directions.

**State the principles of Surveying**

Surveying is

Location of a point by measurement from other points of reference and

Working from whole to part.

**PRINCIPLE OF WORKING FROM WHOLE TO PART**

- It is a fundamental rule to always work from the whole to the part. This implies a precise control surveying as the first consideration followed by subsidiary detail surveying.
- This surveying principle involves laying down an overall system of stations whose positions are fixed to a fairly high degree of accuracy as control, and then the survey of details between the control points may be added on the frame by less elaborate methods.



- Once the overall size has been determined, the smaller areas can be surveyed in the knowledge that they must (and will if care is taken) put into the confines of the main overall frame.

- Errors which may inevitably arise are then contained within the framework of the control points and can be adjusted to it.

(a) Working from the whole to the part is achieved by covering the area to be surveyed with a number of spaced out control point called primary control points called primary control points whose pointing have been determined with a high level of precision using sophisticated equipment's. Based on these points as theoretic, a number of large triangles are drawn. Secondary control points are then established to fill the gaps with lesser precision than the primary control points. At a more detailed and less precise level, tertiary control points at closer intervals are finally established to fill in the smaller gaps. The main purpose of surveying from the whole to the part is to localize the errors as working the other way round would magnify the errors and introduce distortions in the survey. In partial terms, this principle involved covering the area to be surveyed with large triangles. These are further divided into smaller triangles and the process continues until the area has been sufficiently covered with small triangles toa level that allows detailed surveys to be made in a local level. Error is in the whole operation as the vertices of the large triangles are fixed using higher precision instruments.

**(b) Location of a point by measurement from other points of reference**

Using measurements from two control parts to fix other points. Given two points whose length and bearings have been accurately determined, a line can be drawn to join them hence surveying has control reference points. The locations of various other points and the lines joining them can be fixed by measurements made from these two points and the lines joining them. For an example, if A and B are the control points, the following operations can be performed to fix other points.



i) Using points A and B as the centers, ascribe arcs and fix (where they intersect).

ii) Draw a perpendicular from D along AB to a point C. To locate C, measure distance AB and use your protractor to equally measure angle ABC.

iii) To locate C the interior angles of triangle ABC can be measured. The lengths of the sides AC and BC can be calculated by solving the triangle.

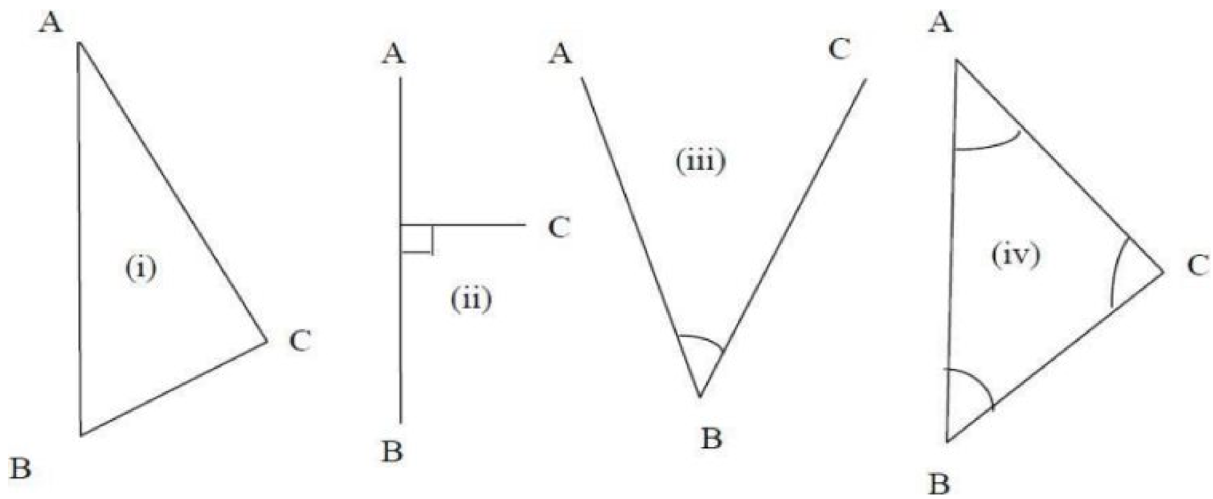



*Fig. .1: Fixing the third points using two points (https://civilengineeringwrld.blogspot.com/2020/10/engineering-survey-2-topics-principles.html?m=1)*

**steps involved in the survey**

Steps to be followed during survey are,



(i) Reconnaissance.

(ii) Marking and fixing survey stations.

(iii) Running survey lines.

**Engineer's scale**

If one cm on the plan represents some whole number of meters on the ground, suchas 1cm = 10m. This type of scale is called Engineer's scale.

**Representative Fraction (R.F).**

If, one unit of length on the plan represents some number of same units of length on the ground, such as 1/1000, etc. This ratio of map distance to the corresponding ground distance is independent of units of measurement and is called Representative Fraction

**Points to be considered while choosing the scale**

1. Choose a scale Large enough so that in plotting or in scaling distance from the finished map, it will be not be necessary to read the scale closer than 0.25mm
2. Choose as small a scale as a consisted with a clear delineation of the smallest detail to be plotted.

**Types of Scales**

Scales used in surveying are

(i) Plain scale.
(ii) Diagonal scale.
(iii) Vernier scale.
(iv) Scale of chords.

## 1.2 Chain Surveying

It is the branch of surveying in which the distances are measured with a chain and tape and the operation is called chaining.

Main station:

Main station is a point in chain survey where the two sides of a traverse are meet. These stations command the boundaries of the survey and are designated by capital letters.

Tie Station (or) Sub Station: -

It is a station on a survey line jointing two main stations. These are helpful for locating interior details of the area to be surveyed and are designated by small letters.

Main survey line:

The chain line joining two main survey stations is called main survey line tie line or Sub line.



A chain line journey two tie station is called sub line. These are provided to locate the interior details.

Base line:-

It is longest main survey line on a fairly level ground and passing through the centerof the area. It is the most importing line as the direction of all other survey line of fixedwith respect to this line.

Check line: - Check line (or) Proof line is a line which is provided to check the accuracy of the field work.

Off set: - It is distance of the object from the survey line. It may be perpendicular (or) oblique.

Chain age: - It is the distance of a well-defined point from the starting point in chain survey it's normally referred to as it the distance of offset from the starting point on the chain age or chain line.

A, B, C, D, E is main station or boundary station

AD = Check line.

BE = Base line

CP = Distance of offset

BP = Chain aged CP

BD = Chain age at D A, B, BC = Tie line.

**CHAIN SURVEYING**

This is the simplest and oldest form of land surveying of an area using linear

## 1. EQUIPMENTS USED IN CHAIN SURVEYING

These equipment's can be divided into three, namely

(i) Those used for linear measurement. (Chain, steel band, linear tape)



(ii) Those used for slope angle measurement and for measuring right angle (Eg.Abney level, clinometer, cross staff, optical squares)

(iii) Other items (Ranging rods or poles, arrows, pegs etc).

**1. Chain:-**

The chain is usually made of steel wire, and consists of long links joined by shorter links. It is designed for hard usage, and is sufficiently accurate for measuring the chainlines and ffsets of small surveys.

*Fig.Chain (https://www.indiamart.com/proddetail/survey-measuring-chain-1747847655.html)*

Chains are made up of links which measure 200mm from centre to Centre of each middle connecting ring and surveying brass handless is fitted at each end. Tallymarkers made of plastic or brass are attached at every whole meter position or at each tenth link. To avoid confusion in reading, chains are marked similarly form both end (E.g. Tally for 2m and 18m is the same) so that measurements may be commenced with either end of the chain. There are three different types of chains used in taking measurement namely:



ii. Gunter's chain

iii Steel bands

**2 Steel Bands:**


This may be 30m, 50m or 100m long and 13mm wide. It has handles similar to thoseon the chain and is wound on a steel cross. It is more accurate but less robust than the chain. The operating tension and temperature for which it was graduated should be indicated on the band.



**3 Tapes:**

Tapes are used where greater accuracy of measurements are required, such as the setting out of buildings and roads. They are 15m or 30m long marked in metres, centimeter and millimeters. Tapes are classified into three types;


**i. Linen or Linen with steel wire woven into the fabric;**

These tapes are liable to stretch in use and should be frequently tested for length. They should never be used on work for which great accuracy is required.

**ii. Fibre Glass Tapes:** These are much stronger than lines and will not stretch in use.

**iii. Steel tapes:** These are much more accurate, and are usually used for setting out buildings and structural steel works. Steel tapes are available in various lengths up to 100m (20m and 30m being the most common) encased in steel or plastic boxes with a recessed winding lever or mounted on open frames with a folding winding lever.

**4. Arrows:**



Arrow consists of a piece of steel wire about 0.5m long, and is used for marking temporary stations. A piece of colored cloth, white or red ribbon is usually attached or tied to the end of the arrow to be clearly seen on the field.

**5. Pegs**

Pegs are made of wood 50mm x 50mm and some convenient length. They are used for points which are required to be permanently marked, such as intersection points of survey lines. Pegs are driven with a mallet and nails are set in the tops.

**6. Ranging Rod:**

These are poles of circular section 2m, 2.5m or 3m long, painted with characteristic red and white bands which are usually 0.5m long and tipped with a pointed steel shoe to enable them to be driven into the ground. They are used in the measurement of lines with the tape, and for marking any points which need to be seen.

**7. Optical Square:**



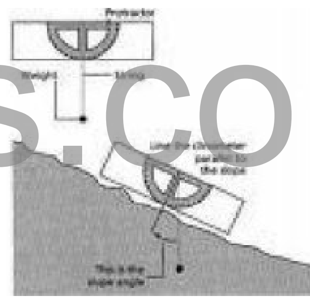
This instrument is used for setting out lines at right angle to main chain line. It is used where greater accuracy is required. There are two types of optical square, one using two mirrors and the other a prism.

- The mirror method is constructed based on the fact that a ray of light is reflected from a mirror at the same angle as that at which it strikes the mirror.
- The prism square method is a simplified form of optical square consisting of a single prism. It is used in the same way as the mirror square, but is rather more accurate.

**8 Cross Staff:**

This consists of two pairs of vanes set at right angle to each other with a wide and narrow slit in each vane. The instrument is mounted upon a pole, so that when it is set up it is at normal eye level. It is also used for setting out lines at right angle to the main chain line

**9. Clinometer**





This instrument is used for measuring angles of ground slopes (slope angle). They are of several form, the common form is the **WATKING'S CLINOMETER,** which consist of a small disc of about 60mm diameter. A weighted ring inside the disc can bemade to hang free and by sighting across this graduated ring angle of slopes can be read off. It is less accurate than abney level.

**2. Abney Level**

This instrument is generally used to obtained roughly the slope angle of the ground. It consists of a rectangular, telescopic tube (without lenses) about 125mm long with a graduated arc attached. A small bubble is fixed to the Vernier arm, once the image of the bubble is seen reflected in the eyepiece the angle of the line of sight can be readoff with the aid of the reading glass.

**Types of Surveying**

On the basis of whether the curvature of the earth is taken into account or not, surveying can be divided into two main categories:

***Plane surveying***: is the type of surveying where the mean surface of the earth is considered as a plane. All angles are considered to be plane angles. For small areas less than 250 $km^2$ plane surveying can safely be used. For most engineering projects such as canal, railway, highway, building, pipeline, etc. constructions, this type of surveying is used. It is worth noting that the difference between an arc distance of 18.5km and the subtended chord lying in the earth's surface is 7mm. Also the sum of the angles of a plane triangle and the sum of the angles in a spherical triangle differ by 1 second for a triangle on the earth's surface having an area of 196 $km^2$.



***Geodetic surveying***: is that branch of surveying, which takes into account the true shape of the earth (spheroid).

**Classification of surveying**

Introduction

For easy understanding of surveying and the various components of the subject, we need a deep understanding of the various ways of classifying it.

**Objective**

Classification on the Basis of Instruments Used.

To enable the students have understanding of the various ways of classifyingsurveying

**Classification Of Surveying**

Surveying is classified based on various criteria including the instruments used, purpose, the area surveyed and the method used.

Classification based on the surface and the area surveyed

i) Land survey

Land surveys are done for objects on the surface of the earth. It can be subdivided into:

(a) Topographic survey: This is for depicting the (hills, valleys, mountains, rivers, etc) and manmade features (roads, houses, settlements…) on the surface of the earth.

(b) Cadastral survey is used to determining property boundaries including those of fields, houses, plots of land, etc.

(c) Engineering survey is used to acquire the required data for the planning, design and Execution of engineering projects like roads, bridges, canals, dams, railways, buildings, etc.



(d) City surveys: The surveys involving the construction and development of towns including roads, drainage, water supply, sewage street network, etc, are generally referred to as city survey.

(2) Marine or Hydrographic Survey: Those are surveys of large water bodies for navigation, tidal monitoring, the construction of harbors etc.

(3) Astronomical Survey:

Astronomical survey uses the observations of the heavenly bodies (sun, moon, starsetc) to fix the absolute locations of places on the surface of the earth.

CLASSIFICATION ON THE BASIS OF PURPOSE

Control survey uses geodetic methods to establish widely spaced vertical andhorizontal control points.

i) Engineering survey
ii) Control Survey:
iii) Geological Survey

Geological survey is used to determine the structure and arrangement of rock strata. Generally, it enables to know the composition of the earth.

iv) Military or Defense Survey is carried out to map places of military and strategic importance

v) Archeological survey is carried out to discover and map ancient/relies ofantiquity.

vi) • Control surveying:

To establish horizontal and vertical positions of control points.

vii) • Land surveying:

To determine the boundaries and areas of parcels of land, also known as property survey, boundary survey or cadastral survey.



viii) • Topographic survey:

To prepare a plan/ map of a region which includes natural as well as and man-made features including elevation.

ix) • Engineering survey:

To collect requisite data for planning, design and execution of engineering projects.

Three broad steps are

x) 1) Reconnaissance survey: To explore site conditions and availability of infrastructures.

xi) 2) Preliminary survey: To collect adequate data to prepare plan/map of area to be used for planning and design.

xi) 3 ) Location survey
To set out work on the ground for actual

xiii) •Route survey:

To plan, design, and laying out of route such as highways, railways, canals, pipelines, and other linear projects. Construction surveys: Surveys which are required for establishment of points, lines, grades, and for staking out engineering works (after the plans have been prepared and the structural design has been done).

xiv) •Astronomic surveys:

To determine the latitude, longitude (of the observation station) and azimuth (of a line through observation station) from astronomical observation.

xv) •Mine surveys:

To carry out surveying specific for opencast and underground mining purposes

xvi) SPECIAL SURVEYS

SPECIAL SURVEYS are conducted for a specific purpose and with a special type of surveying equipment and methods. A brief discussion of some of the special surveys familiar to you follows.



xvii) LAND SURVEYS

(sometimes called cadastral or property surveys) are conducted to establish the exact location, boundaries, or subdivision of a tract of land in any specified area. This typeof survey requires professional registration in all states. Presently, land surveys generally consist of the following chores:

1. Establishing markers or monuments to define and thereby preserve the boundariesof land belonging to a private concern, a corporation, or the government.

