SURVEYING

UNIT- 1 INTRODUCTION OF SURVEYING LINEAR MEASUREMENTS & COMPASS SURVEYING

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Surveying

"Surveying is the art of and science of determining the relative positions of various points or stations on the surface of the earth by measuring the horizontal and vertical distances, angles, and taking the details of these points and by preparing a map or plan to any suitable scale."

Levelling : Leveling is a branch of surveying which deals with the measurement of relative heights of different points on, above or below the surface of the earth. Thus in leveling, the measurements (elevations) are taken in the vertical plane.

Objective of Surveying

The object of surveying is to prepare a map or plan to show the relative positions of the objects on the surface of the earth. The map or plan is drawn to some suitable scale. It also shows the boundaries of districts, states and countries too.

Uses of surveying

- To prepare a contour map to find the topography of the area to find out the best possible site for roads, railways, bridges, reservoirs, canals, etc.
- Surveying is also used to prepare military map, geological map, archaeological map etc.
- For setting out work and transferring details from the map on the ground

Primary Divisions of Surveying

Plain Surveying

- The plain surveying is that type of surveying in which earth surface is considered as a plane and the curvature of the earth is ignored.
- In such surveying a line joining any two stations is considered to be straight.
- The triangle formed by any three points is considered as a plane triangle, and the angles of the triangle are considered as plain angles.
- Surveying is carried out for a small area of less than 250 km^2 .
- It is carried out by local or state agencies like R & B department, Irrigation department, Railway department.

Primary Divisions of Surveying

Geodetic Surveying

- The geodetic Surveying is that type of surveying in which the curvature of the earth is taken into account.
- It is generally extended over larger areas.
- The line joining any two stations is considered as curved line.
- The triangle formed by any three points is considered to be spherical and the angles of the triangle are considered to be spherical angles.
- Geodetic surveying is conducted by the survey of India
- Department and is carried out for a larger area exceeding 250 km^2

Classifications based on function

Classification based on Purpose

1. Geological Survey:

In this both surface and subsurface surveying are conducted to locate different minerals and rocks. In addition, geological features of the terrain such as folds and faults are located.

2. Mine Survey

Mine Survey includes include both surface and underground surveys. It is conducted for the exploration of mineral deposits and to guide tunnelling and other operations associated with mining.

3. Archaeological Survey

It is conducted to locate relics of antiquity, civilization, kingdoms, forts, temples, etc.

Classifications based on function

4. Military Survey

It has a very important and critical applications in the military. Aerial surveys are conducted for this purpose. It is conducted to locate strategic positions for the purpose of army operations.

5. Land Survey

Land Survey is done on land to prepare plan and maps of a given area. Topographical, city and cadastral surveys are some of the examples of land surveying.

6. Hydrological Surveying

This survey is conducted on or near the body of water such as lake, river, coastal area. This Survey consists of locating shore lines of water bodies.

Classifications based on function

7. Astronomical Survey

This survey is conducted for the determining of latitudes, longitudes, azimuths, local time, etc. for various places on earth by observing heavenly bodies (sun or the stars).

8. Aerial Survey

An aerial survey is conducted from aircraft. Aerial cameras take photographs of the surface of the earth in overlapping strips of land. This is also known as photographic survey.

Classification based on instruments

1. Chain Survey:

This is the simplest type of surveying in which only linear measurements are made with a chain or a tape. Angular measurements are not taken.

2. Compass Survey:

In compass horizontal angles are measured with magnetic compass

3. Chain and compass survey:

In this survey linear measurements are made with a chain or a tape and angular measurements with a compass.

4. Plane Table Surveying

It is a graphical method of surveying in which field works and plotting both are done simultaneously.

Classification based on instruments

5. Theodolite Survey:

In theodolite survey the horizontal angles are measured with the theodolite more precisely than compass and the linear measurements are made with a chain or tape.

6. Tachometry Survey:

A special type of theodolite known as tachometer is used to determine horizontal and vertical distances indirectly.

7. Leveling Survey:

This type of survey is used to determine the vertical distances (elevations) and relative heights of points with the help of an instrument known as level.

Classification based on instruments

8. Photogrammetric Survey:

Photogrammetry is the science of taking measurements with the help of photographs taken by aerial camera from the air craft.

9. EDM Survey:

In this type of survey all measurements (length, angles, co-ordinates) are made with the help of EDM instrument (i.e.. Total Station).

Fundamental Principles of Surveying

Two basic principles of surveying are:

- Always work from whole to the part, and
- To locate a new station by at least two measurements (Linear or angular) from fixed reference points.

Plan and Maps

One of the basic objective of surveying is to prepare plans and maps.

Plan

- A plan is the graphical representation to some scale, of the features on, near or below the surface of the earth as projected on a horizontal plane. The horizontal plane is represented by plane of drawing sheets on which the plan is drawn to some scale However the surface of the earth is curved it cannot be truly represented on a plane without distortion. In plane surveying the area involved are small, the earths surface may be considered as plane and hence plan is constructed by orthographic projections. A plan is drawn on a relatively large scale.

Plan and Maps

Map

- If the scale of the graphical projection on a horizontal plane is small, the plan is called a map. Thus graphical representation is called a plan if the scale is large while it is called a map if the scale is small.
- On plan, generally only horizontal distances and directions or angles are shown. On topographical map, however the vertical distances (elevations) are also represented by contour lines.

Linear Measurements

- The determination of the distance between two points on the surface of the earth is one of the basic operation of surveying. Measurement of horizontal distances or measuring linear measurement is required in chain surveying, traverse surveying and other types of surveying.

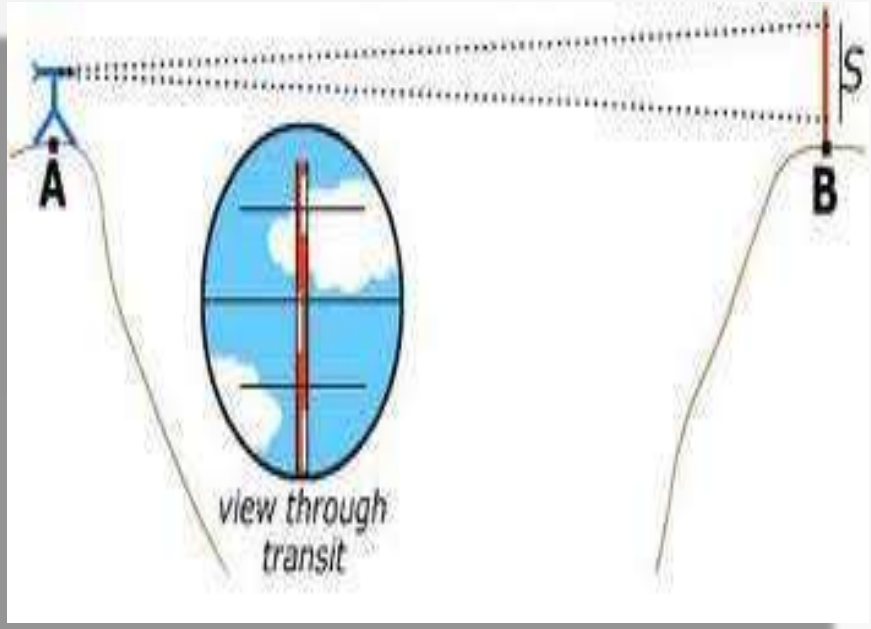
Linear Measurements

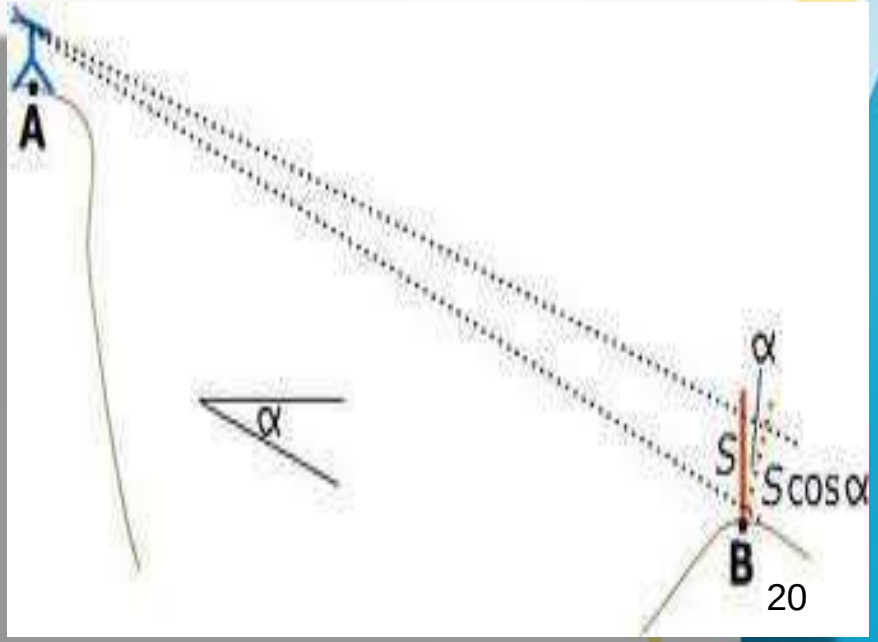
- Methods of making linear measurements
- Direct methods
- Optical methods
- E.D.M methods

Linear Measurements

- In the direct method, the distance is actually measured during field work using a chain or a tape. This is the most commonly used method for linear measurements.
- In the optical methods, principles of optics are used. The distance is not actually measured in field but it is computed indirectly. The instrument used for making observations is called tacheometer.

Optical Methods





Linear Measurements

- Electronic Distance Measuring (E.D.M) instruments have been developed quite recently.
- These are practically replacing the measurement of distances using chains or tapes. There is a large variety of such instruments and depending upon the precision required the instruments should be used.

Linear Measurements

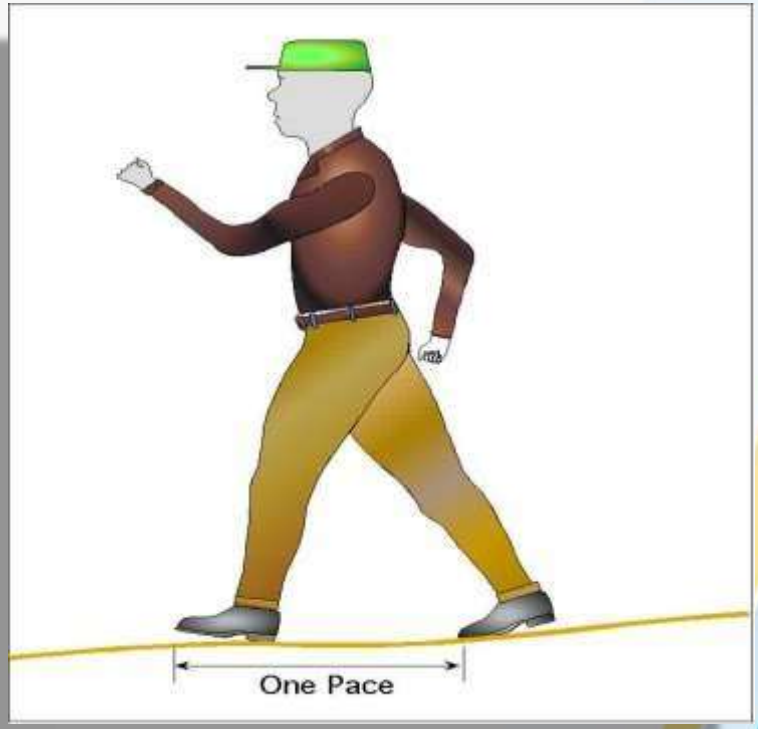
Approximate methods

- The methods given below may be used in reconnaissance or for detecting major mistakes in linear measurements obtained with a chain or a tape.

Pacing

- A distance between two points can be approximately be determined by counting the number of paces and multiplying it with average length of the pace.

Pacing



Instruments Used in Chaining

- The following instruments are used while chaining.
- Chains
- Tapes
- Arrows
- Ranging rods and offset rods
- Laths & Whites
- Pegs
- Plumb bob
- Line Ranger

Instruments Used in Chaining

Chains

- Various types of chains used in surveying are
- Metric Chain
- Gunter‟s Chain or Surveyor‟s Chain
- Engineer‟s Chain
- Revenue Chain
- Steel Band or band chain

Instruments Used in Chaining

Metric Chain

- Normally this chain consists of galvanized mild steel wire of 4 mm diameter known as link. The ends of the links are bent into loop and connected together by means of three oval rings which provide the flexibility to the chain and make it less liable to kinking. Both ends of the chain have brass handle with swivel joint so that the chain can be turned round without twisting

Metric Chain

- In a metric chain at every one meter interval of chain, a small brass ring is provided. Brass tallies are also provided at every 5.0 m length of chain. Each tally has different shape which indicates 5 , 10, 15m from any one side of the chain, metric chains are available in 20 m and 30 m length.
- A 20 m chain has 100 links each of 20 cm and 30 m chain has 150 links. Length of chain is embossed on the brass handles of the chain.

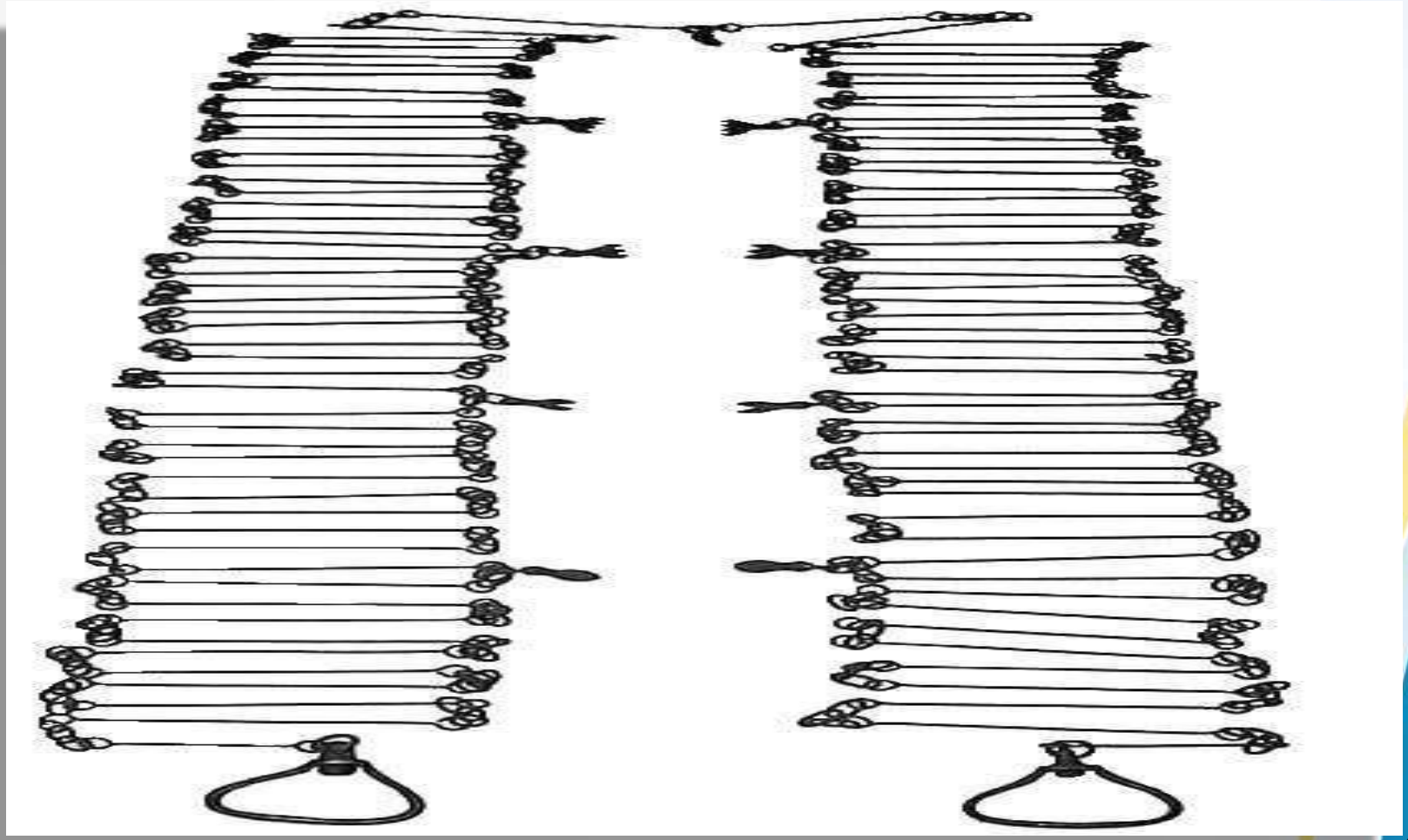
Metric Chain

Instruments Used in Chaining

Gunter's chain

- A 66 feet long chain consists of 100 links each of 0.66 ft it is known as Gunter‟s Chain
- Here, 10 sq chain are equal to 1 acre,
- 10 chains= 1 furlong and 8 furlongs = 1 mile
- This chain is suitable for taking length in miles and areas in acres.

Günter's Chain



Instruments Used in Chaining

Engineer's Chain

- A 100 ft chain of 100 links each of 1 foot is known as Engineer‟s chain. Brass tags are fastened at every 10 links. This chain is used to measure length in feet and area in square yards.

Engineer's Chain

Engineer's Chain

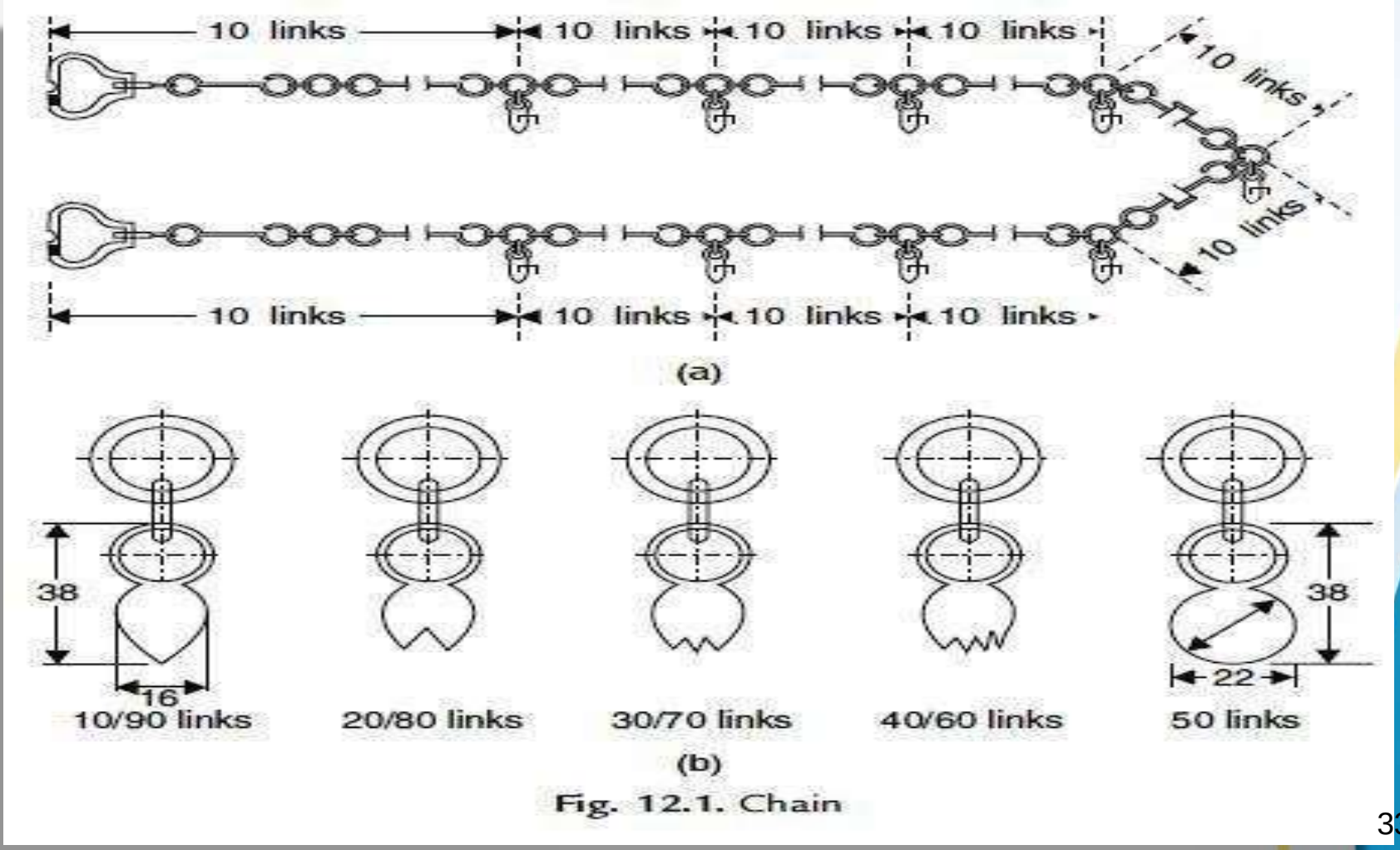


Fig. 12.1. Chain

Instruments Used in Chaining

Revenue Chain

- Revenue chain is 33 ft long chain consisting of 16 links. This chain is used for distance measurements in feet & inches for small areas.