2. Relocating markers or monuments legally established by original surveys. This requires examining previous survey records and retracing what was done. When some markers or monuments are missing, they are re-established following recognized procedures, using whatever information is available.

3. Rerunning old land survey lines to determine their lengths and directions. As a result of the high cost of land, old lines are re-measured to get more precise measurements.

4. Subdividing landed estates into parcels of predetermined sizes and shapes.

5. Calculating areas, distances, and directions and preparing the land map to portray the survey data so that it can be used as a permanent record.

6. Writing a technical description for deeds.

CONTROL SURVEYS provide "basic control" or horizontal and vertical positions of points to which supplementary surveys are adjusted. These types of surveys (sometimes termed and traverse stations and the elevations of bench marks. These control points are further used as References for hydrographic surveys of the coastal waters; for topographic control; and for the control of many state, city, and private surveys.

**Classification Based On Instrument Used**

i. Chain/Tape Survey: This is the simple method of taking the linear measurement using a chain or tape with no angular measurements made.



ii. Compass Survey: Here horizontal angular measurements are made using magnetic compass with the linear measurements made using the chain or tape.

iii. Plane table survey: This is a quick survey carried out in the field with the measurements and drawings made at the same time using a plane table.

iv. Leveling

This is the measurement and mapping of the relative heights of points on the earth's surface showing them in maps, plane and charts as vertical sections or with conventional symbols.

Vi. Theodolite Survey:

Theodolite survey takes vertical and horizontal angles in order to establish controls

**Classification based on object:**

Based on object, surveying can be classified into:

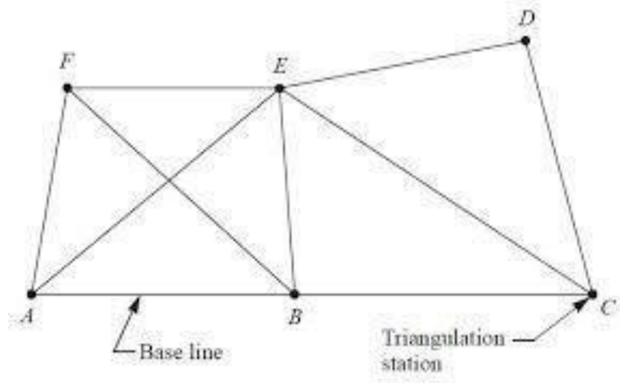


1. Geological Surveying
2. Mine Surveying
3. Archaeological surveying
4. Military surveying

CLASSIFICATION BASED ON THE METHOD USED

1. Triangulation Survey

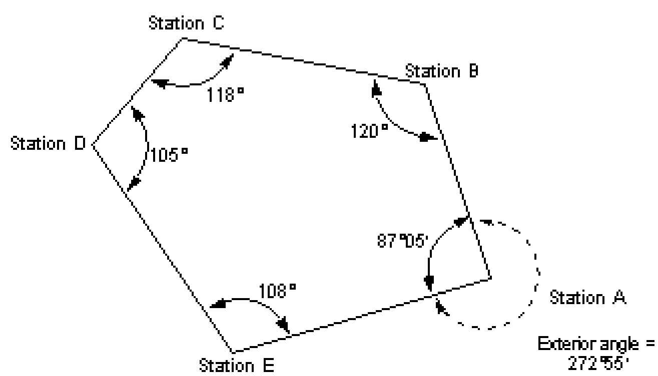
In order to make the survey, manageable, the area to be surveyed is first covered with series of triangles. Lines are first run round the perimeter of the plot, then the details fixed in relation to the established lines. This process is called triangulation.The triangle is preferred as it is the only shape that can completely over an irregularly shaped area with minimum space left.




ii. Traverse survey:

If the bearing and distance of a place of a known point is known: it is possible to establish the position of that point on the ground. From this point, the bearing and distances of other surrounding points may be established. In the process, positions of points linked with lines linking them emerge. The traversing is the process of establishing these lines, is called traversing, while the connecting lines joining two points on the ground. Joining two while bearing and distance is known as traverse. A traverse station is each of the points of the traverse, while the traverse leg is the straight line between consecutive stations. Traverses may either be open or closed.






**1. Closed Traverse :**

When a series of connected lines forms a closed circuit, i.e. when the finishing point coincides with the starting point of a survey, it is called as a ‘closed traverse’, here ABCDEA represents a closed traverse. (Fig 2.1 (a))

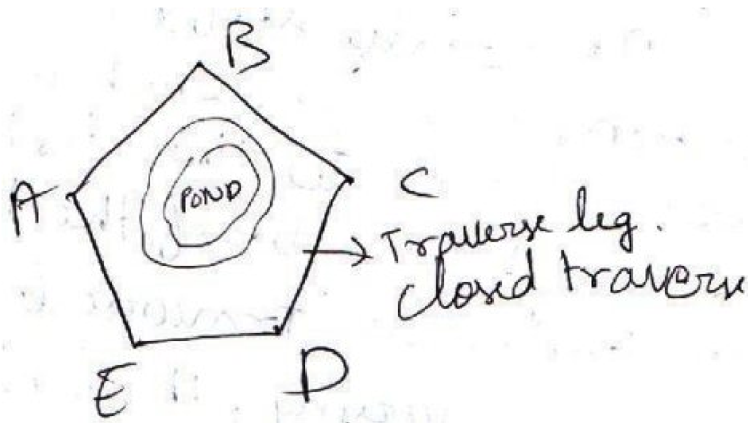



*Fig 2.1 (a) Closed traverse is suitable for the survey of boundaries of ponds, forestsetc.*

**2. Open Traverse :**

When a sequence of connected lines extends along a general direction and does not return to the starting point, it is known as 'open traverse' or (unclosed traverse). Here ABCDE represents an open traverse. Fig 2.2 (b)



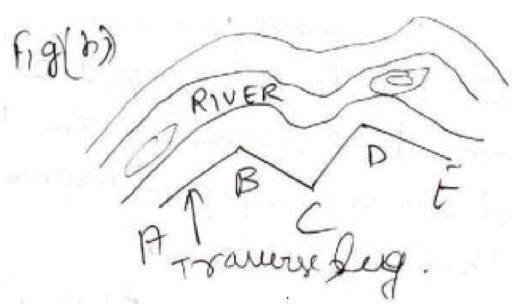
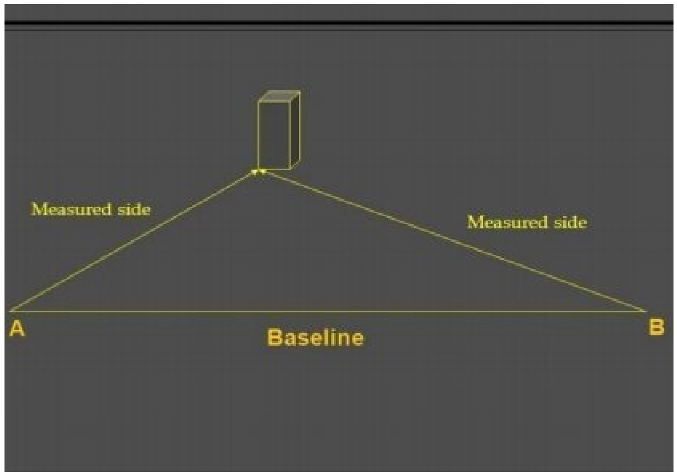



*Fig 2.2 (b) Open traverse is suitable for the survey of roads, rivers etc.*

**3) Trilateration:** In which the lengths of the sides of a triangle are measured, usually by electronic means, and, from this information, angles are computed. By constructing a series of triangles adjacent to one another, a surveyor can obtain other distances and angles that would not otherwise be measurable.




## ERRORS IN SURVEYING



- Surveying is a process that involves observations and measurements with a wide range of electronic, optical and mechanical equipment some of which are very sophisticated.

- Despite the best equipment's and methods used, it is still impossible to take observations that are completely free of small variations caused by errors which must be guided against or their effects corrected.

## TYPES OF ERRORS

### 1. Gross Errors

- These are referred to mistakes or blunders by either the surveyor or his assistants due to carelessness or incompetence.

- On construction sites, mistakes are frequently made by in – experienced Engineers or surveyors who are unfamiliar with the equipment and method they are using.

- These types of errors include miscounting the number of tapes length, wrong booking, sighting wrong target, measuring anticlockwise reading, turning instruments incorrectly, displacement of arrows or station marks etc.

- Gross errors can occur at any stage of survey when observing, booking, computing or plotting and they would have a damaging effect on the results if left uncorrected.

- Gross errors can be eliminated only by careful methods of observing booking and constantly checking both operations.

**2. Systematic or Cumulative Errors**

- These errors are cumulative in effect and are caused by badly adjusted instrument and the physical condition at the time of measurement must be consideredin this respect. Expansion of steel, frequently changes in electromagnetic distance (EDM) measuring instrument, etc are just some of these errors.



- Systematic errors have the same magnitude and sign in a series of measurements that are repeated under the same condition, thus contributing negatively or positively to the reading hence, makes the readings shorter or longer.

- This type of error can be eliminated from a measurement using corrections (e.g. effect of tension and temperature on steel tape).

- Another method of removing systematic errors is to calibrate the observing equipment and quantify the error allowing corrections to be made to further observations.

- Observational procedures by re-measuring the quantity with an entirely different method using different instrument can also be used to eliminate the effect of systematic errors.

**3. Random or Compensating Errors**

- Although every precaution may be taken certain unavoidable errors always existin any measurement caused usually by human limitation in reading/handling of instruments.

- Random errors cannot be removed from observation but methods can be adopted to ensure that they are kept within acceptable limits.

- In order to analyze random errors or variable, statistical principles must be used and in surveying their effects may be reduced by increasing the number of observations and finding their mean. It is therefore important to assume those random variables are normally distributed.

**4. Instrumental Error**

The Error due to, Imperfection in construction and adjustment of the instrument, The incorrect graduation. The improper adjustment of the plate level is called Instrumental Error.



**5. Personal Error.**

The Error due to, Lack of perfection in human sight, Lack of perfection in and setting the instruments are called personal Error.

**6. Natural Error**

The Error due to Variations in Natural phenomena such as Temperature,humidity, gravity, refraction and magnetic declination are called Natural Error.

**Corrections to Linear Measurement and their Application: -**

The following corrections are to be applied to the linear measurements with a chain ora tape where such accuracy is required.

(i) Pull correction,

(ii) Temperature correction

(iii) Standard length correction

(iv) Sag correction

(v) Slope correction

(vi) Mean sea level correction.

## 3. Pull Correction:-

A chain or tape of nominal length 'L' having cross sectional area of the link or that ofa tape, as the case may be, equal to A and standardized under a pull $P_s$ is employed to measure a length at a pull $P_F$.



$$C_P = (P - P_O / AE) \text{ X } L$$

The recorded length is less than the actual by this extension. The error is here, -ve, the actual length is obtained by adding the extension to L. the correction is +ve. If $P_F$ is less than $P_S$ the error will be +ve and correction –ve.

## 4. Temperature Correction:-

A chain or a tape of nominal length 'L' standardized at temperature $T_S$ and havingcross sectional area A is employed to measured length at temperature $T_F$ beingthe coefficient of linear expansion of the material of the chain or tape per unit rise of temperature ,

the extension = □(T – $T_{SF}$)L.

If $T_F$ is more than $T_S$, recorded length is less than the actual by the amount of extension. The error is –ve and the correction to the length L is +ve by the amountof extension. If the field temperature $T_F$ is less than $T_S$ the error is =+ve and the corrections is –ve.

**5. Sag Correction :-**

In case of suspended measurement across a span L the chain or tape sag to take the form of curve known as catenary.

$$C_{Sa} = \frac{(wl_1)^2 l}{24P^2} = \frac{W^2 l_1}{24P^2}$$

Where w= weight of the tape per metre length W=

Total weight of the tape

P=pull applied (in N)



$l_1$ = The length of tape suspended between two supports

$l$ = length of the tape =n $l_1$ (in m) Sag correction is always negative.

Error in chain survey measurements and how it can be rectified.

Errors in measurement :-

Due to continues usage of chain over rough areas the chain becomes to long or to short over at period of time. The chain is to long the measure distance will be less and on the other hand it to short a measured distance will move. Let

L – be the true length of the chain

L' – be the faulting length of the chaining when true line of the line equal

= L1 /L x measured length true area equal toArea

= ( L1 /L)2 x measured area

True volume : (L1/L)3 x measured volume.

1. The length of line measured with he was found to be 250ms calculate the truelength of line if 1. Length was measured with 30m chain and the chain was 10cm. to long.

2. Length of chain 30m in the beginning and the 30.1m at the end of the work.

Actual Length (L) = 30mn F

(L1)= 30.10M

True length = L1/L x measurement of length

= 30.1 /30 x 250 = 250.83M



Average length of full length = 30.00 + 30.10 /2

= 30.05

= 30.05/30 x 250 = 250.42M.

**PROBLEM:I**

The area of plane of an old survey platen to a scale of 10m = 1cm now measured as 19.5cm$^2$ as found by plane meter. The plan is found to have shrunk that a line originally 10cm long now measures 9.5cm only. A note on the plane also states thatthe 20m. Chain used was 9cm short. Find true area of the survey?

SOLUTION:

Measured Area = 19.5cm$^2$

Actual length of paper -> 10cm.

Measured error length -> 9.5cm.

True Area = $(L1/L)^2$ x measured Area.

= $(9.5/10)^2$ x 19.5= 17.59 $cm^2$

Scale -> 10cm = 1.cm.

$1cm^2$ = 1 x 1cm.

= 10m x 10m

= $100m^2$

$17.cm^2$ = 17.59 x 100 $m^2$ = $1759.8m^2$

Area is field when measured with = $1759.8m^2$

A chain (L) = 20m

Error (L1) = 20 – 0.9 = 19.91m



True area = $(19.91 / 20)^2$ x 1759.8

= 1743.9 $m^2$

**PROBLEM:II**

A field was measured using 30 m chain which was 15m too short. The area was calculated as $320m^2$ after applying correction. Later it was found that the chain is 15cm too long calculate the true area.

Data :

True area = (true length/ measured length) $^2$ X measured area

A = 320 $m^2$

$L_E$ = 30 – 0.15 = 29.85m$L_A$ =

30.00 m

True area

320 m² = (29.85 /30)² x Measured Area (M.A)

M.A = 316.8 m²

Correction = 30 +0.15 = 30.15 m

$L_A$ = 30.00 m

= ( 30.15 / 30)² x 316.8

True area = 319. 99 m²

**PROBLEM:III**



A field was measured using 30 m chain which was 15m too long. The area was calculated as 320m² after applying correction. Later it was found that the chain is 15cm too short calculate the true area.