Revenue Chain

Instruments Used in Chaining

Steel Band or Band Chain

- Steel bands are preferred than chains because they are more accurate, but the disadvantages is that they get broken easily and are difficult to repair in the field. They are 20 and 30 m long, 12 to 16 mm wide and 0.3 to 0.6 mm thick. They are numbered at every metre and divided by brass studs at every 20 cm

Steel Band or Band Chain

Steel Band or Band Chain

Testing and Adjustment of Chain

- During continuous use, the length of a chain gets altered. Its length is shortened chiefly due to the bending of links. Its length is elongated either due to stretching of the links and joints and opening out of the small rings. For accurate work it is necessary to test the chain time to time. The chain can be thus tested by a steel tape or by a standard chain. Sometimes, it is convenient to have a permanent test gauge established where the chain is tested.

Testing and Adjustment of Chain

- When the length of a chain is measured at a pull of 8 kg at 20 ^{0}C the length of the chain should measure 20 m $\pm$ 5 mm and 30 m $\pm$ 8 mm for 20 m and 30 m long chain shall be accurate to within 2 mm. Following measures are taken to adjust the length of a chain.

Testing and Adjustment of Chain

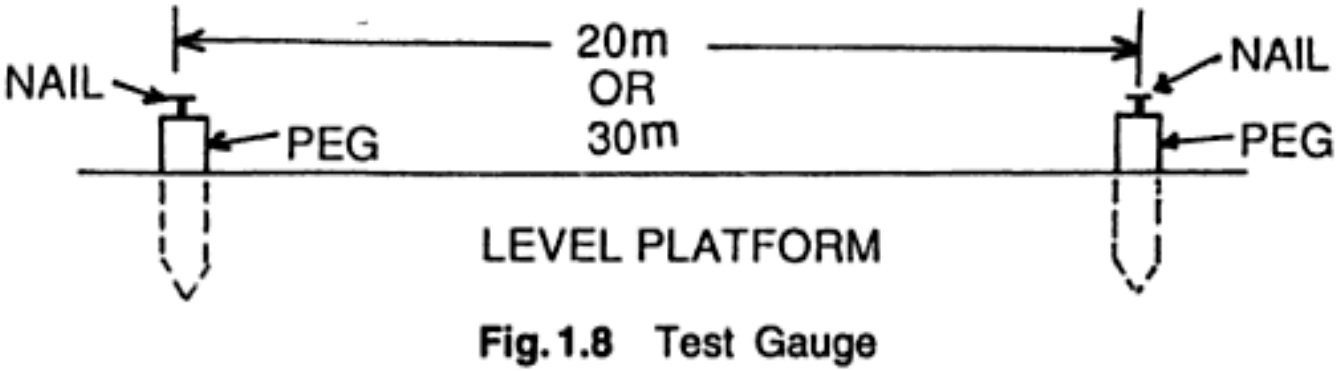
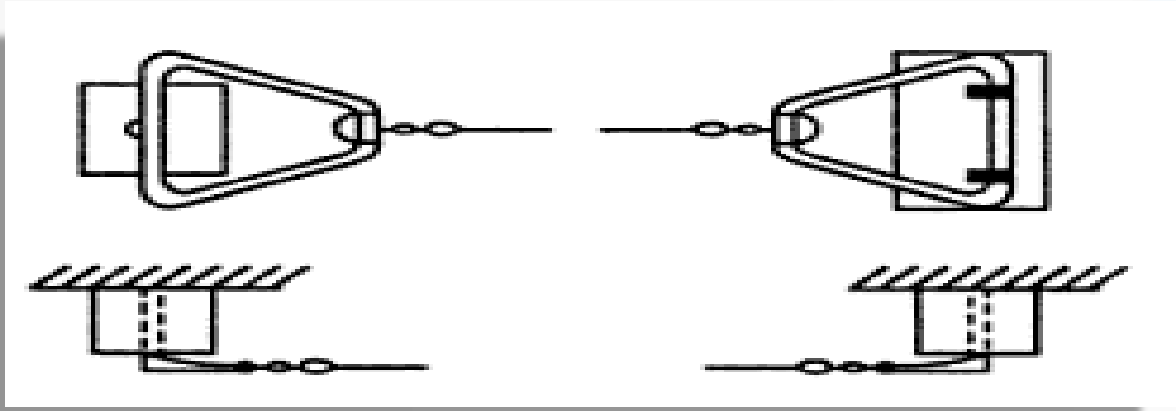


Fig. 1.8 Test Gauge



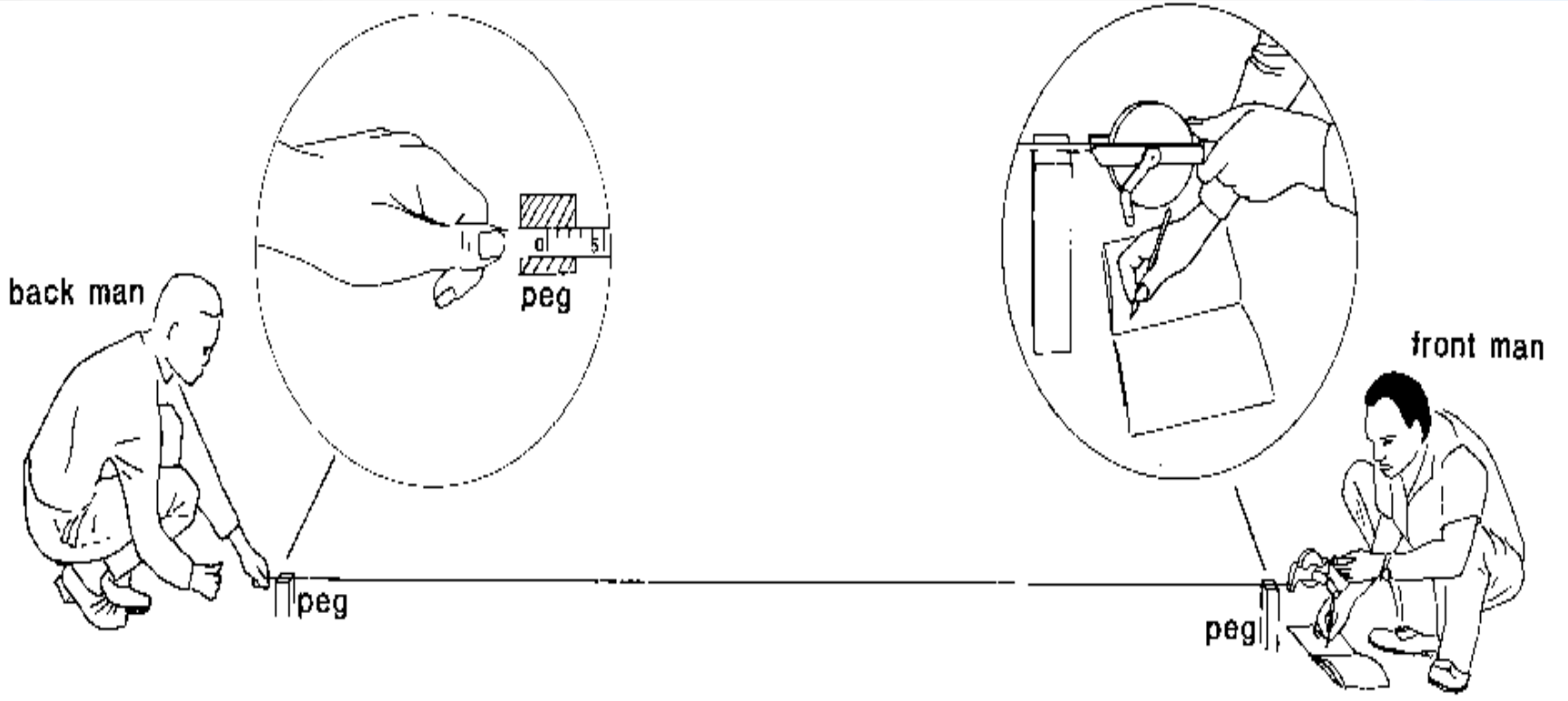
Testing and Adjustment of Chain

- If the chain is found to be too short
- Straightening the bent links
- Opening the joints of the rings
- Replacing one or more small circular rings by bigger ones.
- Inserting new rings where necessary.
- Adjusting the links at the end.

Measuring Tapes

- Tapes are used for more accurate measurement. The tapes are classified based on the materials of which they are made of such as:
- Cloth or linen tape
- Fibre Tape
- Metallic Tape
- Steel tape
- Invar Tape

Measuring Tapes



Measuring Tapes

Cloth or linen Tape

- Linen tapes are closely woven linen and varnished to resist moisture. They are generally 10 m, 20 m, 25 m and 30 m long in length and 12 to 15 mm wide. They are generally used for offset measurements. These tapes are light and flexible.

Cloth or linen Tape

Measuring Tapes

- **Fibre Glass Tape**
- These tapes are similar to linen and plastic coated tapes but these are made of glass fibre. The tapes are quite flexible, strong and non-conductive. These can be used in the vicinity of electrical equipment. These tapes do not stretch or shrink due to changes in temperature or moisture. These tapes are available in length of 20 m, 30 m and 50 m length.

Fibre Glass Tape

Measuring Tapes

- **Metallic Tape**
- A linen tape reinforced with brass or copper wires to prevent stretching or twisting of fibres is called a metallic tape. As the wires are interwoven and tape is varnished these wires are visible to naked eyes. This is supplied in a lather case with a winding device. Each metre length is divided into ten parts (decimetres) and each part is further sub-divided into ten parts. It is commonly used for taking offset in chain surveying.

Metallic Tape

Measuring Tapes

- **Steel Tape**
- The steel tape is made of steel ribbon of width varying from 6 to 16 mm. The commonly available length are 10 m, 15 m, 20 m, 30 m and 50 m. It is graduated in metres, decimetres, and centimetres. Steel tapes are used for accurate measurement of distances.

Steel Tape

Measuring Tapes

- **Invar Tape**
- Invar tape are made of alloy of nickel 36 % and steel 64 % having very low co-efficient of thermal expansion. These are 6 mm wide and generally available in length of 30 m, 50m, 100m. It is not affected by change of temperature therefore, it is used when high degree of precesion is required.

Invar Tape

Arrows

- Arrows are made of tempered steel wire of diameter 4 mm. one end of the arrow is bent into ring of diameter 50 mm and the other end is pointed. Its overall length is 400 mm. Arrows are used for counting the number of chains while measuring a chain line. An arrow is inserted into the ground after every chain length measured on the ground.

Arrows

Arrows

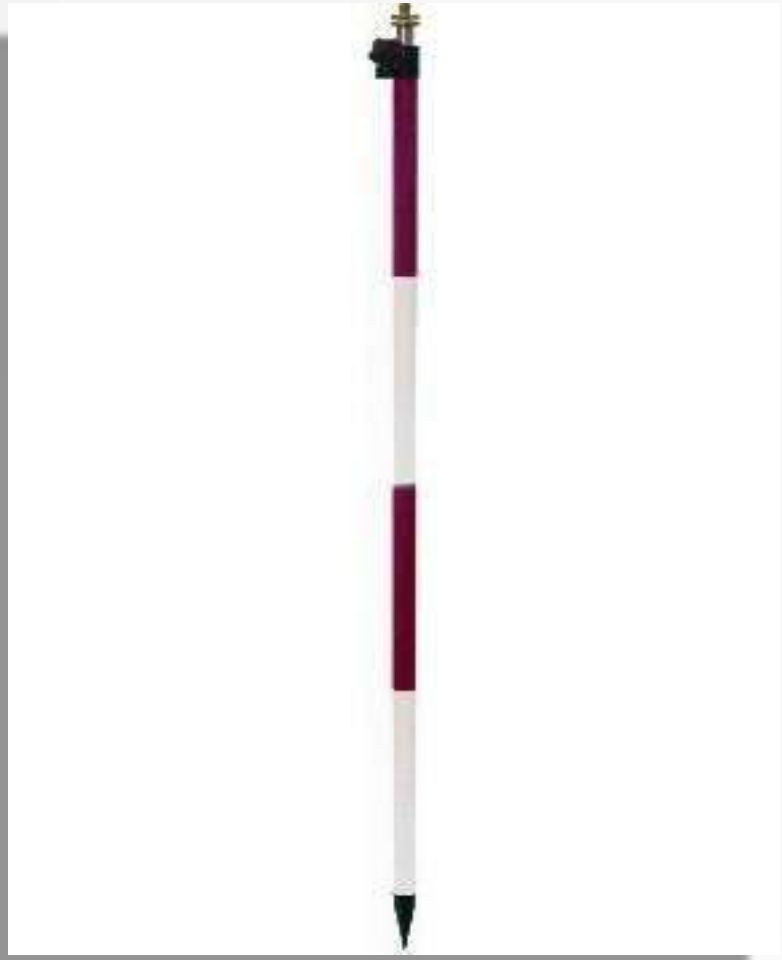
Ranging Rods and Offset Rods

- Ranging rods are used for ranging some intermediate points on the survey line. Ranging rods are generally 2 to 3 m in length and are painted with alternate bands of black or white or red and white colour with length of each equalizing 20 cm. The location of any survey station can be known from long distances only by means of ranging rods. If the distance is too long, a rod of length 4.0 to 6.0 m is used and is called ranging pole.
- The offset rod is similar to ranging rod with the exception that instead of the flag, a hook is provided at the top for pushing and pulling the chain or the tape. It is also used for measuring small offsets

Ranging Rods

Ranging Rods

Offset Rods



Ranging Rods and Offset Rods

Fig. 12.7 Ranging rod

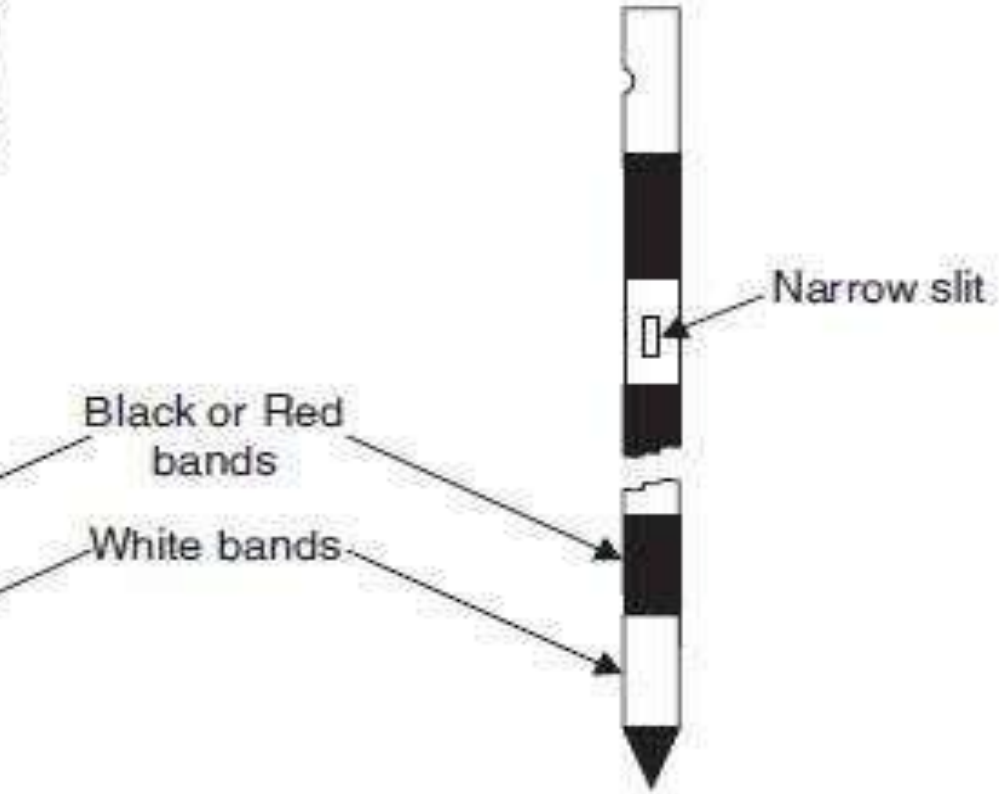


Fig. 12.8. Offset rod

Laths & Whites

Laths

- Laths are 0.5 to 1.0 m long sticks of soft wood. They are sharpened at one end and are painted with white or light colours. They are used as intermediate points while ranging or while crossing depressions.

Whites

- Whites are the pieces of sharpened thick sticks cut from the nearest place in the field. One end of the stick is sharpened and the other end is split. White papers are inserted in the split to improve the visibility. Whites are also used for the same purpose as laths

Laths & Whites

Pegs

- Pegs are made of timber or steel and they are used to mark the position of the station or terminal points of a survey line. Wooden pegs are 15 cm long and are driven into the ground with the help of a hammer.

Wooden Pegs

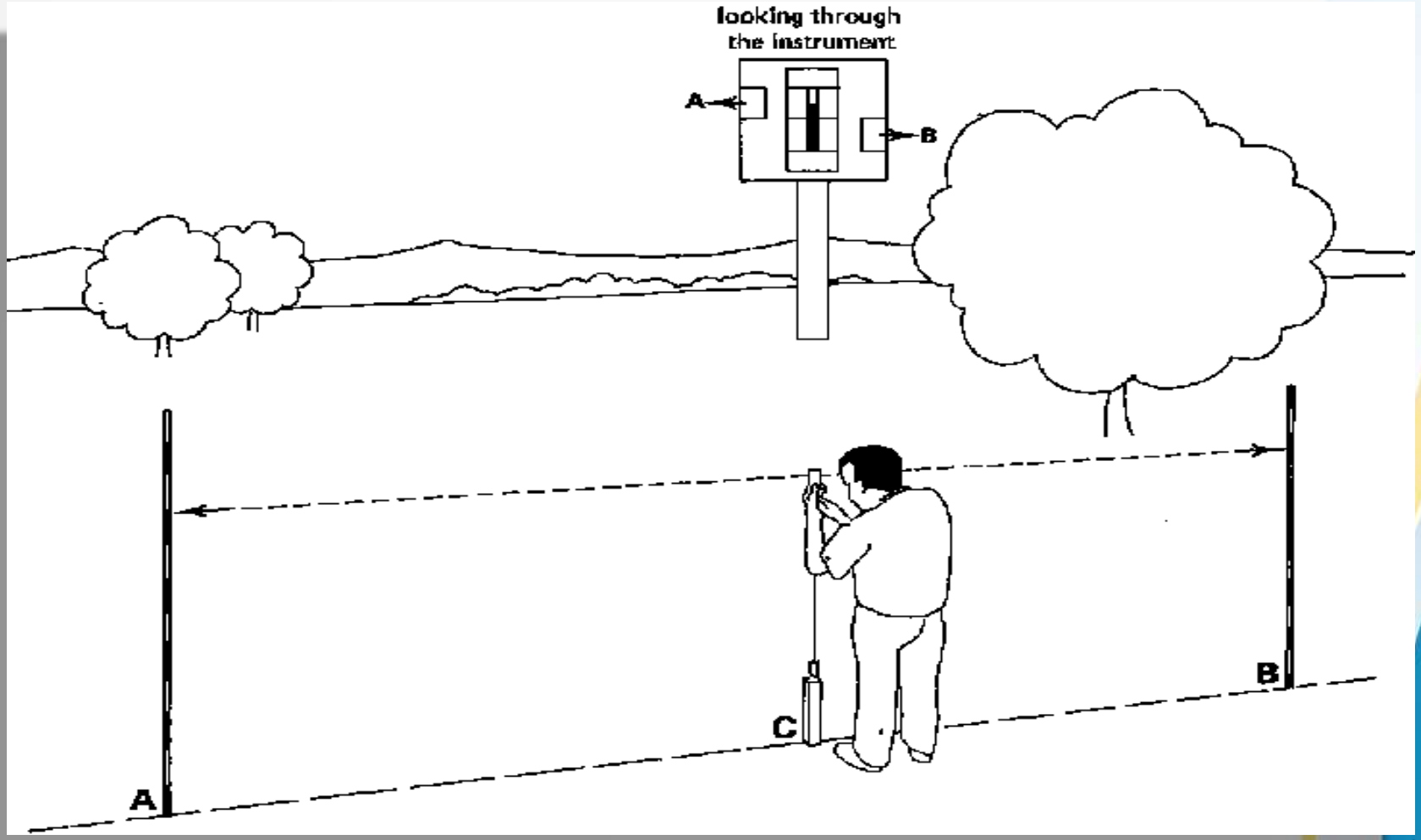
Plumb Bob

- Plumb-bob is used to transfer points on the ground. It is also used for fixing the instruments exactly over the station point marked on the ground by checking the centre of the instrument whether coincides with the centre of the peg or station not, by suspending the plumb-bob exactly at the centre of the instrument under it. Plumb bob is thus used as centring aid in theodolites and plane table.

Line Ranger

- It is an optical instrument used for locating a point on a line and hence useful for ranging. It consists of two isosceles prisms placed one over the other and fixed in an instrument with handle. The diagonals of the prisms are silvered so as to reflect the rays.

Ranging by Line Ranger



Line Ranger

- Its advantage is it needs only one person to range. The instrument should be occasionally tested by marking three points in a line and standing on middle point observing the coincidence of the ranging rods. If the images of the two ranging rods do not appear in the same line, one of the prism is adjusted by operating the screw provided for it.

Line Ranger

Line Ranger

- To locate point C on line AB (ref. Fig.) the surveyor holds the instrument in hand and stands near the approximate position of C. If he is not exactly on line AB, the ranging rods at A and B appear separated as shown in Fig. (*b*). *The surveyor moves to and fro at right angles to the line* AB till the images of ranging rods at A and B appear in a single line as shown in Fig. (*c*). *It* happens only when the optical square is exactly on line AB. Thus the desired point C is located on the line AB.

Chain Surveying

- Chain surveying is the type of surveying in which only linear measurements are taken in the field.
- This type of surveying is done for surveying of small extent to describe the boundaries of plots of land and to locate the existing feature on them.
- It is the method of surveying in which the area is divided into network of triangles and the sides of the various triangles are measured directly in the field with a chain or a tape and no angular measurements are taken.

Principles of Chain Surveying

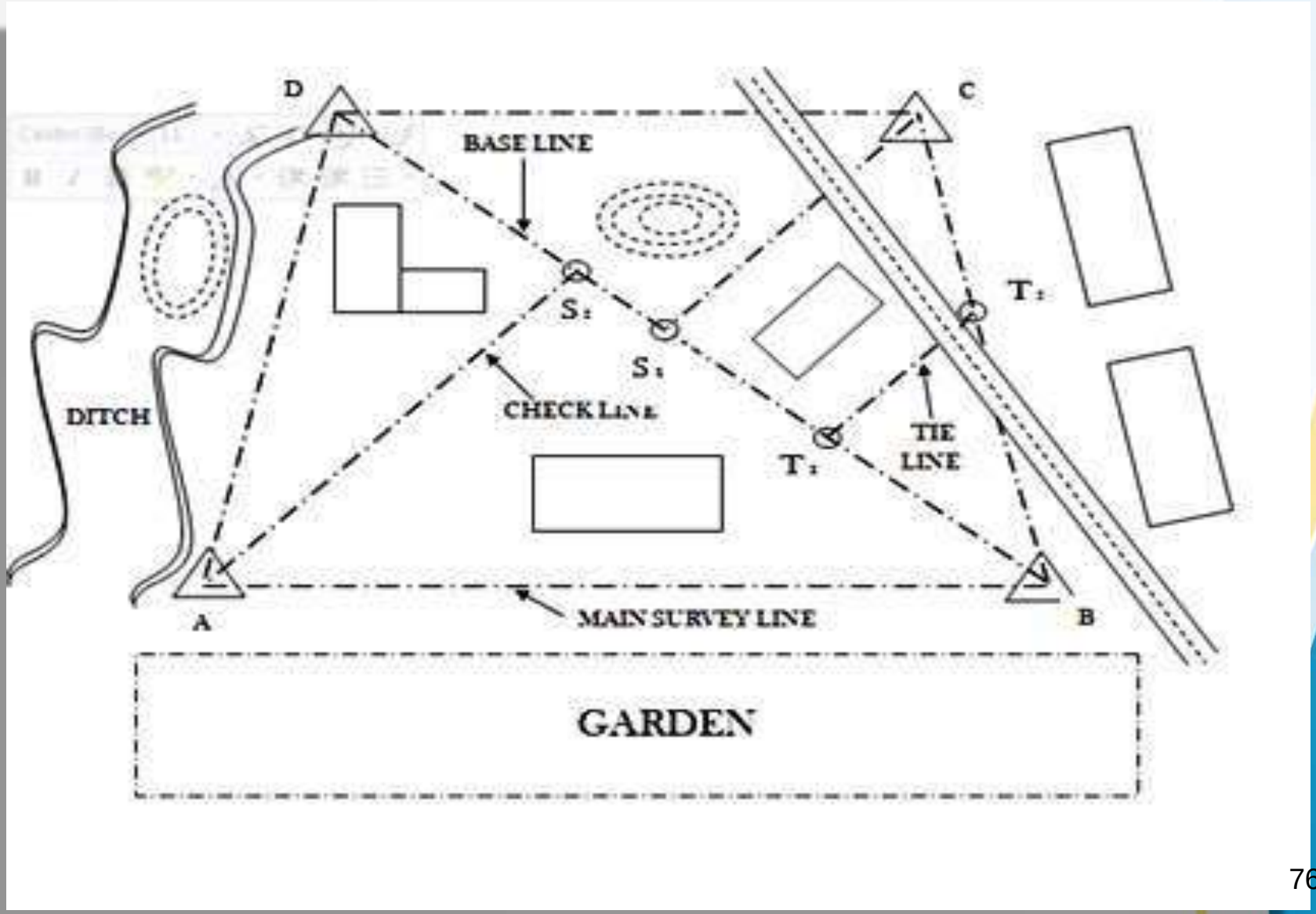
- The principle of chain surveying is to divide the area into a number of triangles of suitable sides. As a triangle is the only simple plane geometrical figure which can be plotted from the length of the three sides even if the angles are not known. A network of triangles is preferred to chain surveying.
- Triangulation is the principle of chain surveying. If the area to be surveyed is triangle in shape and if the lengths and sequence of its three sides are recorded, the plan of the area can be easily drawn.

Terms related to Chain Surveying

Survey Stations

- Survey stations are the points at the beginning and at the end of a chain line they may also occur at any convenient position on the chain line. Such station may be
- Main Stations
- Subsidiary Stations
- Tie Stations

Terms related to Chain Surveying



Terms related to Chain Surveying

- Main Station Stations along the boundary of an area as controlling points are known as „Main Stations“ The lines joining the main station are called „ Main Survey Lines“. The main survey lines should cover the whole area to be surveyed. The main stations are denoted by Δ.

Terms related to Chain Surveying

- **Subsidiary Stations:** Stations which are on the main survey lines or any other survey lines are known as „Subsidiary Stations" these stations are taken to run subsidiary lines for dividing the area into triangles, for checking the accuracy of triangles and for locating interior details.

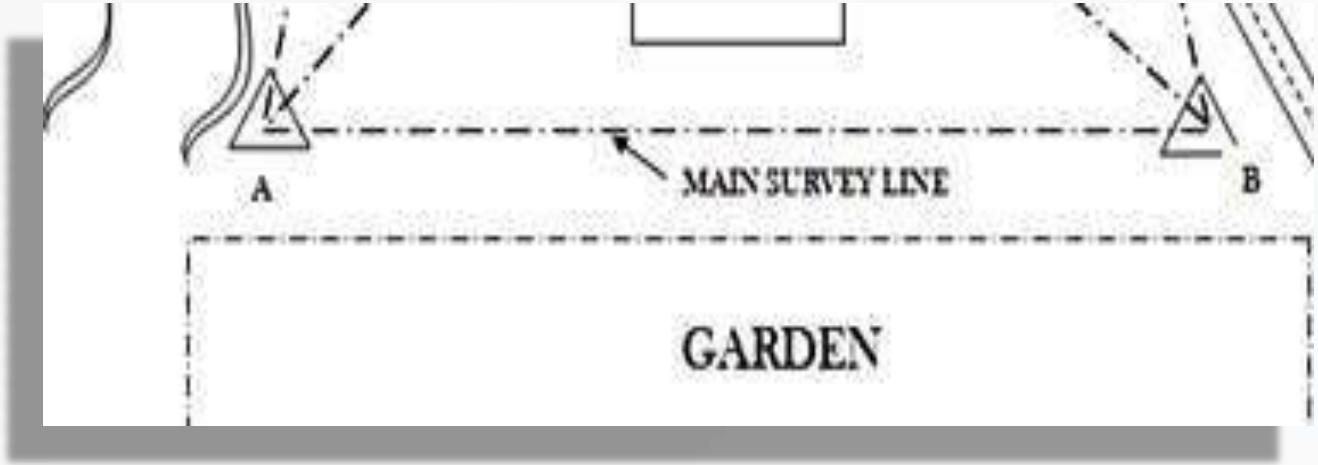
Terms related to Chain Surveying

- **Tie Stations:**
- These stations are also subsidiary stations taken on the main survey lines. Lines joining the stations are known as „ Tie lines“ Tie lines are taken to locate interior details.

Terms related to Chain Surveying

Main Survey Lines:

- The line joining the main stations are called main survey lines or chain lines.

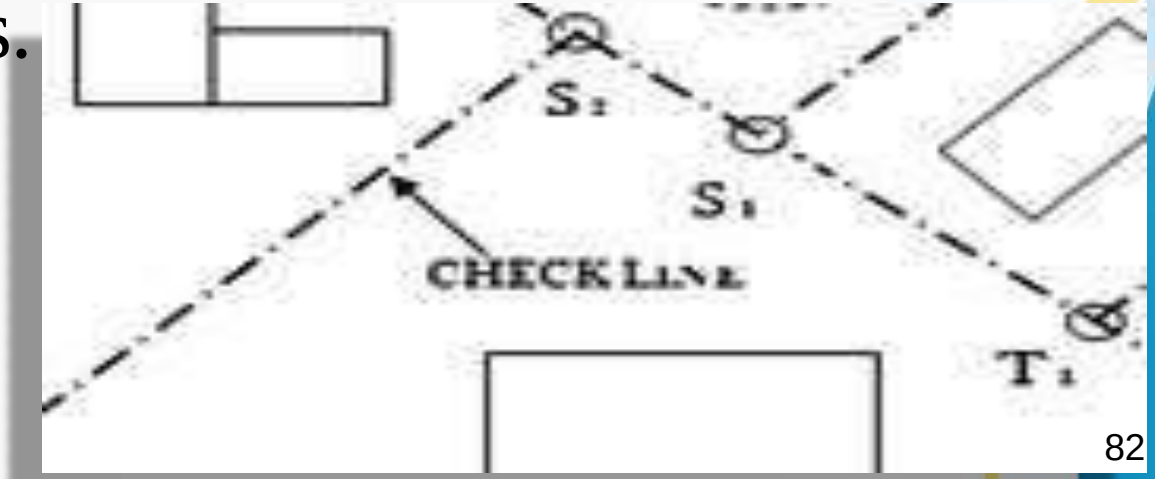


Terms related to Chain Surveying

- **Base Line:** The line on which the framework of the survey is built is known as „ Base line". It is the most important line of the survey. Generally the longest of the main survey lines is considered as the base line. This lines should be taken through fairly level ground, and should be measured very carefully and accurately.

Terms related to Chain Surveying

- **Check Line**
- The line joining the apex point of a triangle to some fixed points on its base is known as „ Check line". It is taken to check the accuracy of the triangle. Sometimes this line helps to locate interior details.



Terms related to Chain Surveying

- **Tie Line**
- A line joining tie stations is termed as a tie line. It is run to take the interior details which are far away from the main lines and also to avoids long offsets. It can also serve as check line.

Selection of Survey Station

- The following points should be considered while selecting survey stations:
- It should be visible from at least two or more stations.
- As far as possible main lines should run on level ground.
- All triangles should be well conditioned (No angle less than 30º).
- Main network should have as few lines as possible.

Selection of Survey Station

- Each main triangle should have at least one check line.
- Obstacles to ranging and chaining should be avoided.
- Sides of the larger triangles should pass as close to boundary lines as possible.
- Trespassing and frequent crossing of the roads should be avoided

Operation in Chain Surveying

- The following operations are involved in chain surveying.
- Chaining
- Ranging
- Offsetting
- These three operations are done simultaneously during chain Surveying.

Operation in Chain Surveying

- Chaining
- Chaining on Level Ground
- The method of taking measurement with the help of chain or tape is termed as chaining.
- *Chaining involves following operations*
- Fixing the stations
- Unfolding the chain
- Ranging
- Measuring the distance (Survey Line)
- Folding the Chain

Operation in Chain Surveying

Fixing of Station

- Stations are first of all marked with pegs and ranging rods to make them visible.

Unfolding of a Chain

- To open a chain, the strap is unfastened and the two brass handles are held in the left hand and the bunch is thrown forward with the right hand. Then one chainmen moves forward by holding the other handle until the chain is completely extended.

Operation in Chain Surveying

Ranging

- The process of establishing intermediate points on a straight line between two end points is known as ranging. Ranging must be done before a survey line is chained

Ranging (Code of Signals)

Sr. No.	Signal by the Surveyor	Meaning of the signal to the assistant
1	Rapid Sweep with right hand	Move considerable towards left
2	Slow Sweep with right hand	Move slowly towards left
3	Right arm extended	Continuously move towards left
4	Right arm up and move to the right	Plumb the rod towards left
5	Rapid Sweep with left hand	Move considerable towards right
6	Slow Sweep with left hand	Move slowly towards right
7	Left arm extended	Continuously move towards right
8	Left arm up and move to the right	Plumb the rod towards right
9	Both hand above head and brought down	Ranging is correct
10	Both arm extended horizontally and brought down quickly	Fix the ranging rod

Compass Surveying

- Chain surveying can be used when the area to be surveyed is comparatively small and is fairly flat.
- But when the area is large, undulated and crowded with many details, triangulation (which is the principle of chain survey) is not possible. In such an area, the method of traversing is adopted.

Principle of Compass Surveying

The Principle of Compass Survey is Traversing

which involves a series of connected lines the magnetic bearing of the lines are measured by prismatic compass and the distance (lengths) of the are measured by chain. Such survey does not require the formulation of a network of triangle.

- Compass surveying is recommended when the area is large, undulating and crowded with many details.
- Compass surveying is not recommended for areas where local attraction is suspected due to the presence of magnetic substances like steel structures, iron ore deposits, electric cables conveying currents, and so on.

Types and Uses of Compass

- **Compass:** A compass is a small instrument essentially Consisting of magnetic needle, a graduated circle, and a line of sight. The compass can not measure angle between two lines directly but can measure angle of a line with reference to magnetic meridian at the instrument station point is called magnetic bearing of a line. The angle between two lines is then calculated by getting bearing of these two lines.

There are two forms of compass available:

- **The Prismatic Compass**
- **The Surveyor's Compass**

Working of the Prismatic Compass

- When the needle of the compass is suspended freely. It always points towards the north. Therefore, all the angles measured with prismatic compass are with respect to north (magnetic meridian).
- “The horizontal angle made by a survey line with reference to magnetic meridian in clockwise direction is called the bearing of a line.’
- While using the compass, it is usually mounted on a light tripod which is having vertical spindle in the ball and socket arrangement to which the compass is screwed.

Temporary Adjustment of a Prismatic Compass

The following procedure should be adopted after the prismatic compass on the tripod for measuring the bearing of a line:

Centering

Centering is the operation in which compass is kept exactly over the station from where the bearing is to be determined. The centering is checked by dropping a small pebble from the underside of the compass. If the pebble falls on the top of the peg then the centering I correct, if not then the cantering is corrected by adjustment the legs of the tripod.

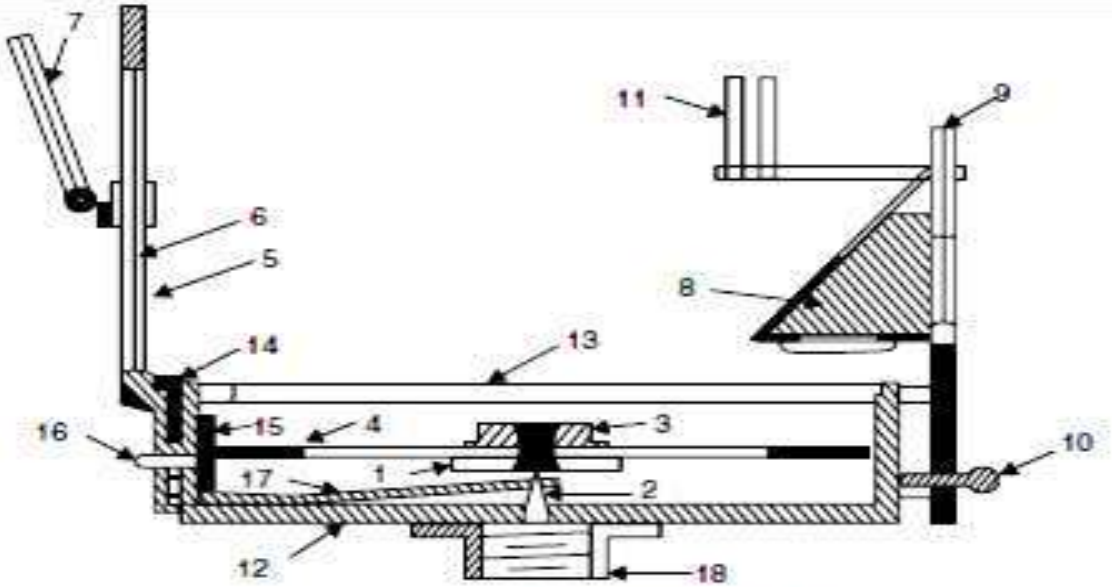
Levelling

Levelling of the compass is done with the aim to freely swing the graduated circular ring of the prismatic compass. The ball and socket arrangement on the tripod will help to achieve a proper lever of the compass. This can be checked by rolling round pencil on glass cover.

Focusing

The prism is moved up or down in its slide till the graduations on the aluminium ring are seen clear, sharp and perfect focus. The position of the prism will depend upon the vision of the observer.

The Prismatic Compass



1. Needle
2. Pivot
3. Agate cap
4. Graduated disc
5. Slit metal frame
6. Horse hair
7. Mirror
8. Reflecting prism with cap
9. Eye vane
10. Focussing stud
11. Dark sunglasses
12. Box
13. Glass cover
14. Lifting pin
15. Light spring
16. Brake pin or knob
17. Lifting lever
18. Support to fit on tripod

The Surveyor's Compass

Bearing

- The bearing of a line is the horizontal angle which it makes with a reference line (meridian) depending upon the meridian, there are four types of bearings.
- **True Bearing**
- The true bearing of a line is the horizontal angle between the true meridian and the survey line. The true bearing is measured from the true north in the clockwise direction.
- **Magnetic Bearing**
- The magnetic bearing of a line is the horizontal angle which the line makes with the magnetic north.

Bearing

- **Grid Bearing**
- The grid bearing of a line is the horizonta angle which the line makes with the grid meridian.
- **Arbitrary Bearing**
- The arbitrary bearing of a line is the horizontal angle which the line makes with the arbitrary meridian

Designation of Bearings

- The bearing are designated in the following two systems.
- Whole Circle Bearing System (W.C.B)
- Quadrantal Bearing System (Q.B.)

Whole Circle Bearing System (W.C.B)

- The bearing of a line measured with respect to magnetic meridian in clockwise direction is called magnetic bearing and its value varies between 0^0 to 360^0.
- The Quadrants start from North and Progress in a clockwise direction as the first quadrant is 0^0 to 90^0 in clockwise direction, 2^{nd} 90^0 to 180^0, 3^{rd} 180^0 to 270^0, and up to 360^0 is 4^{th} one.

Quadrant Bearing System (Q.B.)