Data :

A = 320 m²

$L_E$ = 30 + 0.15 = 30.15 m$L_A$ =

30.00 m

True area

320 m² = (30.15 /30)² x Measured Area (M.A)

M.A = 323.21m²

Correct = 30 -0.15 = 29.85 m

$L_A$ = 30.00 m

= $(29.85 / 30)^2$ x 323.21

True area = 319. 99 $m^2$

Tape corrections that can be applied for the measured lengths.

Corrections :-

Depending on the accuracy requires certain correction are to be made to theoriginal measurements correction for

Error in chain Length :



Before using tape the axial length is ascertain by comparing with the std tape of known length. If the axial tape button is not equal to the value. A correction will have to be applied to the measured length.

True length = (L1/L) X Measured length

Where L1 is corrected length of chain or tape

L is observed length of chain or tape

Correction for slope :-

The distance measured along the slope is always greater than the horizontal distance between the print ........ the distance is measured on the slope it must be immediately reduced to its corresponding horizontal distance.

Correction for slope $C_{SL} = h^2/2L$

Correction for slope $C_{SL} = L – DCos\ \theta$

$= D / L$

$D = L \cos \theta$

Correction for tension (or) pull :-

It the pull applied the tape during measurement is more than the std pull at which the tape was std is length increases take the distance measured becomes less than the actual. Hence correction for pull.

$C_P = (P – P_O / AE)\ X\ L$

Where

$P_O$ is Std pull P = pull applied during measurement

A = Area of Cr s of tap; E = young's modulus 2.1 x $10^5$ N/m² for steel L is thetape length`



Correction for Temp :-

The tape length changes due to changes with temperature while take a measurements. The fare temperature cared.

$$C_T = \alpha\ (T_m – T_o)\ L$$

$T_m$ is mean Temp during measurement $T_o$ is Temp at which the tape is sodalist α = co-efficient of thermal expansion α = 0.0000032 m/oc for steel = 0.00000122 m/oc for invar.

Sag Correction:

When the tape is stretch between two points. It takes be form d catenae. Assure toa parabola considerately. The measured length is more than the actual length.

$$C_{SC} = W^2 L^1 / 24P^2$$

W = weight of tap

P = pull apply in new tan's spans

$L_1$ = measurement length of tape between spans

Sag correction will be always negative i.e. it has to be always subtracted from the measured length.

**Problem:1**

A line was measured with a steel tape which exactly 30m at a temperature 20°c and pull of 10 Kg. the measure length 1650 m. temperature during measured 30°c and pull apply was 15 Kg. tin the true length of live C.S.A. of tape was 0.025 Cm² & = 40°c is 3.5 x $10^6$ and E is of take 2.1 x $10^6$ Kg/Cm².



Given:- $L_t$ = 30

$T_o$ = 20°c $T_n$ =30°c

$P_o$ = 10kg $P_r$ = 15Kg$P_m$ = 1650

$\partial$ = 3.5 x $10^{-6}$ M/sec.

E = 2.1 x $10^6$Kg/Cm$^2$A = 0.025 Cm².

$$C_t = \partial (T_m - T_o) L$$

$$= 3.5\times10^{-6} \times (30°c - 20°c)1650$$

$$= 0.05775 \text{ ms.}$$

$$C_P = P - P_O / AE \times L = 15 - 10 / (0.025 \times 2.1 \times 10^6)\ 1650 \times 10^2$$

= 15.71 kg/cm = 0.157 kg/cm

True length = 1650 + 0.057775 + 0.157

= 1650.215m

The down hill end of 30m tape is 90cm too low what is horizontal distancemeasured.

$L_t$ = 30m

Correction for slope $C_{SL}$

$C_s = h^2/2L = (0.9)^2 /2 \times 30 = 0.0135$m

D = L - $C_s$ => 30 – 0.0135

= 29.99 mm



**Problem:2**

The 100m tape is suspended between the ends attached to a load of 200N the weightof tape is 30N. Find correct distance between the ends.

Given:

$W_F$ = 30N  l = 100M  P = 200N  P = 200N

$l_F$ = 100  W = 30N

Correction for pull

$C_{sg} = W^2L^1 / 24 P^2 = 30^2 \times 100 /24 \times 200^2$

= 0.09375 m

True length = 100 – 0.9375= 99.91m

**Problem:3**

A steel tape is 30 m long between the end graduation 30m long between the at a temp 15°c when it's horizontal and the ground when sectional area = 0.065cm² total weight 15.8N. And the co-efficient expansion being 11.5 x $10^{-6}$°c. The tape it'sstretch on two support 30M append it's also supports in the tape. The three supportsbeing at the same level. Calculate axial level between the ends it temperature duringmeasurement is 25°c pull a the tape 100N and E=2.11 x $10^{5N}$ /$n^2$

Given:

L = 30M

Correction for temperature:

$C_T = \partial (T_m - T_o) L$

$= 11.5 \times 10^{-6} (25°c - 15°c) 30$

$= 0.00034M$

$C_P = (P – P_O) / AE \times L$

Sag Correction:

$C_{sag} = (7.9)2 \times 15 / 24 \times (100^2)$

$= 0.0039M$

Correction pull :

$C_P = (P – P_O) / AE \times L$

$= 100 – 0 / 0.065 \times 271 \times 10^5 \times 30$ $= 0.219m$

True length = 30 – 0.0039 x 2 + 0.0034 + 0.219

= 29.99 m

The distance P & Q measured along a slope is 250M fink horizontal distancebetween P. If (1) angle of slope 10° (2) slope is 14.5 (3) the differential elevation.

If angle of slope 10°

D = L cos θ= 250 cos 10°D = 246.20M
Slope is 14.5 tan θ = opp x d / adjust x d

= 1 / 4.5

tan θ = 0.22

D = 250 cos 12°.54 = 244.17mθ

= $\tan^{-1}$ 0.22 = 12°24’’

$C_{SL} = h^2 / 2L = 35^2 / 2x\ 250 = 2.45$

D = L – 2.45 = 247.55



**Traversing**

Traversing is the type of survey, in which a number of connected survey lines formthe framework and the directions and lengths of the survey lines are measured with the help of an angle measuring instrument and a chain or tape.

**closed traverse and open traverse**

When the survey lines form a circuit which ends at the starting point, is called Closed Traverse. If the circuit ends elsewhere, it is called open traverse. Open Traverse.

**State the methods of Traversing.**

(i) Chain Traversing,

(ii) Chain and compass traversing (loose needle method)

(iii) Transit Tape Traversing:

(a) By fast needle method.

(b) By measurement of angles between the lines.

(iv) Plane –table traversing.

chain Traversing

In this method the whole of the work is done with the chain and tape. No angle measuring instrument is used and the direction of lines are fixed entirely by linear measurements.

chain angles

In chain traversing, the angles fixed by linear or tie measurements are known as chain angles. Well-conditioned and Ill Conditioned Triangles.



**Well-conditioned Triangle: -**

The triangles having internal angles between 30° & 130° are known as wellcondition triangle. ILL conditioned Triangles: -

The triangles having angles less than 30° and more than 130° are known ill condition triangle.

**Pantograph.**

Pantograph is an instrument used for reproducing, enlarging and reducing the maps. It is based on the principle of similar triangles.

Offsets: -

An offset is the lateral distance of an object or ground feature measured from a survey line. By method of offsets, the point or object is located by measurement of a distance and angle from a point on the chain line.

Perpendicular offset

When the angle of offset is 90°, the it is called *Perpendicular offset* or simply *offset*. In this method, the leader holds the zero end of the tape at the point ‘P’ to be located and the follower carries the tape box and swing the tape along the chain. The length of the offset is the shortest distance from the object to the chain obtained by swinging the tape about the object as center. The position of the offset on the chain is located by the point where the arc is tangential to the chain.

Oblique offset

when the angle is other than 90° then it is called an *oblique offset* Method of ’ties’ in this method the distance of the point is measured from two separate points on the chain line such that the three points form, as nearly as possible an equilateral triangle.

## 1.3 Ranging

The process if marking some intermediate points and a survey line join in two station in the field, so that the line between the two station is a straight line and the length between the station can be measured correctly, is called Ranging

The process of ranging can be done by two methods:

1. Direct Ranging
2. Indirect Ranging

**1. Direct Ranging**

Direct ranging is the ranging conducted when the intermediate points are intervisible. Direct ranging can be performed by eye or with the help of an eye instrument.

**Ranging by Eye**



As shown in figure-1 below, let A and B are the two intervisible points at the endsof the survey line. The surveyor stands with a ranging rod at the point A by keepingthe ranging rod at the point B. The ranging rod is held at about half meter length.

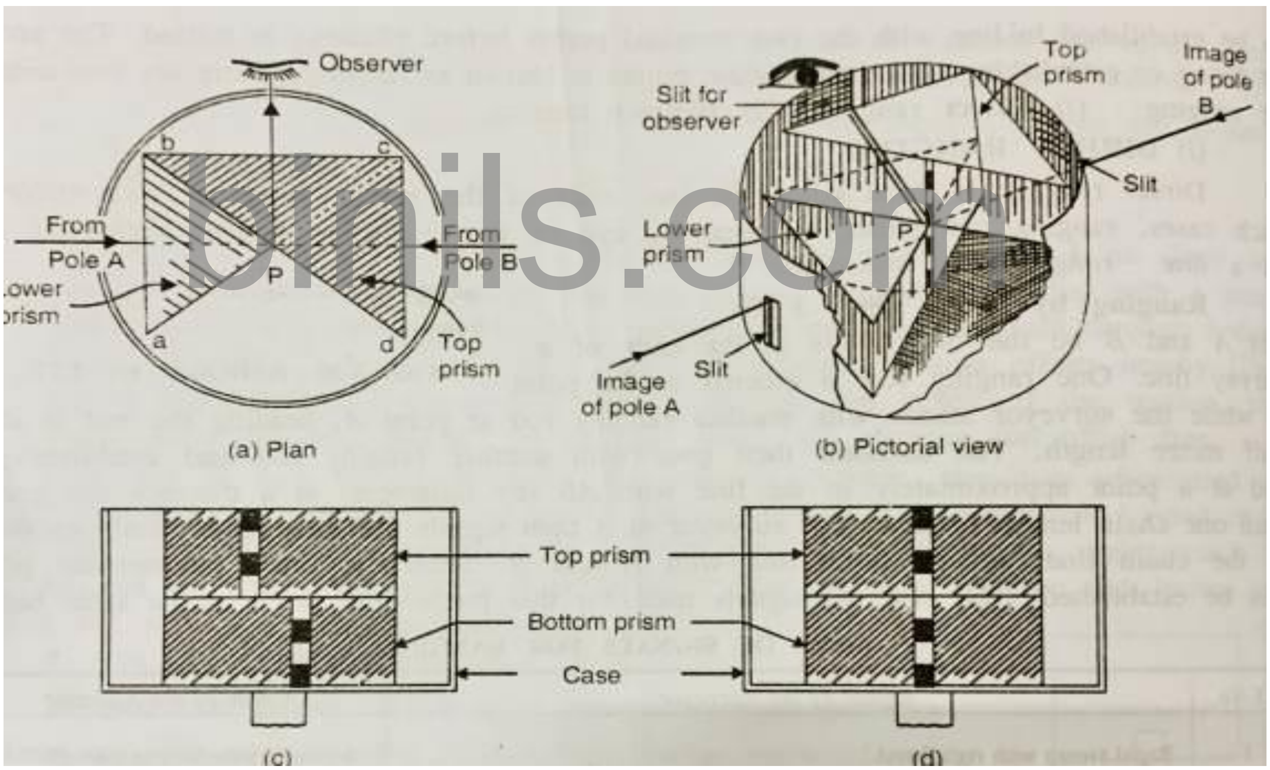
The assistant then takes the ranging rod and establishes at a point in between AB, almost in line with AB. This is fixed at a distance not greater than one chain length from point A.

The surveyor can give signals to the assistant to move traverse till the rod is in line with A and B. In this way, other intermediate points are determined.

*Ranging by Line Ranger*

The figure-2 below shows a line ranger that has either two plane mirror arrangement or In order to handle the instrument in hand a handle with hook is provided. The hook is to enable a plumb- bob to help transfer the point to the ground. two isosceles prisms that are placed one over the other. The diagonals of the prism are.

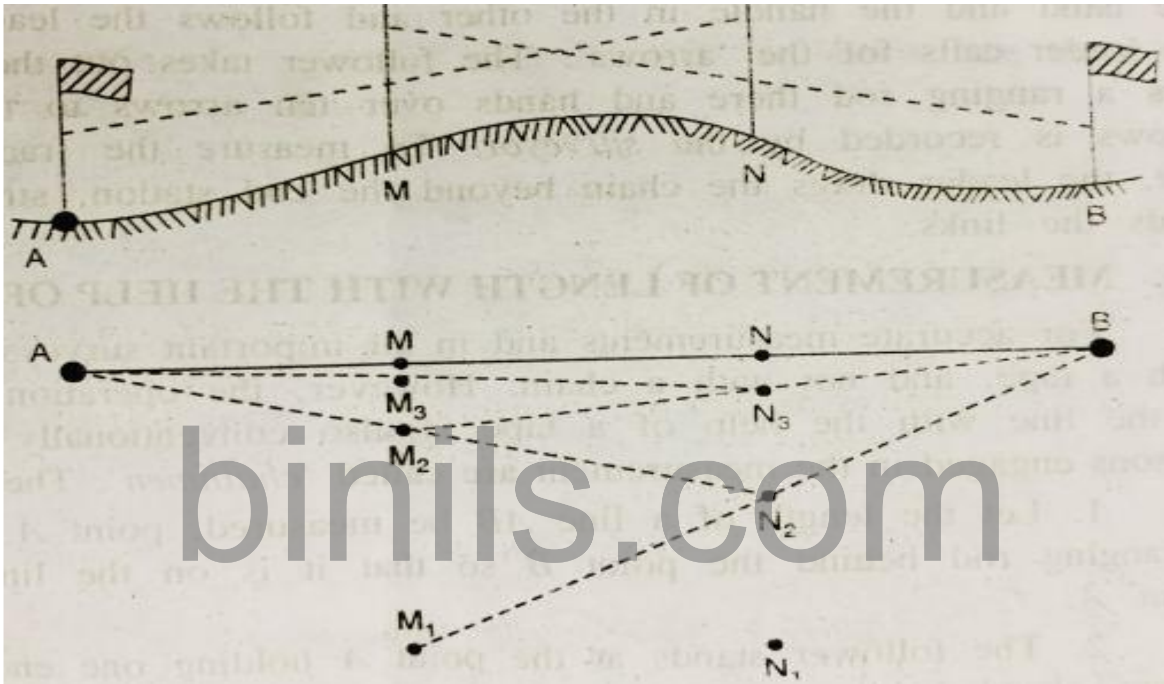
In order to range the point 'P', initially two rods are fixed at points A and B. By eye judgment, the surveyor holds the ranging rod at P almost in line with AB. The lower prism a b c receives the rays coming from A which is then reflected by the diagonal ac towards the observer. The upper prism d b c receives the rays from B which is then reflected by the diagonal b d towards the observer. Hence the observer can see the images of the ranging rods A and B, which might not be in the same vertical line as shown in figure-2(c).




The surveyor moves the instrument till the two images come in the same vertical line as shown in figure-2(d). With the help of a plumb bob, the point P is then transferred to the ground. This instrument can be used to locate the intermediate points without going to the other end of the survey line. This method only requires one person to hold the line ranger.

**2.** Indirect Ranging

Indirect ranging is employed when the two points are not intervisible or the two points are at a long distance. This may be due to some kind of intervention between the two points. In this case, the following procedure is followed. As shown in figure-3, two intermediate points are located M1 and N1 very near to chain line by judgment such that from M1, both N1 and B are visible & from N1 both M1 and A are visible.




At M1 and N1 two surveyors stay with ranging rods. The person standing at M1 directs the person at N1 to move to a new position N2 as shown in the figure. N2 must be inline with M1B.

Next, a person at N2 directs the person at M1 to move to a position M2 such that it is inline with N2A. Hence, the two persons are in points are M2 and N2.

The process is repeated until the points M and N are in the survey line AB. Finally, it reaches a situation where the person standing at M finds the person standing at N in line with NA and vice versa. Once M and N are fixed, other points are fixed by direct ranging.

## 1.4 COMPASS SURVEYING

The principle of surveying is traversing; which involves a series of lines, which are connected Compass surveying, is a branch of surveying in which directions of survey lines are determined with a compass and lengths of the lines are measured with a tape or a chain

INSTRUMENTS USED FOR COMPASS SURVEYING

- ✓ The various instruments used in the compass survey are :
- Prismatic compass
- Tape
- Ranging rods
- Tripod
- Arrows
- Plumb Bob



TYPES OF COMPASS

a) To measure the directions

- PRISMATIC COMPASS
- SURVEYOR'COMPASS

b) To measure the angles

- Sextant
- theodolite

THE PRISMATIC COMPASS

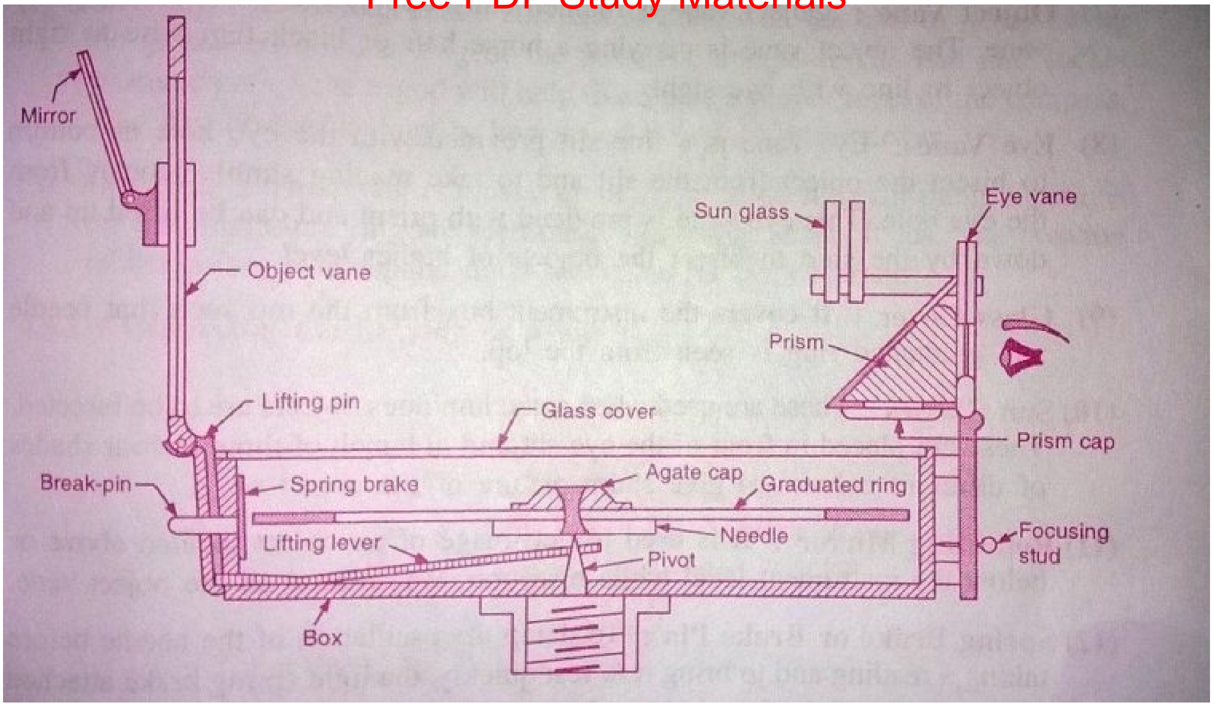



*Fig. Prismatic Compass*
*(https://slideplayer.com/slide/4767731/)*

CONSISTING PARTS

1. Cylindrical metal box
2. Pivot
3. Lifting pin and lifting liver
4. Magnetic Needle
5. Graduated Ring
6. Prism
7. Object vane
8. Eye Vane
9. Glass Cover
10. Sun Glasses
11. Reflecting Mirror
12. Spring Brake or Brake Pin



**PRISMATIC COMPASS**

- Prismatic Compass comprises of a magnetic needle attached to the circular ringmade up of aluminum.
- The needle is on the pivot and will orient itself in the magnetic meridian

- The objective vane defines the line of sight and the eye slit, both attached tothe compass box.
- A triangular prism is fitted below the eye slit.
- The readings increase in clockwise direction.
- The object vane frame can be folded on the glass lid, which covers the top atbox.
- Lever, which lifts the needle of the pivot and holds it against the glass lid.
- When bright objects are sighted, dark glass may be interposed in to the line ofsight.

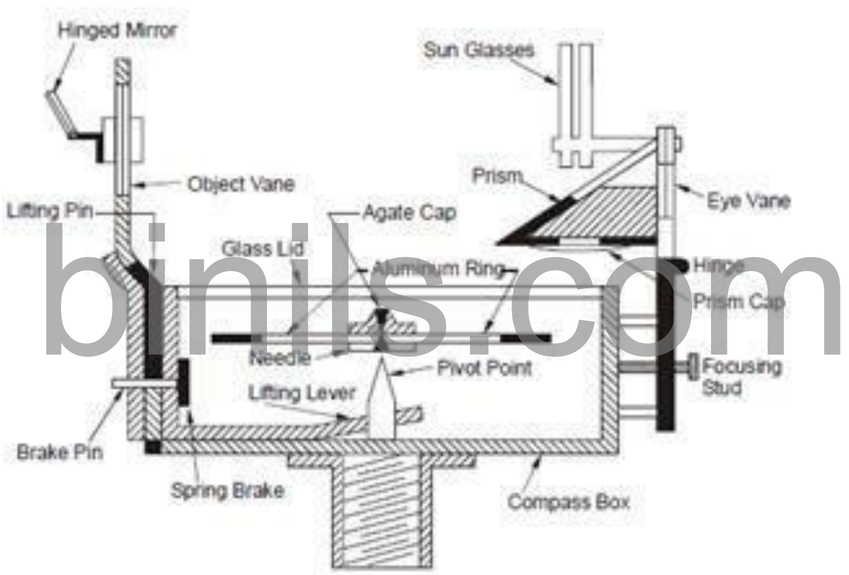



*Fig. Prismatic Compass*
*(https://www.brainkart.com/article/Compass-survey_6527/)*



Adjustments of Prismatic Compass:

The following are the adjustments usually necessary in the prismatic compass:

- Centering
- Leveling
- Focusing the prism

**CENTERING:**

The center of the compass is placed vertically over the station point by dropping a small piece of stone below the center of the compass; it falls on the top of the peg marking that station.

**LEVELLING:**

By means of ball and socket arrangement, the Compass is then leveled the graduated ring swings quite freely. It may be tested by rolling around pencil on the compass box.

**FOCUSSING THE PRISM:**

The prism attachment is slid up or down focusing until the readings are seen to be sharp and clear.

**THE SURVEYOR'S COMPASS**

In this type of compass, reading is taken from the top of glass and under the tip of north end of the magnetic needle directly. No prism is provided here. Construction and bearing system of the surveyor's compass differs from prismatic compass.

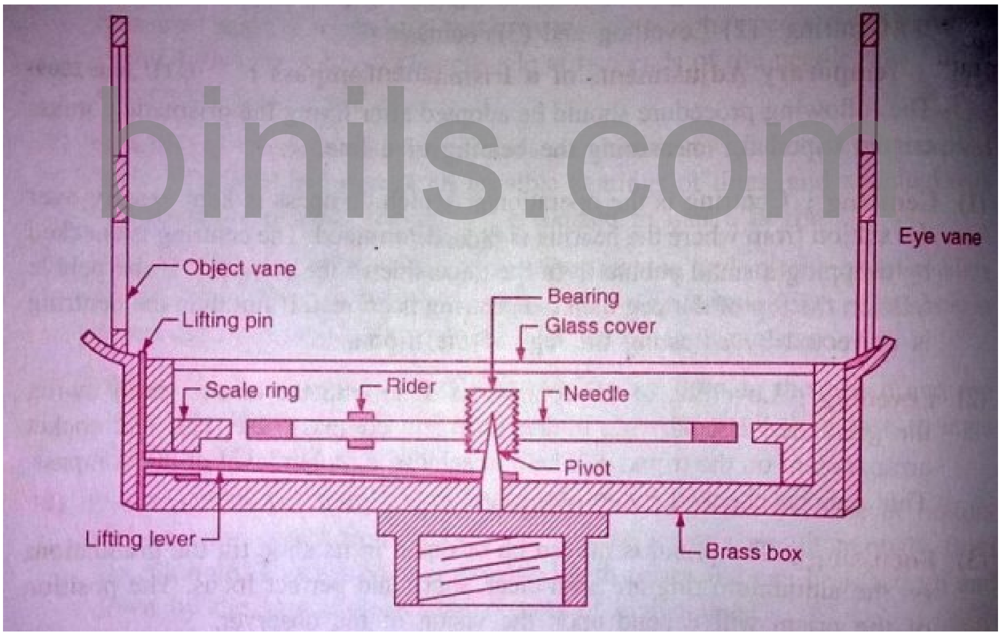



*Fig. Surveyors Compass*
*(https://slideplayer.com/slide/4767732/)*

CONSISTING PARTS

**WORKING OF SURVEYOR'S COMPASS**

1. Centering
2. Levelling
3. Observing the bearing line

4. Magnetic bearing
5. Grid bearing
6. Arbitrary bearing

Bearing

bearing of a line is its direction relative to a given meridian

TYPES OF BEARINGS

1. True bearing
2. Magnetic Meridians and Magnetic Bearing
3. True Meridian and True Bearing
4. Arbitrary Meridian and Arbitrary Bearing

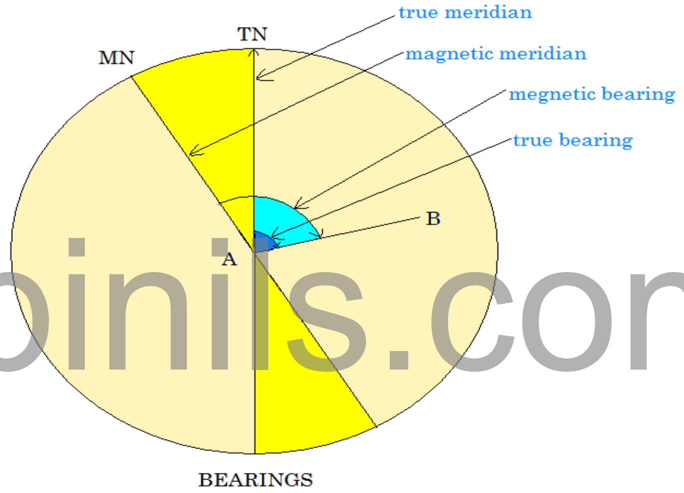



*Fig- Bearing diagram*

*(https://www.chegg.com/homework-help/definitions/magnetic-bearing-8)*

TYPES OF MERIDIANS

Azimuth

The angle b/w a line and the meridian measured with clockwise direction usually from north

DEFLECTION ANGLE

The angle b/w a line and the prolongation of the proceeding line

ANGLES TO THE RIGHT

If the angles are measured clockwise from the proceeding line to the following line

INTERIOR ANGLE

Inside angles between adjacent lines of a polygon

FORE BEARING

The angle measurement in forward direction

BACK BEARING

The angle measurement in backward direction

**The difference b/w FB and BB= 180˚**

DESGNATION OF BEARING

WHOLE CIRCLE BEARING (WCB)

The bearing of a line is always measured clockwise from the north point towards the line

REDUCED BEARING

The bearing of lines are measured clockwise from north or south

MEASUREMENTS OF BEARINGS



| **W.C.B OF ANY LINE** | **QUADRANT IN WHICH IT LIES** | **RULE FOR CONVERSION** | **QUADRANT** |
|---|---|---|---|
| 0° to 90° | First | RB = WCB | N-E |
| 90° to 180° | Second | RB = 180° - WCB | S-E |
| 180° to 270° | Third | RB = WCB - 180° | S-W |
| 270° to 360° | Fourth | RB = 360° - WCB | N-W |

**Problem-I**

Convert the following whole circle bearings of lines to quadrant bearings.

a) OA 32° b) OB 109° c) OC 211° d) OD 303°

a) W.C.B of OA = 32° Quadrant bearing = N 32° E

b) W.C.B of OB = 109°

quadrant bearing = 180° – W.C.B = 180° – 109° = S 71° E

c) W.C.B of OC = 211°

quadrant bearing = W.C.B – 180° = 211° – 180° = S 31° W

d) W.C.B of OD = 303°

quadrant bearing = 360° – W.C.B = 360° – 303° = N 57° W

**Problem2**

Convert following reduced bearings to the whole circle bearings: (i)N 52°30'E (ii)S 30°15'E (iii)S85°45'W (iv)N 15°10'W

(i) R.B. = N 52°30'E & which is in the NE quadrant, Therefore W.C.B =same as R.B = 52°30'

(ii) S 30°15'E which is in the SE quadrant, Therefore W.C.B =180° -30°15'= 149°45'

(iii) S 85°45' W which is in the SW quadrant, Therefore W.C.B =180° + 85°45' =265°45'



(iv) N 15°10'W which is in the NW quadrant, Therefore W.C.B =360° - 15°10' =344°50'

**Local Attraction**

A compass needle is affected by the presence of masses of iron and steel such as lamp posts electric cables, steel girders etc., they deflect the needle and the effect of this disturbance is called local attraction. Due to local attraction, the difference between the fore bearing and back bearing of a survey line will not be equal to 180°