- In this system, the bearing of survey lines are measured with respect to north line or south line which ever is the nearest to the given survey line and either in clockwise direction or in anticlockwise direction.
- he quadrantal bearing (QB) of a line is the acuate angle which the line makes with the meridian. Quadrantal bearing is measured either from north end or south end as the case may be i.e. whichever is nearer to the line. The quadrantal bearing of a line can vary from 0° to 90°

The Following Table Should be Remembered for Conversion of WCB to RB

Case	WCB between	R.B.	QUADRANT
1	0^0 TO90^0	WCB	N-E
2	90^0 TO -180^0	180-WCB	S-E
3	180^0 TO -270^0	WCB-180^0	S-W
4	270^0 TO 360^0	360-WCB	N-W

The Following Table Should be Remembered for Conversion of RB to WCB

Case	R.B in quadrant	Rule of W.C.B.	W.C.B between
1	N-E	WCB=R.B	0^0 TO90^0
2	S-E	WCB =180-R.B	90^0 TO -180^0
3	S-W	WCB =R.B+180	180^0 TO -270^0
4	N-W	WCB =360-R.B	270^0 TO 360^0

Fore Bearing and Back Bearing

- The bearing of a line measured in the forward direction of survey line is called the ‘Fore Bearing’ (FB) of that line.
- The bearing of the line measured opposite to the direction of progress of survey is called the ‘Back Bearing’ (BB) of the line.

Magnetic Declination

- The horizontal angle between magnatic meridian and true meridian is called as Magnetic declination’
- When the north end of the magnetic needle is pointed towards the west side of the true meridian the position is termed as ‘Declination West (ϴW).
- When the north end of the needle is pointed towards east side of the true meridian the position is termed as ‘Declination East (ϴ E)

Determination of True bearing and and Magnetic Bearing

- **True Bearing = Magnetic Bearing Declination**
- Use + sign when declination is towards East
- Use – sign when declination is towards West

- **Magnetic Bearing = True Bearing Declination**
- Use + sign when declination is towards West
- Use – sign when declination is towards East

Local Attraction

- **Detection of Local Attraction**
- The presence of local attraction at any station may be detected by observing the fore and back bearing of the line. If the difference between fore and back bearing is 180^0, both end station are free from local attraction. If not, the discepancy may be due to
- An error in observation of either fore and back bearing or both
- Presence of Local Attraction at either station
- Presence of local Attraction at both the stations

Local Attraction

- It may be noted that local attraction at any station affects all the magnetic bearings by an equal amount and hence, the included angles deduced from the affected bearing are always correct.
- In case the fore and back bearing of neither line of traverse differ by the permissible error of reading, the mean value of the bearing of the line least affected may be accepted. The correction to other stations, may be made according to the following methods.
- **By calculating the Included Angles at the affected stations**
- **By checking the required correction, starting from the unaffected bearing.**

Precaution to be taken in Compass Surveying

The following precaution should be taken conducting a compass traverse

- The centring should be done perfectly
- To stop the rotation of the graduation ring, the break pin should be pressed very gently and not suddenly.
- Reading should be taken along the line sight and not from any side.
- When the compass has to be shifted from one station to other, the sight vane should be folded over the glass cover. This is done to lift the ring out of the pivot to avoid unnecessary wear of the pivot.

Precaution to be taken in Compass Surveying

- The compass box should be tapped gently before taking the reading. This is done to find out whether the needle rotates freely.
- The station should not be selected near magnetic substances.
- The observer should not carry magnetic substances.
- The glass cover should not be dusted with a handkerchief, because the glass may be charged with electricity and the needle may be deflected from its true direction. The glass cover should be cleaned with a moist finger.

THANK YOU..

SURVEYING

UNIT- 2 LEVELLING, CONTOURING AREAS &VOLUMES

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CONTENTS

- LEVELLING - Types of Levels and Leveling Staves
- Temporary Adjustments
- Methods of Leveling
- Determination of levels
- Effect of Curvature of Earth
- Refraction
- CONTOURING - Characteristics and uses of Contours
- Methods of Contour Surveying

CONTENTS

- AREAS - Determination of areas consisting of irregular boundary and regular boundary.
- VOLUMES - Determination of volume of earth work in cutting and embankments for level section,
- Volume of borrow pits & Capacity of reservoirs.

Levelling (Heighting)

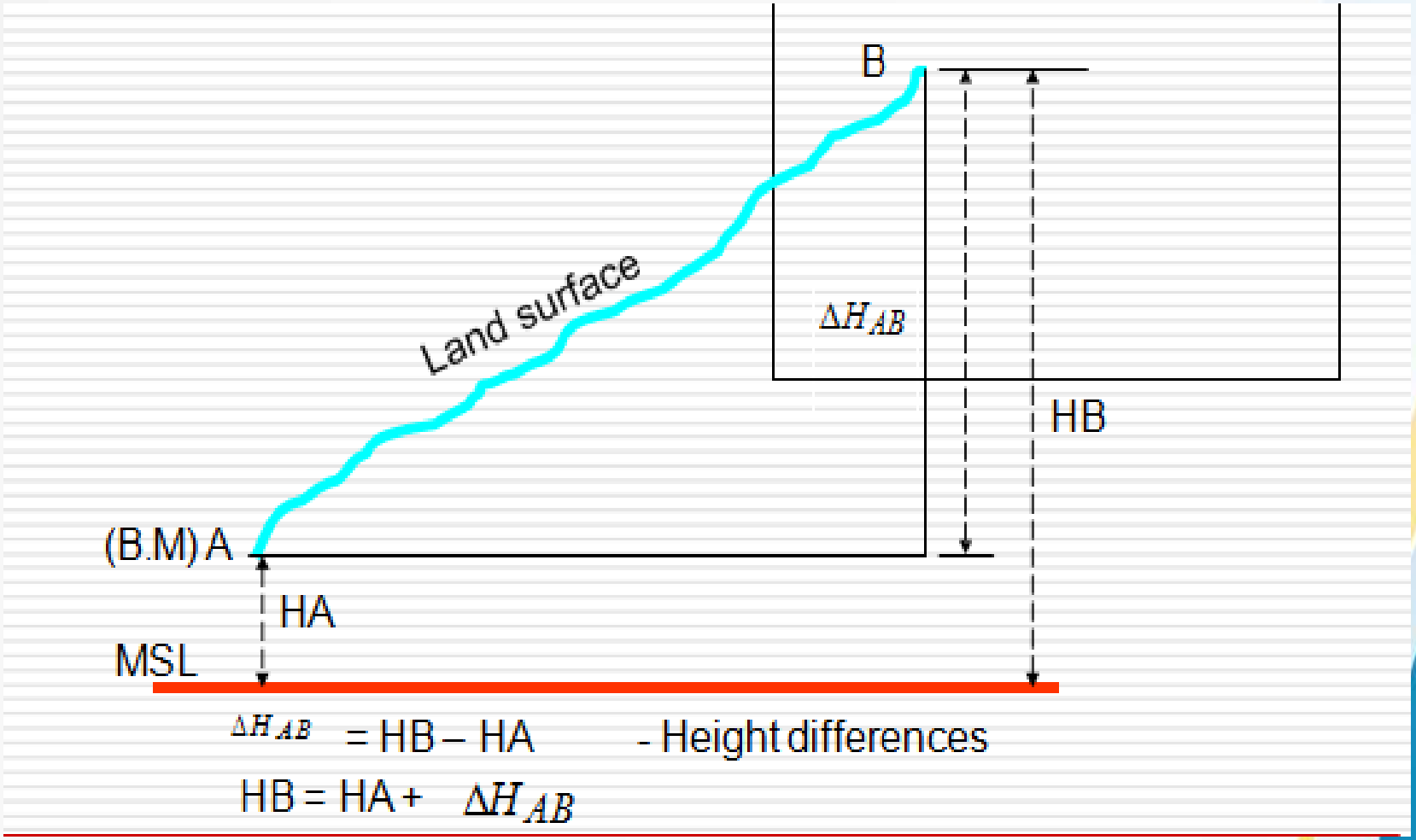
- Levelling is the process of determining the relative differences in heights between two or more points on the Earth surface.

- If the height of one point above a certain reference datum is known, then the height of other points above the same datum can be determined

Level and Levelling Staff

Level Instrument

Determination of height differences



Used terms

- **Mean Sea Level (MSL)/Datum** arbitrary surface to which the observed height of points may be referred.
- **Bench Mark (B.M)** A point of known Reduced Level (R.L.). Usually a permanent stable reference point.
- **Vertical line** Direction defined by a plumb line under a pull of gravity OR the direction followed by a freely falling object
- **A level surface (line)** This is a surface such that the direction of gravity is perpendicular to it at all points. Hence it follows the earth surface curvature

Used terms

- **A horizontal surface (line)** This will form a tangent to the level surface and perpendicular to a vertical line at one point.

- **Line of Collimation** This is the line of sight defined by the optical centre of the objective lens and the centre of the cross-hair

Definitions

- **Back sight (BS)**
- The first reading taken by an observer at every instrument station.
- **Foresight (FS)**
- The last reading taken at an instrument station

TYPE OF LEVELLING

- Trigonometric levelling
- Barometric levelling
- Hydrostatic levelling
- Spirit levelling

Equipments used in Levelling

- A LEVEL: A device that can give us a truly horizontal line
- A LEVELLING STAFF: A suitable graduated staff for taking vertical reading

There are three types of levels:

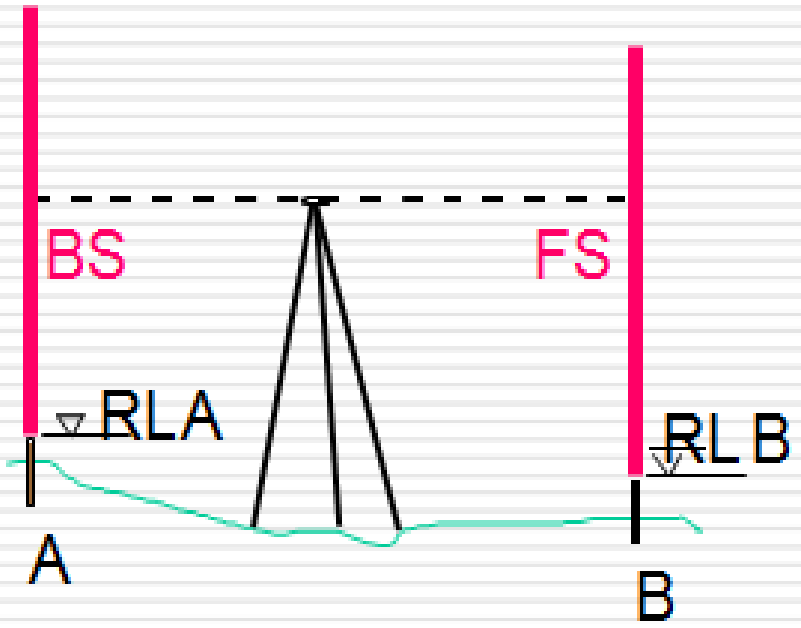
- dumpy levels
- tilting levels
- automatic levels

- 'The differences between the three types being in the way in which the instruments are designed to be adjusted to give a horizontal line'

Procedure in Levelling

- 1) Rise and Fall method
- 2) The height of Instrument method

Rise and Fall method



ΔH_{AB} = BS - FS

assuming that, RL A is known,

Then, level at B = Level at A - + Fall/Rise

RL B = RL A + ΔH_{AB}

RL B = RL A - ΔH_{AB}

The Height of Instrument (HI) Method

- Line of collimation above the datum is found by adding the staff reading on a point of known level

☞ **HI = Known RL + Back Sight**

Comparison of the methods

- Rise and Fall method

  - The method is slow, involves a lot of calculations and is not suitable for job involving intermediate sights os setting out

  - The method is preferred in precise levelling of establishing the benchmarks because of complete arithmetic checks it have

Comparison of the methods

- The Height of Instrument Method
  - Has less arithmetic check
  - Intermediate sights are not checked
  - Method is faster, involve less calculations and is suitable for jobs involving setting out
  - Is not preferred in precise levelling for establishing other benchmarks because of lack of the complete arithmetic checks

Source of Errors in Levelling

- Can be grouped in three category

1) Instrument Errors

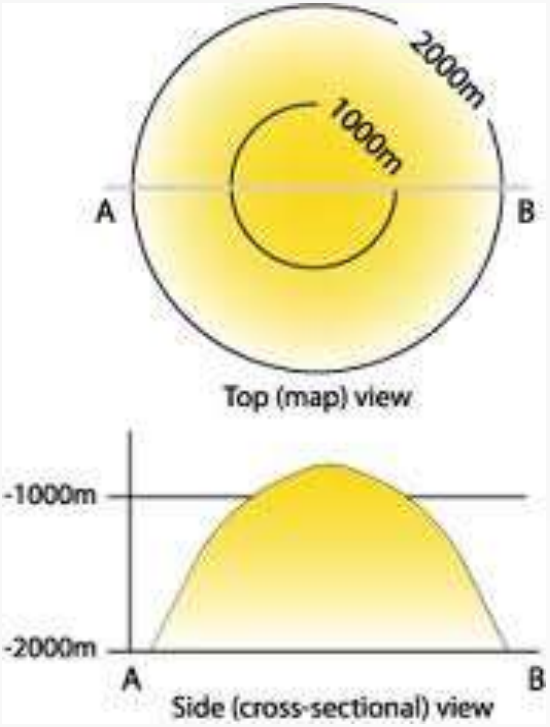
2) Error in handling the instrument

3) Error from natural sources

CONTOURING

- **Contours**

A Contour is an imaginary line on the ground joining the points of equal elevation or reduced level.

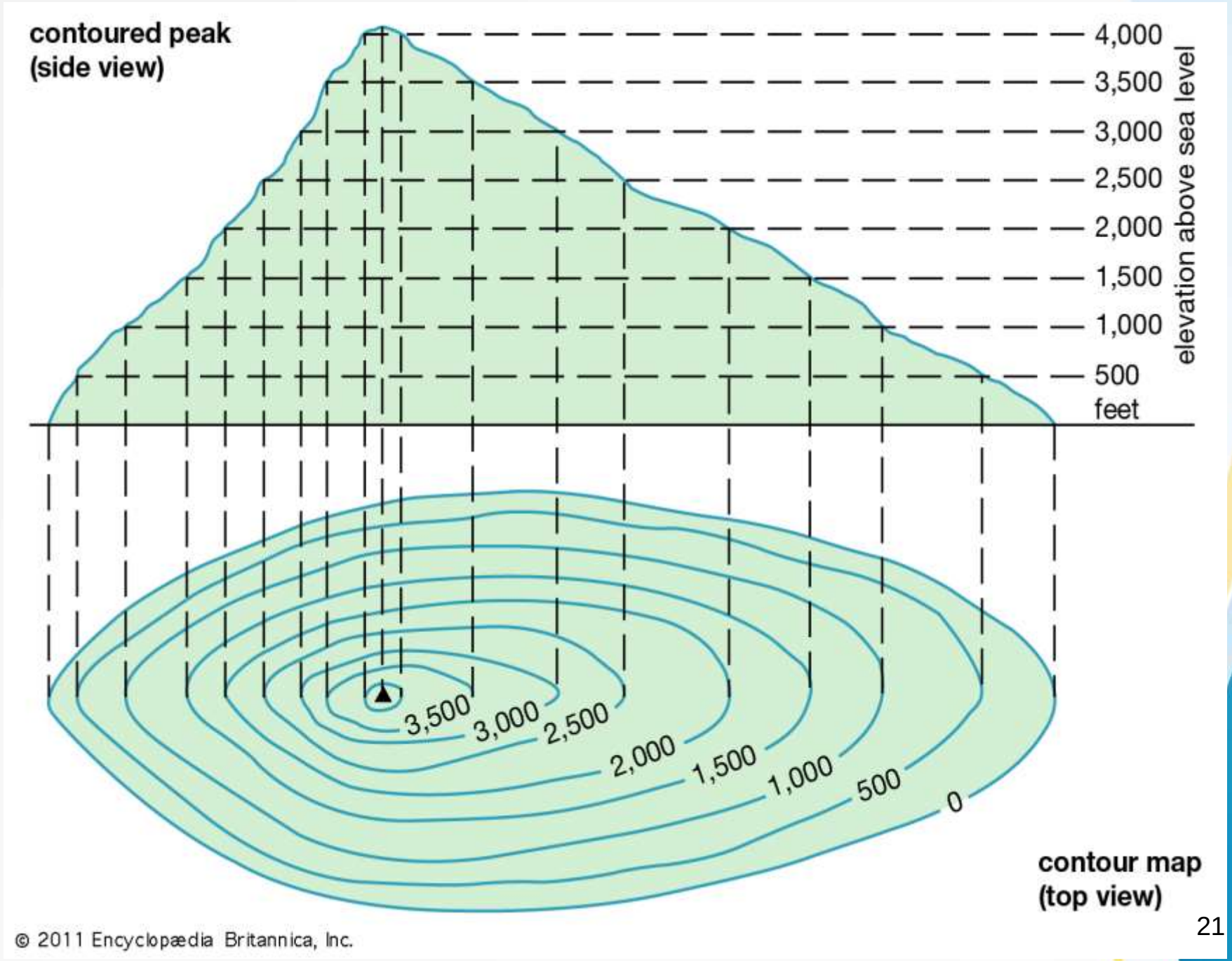


- **Contour line**

A contour line is a line on the map representing a contour.

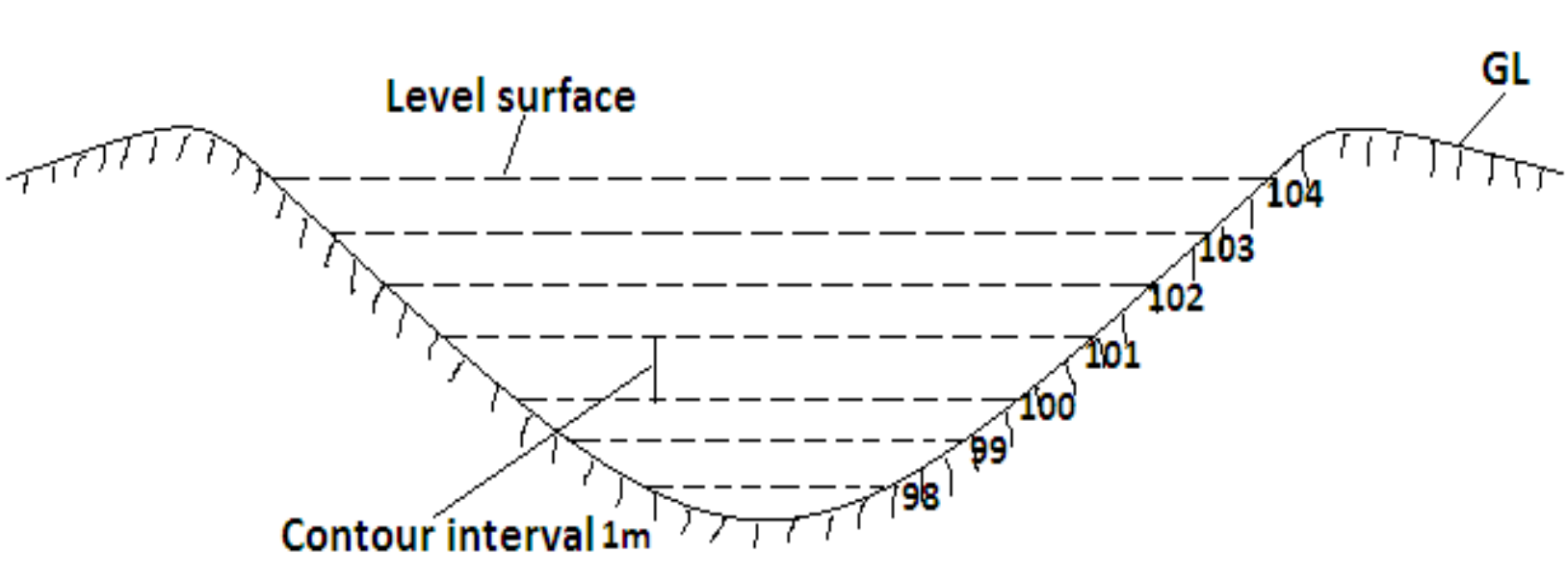
what is contouring?

- A contour is defined as an imaginary line of constant elevation on the ground surface. It can also be defined as the line of intersection of a level surface with the ground surface.
- For example, the line of intersection of the water surface of a still lake or pond with the surrounding ground represents a contour line.
- The process of tracing contour lines on the surface of earth is called contouring.
- A contour map gives the idea of the altitudes of the surface features as well as their relative positions in a plan.



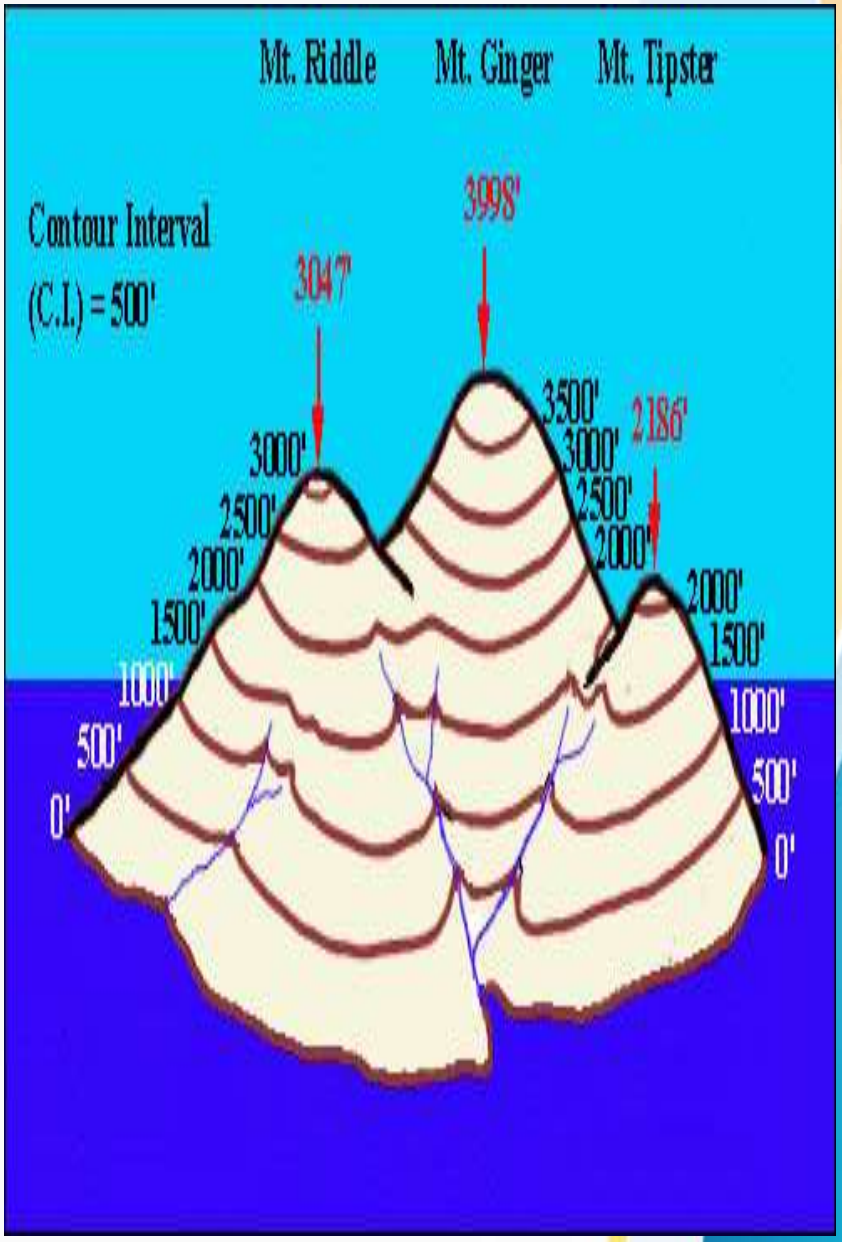
- **Contour interval**

The vertical distance between two successive contours is known as ‘Contour interval’. It remains constant for a given map. The difference in R.L.’s of two contour gives contour interval.



Contour interval is the difference between the levels of consecutive contour lines on a map. The contour interval is a constant in a given map.

Example, the contour interval is 1m.



- **COMMON VALUES OF THE CONTOUR - INTERVAL**

i) For large scale maps of flat country, for building sites, for detailed design work and for calculation of quantities of earth work; 0.2 to 0.5 m.

ii) For reservoirs and town planning schemes;

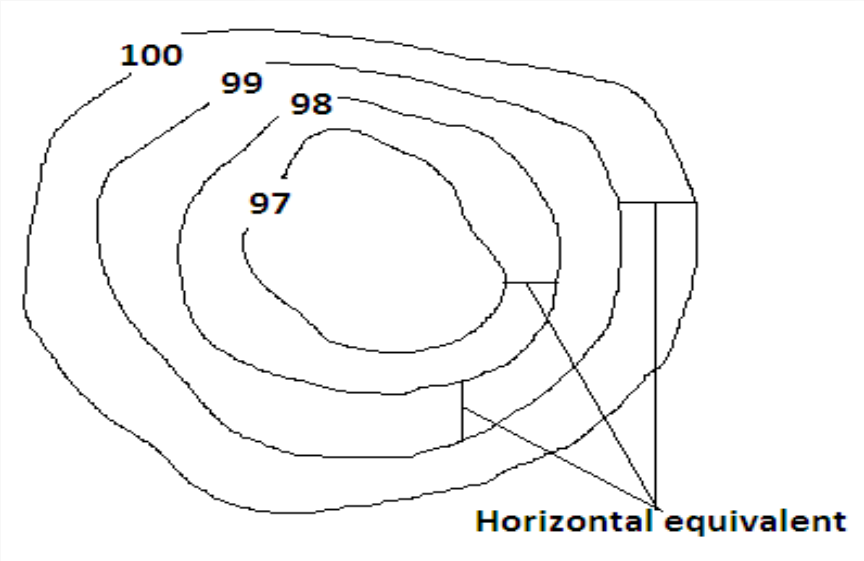
0.5 to 2m.

iii) For location surveys. 2 to 3m.

iv) For small scale maps of broken country and general topographic work; 3m,5m,10m,or 25m.

- **Horizontal equivalent**

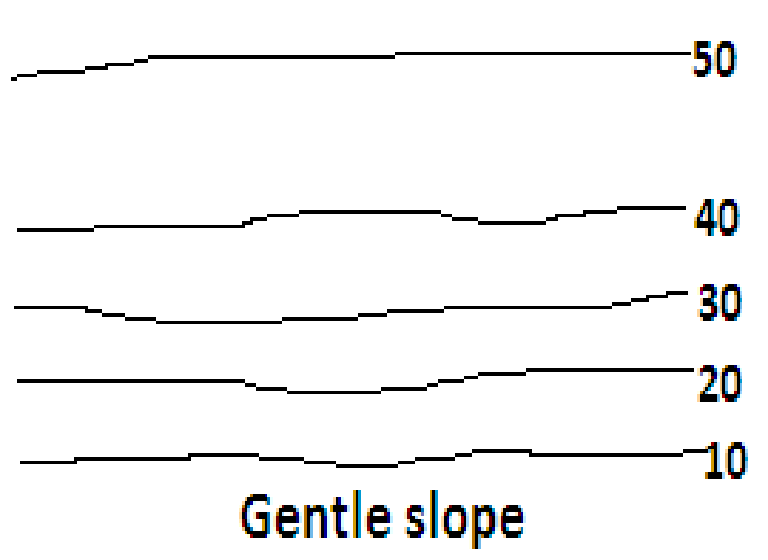
The horizontal distance between two successive contours is known as ‘Horizontal equivalent’. It is not constant for a given map, it varies according to the steepness of the ground.

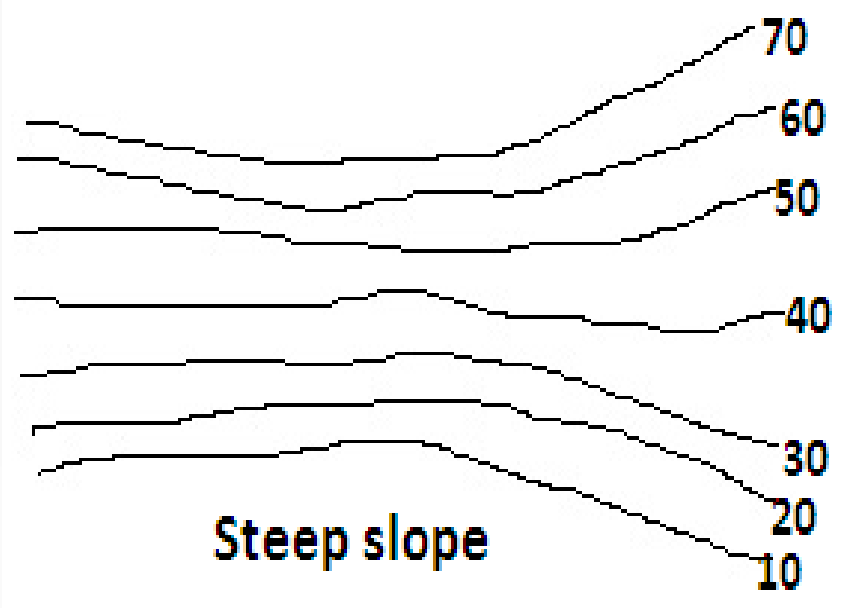


- **CHARACTERISTICS OF CONTOURS**

i) All points in a contour line have the same elevation.

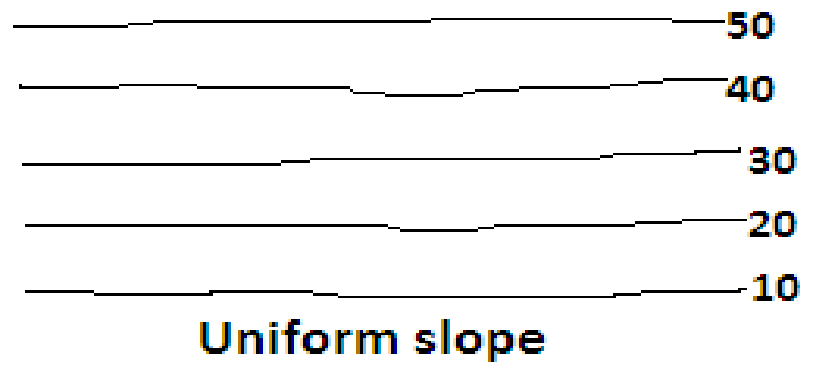
ii)Flat ground is indicated where the contours are widely separated and steep- slope where they run close together.



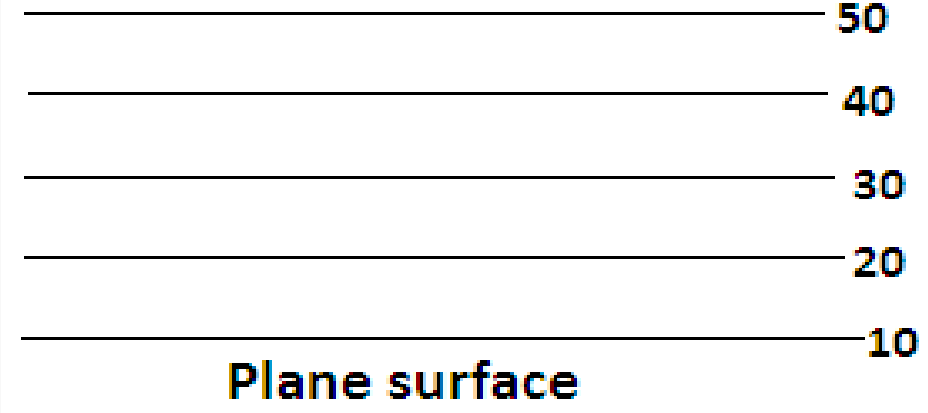


- **CHARACTERISTICS OF CONTOURS**

iii) A uniform slope is indicated when the contour lines are uniformly spaced and

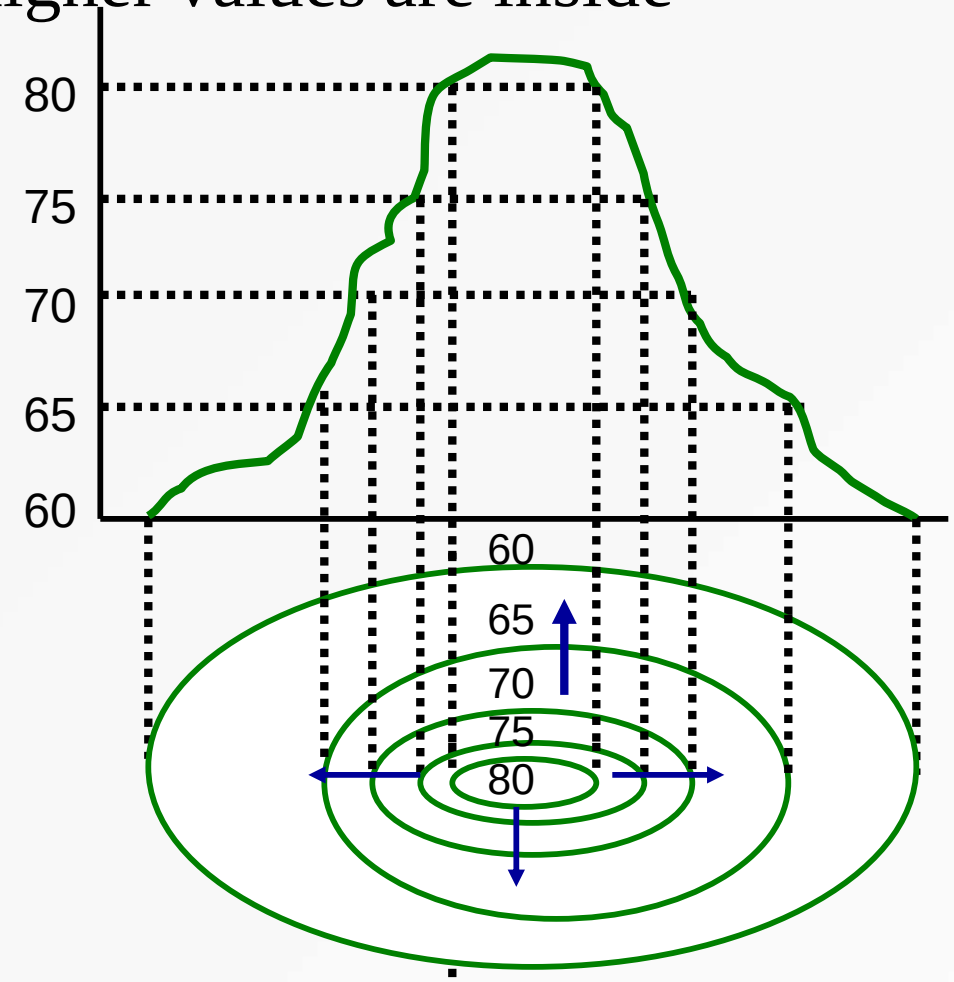


iv) A plane surface when they are straight, parallel and equally spaced.



- **CHARACTERISTICS OF CONTOURS**

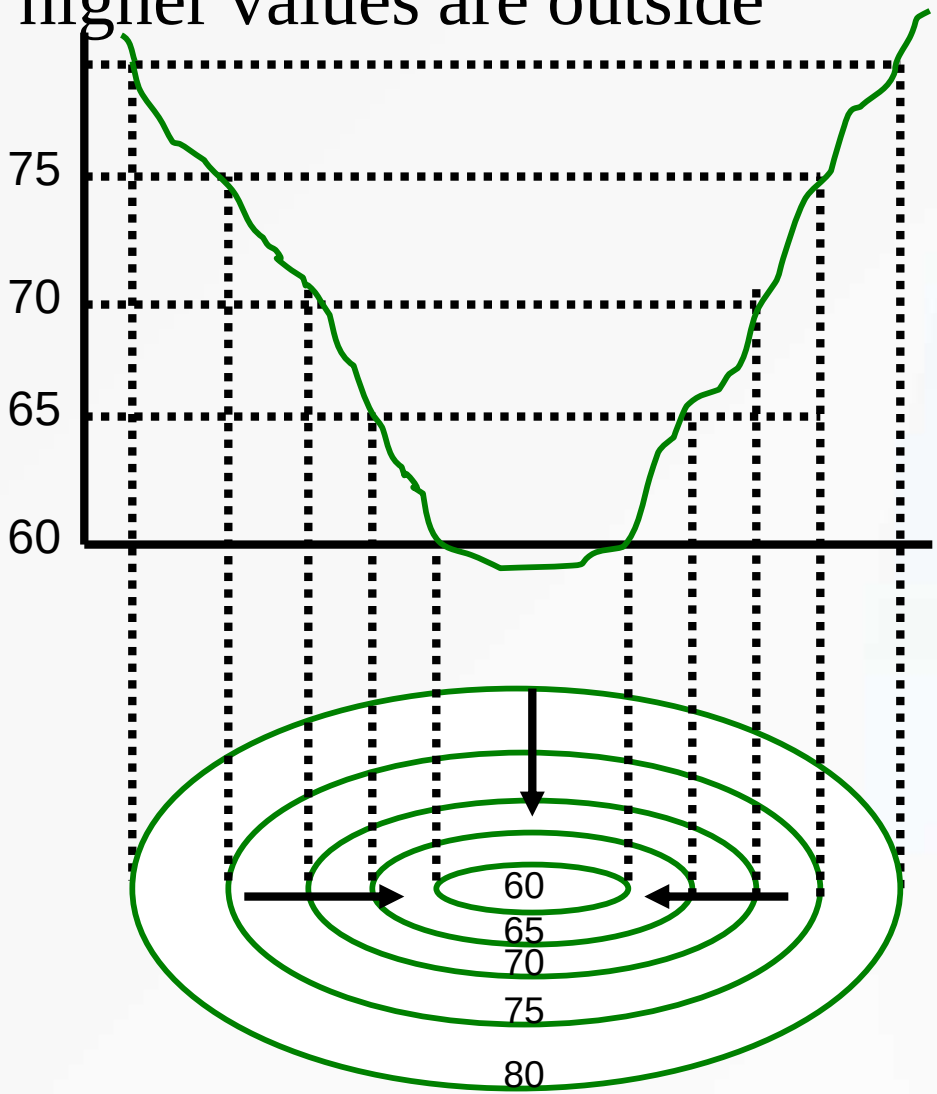
v) A series of closed contour lines on the map represent **a hill** , if the higher values are inside



HILL

- **CHARACTERISTICS OF CONTOURS**

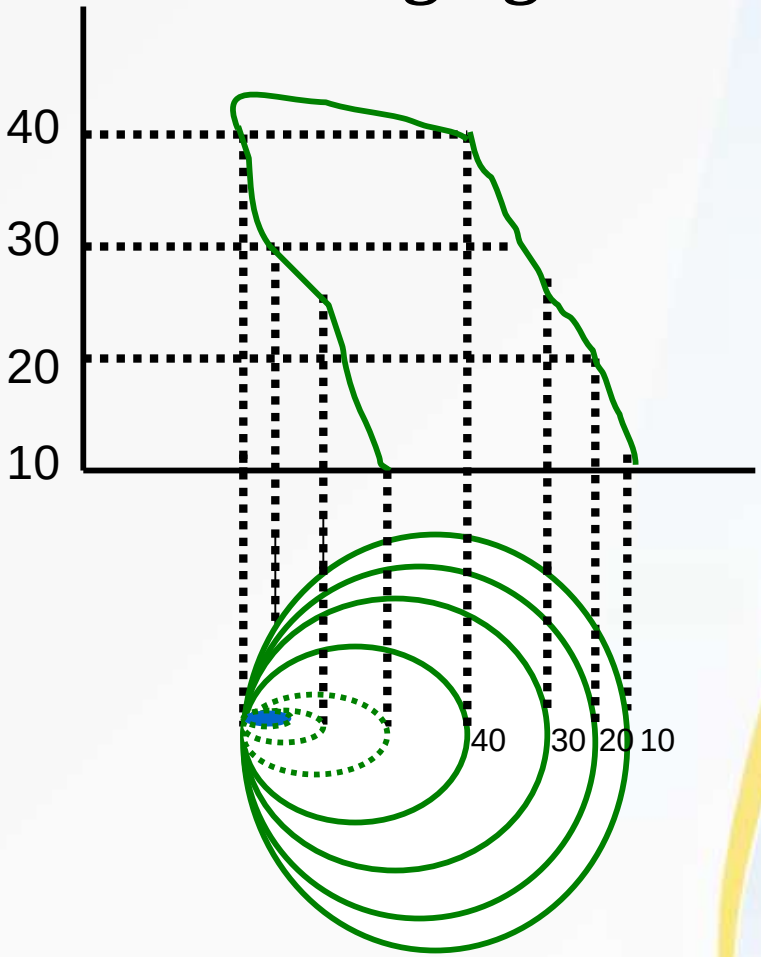
vi) A series of closed contour lines on the map indicate **a depression** if the higher values are outside



DEPRESSION

- **CHARACTERISTICS OF CONTOURS**

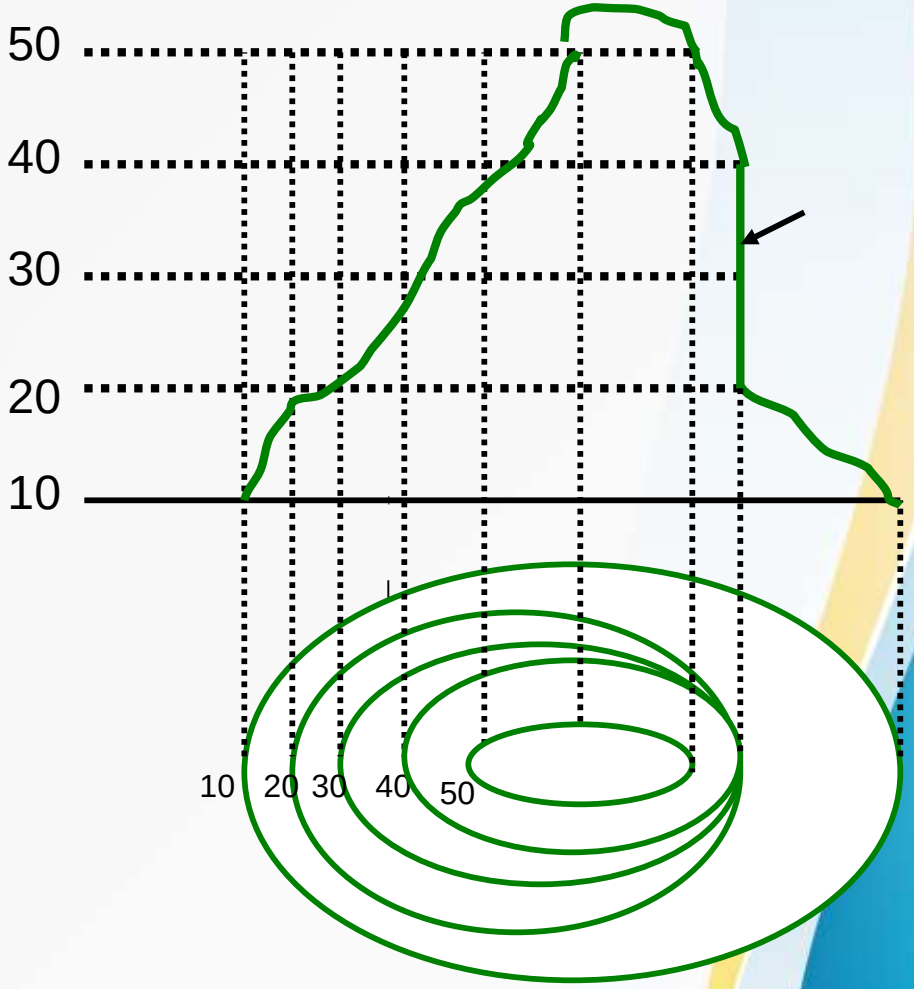
x) Contour lines cannot merge or cross one another on map except in the case of **an overhanging cliff.**



OVERHANGING CLIFF

CHARACTERISTICS OF CONTOURS

- xi) Contour lines never run into one another except in the case of a vertical cliff. In this case ,several contours coincide and the horizontal equivalent becomes zero.