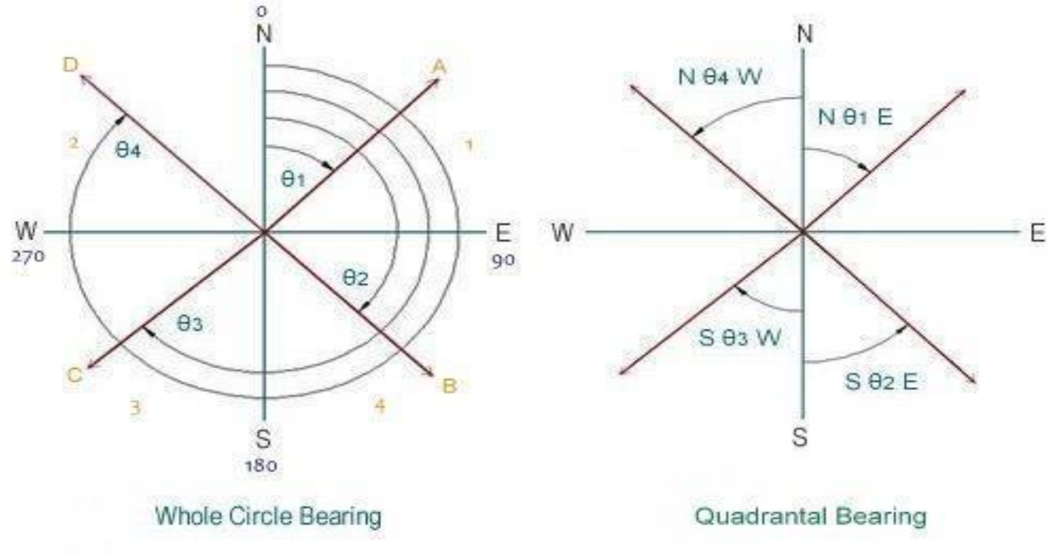



*Fig- Quantrant Bearing*
*(https://civilsnapshot.com/whole-circle-bearing-quadrantal-bearing/)*

**Problem 3**

The following are the bearings of the lines of the closed traverse ABCDA taken with a compass in a place where local attraction was suspected.



| Line. | F.B. | B.B |
|---|---|---|
| AB | 35°30’ | 215°30’ |
| BC | 115° 15’ | 294° 15’ |
| CD | 180° 45’ | 3 °45’ |
| DA | 283 °45’ | 101 °45’ |

Observed F.B. of BC = 115°15’Add = 180°0’

Correct BB of BC = 295°15’

Less Observed BB of BC = 294°15’ Error due to local attraction at C = 1°00’

Since the error is negative all bearing observed at C must be corrected by adding 1°00’

Observed F.B. of CD = 180°45’Add correction = 1° 00’

Correct FB of CD = 181°45’Deduct 180° = 180° 00’

Correct BB of CD = 1°45’. Observed BB of CD = 3°45’.

Error due to local attraction at D = 2°00'.

Hence, all bearings observed at D must be corrected by -2°00' for local attraction.

Observed F.B. of DA = 283°45' Add correction at D = - 2°00' Correct FB of DA = 281°45'

Less = 180°00' Correct BB of DA = 101°45'

This is the same as the observed BB of DA, which shows that there is no local

## 1.5 LEVELING

### Leveling Head Assembly

The leveling head of the transit normally is the four-screw type, constructed so the instrument can be shifted on the footplate for centering over a marked point on the ground.

### Lower Plate Assembly

The lower plate assembly of the transit consists of a hollow spindle that is perpendicular to the

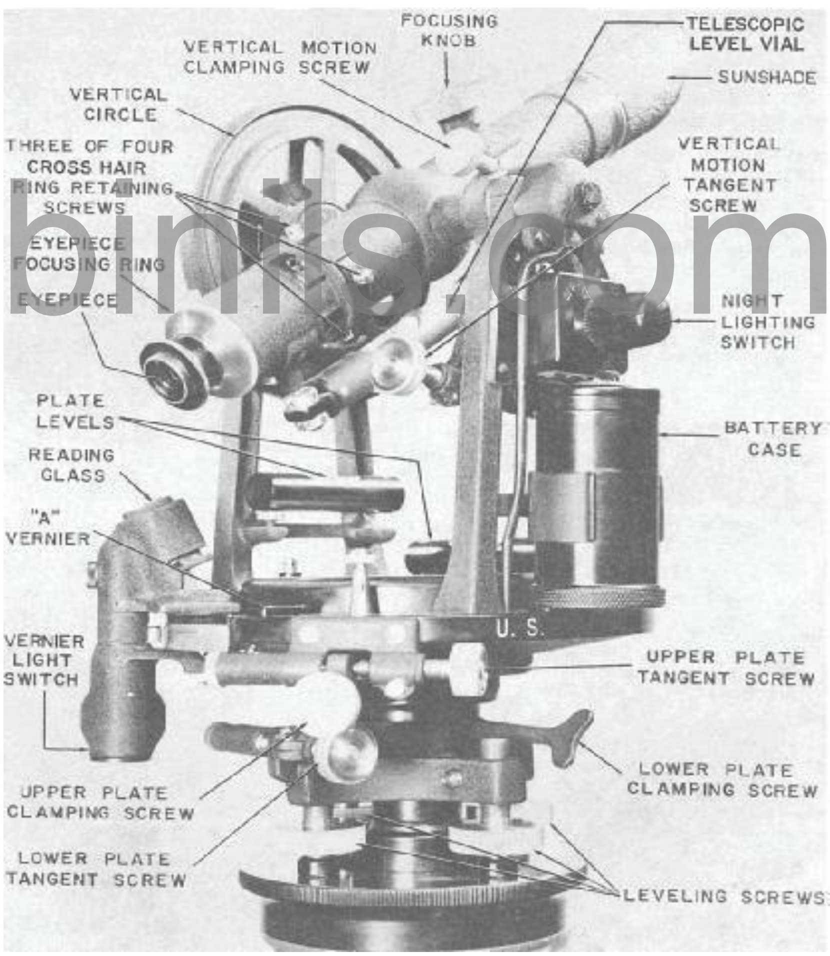
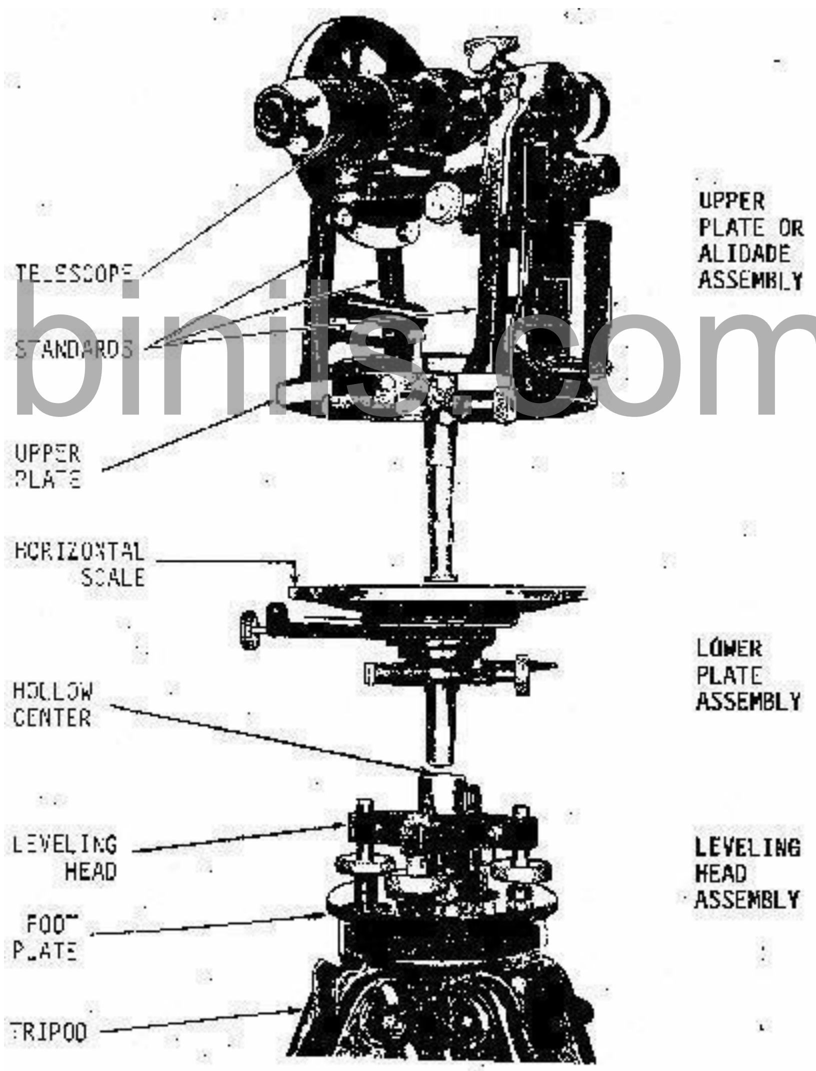



*Figure 11-6.-An engineer's transit.*
*(http://www.tpub.com/engbas/11-11.htm)*

center of a circular plate and accurately fitted the socket in the leveling head. The lower plate contains the graduated horizontal circle on which the values of horizontal angles are read with the aid of two verniers, A and B, set on the opposite sides of the circle. A clamp controls the rotation of the lower plate and provides a means for locking it in place. A slow- motion tangent screw is used to rotate the lower plate a small amount to relative to the leveling head. The rotation accomplished by the use of



the lower clamp and tangent screw is known as the **Lower Motion.**

Upper Plate or Alidade Assembly

The upper plate, alidade, or vernier assembly consists of a spindle attached plate to a circular plate carrying verniers, telescope standards, plate-level vials, and a magnetic compass. The spindle is accurately fitted to coincide with the socket in the lower plate spindle. A clamp is tightened to hold the two plates together or loosened to permit the upper plate to rotate relative to the lower plate. A tangent screw permits the upper plate to be moved a small amount and is known as the **Upper Motion.**

The standards support two pivots with adjustable bearings that hold the horizontal axis and permit the telescope to move on a vertical plane. The vertical circle moves with the telescope. A clamp and tangent screw are provided to control this vertical movement. The vernier for the vertical circle is attached to the left standard. The telescope is an erecting type and magnifies the image about 18 to 25 times. The reticle contains stadia hairs in addition to the cross hairs. A magnetic compass is mounted on the upper plate between the two standards and consists of a magnetized needle pivoted on a jeweled bearing at the center of a graduated circle. A means is provided for lifting the needle off the pivot to protectthe bearing when the compass is not in use.



**LEVEL VIALS.-** Two plate level vials (fig. 11-6) are placed at right angles to each other. On many transits, one plate level vial is mounted on the left side, attached to the standard, under the vertical circle vernier. The other vial is then parallel to the axis of rotation for the vertical motion. The sensitivity of the plate level vial bubbles is about 70 sec of movement for 2 mm of tilt. Most engineer'stransitshave a level vial mounted on the telescope to level it. The sensitivity of this bubble is about 30 sec per 2-mm t i l t.

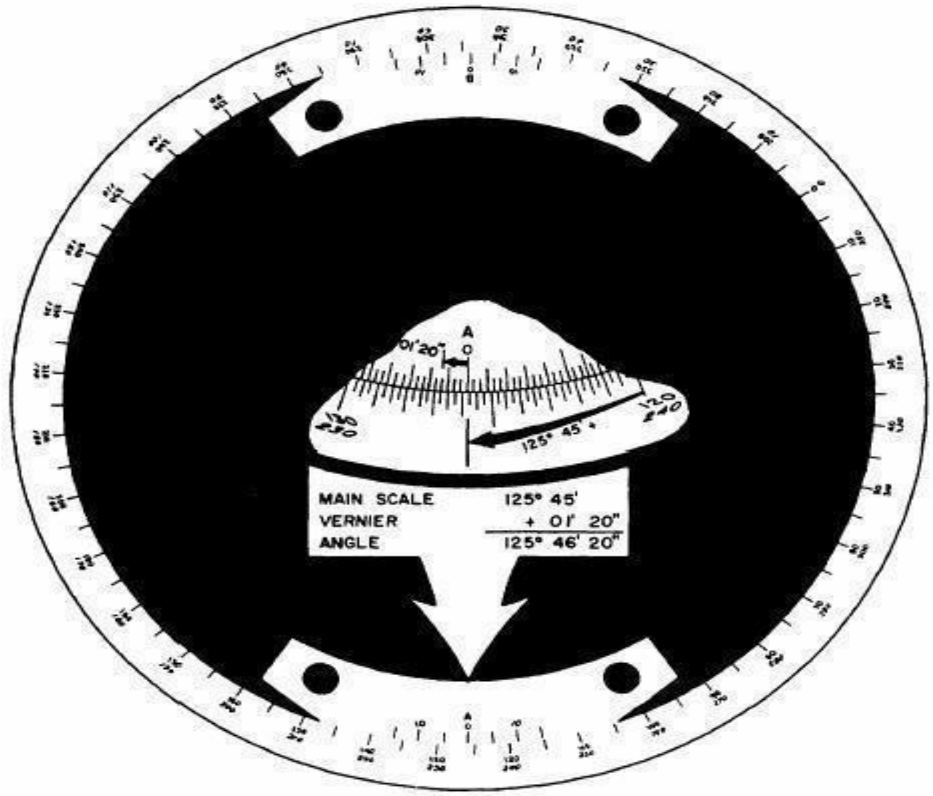





*Figure 11-8.-Horizontal scales, 20 second transit.*
*(https://www.brainkart.com/article/Direct-Vernier-and-Vernier-For-Circles_4608/)*

**CIRCLES AND VERNIERS.-**

The horizontal and vertical circles and their verniers are the parts of the engineer's transit by which the values of horizontal and vertical angles are determined. A stadia arc is also included with the vertical circle on some transits.

The horizontal circle and verniers of the transit that are issued to SEABEE units are graduated to give least readings of either 1 min or 20 sec of arc. The horizontal circle is mounted on the lower plate. It is graduated to 15 min for the 20-sec transit (fig. 11-8) and 30 min for the 1-min transit (fig. 11-9). The plates are numbered from 0 o to 360 o , starting with a common point and running both ways around the circle. Two double verniers, known as the A and B verniers, are mounted on the upper plate with their indexes at circle readings 180 o apart. A double vernier is one that can be read in both directions from the index line. The verniers reduce the circle graduations to the final reading of either 20 sec or 1min.

The A vernier is used when the telescope is in its normal position, and the B vernier is used when the telescope is plunged.

The VERTICAL CIRCLE of the transit (fig. 11-10) is fixed to the horizontal axis so it will rotate with the telescope. The vertical circle normally is graduated to 30� with 10 o numbering. Each quadrant is numbered from 0 º to 90 º ; the 00 graduations define a horizontal plane, and the 90 º graduations lie in the vertical plane of the instrument. The double vernier used with the circle is attached to the left standard of the transit, and its least reading is 1 . The left half of the double vernier is used for reading angles of depression, and the right half of this vernier is used for reading angles of elevation. Care must be taken to read the vernier in the direction that applies tothe angle observed.