CHARACTERISTICS OF CONTOURS

- Xii) Depressions between summits is called **a saddle**. It is represented by four sets of contours as shown. It represents a dip in a ridge or the junction of two ridges.

Table 3.1 Summary of Characteristics of Contour Lines

1. Contour lines connect points of equal elevation.
2. Steep slopes are shown by closely spaced contour lines.
3. Gentle slopes are shown by widely spaced contour lines.
4. Contour lines do not intersect, branch, or cross. They may merge in a vertical or overhanging cliff.
5. Contour lines always close either on the map or on adjacent map sheets.
6. When contour lines cross streams, they bend upstream; that is, the segment of the contour line near the stream forms a "V" with the apex pointing in an upstream direction.
7. Closed contours appearing on the map as ellipses or circles represent hills or knobs.
8. Closed contours with hachures, short lines pointing toward the center of the closure (i.e., pointing downslope), represent closed depressions. The outer hachured contour line has the same elevation as the adjacent regular contour line. (See "Depression" under the "Contours" heading in Appendix B.)

USES OF CONTOUR MAP

(i) A contour map furnishes information regarding the features of the ground , whether it is flat, undulating or mountainous.

(ii) From a contour map , sections may be easily drawn in any direction

(iii) Intervisibility between two ground points plotted on map can be ascertained

(iv) It enables an engineer to approximately select the most economical or suitable site for an engineering project such as a road, a railway, a canal or a pipe line etc.

(v) A route of a given grade can be traced on the map.

(vi) Catchment area and capacity of a reservoir may be determined from the contour map.

(vii) Contour map may be used to determine the quantities of earth work.

METHODS OF CONTOURING

There are mainly two methods of locating contours:-

(1)Direct Method and

(2) Indirect Method.

- **a) by square method**
- **b) by cross sections**
- **c) by tacheometric method**

INTERPOLATION OF CONTOURS

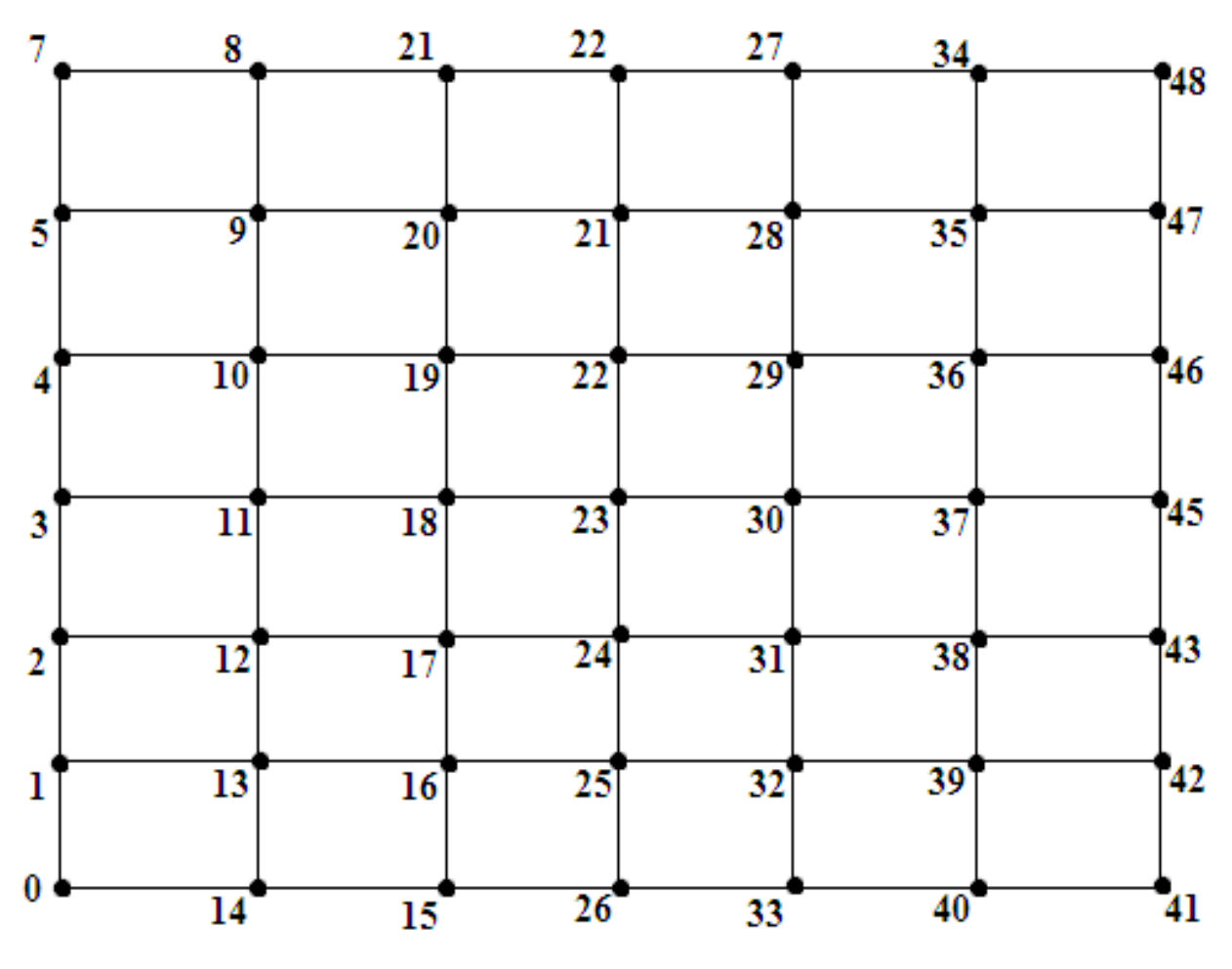
There are three main methods of interpolation:

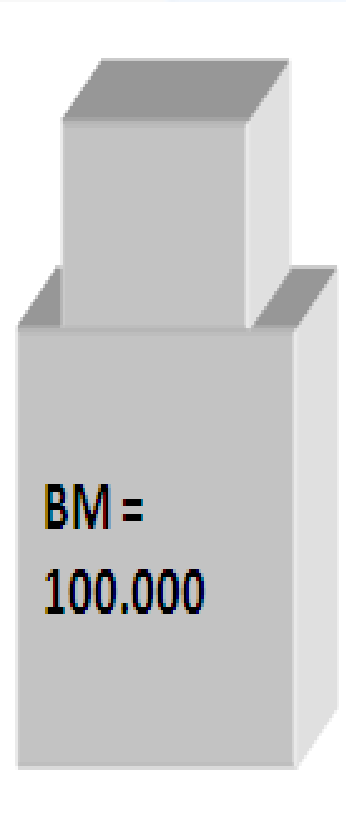
i) **By Estimation:-** The position of the contour points between ground - points are estimated roughly and the contours are then drawn through these points. This is a rough method and is suitable for small scale maps.

ii) **By arithmetical calculation:-** This is very tedious but accurate method and is used for small areas where accurate results are necessary. The contours are interpolated as under:

INTERPOLATION OF CONTOURS

ii) By arithmetical calculation:-

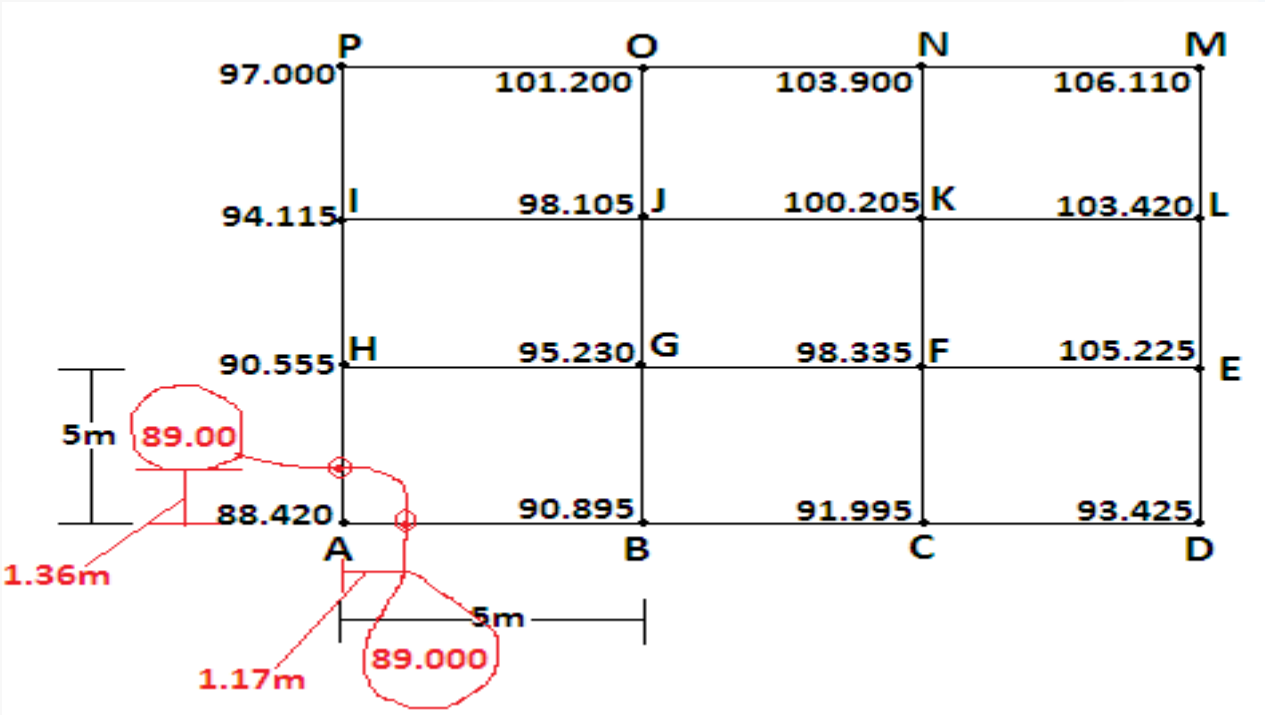


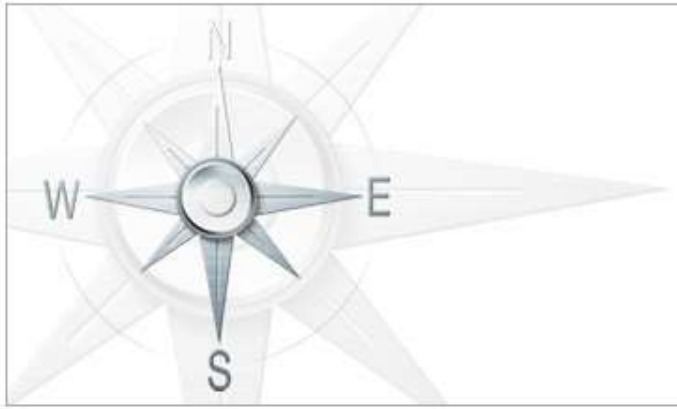


INTERPOLATION OF CONTOURS

ii) By arithmetical calculation:-

Now consider the ADMP is surveyed plot, then whole area is divided into no.of squares and RL are plotted at every spot. Then if the required contour is 89.000m, then consider small square ABGH.





AREA & VOLUME

INTRODUCTION

Estimation of area and volume is basic to most engineering schemes

Earthwork volumes must be estimated :

- To enable route alignment to be located at such lines and levels that cut and fill are balanced as far as practical.
- To enable contract estimates of time and cost to be made for proposed work.
- To form the basis of payment for work carried out.

Areas and volumes

- The area is calculated using one of the methods listed below-
- Graphical method
- Co-ordinate method
- Planimeter
- The co-ordinate method is the most often used in land surveying for determining catchment area, drainage area, cross-sections of rivers, and channels, among other things.
- This method divides a given area into two halves, with a basic line running through the middle.

Areas and volumes

Trapezoidal Rule

- Boundaries of the ordinates are presumed to be straight. Therefore the area between the lines is considered to be a trapezoid.
- A=[common distance between ordinate [{first ordinate + last ordinate} + 2{sum of other ordinates}]]/2
- This rule can be used for any number of ordinates, and hence it has no drawbacks or limitations.

Simpson's Rule:

- An arc is assumed to be present between the boundaries of the ordinates. Therefore it is also known as the parabolic rule.
- Area= [Common distance[(First ordinate + last ordinate) + 4(Sum of even ordinates) + 2(Sum of odd ordinates)]]/3
- The only limitation to this rule is that it can only be used when the number of ordinates is odd.

Areas and volumes

Volume

The Trapezoidal Rule:

- It is also known as the average end area rule, it is used when the number of sections is even, and the end section is taken separately.
- Volume= [Common distance [Area of first section + Area of last section + 2 (Sum of areas of other sections)]]/2

The Prismoidal Rule:

- This rule is applicable for the odd number of sections.
- Volume= {Common distance [Area of first section + Area of last section + 4 (Sum of areas of even section) + 2(Sum of Area of odd sections)]}/3

THANK YOU..

SURVEYING

UNIT- 3 THEODOLITE SURVEYING & TRAVERSING

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CONTENTS

- Theodolite Surveying: Types of Theodolites
- Fundamental Lines, Temporary adjustments
- Measurement of Horizontal angle by Repetition method and Reiteration method
- Measurement of Vertical Angle
- Trigonometrical leveling when base is accessible and inaccessible.
- Traversing: Methods of traversing traverse computations and adjustments
- Omitted measurements.

THEODOLITE SURVEYING

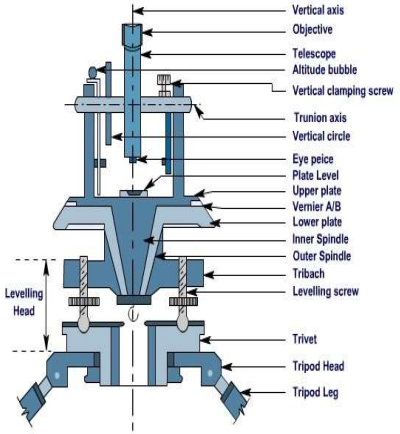


Figure 20.4 Sectional view of a Thedolite

3

THEODOLITE SURVEYING

- So far we have been measuring horizontal angles by using a *Compass* with respect to *meridian*, which is *less accurate* and also it is not possible to measure vertical angles with a Compass.
- So when the objects are at a considerable distance or situated at a considerable elevation or depression ,it becomes necessary to measure horizontal and vertical angles more precisely. So these measurements are taken by an instrument known as a *theodolite***.**

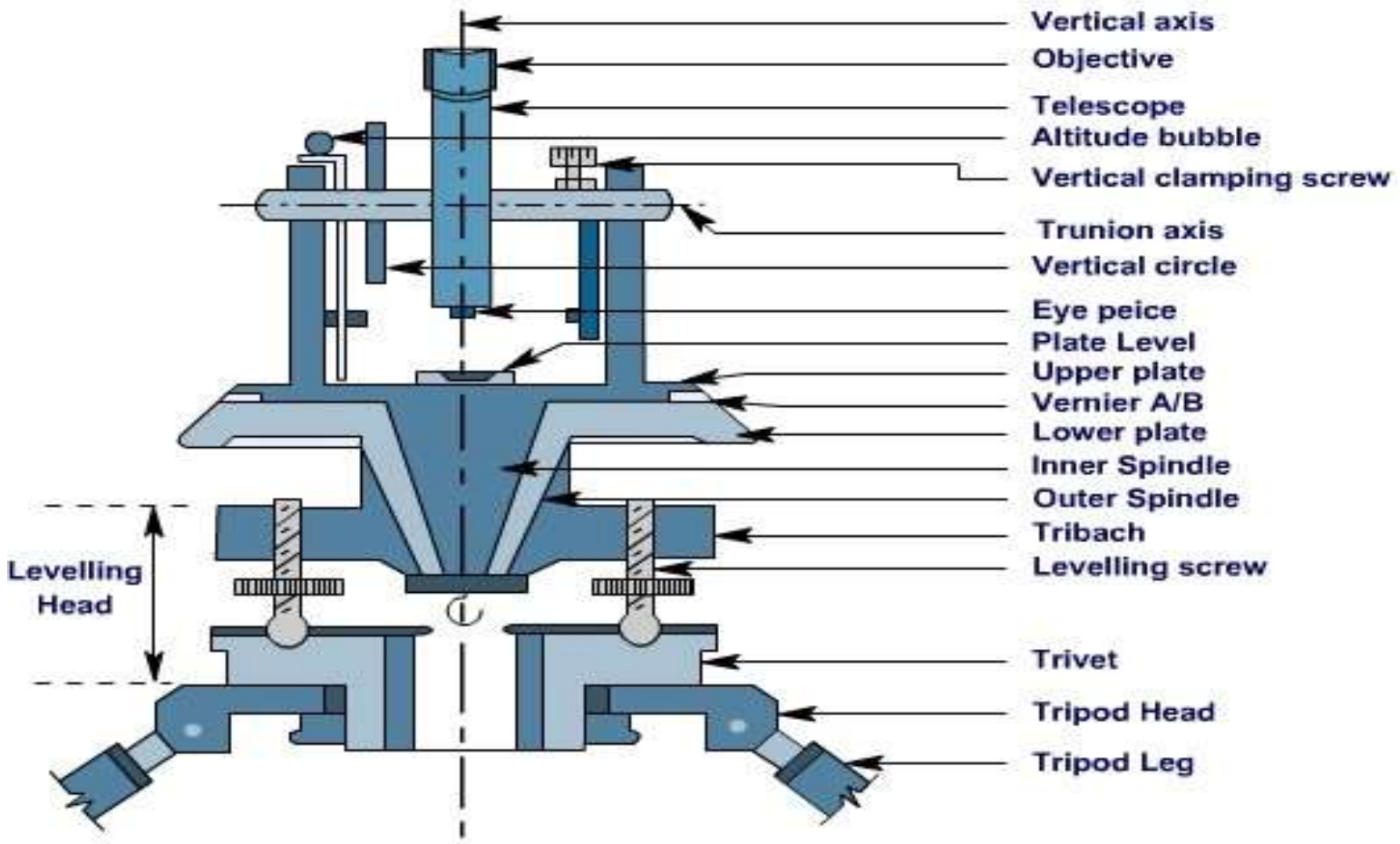
Theodolite surveying

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

THEODOLITE is mainly used for

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

Transit theodolite



CLASSIFICATION OF THEODOLITES

- Theodolites may be classified as ;

i) Transit Theodolite.

ii)Non Transit Theodolite.

iii)Vernier Theodolites.

iv)Micrometer Theodolites.