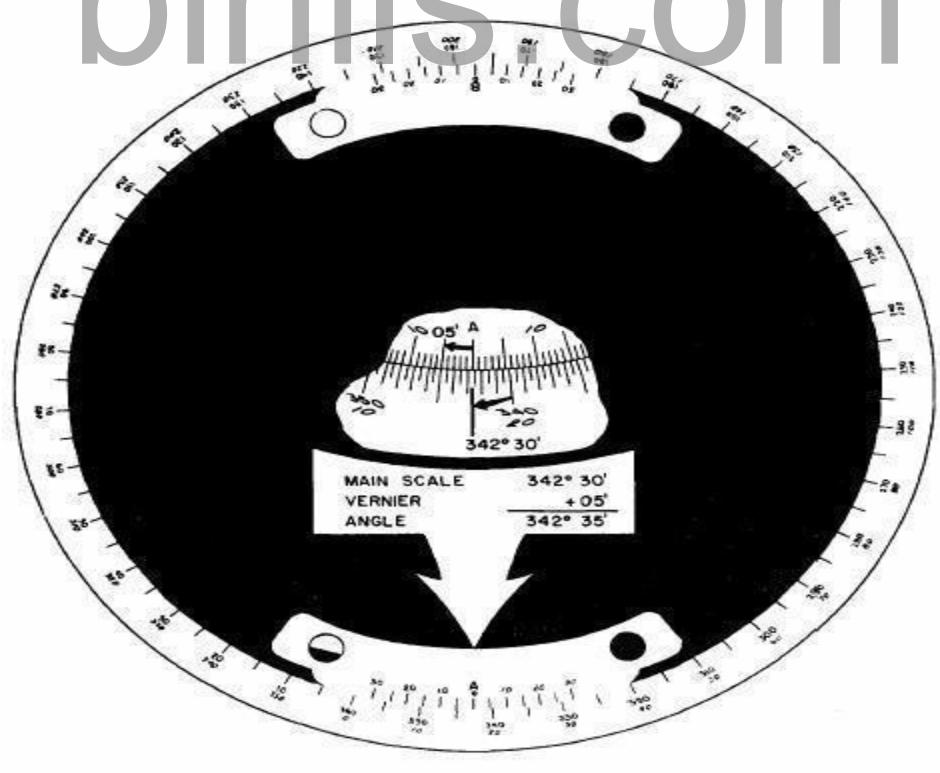



*Figure.( 11-10).-Horizontal scales, 20 second transit.*
*(https://www.brainkart.com/article/Direct-Vernier-and-Vernier-For-Circles_4608/)*

In addition to the vernier, the vertical circle may have an H and V (or HOR and VERT) series of graduations, called the STADIA ARC (fig. 11-10). The H scale is adjusted to read 100 when the line of sight is level, and the graduations decrease in both directions from the level line. The other scale, V, is graduated with 50 at level, to 10 as the telescope is depressed, and to 90 as it is elevated.

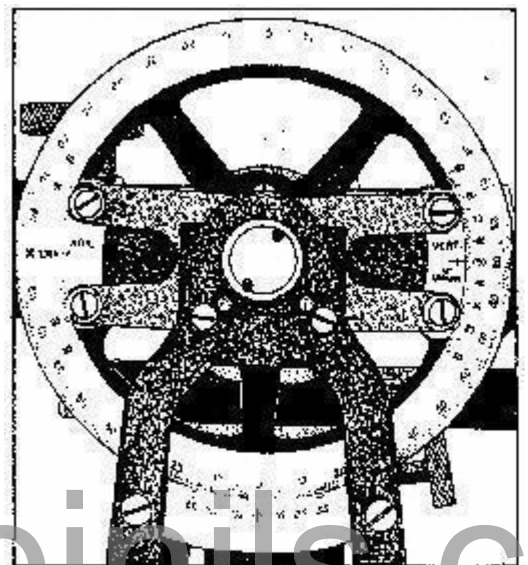




*Figure 11-10.-Vertical circle with verniers, scales, and stadia arc.*

*(https://www.brainkart.com/article/Circles-And-Verniers_4607/)*

The VERNIER, or vernier scale, is an auxiliary device by which a uniformly graduated main scale can be accurately read to a fractional part of a division. Both scales may be straight as on a leveling rod or curved as on the circles of a transit. The vernier is uniformly divided, but each division is either slightly smaller (direct vernier) or slightly larger (retrograde vernier) than a division of the main scale (fig. 11-11). The amount a vernier division differs from a division of the main scale determines the smallest reading of the scale that can be made with the particular vernier. This smallest reading is called the LEAST COUNT of the vernier. It is determined by dividing the value of the smallest division on the scale by the number of divisions on the vernier.

**Different types of levels ( Levelling Instrument) with neat sketches**

Dumpy Level, Wye Level, Reversible Level, Tilting Level, and Digital level

## 1. Dumpy level:

A schematic diagram of an engineer's level is shown in. An engineer's level primarily consists of a telescope mounted upon a level bar which is rigidly fastened to the spindle. Inside the tube of the telescope, there are objective and eye piece lens at the either end of the tube. A diaphragm fitted with cross hairs is present near the eye piece end. A focussing screw is attached with the telescope. A level tube housing a sensitive plate bubble is attached to the telescope (or to the level bar) and parallel to it. The spindle fits into a cone-shaped bearing of the leveling head. The leveling head consists of tribrach and trivet with three foot screws known as leveling screws in between. The trivet is attached to a tripod stand. It is simple compact and stable. The telescope is rigidly fixed to its support therefore cannot be rotated about its longitudinal axis. A long bubble tube is attached to the top of telescope. Dumpy literally means short and thick.



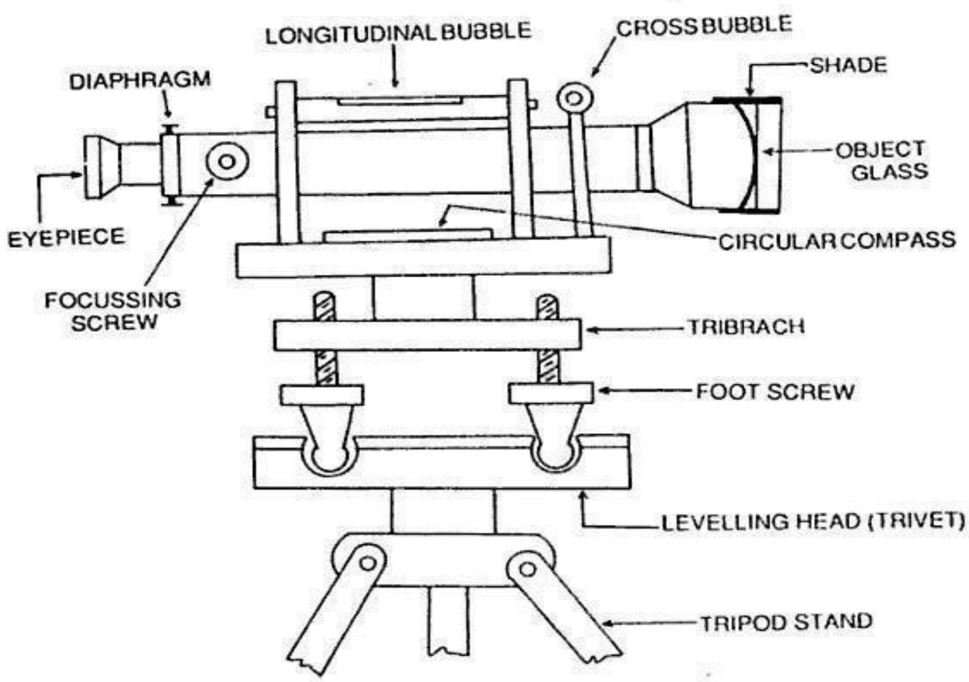



*Fig- Dumpy Level*

*(https://www.facebook.com/103078567894545/posts/dumpy-level/172205090981892/ )*

**Telescope :** used to sight a staff placed at desired station and to read staff reading distinctly.

**Diaphragm :** holds the cross hairs (fitted with it).

**Eye piece :** magnifies the image formed in the plane of the diaphragm and thus toread staff during leveling.

**Level Tube :** used to make the axis of the telescope horizontal and thus the lineof sight.

**Leveling screws :** to adjust instrument (level) so that the line of sight ishorizontal for any orientation of the telescope.

**Tripod stand :** to fix the instrument (level) at a convenient height of an observer.



## 2. Wye level:

The essential difference between the dumpy level and the Wye level is that in the former case the telescope is fixed to the spindle while in the Wye level, the telescope is carried in two vertical Wye supports. The Wye support consists of curved clips. The clips are raised, the telescope can be rotated in the Wyes, or removed and turned end for end. When the clips are fastened the telescope is held from turning about its axis by a lug on one of the clips. The bubble tube may be attached either to the telescope or to the stage carrying the wyes.

## 3. Reversible level:

A reversible level combines the features of both the dumpy level and the Wye level. The telescope is supported by two rigid sockets into which the telescope can be introduced from either end and then fixed in position by a screw. The sockets are rigidly connected to the spindle through a stage.

**4. Tilting level :**

It consists of a telescope attached with a level tube which can be tilted within few degrees in vertical plane by a tilting screw.

The main peculiarity of this level is that the vertical axis need not be truly vertical, since the line of collimation is not perpendicular to it. The line of collimation, is, however, made horizontal for each pointing of telescope by means of tilting screw. It is mainly designed for precise leveling work.

**5. Digital level**

There are fundamentally two types of automatic levels.

First, the optical one whose distinguishing feature is self-leveling i.e., the instruments gets approximately leveled by means of a circular spirit level and then it maintains a horizontal line of sight of its own.



Second, the digital levels whose distinguishing features are automatic leveling, reading and recording.

**The different types of leveling**

**I ) Direct Leveling** : Direct measurement, precise, most commonly used;

**Types:**

**(1) Simple leveling :** One set up of level. To find elevation of points. When the difference of level between two points is determined by setting the leveling instrument midway between the points , the process is called simple leveling.

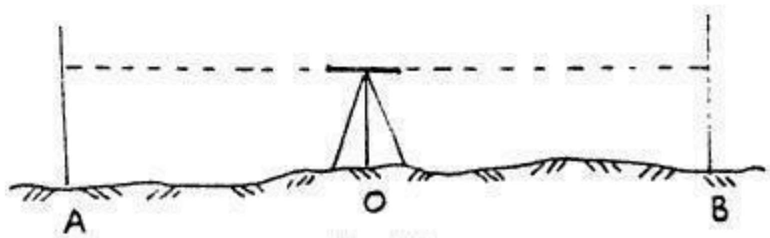



*Fig- Simple Leveling*

*(https://www.rjmcivil.com/2020/10/Levelling.html )*

**2. Differential leveling :**

Differential leveling is adopted when :

(i) the points are at a great difference apart,

(ii) the difference of elevation between the points is large,

(iii) there are obstacles between the points. To find elevation of non-intervisible points.

This method is called compound leveling or continuous leveling.



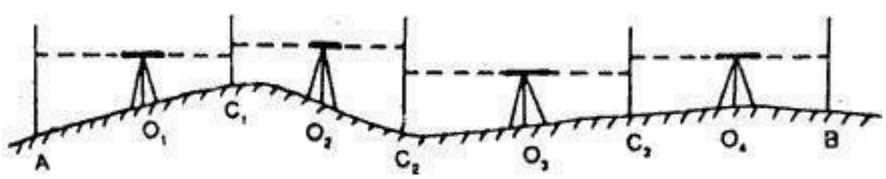



*Fig- Differential leveling*

*(https://www.rjmcivil.com/2020/10/Levelling.html )*

**3. Fly leveling :**

When differential leveling is done in order to connect a bench mark to the starting point of the alignment of any project, it is called fly leveling. Fly leveling is done to connect the BM to any intermediate point of the alignment for checking the accuracy of the work. Only back sight and fore sight readings are taken at every set up of the level and no distances are measured along the direction of leveling.

Low precision, to find/check approximate level, generally used during reconnaissance survey.

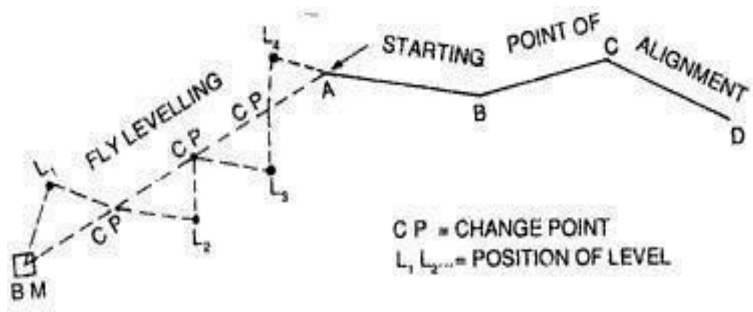



*Fig- Fly leveling*

*(https://www.rjmcivil.com/2020/10/Levelling.html )*

4. **Precise leveling :** Precise form of differential leveling.

5. **Profile leveling :** Finding of elevation along a line and its cross section.



6. **Reciprocal leveling :** Along a river or pond. Two level simultaneouslyused, one at either end.

7. **Check leveling**

The fly leveling is done at the end of day's work starting point on that particularday is known as check leveling.

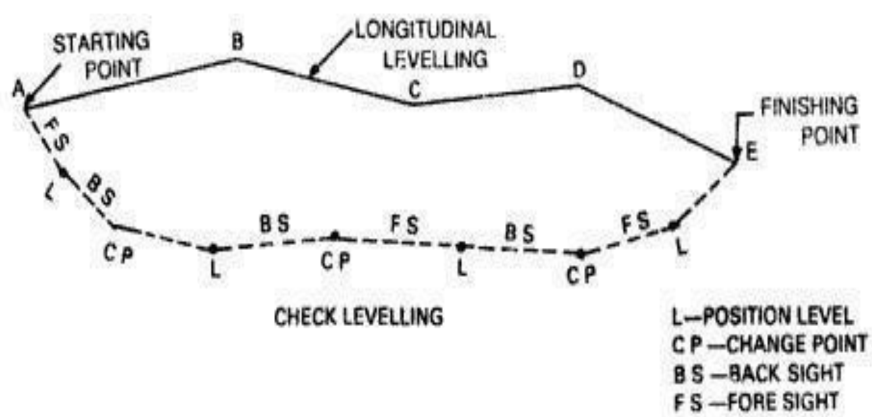



*Fig- Check leveling*

*(https://www.rjmcivil.com/2020/10/Levelling.html )*

**(II)** **Indirect or Trigonometric Leveling :** By measuring vertical angles and horizontal distance; Less precise.

**(III)** **Stadia Leveling :** Using tacheometric principles.

**(IV)** **Barometric Leveling :** Based on atmospheric pressure difference; Using

| Sl.No | Height of collimation system | Rise and fall system |
|---|---|---|
| 1 | It is rapid as it involves few calculation | It is laborious involvir calcuation |
| 2 | There is no check on the RL of the intermediate sight | There is a check on the intermediate points |
| 3 | Errors in the intermediate RLs cannot be detected. | Errors in the intermediat be detected as all the correlated |
| 4 | There are two checks on the accuracy of RL calculation | There are three check accuracy of RL calculatior |
| 5 | This system is suitable for longitudinal leveling where there are a number of intermediate sights | This system is suitabl leveling where there intermediate sights |



altimeter; Very rough estimation

**Height of collimation system Vs Rise and fall system**

1 It is rapid as it involves few Calculation It is laborious involving several calculation

2 There is no check on the RL of the intermediate sight There is a check onthe RL of the intermediate points

3 Errors in the intermediate RLs cannot be detected. Errors in the intermediate RLs can be detected as all the points are correlated

4 There are two checks on the accuracy of RL calculation There are three checks on the accuracy of RL calculation

5 This system is suitable for longitudinal leveling where number of intermediate sights This system is suitable for fly there are a leveling where there are no intermediate sights



**Height of collimation system**

1 It is rapid as it involves few Calculation

2 There is no check on the RL of the intermediate sight

3 Errors in the intermediate RLs cannot be detected.

4 There are two checks on the accuracy of RL calculation

5 This system is suitable for longitudinal leveling where number of intermediate sights

**Rise and fall system**

It is laborious involving several calculation there is check on the RL of the intermediate points Errors in the intermediate RLs can be detected as all the points are correlated There are three checks on the accuracy of RL calculation This system is suitable for fly there are a leveling where there are no intermediate sights

**Temporary Adjustment of a Level**

At each set up of a level instrument, temporary adjustment is required to be carried out prior to any staff observation. It involves some well-defined operations which are required to be carried out in proper sequence. The temporary adjustment of a dumpy level consists of (1)Setting ,

(2) Leveling and

(3) Focusing .

During **Setting**, the tripod stand is set up at a convenient height having its head horizontal (through eye estimation). The instrument is then fixed on the head by rotating the lower part of the instrument with right hand and holding firmly the upper part with left hand. Before fixing, the leveling screws are required to be brought in between the tribrach and trivet. The bull's eye bubble (circular bubble), if present, is then brought to the centre by adjusting the tripod legs.



Next, **Leveling** of the instrument is done to make the vertical axis of the instrument truly vertical. It is achieved by carrying out the following steps:

**Step 1:** The level tube is brought parallel to any two of the foot screws, by rotating the upper part of the instrument.

**Step 2:** The bubble is brought to the centre of the level tube by rotating both the foot screws either inward or outward. (The bubble moves in the same direction as the left thumb.)

**Step 3:** The level tube is then brought over the third foot screw again by rotating the upper part of the instrument.

**Step 4:** The bubble is then again brought to the centre of the level tube by rotating the third foot screw either inward or outward.

**Step 5:** Repeat Step 1 by rotating the upper part of the instrument in the same quadrant of the circle and then Step 2.

**Step 6:** Repeat Step 3 by rotating the upper part of the instrument in the same quadrant of the circle and then Step 4.

**Step 7:** Repeat Steps 5 and 6, till the bubble remains central in both the positions.

**Step 8:** By rotating the upper part of the instrument through 180 o , the level tube is brought parallel to first two foot screws in reverse order. The bubble will remain in the centre if the instrument is in permanent adjustment.

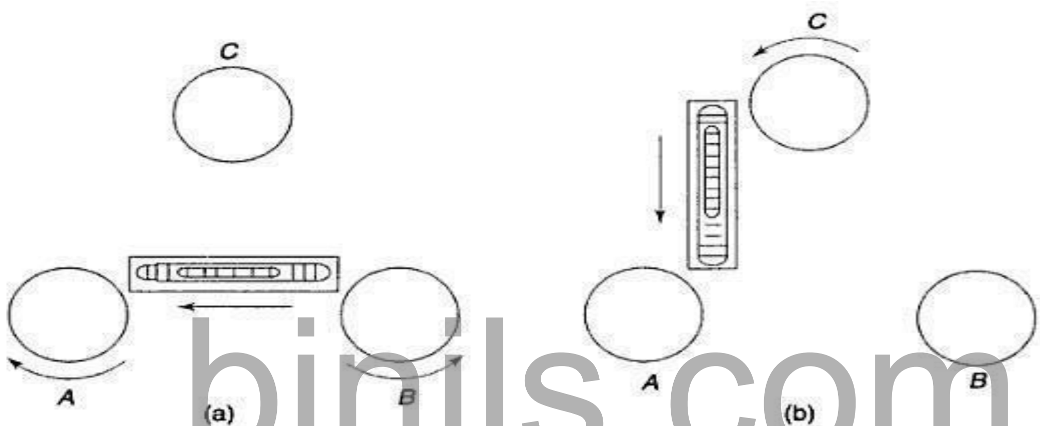





**Fig. 6.22** *Levelling with three foot screws*

*(https://www.brainkart.com/article/Temporary-Adjustment-of-a--Surveying-Level_4625/)*

In the case of four foot screws the levelling is to be carried out as follows

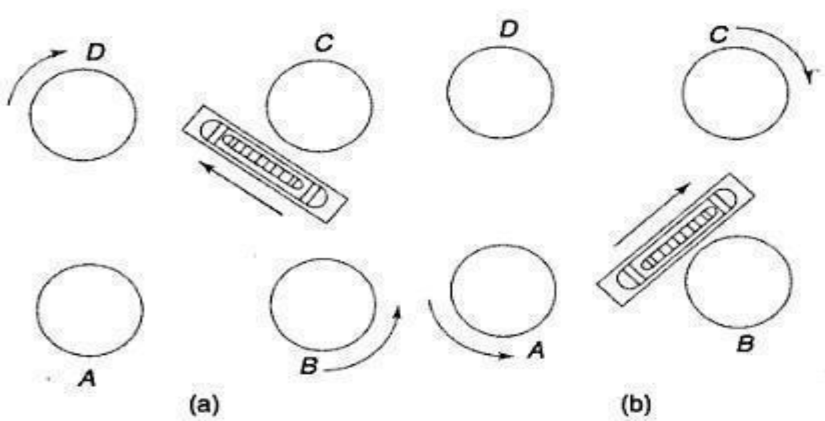



**Fig. 6.23** *Levelling with four foot screws*

*(https://www.brainkart.com/article/Temporary-Adjustment-of-a--Surveying-Level_4625/)*

**Focusing** is required to be done in order to form image through objective lens at the plane of the diaphragm and to view the clear image of the object through eye- piece. This is being carried out by removing parallax by proper focusing of objective and eye-piece.

**For focusing the eye-piece**, the telescope is first pointed towards the sky. Then the ring of eye-piece is turned either in or out until the cross-hairs are seen sharp and distinct. Focusing of eye-piece depends on the vision of observer and thus required whenever there is a change in observer.

**For focusing the objective,** the telescope is first pointed towards the object. Then, the focusing screw is turned until the image of the object appears clear and sharp and there is no relative movement between the image and the cross-hairs. This is required to be done before taking any observation.



**Proceed profile leveling or longitudinal sectioning in the field. Profile Leveling**

Profile leveling is a method of surveying that has been carried out along the central line of a track of land on which a linear engineering work is to be constructed/ laid. The operations involved in determining the elevation of ground surface at small spatial interval along a line is called profile leveling.

**Stations**

The line along which the profile is to be run is to be marked on the ground before taking any observation. Stakes are usually set at some regular interval which depends on the topography, accuracy required, nature of work, scale of plotting etc. It is usually taken to be 10 meter. The beginning station of profile leveling is termed as 0+00. Points at multiples of 100m from this point are termed as full stations. Intermediate points are designated as pluses.

**Procedure**

In carrying out profile leveling, a level is placed at a convenient location (say I1) not necessarily along the line of observation. The instrument is to be positioned in such a way that first backlight can be taken clearly on a B.M. Then, observations are taken at regular intervals (say at 1, 2, 3, 4) along the central line and foresight to a properly selected turning point (say TP1). The instrument is then re- positioned to some other convenient location (say I2). After proper adjustment of the instrument, observations are started from TP1 and then at regular intervals (say at 5, 6 etc.) terminating at another turning point, say TP2 . Staff readings are also taken at salient points where marked changes in slope occur, such as that at The distance as well as direction of lines are also measured.

**Field book for Reduction of Level**

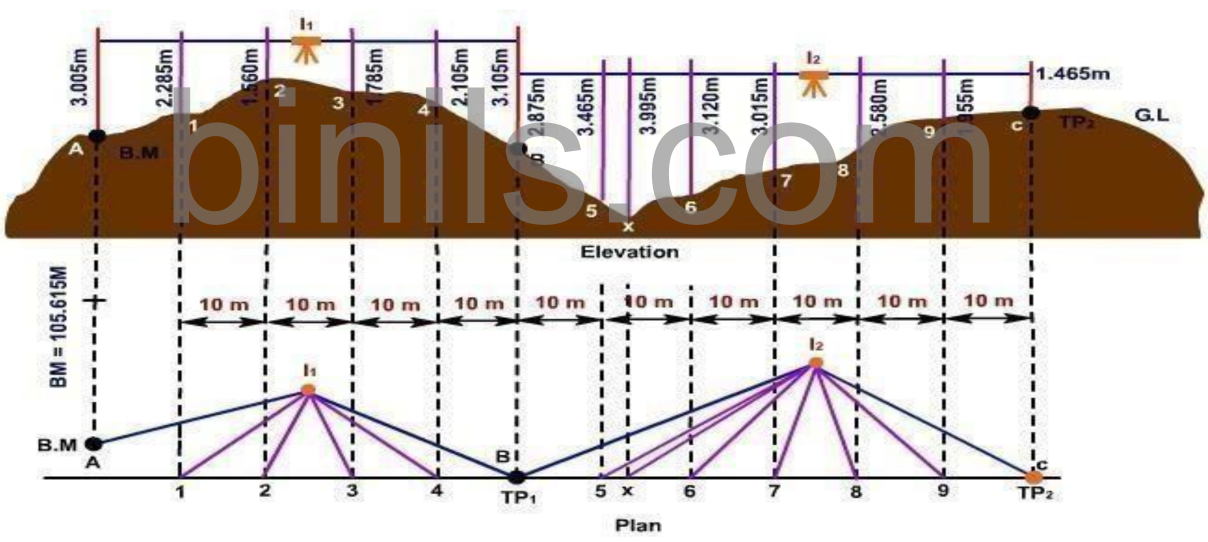



Figure 14.1 Profile Levelling

*(https://www.brainkart.com/article/Proceed-profile-leveling-or-longitudinal-sectioning-in- the-field_4626/)*

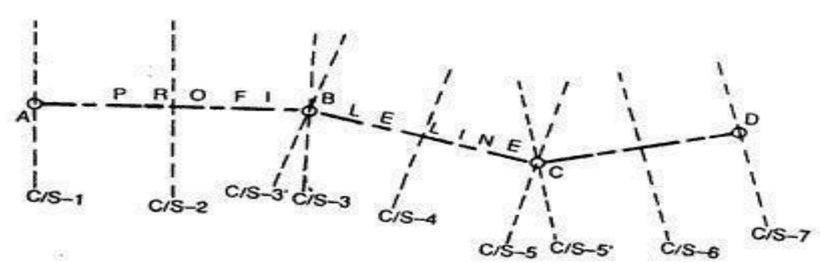
Table 1 -(*https://www.brainkart.com/article/Proceed-profile-leveling-or-longitudinal-sectioning-in-the-field_4626/)*

*Fig- Cross Sectioning*
*(https://www.brainkart.com/article/Proceed-profile-leveling-or-longitudinal-sectioning-in-*

**Field book for Reduction of Level**

| Pegs | Distance(m) | Direction | Staff Reading (m) | | | Difference in Elevation (m) | | H.I (m) | R.L(m) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | B.S | I.S | F.S | Rise | Fall | | | |
| A | | | 3.005 | | | | | 108.620 | 105.615 | B.M. |
| 1 | 0+00 | | | 2.285 | | 0.720 | | | 106.335 | |
| 2 | 0+10 | | | 1.560 | | 0.725 | | | 107.060 | |
| 3 | 0+20 | | | 1.785 | | | 0.225 | | 106.835 | |
| 4 | 0+30 | | | 2.105 | | | 0.320 | | 106.515 | |
| B | 0+40 | | 2.875 | | 3.105 | | 1.000 | 108.390 | 105.515 | T.P.1 |
| 5 | 0+50 | | | 3.465 | | | 0.590 | | 104.925 | |
| X | 0+53.35 | | | 3.955 | | | 0.490 | | 104.435 | |
| 6 | 0+60 | | | 3.120 | | 0.835 | | | 105.270 | |
| 7 | 0+70 | | | 3.015 | | 0.105 | | | 105.375 | |
| 8 | 0+80 | | | 2.580 | | 0.435 | | | 105.810 | |
| 9 | 0+90 | | | 1.955 | | 0.625 | | | 106.435 | |
| C | 1+00 | | | | 1.465 | 0.490 | | | 106.925 | T.P.2 |
| | | | | | | | | | | |
| | | □□ | 5.880 | | 4.570 | 3.935 | 2.625 | | | |





**Cross Sectioning**

In many projects, terrain information transverse to the longitudinal section (through profile leveling) is also required such as for highways, railways, canals etc. In those cases, surveying is carried out at right angle to the central line, generally, at regular interval is being carried out and is termed as cross- sectioning. If, for any reason, a cross-section is run in any other direction, the angle with the centre line is required to be noted. The observations are then recorded as being to the left or right of the centre line. The notes of the readings are maintained as shown in for taking a cross- section along the stake point 4. Reduction of levels, Plotting etc. can be done as in case of profile leveling.

Table 2

*(https://www.brainkart.com/article/Proceed-profile-leveling-or-longitudinal-sectioning-in- the-field_4626/)*

| Pegs | Distance(m) | Direction | Staff reading (m) | | | Difference in elevation (m) | | H.I (m) | R.L (m) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | B.S. | I.S. | F.S. | Rise (m) | Fall (m) | | | |
| A | | | 3.005 | | | | | 108.620 | 105.615 | B.M. |
| : | | | | | | | | | | |
| 4 | 0+30 | | | 2.105 | | | 0.320 | | 106.515 | 0m |
| | | | | 1.850 | | | | | 106.770 | 2m left |
| | | | | 1.725 | | | | | 106.895 | 4m left |
| | | | | 1.680 | | | | | 106.940 | 6m left |
| | | | | 1.985 | | | | | 106.635 | 2m right |
| | | | | 1.875 | | | | | 106.745 | 4m |
| | | | | | | | | | | right |
| | | | | 1.780 | | | | | 106.840 | 6m right |
| B | 0+40 | | 2.875 | | 3.105 | | 1.000 | 108.390 | 105.515 | T.P.$_1$ |
| : | | | | | | | | | | |

**Reciprocal leveling done**

In the case of an obstacle like river valley, it is not possible to set the up the level

midway between two points on the opposite banks. In such cases the method of reciprocal leveling is adopted, which involv3es reciprocal observations from both banks of the river or valley. Two sets of staff readings are taken by holding the staff on both banks. In this case it is found that the errors are completely eliminated and the true difference of level is equal to the mean of the two apparent differences of level. The principle is explained as follows up very near a and after proper temporary adjustment , staff readings are taken at A and B. Suppose the readings are a1 and b1.