CLASSIFICATION OF THEODOLITES

- A. Transit Theodolite: A theodolite is called a transit theodolite when its telescope can be transited i.e revolved through a complete revolution about its horizontal axis in the vertical plane, whereas in a-
- Non-Transit type, the telescope cannot be transited. They are inferior in utility and have now become *obsolete.*

Vernier Theodolite

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

- Whereas, if a micrometer is provided to read the graduated circle the same is called as a Micrometer Theodolite. Vernier type theodolites are commonly used .

SIZE OF THEODOLITE

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

DESCRIPTION OF A TRANSIT VERNIER THEODOLITE

A Transit vernier theodolite essentially consist of the following : 1. Levelling Head.

2. Lower Circular Plate.

3. Upper Plate.

4. Telescope.

5. Vernier Scale.

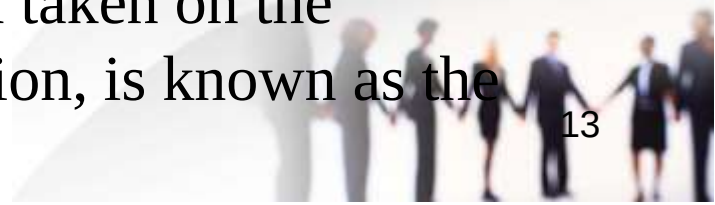
6. T- Frame

7. Plumb –bob

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.

- 3. **Swinging the telescope** It means turning the telescope about its vertical axis in the horizontal plane. A swing is called right or left according as the telescope is rotated clockwise or counter clockwise.
- 4. **Face Left** If the vertical circle of the instrument is on the left side of the observer while taking a reading ,the position is called the face left and the observation taken on the horizontal or vertical circle in this position, is known as the face left observation
- 5. **Face Right** If the vertical circle of the instrument is on the right side of the observer while taking a reading ,the position is called the face right and the observation taken on the horizontal or vertical circle in this position, is known as the face right observation.



- 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 degrees in a vertical plane and then rotate it through 180 degrees in the horizontal plane i.e first transit the telescope and then swing it through 180 degrees.
- **7. Line of Collimation** It is also known as the line of sight .It is an imaginary line joining the intersection of the cross- hairs of the diaphragm to the optical centre of the object- glass and its continuation.
- **8. Axis of the telescope** It is also known an imaginary line joining the optical centre of the object- glass to the centre of eye piece.
- 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.

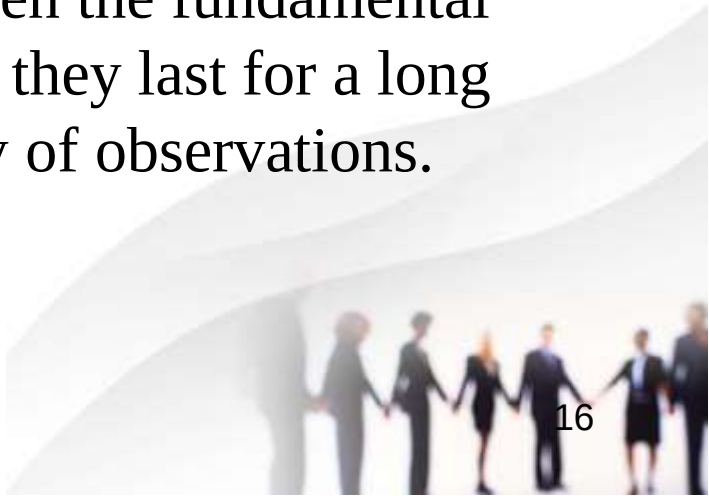
- **10. Vertical Axis** It is the axis about which the telescope can be rotated in the horizontal plane.

- **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.

ADJUSTMENT OF A THEODOLITE

- The adjustments of a theodolite are of two kinds :-
  1. Permanent Adjustments.
  2. Temporary Adjustments.

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



ADJUSTMENT OF A THEODOLITE

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

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

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

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

ADJUSTMENT OF A THEODOLITE

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

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

ADJUSTMENT OF A THEODOLITE

2. Temporary Adjustment The temporary adjustments are made at each set up of the instrument before we start taking observations with the instrument.

There are three temporary adjustments of a theodolite:-

i) Centering.

ii) Levelling.

iii) Focussing.

MEASUREMENT OF HORIZONTAL ANGLES

There are three methods of measuring horizontal angles:-

i) Ordinary Method.

ii) Repetition Method.

iii) Reiteration Method.

TRAVERSING

TRAVERSING

- A series of connected straight lines each joining two points on the ground, is called a '*traverse*'. End points are known as traverse stations & straight lines between two consecutive stations, are called traverse legs.

- A traverse survey is one in which the framework consists of a series of connected lines, the lengths and directions of which are measured with a chain or a tape, and with an angular instrument respectively.

TYPES OF 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 and "balanced". It is particularly suitable for locating the boundaries of lakes, woods, etc. and for the survey of moderately large areas.
2. **Open Traverse:** A traverse is said to be open or unclosed when it does not form a closed polygon. It consists of a series of lines extending in the same general direction and not returning to the starting point. Similarly, it does not start and end at the points whose positions on plan are known. It is most suitable for the survey of a long narrow strip of country e.g. the valley of a river, the coast line, a long meandering road, or railway, etc.

Classification of traverses based on instruments used:

- **Classification of traverses based on instruments used:**

  1. Chain Traversing: In chain traversing, the entire work is done by a chain or tape & no angular measuring instrument is needed. The angles computed by tie measurements are known as chain angles.

  2. Compass Traversing: The traverse in which angular measurements are made with a surveying compass, is known as compass traversing. The traverse angle between two consecutive legs is computed by observing the bearings of the sides.

  3. Plane Table Traversing: The traverse in which angular measurements between the traverse sides are plotted graphically on a plane table with the help of an alidade is known as plane table traversing.

  4. Theodolite Traversing: The traverse in which angular measurements between traverse sides are made with a theodolite is known as theodolite traversing.

  5. Tachometric Traversing: The traverse in which direct measurements of traverse sides by chaining is dispensed with & these are obtained by making observations with a tachometer is known as tachometer traversing.

Important Technical Terms:

- **Important Technical Terms:**

1. **Meridians and Bearings:** The direction of survey lines may be defined in two ways:

a). Relatively to each other

b). Relatively to some reference direction

In the first case, directions are expressed in terms of the angles between two consecutive lines. In second case, these are expressed in terms of bearings.

The fixed direction on the surface of the earth with reference to which, bearings of survey lines are expressed is called a **meridian**. The meridians of reference directions employed in surveying may be one of the following:

a). True Meridian b). Magnetic Meridian

c). Grid Meridian d). Arbitrary Meridian

Important Technical Terms:

- The line of intersection of the earth surface by a plane containing north pole, south pole and the given place is called **true meridian** or **geographical meridian**.
- The geometrical longitudinal axis of a freely suspended & properly balanced magnetic needle, unaffected by local attractive forces, defines the magnetic north-south line which is called the **magnetic meridian**.
- The convenient direction assumed as meridian for measuring bearings of survey lines is known as arbitrary meridian

Bearing

The horizontal angle between the reference meridian and the survey line measured in a clockwise direction is called **bearing**.

a). True Bearing
b). Azimuth
c). Magnetic Bearing
d). Grid Bearing

- The horizontal angle between the true meridian and a line measured in a clockwise direction is called **true bearing** of the line.
- The smaller angle which a survey line makes with true meridian is called **azimuth**.
- The horizontal angle which a line makes with the magnetic meridian is called **magnetic bearing**.
- Bearings of survey lines referred to and reckoned from grid lines are called grid bearings.
- The angle between the true meridian & the magnetic meridian at any place is known as **magnetic declination**, whereas, the angle between the true meridian & the grid meridian at any place is known as **grid convergence**.

WBC & QB

- **Designation of Bearings:**
  1. The Whole Circle Bearing System (W.C.B)
  2. The Quadrantal Bearing System (Q.B)

1. **The W. C. B System:** The W. C. B system is also sometimes known as **Azimuthal System**. In this system, bearing of a line is measured from the true north or magnetic north in clockwise direction. The value of a bearing may vary from 0° to 360°, utilizing the whole circle of graduations. Prismatic Compass is graduated on whole circle bearing system.

Designation of Bearings

- 2. **The Q. B System:** In Q. B System, bearings of survey lines are measured eastward or westward from North and South whichever is nearer. In this system, both north and south directions are used as reference meridians & bearings are reckoned either clockwise or anticlockwise, depending upon the position of the line. The quadrant in which a line lies is mentioned to specify the location of the line. Surveyor's compass is graduated in quadrantal bearing system.

  Bearings designated by Q.B. System are sometime called **Reduced Bearings**.

Conversion Of W.C.B into Q.B

CASE	W.C.B between	Rule for Q.B	Quadrant
I	0˚ and 90˚	W.C.B	N.E.
II	90˚ and 180˚	180˚ - W.C.B	S.E.
III	180˚ and 270˚	W.C.B - 180˚	S.W.
IV	270˚ and 360˚	360˚ - W.C.B	N.W.

Conversion Of Q.B into W.C.B

CASE	R.B	Rule for W.C.B	W.C.B between
I	N α° E	R.B	0˚ and 90˚
II	S β° E	180˚ - R.B	90˚ and 180˚
III	S γ° W	180˚+R.B	180˚ and 270˚
IV	N δ° W	360˚ - R.B	270˚ and 360˚

- **FORE and BACK Bearings:**

Every line may be defined by two bearings, one observed at either end of the line. Both the bearings expressed in W.C.B System differ each other by 180°. The bearing of a line in the direction of the progress of survey, is called **Fore or Forward Bearing** (F.B) while the bearing in the opposite direction of the progress of survey is known as **Reverse or Back Bearing** (B.B).

Relationship Between Fore and Back Bearings:

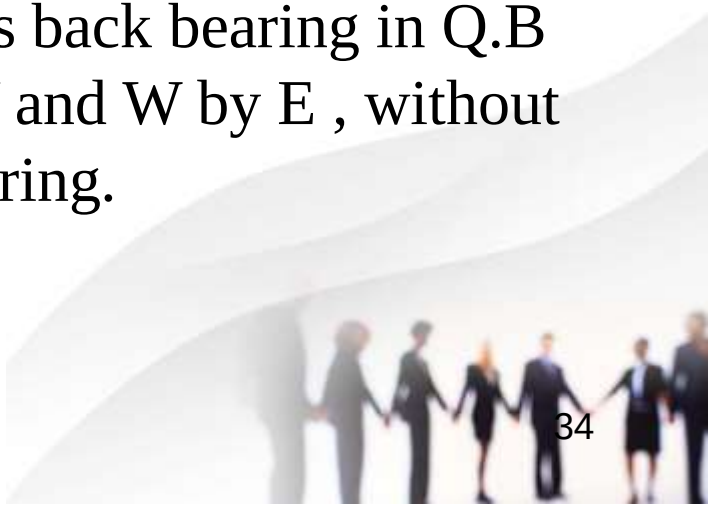
a). W.C.B System:

Back bearing = Fore Bearing $\pm$ 180˚

Positive sign is used when fore bearing is less than 180˚ and negative sign is used when the fore bearing is greater than 180˚.

b). Q.B System:

To convert the fore bearing of a line into its back bearing in Q.B system, replace N by S, S by N, E by W and W by E , without changing the numerical value of the bearing.



THANK YOU..

SURVEYING

UNIT- 4 CURVES & TACHOMETRIC SURVEYING

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CONTENTS

- Curves: Types of curves and their necessity
- Elements of Simple, Compound, Reverse, Transition and Vertical Curves.
- Introduction to Tacheometric Surveying
- Principles of Tacheometry
- Stadia methods of Tacheometry
- Tangential methods of Tacheometry

CURVES

- Curves are regular bends provided in the lines of communication like roads, railways and canals etc. to bring about gradual change of direction.

CURVES

- Curves are defined as arcs, with some finite radius, provided between intersecting straights to gradually negotiate a change in direction. This change in direction of the straights may be in a horizontal or vertical plane, resulting in the provision of a horizontal or vertical curve respectively. Curves are generally used on highways and railways where it is necessary to change the direction of motion. A curve may be circular, parabolic or spiral and is always tangential to the two straights

Classification of curves

- CLASSIFICATION

1. Horizontal curves – intersecting straights are in horizontal plane
2. 2. Vertical curves - intersecting straights are in vertical plane. These curves are of two types i.e., summit curves and sag / valley curves.

Horizontal curves

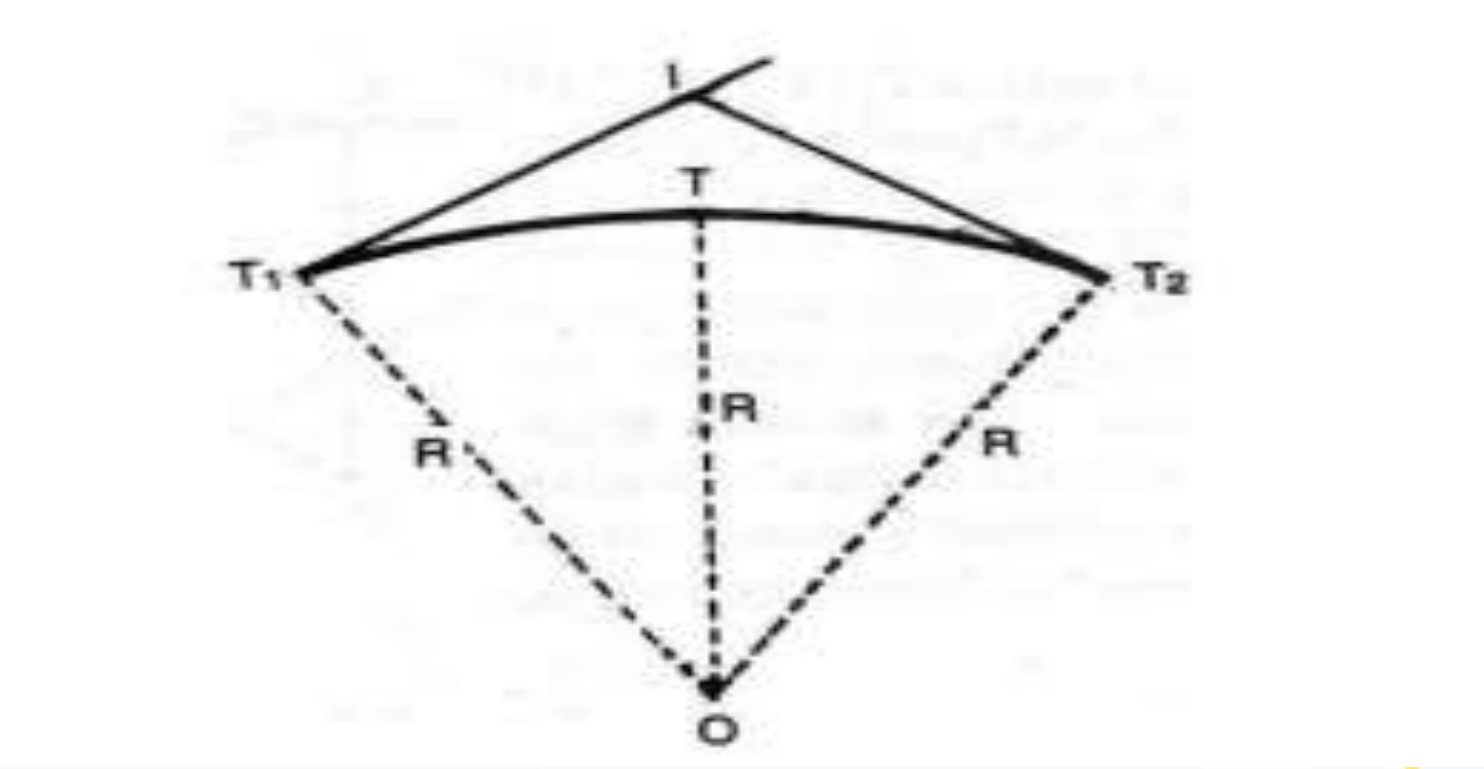
- Horizontal curves are further classified as:
- a) Circular curves
- b) Non-circular curves – transition curves

- Types of Circular Curves:
- Circular curves are divided into three types:

I. Simple Circular Curve
II. Compound Curve
III. Reverse Curve

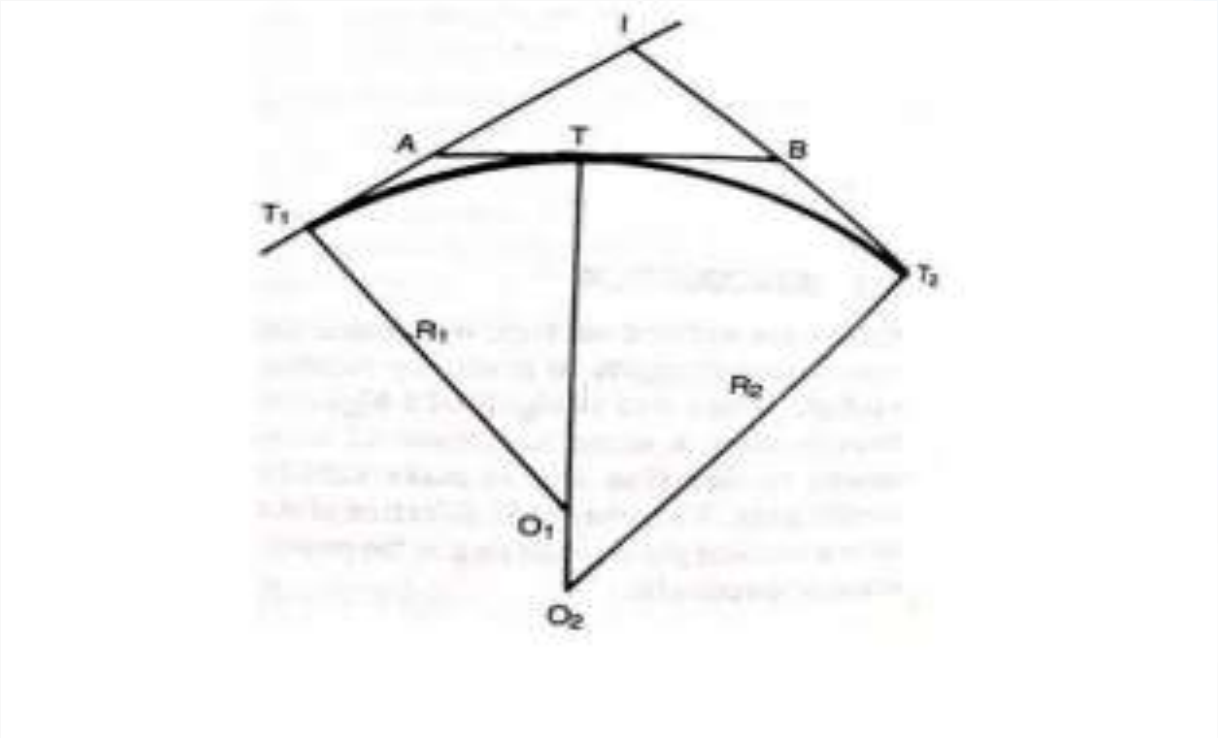
Simple Circular Curve

- Simple Circular Curve: A curve which consists of a single arc of a circle connecting two straights is called simple circular curve.