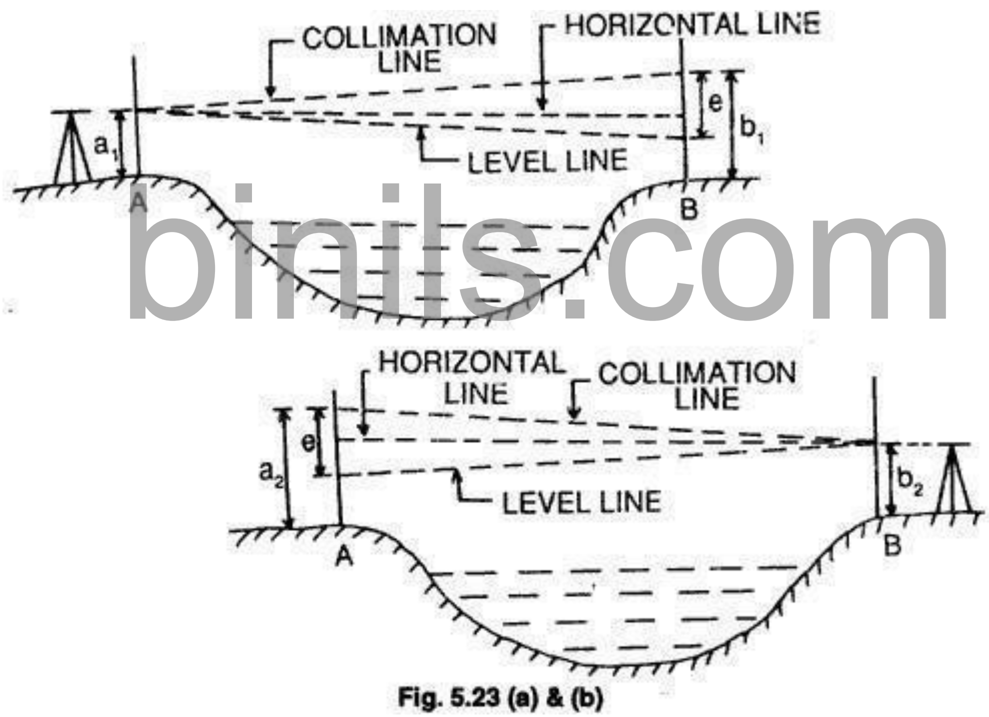



*Fig **Reciprocal leveling***
(*https://www.brainkart.com/article/Proceed-profile-leveling-or-longitudinal-sectioning-in- the-field_4626/*)

The level is shifted and set up very near B and after proper adjustment, staff readings are taken at A and B .Suppose the readings are a2 and b2.

Let h = true difference of level between A and B e = Combined error due to curvature , refraction and collimation

**PROBLEMS**

**1.The following staff readings were obtained during a leveling work with the instrument being shifted after the 4th, 7th and 10th. Readings: 2.305, 0.940, 0.865, 1.325, 2.905, 1.185, 1.205, 2.015, 1.365, 0.985 and 1.785.** Find **the reduced levels of the remaining points if the RL of the second turning point is 200.00**

**Solution:**

| Points | B.S | I.S | F.S | Rise | Fall | R.L | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | 2.305 | | | | | 198.635 | |
| 2 | | 0.940 | | 1.365 | | 200 | RL=200 |
| 3 | | 0.865 | | 0.075 | | 200.075 | |
| 4 | 2.905 | | 1.325 | | 0.46 | 199.615 | C.P |
| 5 | | 1.185 | | 1.72 | | 201.335 | |
| 6 | 2.015 | | 1.205 | | 0.02 | 201.315 | C.P |
| 7 | | 1.365 | | 0.65 | | 201.965 | |
| 8 | | 0.985 | | 0.38 | | 202.345 | |
| 9 | | | 1.785 | | 0.80 | 201.545 | Endpoint |
| Total | ∑B.S=7.225 | | ∑F.S=4.315 | ∑Rise=0.53 | ∑Fall=1.6 | | |



**Arithmetic Check :**

∑B.S –∑F.S = ∑Rise – ∑Fall = Last R.L – First R.L

= 7.225 – 4.315 =4.19 – 1.28 = 201.545 – 198.635

**= 2.91=2.91=2.91m**

Hence checked.

**2. Eight readings were taken with a level in sequence as follows: 1.585, 1.315, 2.305, 1.225, 1.325, 1.065, 1.815, and 2.325. The level was shifted after the third and sixth readings. The second change point was a benchmark of elevation 175.975. Find the reduced levels of the remaining stations. Use the rise and fall method.**

**Uses of contours maps**

Contours provide valuable information about the nature of terrain. This is very important for selection of sites, determination of catchment area of a drainage basin, to find indivisibility between stations etc. Some of the salient uses of contours are described below

**Nature of Ground**

To visualize the nature of ground along a cross section of interest,

**To Locate Route**

Contour map provides useful information for locating a route at a given gradient such as highway, canal, sewer line etc.

**Indivisibility between Stations**

When the indivisibility between two points cannot be ascertained by inspection of the area, it can be determined usingcontour map.

**To Determine Catchment Area or Drainage Area**

The catchment area of a river is determined by using contour map. The watershed line which indicates the drainage basin of a river passes through the ridges and saddles of the terrain around the river. Thus, it is always perpendicular to the contour lines. The catchment area contained between the watershed line and the river outlet is then measured with a planimeter



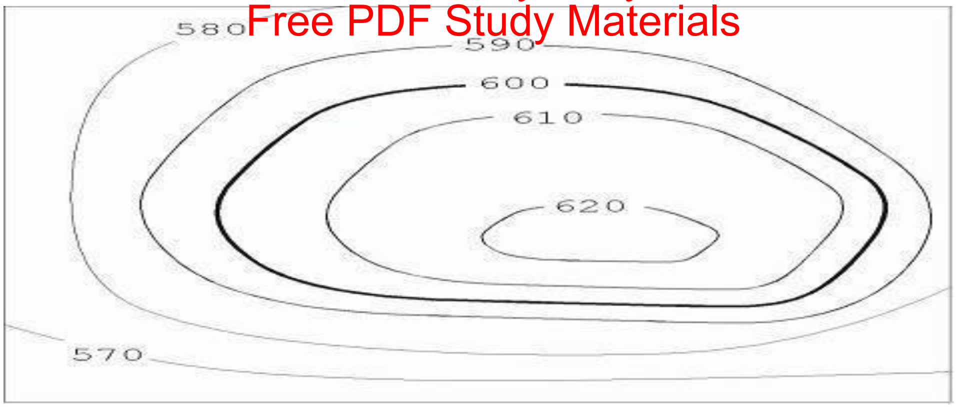
**Storage capacity of a Reservoir**

The storage capacity of a reservoir is determined from contour map. The contour line indicating the full reservoir level (F.R.L) is drawn on the contour map. The area enclosed between successive contours are measured by planimeter. The volume of water between F.R.L and the river bed is finally estimated by using either Trapezoidal formula or Prismoidal formula.

**Characteristics of Contour**

The principal characteristics of contour lines which help in plotting or reading a contour map are as follows:

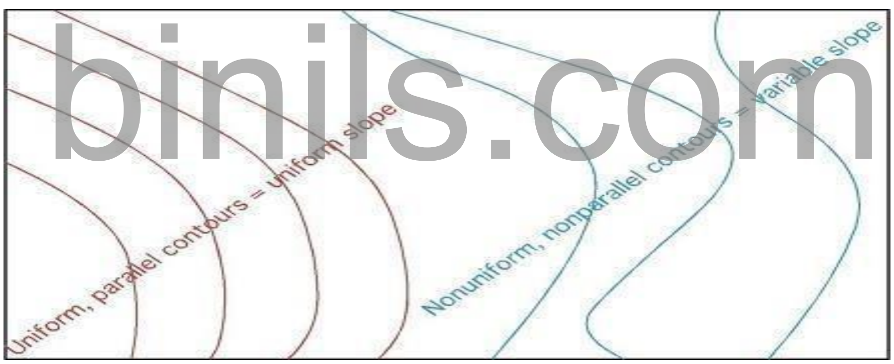
1. The variation of vertical distance between any two contour lines is assumed to be uniform. Contours are continuous.




(Fig: Contours are continuous)

(https://www.brainkart.com/article/Proceed-profile-leveling-or-longitudinal-sectioning-in- the-field_4626/)

The horizontal distance between any two contour lines indicates the amount of slope and varies inversely on the amount of slope. Thus, contours are spaced equally for uniform slope ; closely for steep slope contours; widely for moderate slope






(Fig: Slope) (https://www.brainkart.com/article/Proceed-profile-leveling-or-longitudinal-sectioning-in-the-field_4626/)

3. The steepest slope of terrain at any point on a contour is represented along the normal of the contour at that point. They are perpendicular to ridge and valley lines where they cross such lines.

4. Contours do not pass through permanent structures such as buildings

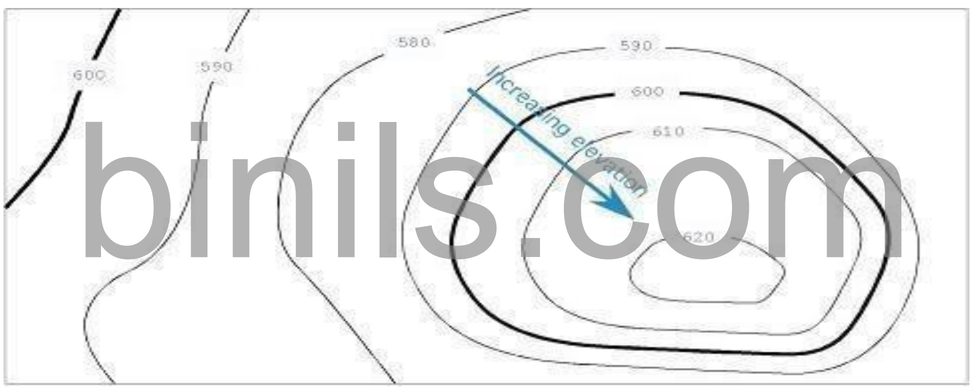
5. Contours of different elevations cannot cross each other (caves and overhanging cliffs are the exceptions).

6. Contours of different elevations cannot unite to form one contour (vertical cliff is an exception).

7. Contour lines cannot begin or end on the plan.

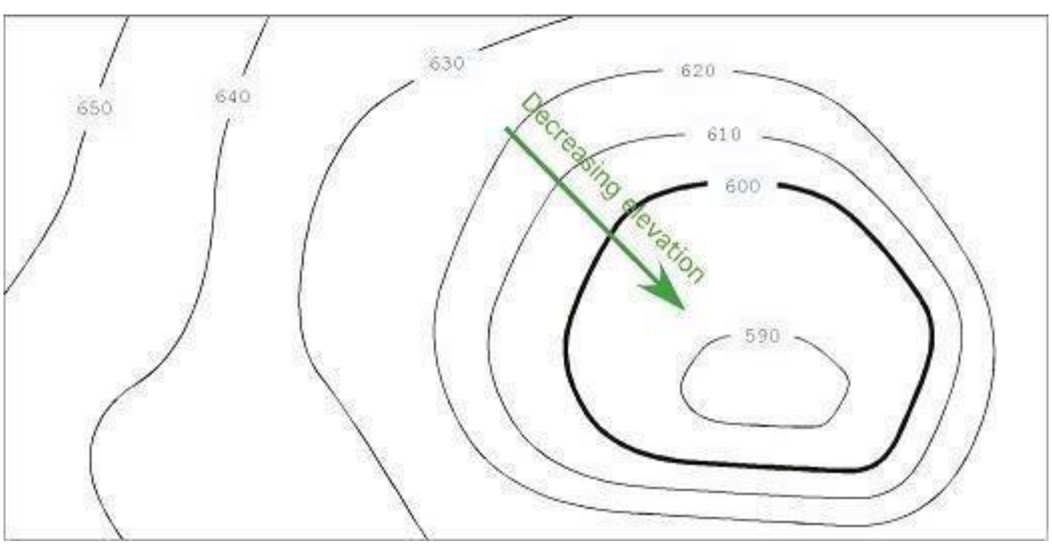
8. A contour line must close itself but need not be necessarily within the limits of the map.

9. A closed contour line on a map represents either depression or hill . A set of ring contours with higher values inside, depicts a hill whereas the lower value inside, depicts a depression (without an outlet).



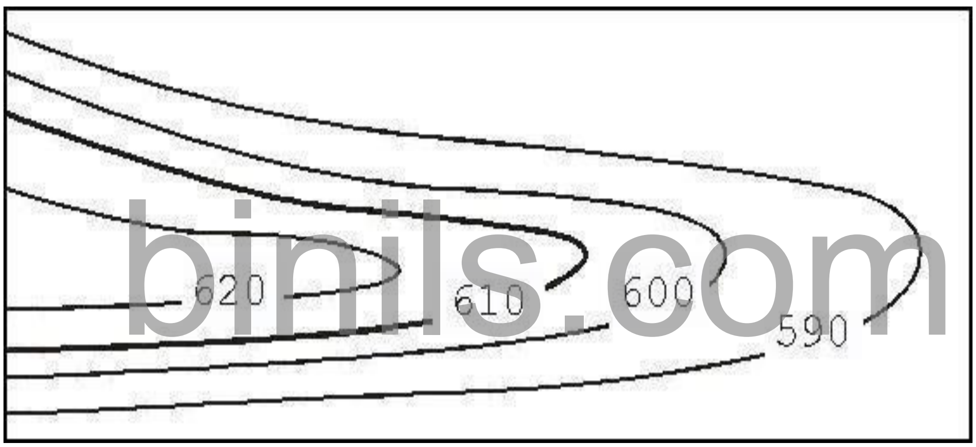

*(Fig: Contours showing Hill)*

(https://www.brainkart.com/article/Proceed-profile-leveling-or-longitudinal-sectioning- in-the-field_4626/)




***(Fig: Contours showing Depression)***
*([https://www.brainkart.com/article/Proceed-profile-leveling-or-longitudinal-sectioning- in-the-field_4626/](https://www.brainkart.com/article/Proceed-profile-leveling-or-longitudinal-sectioning-in-the-field_4626/))*

10. Contours deflect uphill at valley lines and downhill at ridge lines. Contour lines in U-shape cross a ridge and in V-shape cross a valley at right angles. The concavity in contour lines is towards higher ground in the case of ridge and towards lower ground in the case of valley





*(Fig: Contours showing valley)*

***([https://www.brainkart.com/article/Proceed-profile-leveling-or-longitudinal-sectioning- in-the-field_4626/](https://www.brainkart.com/article/Proceed-profile-leveling-or-longitudinal-sectioning-in-the-field_4626/))***