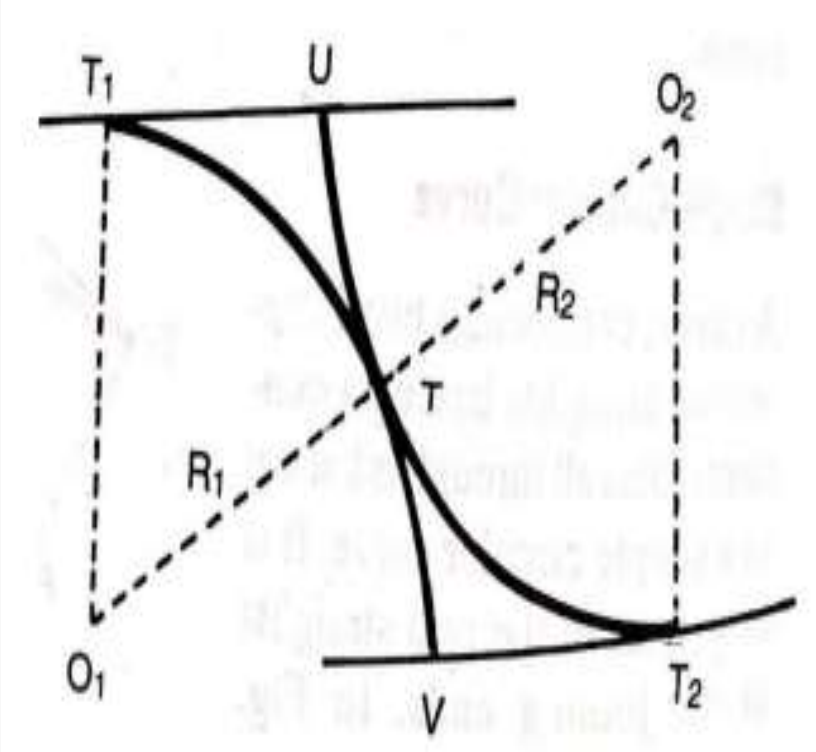
Compound Curve

- Compound Curve: A curve which consists of two or more arcs of different radii deflecting in the same direction and lying on the same side of common tangent is known as compound curve

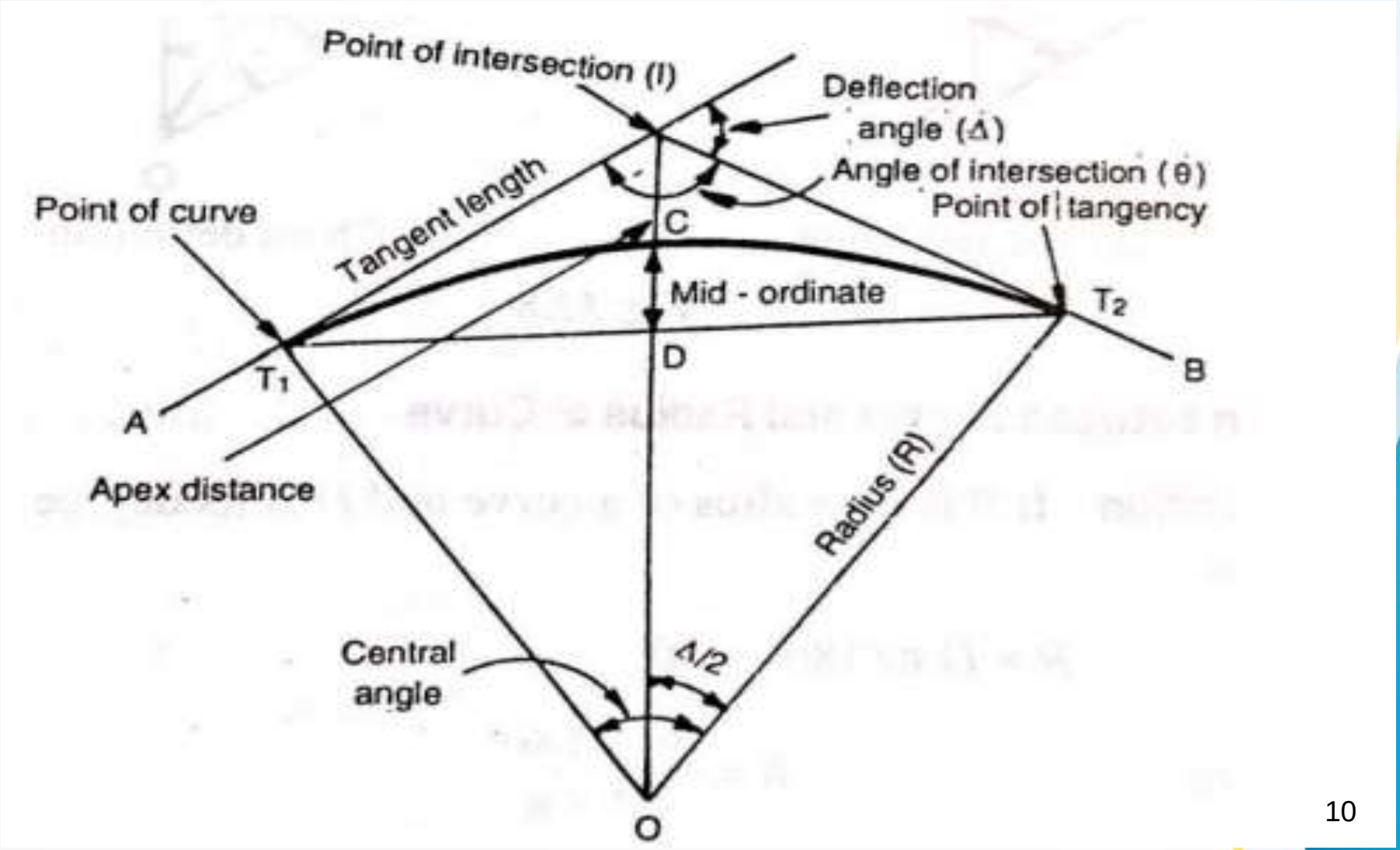


Reverse Curve

- A curve which consists of two circular arcs of same or different radii, having their centres on the opposite sides of common tangent is known as reverse curve These curves are quite common in railway yards, but are unsuitable for modern highways. These are also known as serpentine curve or S-curve because of their shape



Elements/ Component Parts of a Simple Circular Curve:



Elements/ Component Parts of a Simple Circular Curve:

1. **Back Tangent:** The tangent previous to the curve is known as back tangent or first tangent.
2. **Forward Tangent:** The tangent following the curve is known as forward tangent or second tangent.
3. **Point of Intersection (P.I):** The point at which the two tangents intersect is called the point of intersection.
4. **Point of Curve (P.C):** The point at which the curve changes its alignment from straight to a curve is called as point of curve. It is the beginning of the curve.
5. **Point of Tangency (P.T):** The point at which the curve changes its alignment from curve to a straight is called as point of tangency. It is the end of the curve.

Elements/ Component Parts of a Simple Circular Curve:

6. **Intersection Angle (ϕ):** The interior angle between the two tangents is called intersection angle.

7. **Deflection Angle (Δ):** The exterior angle between the two tangents is called deflection angle.

8. **Tangent Length/Distance (T):** The distance between point of curve/point of tangency and the point of intersection is called tangent distance/length.

9. **External Distance (E):** The distance between mid-point of the curve and point of intersection is called external distance.

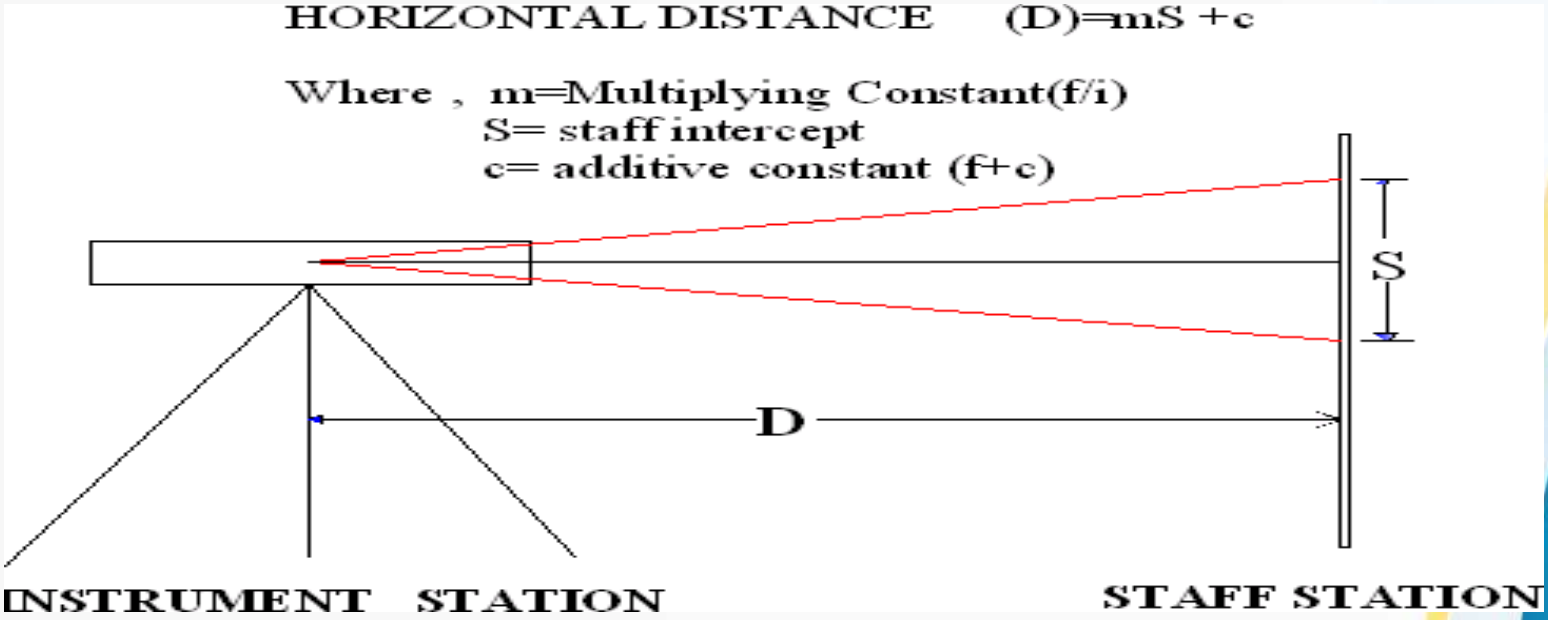
10. **Length of the Curve (l):** The curved distance between point of curve and point of tangency is called length of curve.

11. **Long Chord (L):** The straight distance between point of curve and point of tangency is called long chord

- **12. Mid-Ordinate (M):** The vertical distance between mid-point of curve and mid-point of long chord is known as mid-ordinate.
- **13. Normal Chord (c):** The horizontal distance between two successive regular stations on the curve is called normal chord.
- **14. Sub-Chord (c'):** Any chord shorter than the normal chord is called sub-chord.
- **15. Right Handed Curve:** If the curve deflects to the right hand side of the progress of the survey work, then it is called a right handed curve.
- **16. Left Handed Curve:** If the curve deflects to the left hand side of the progress of the survey work, then it is called a left handed curve.

Tacheometry

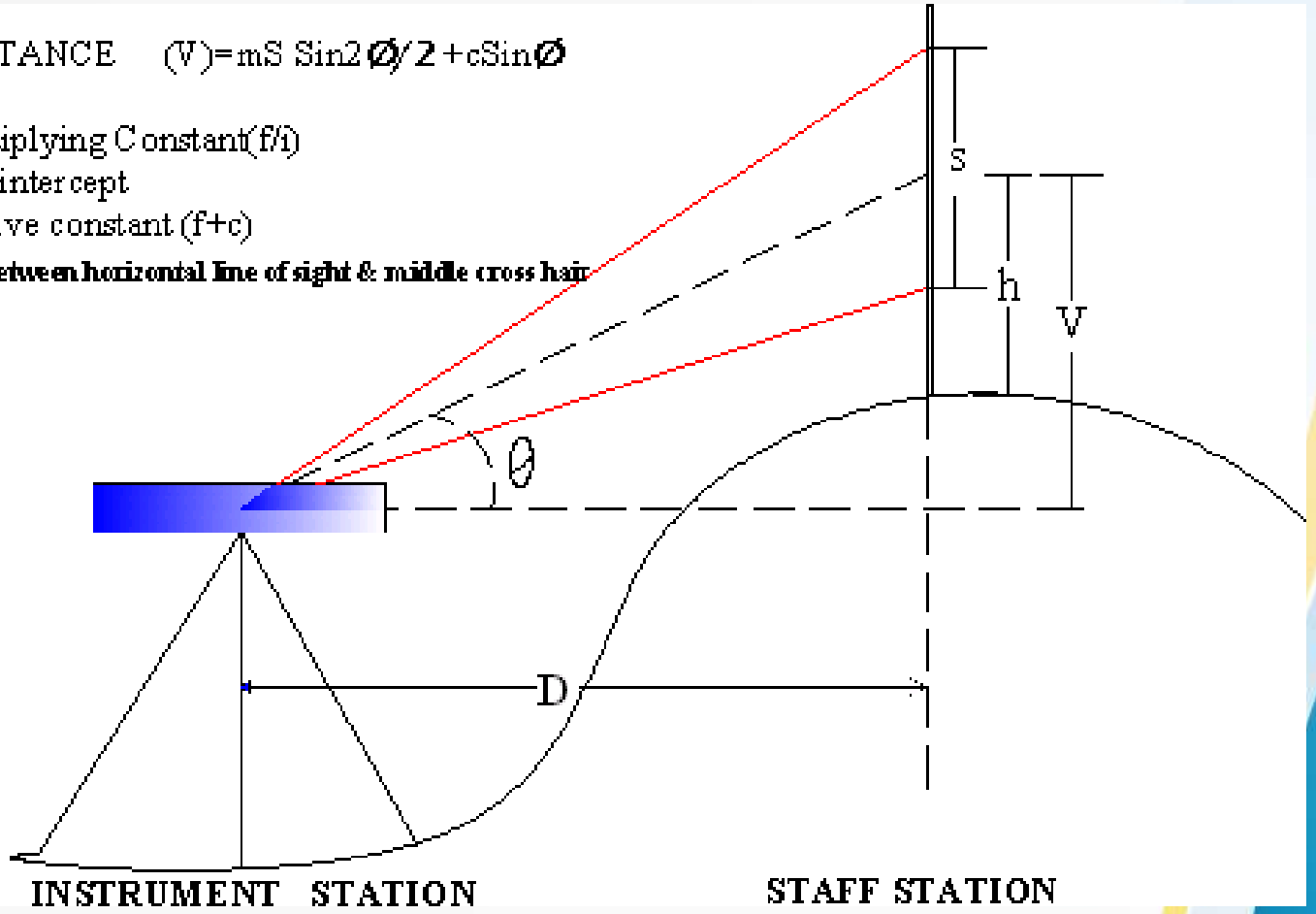
- **Definition-**It is the branch of angular surveying the Horizontal distances from station to the staff and the vertical distance of a point are determined from instrumental observation
  Horizontal distance



Vertical distance

VERTICAL DISTANCE (V)=mS Sin2Ø/2+cSinØ

Where, m=Multiplying Constant(f/i)
S= staff intercept
c= additive constant (f+c)
Ø=Angle between horizontal line of sight & middle cross hair



Situation where tacheometry can be used

- When obstacles like river, broken ground,streches of water, tacheometry gives speed & accuracy to work.
- In rough country where measurement of horizontal & vertical distances are difficult, inaccurate & slow.
- In locating contours & filling details in a topographic survey, this method is fast & best.

Advantages of tacheometry

- Tacheometer is used where chaining is difficult such as river, vally, broken boundries, stiff slope, undulations.
- It is used in the preparation of contour maps, in which horizontal & vertical distances are required to be measured.
- It is used for the survey road, railway.
- It is also used for the hydrographic survey.
- It is used for checking distances measured by tape, chain & dumpy level.
- It is used where accuracy is not required.
- It saves time & money.

Difference between theodolite and tacheometer

- Tacheometer
- It is used for measurement of horizontal & vertical distances.
- In tacheomtric survey ,direct measurement of distances are possible.
- Suitable in case obstacles like river broken ground.
- Less stations are required in tacheometric survey.

- Theodolite
- It is used for measurement of horizontal & vertical angle.
- In theodolite survey , distances are measured by chain or tape.
- Suitable for plane & hilly area with less obstacles.
- More stations are required in theodolite survey.

Constants of Tacheometer

- Multiplying constant ie. (f/i) or m.
- Additive constant ie (f+c) or C.

Where f= focal length of image

glass c= legth of image

Object of tacheometry

- Preparation of contour maps or plans.
- Used in hydrographic survey.
- Location survey for roads,railways, reservoir etc.
- For checking of more precise measurements.

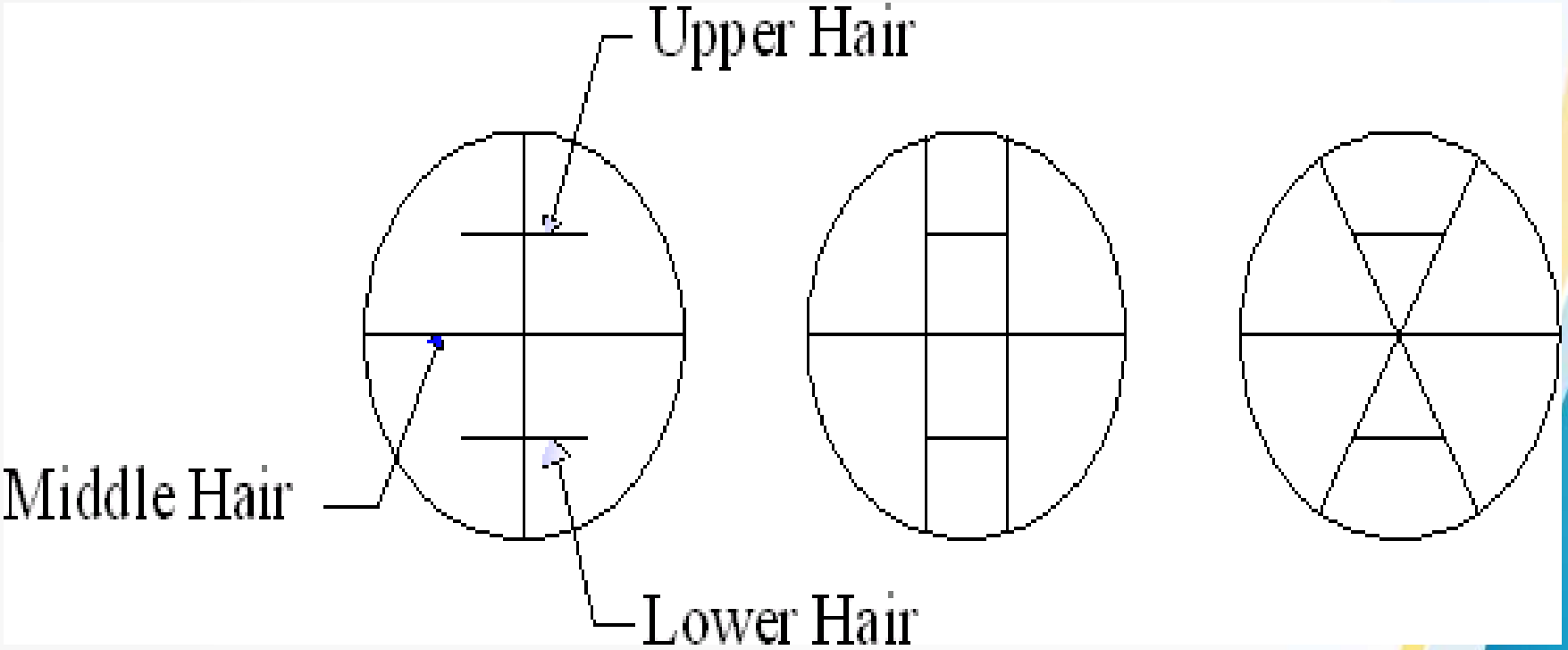
Instrument used in Tacheometer

I) Tacheometer
II) Levelling or stadia rod

I)Tacheometer –It is a transit theodolite provided with a stadia diaphragm.

- The diaphragm is provided with two horizontal stadia hairs in addition to regular cross hair.
- Additional hair should be equidistant from central one.
- Types of diaphragm commonly used as follows.

Types of diaphragm



Types of Telescope in Tacheometry

- External focusing
- Internal focusing
- External focusing fitted with anallatic lens.

Anallatic lens -It is an additional lens generally provided in the external focusing tacheometer between object glass & eyepiece

Advantages of anallatic lens.

1) For calculation of horizontal & vertical distances constant (f+c)=0, if tacheometer is provided with anallatic lens.
2) Calculation becomes simple.

Essential characteristics of Tacheometer

- The value of constant (f/i)=100.
- The telescope should be provided with anallatic lens.
- The telescope should be powerful, magnification should be 20 to 30 times the diameter.
- The vision through the telescope should be clear & bright image at longer distance.

Essential characteristics of Tacheometer

- The value of constant (f/i)=100.
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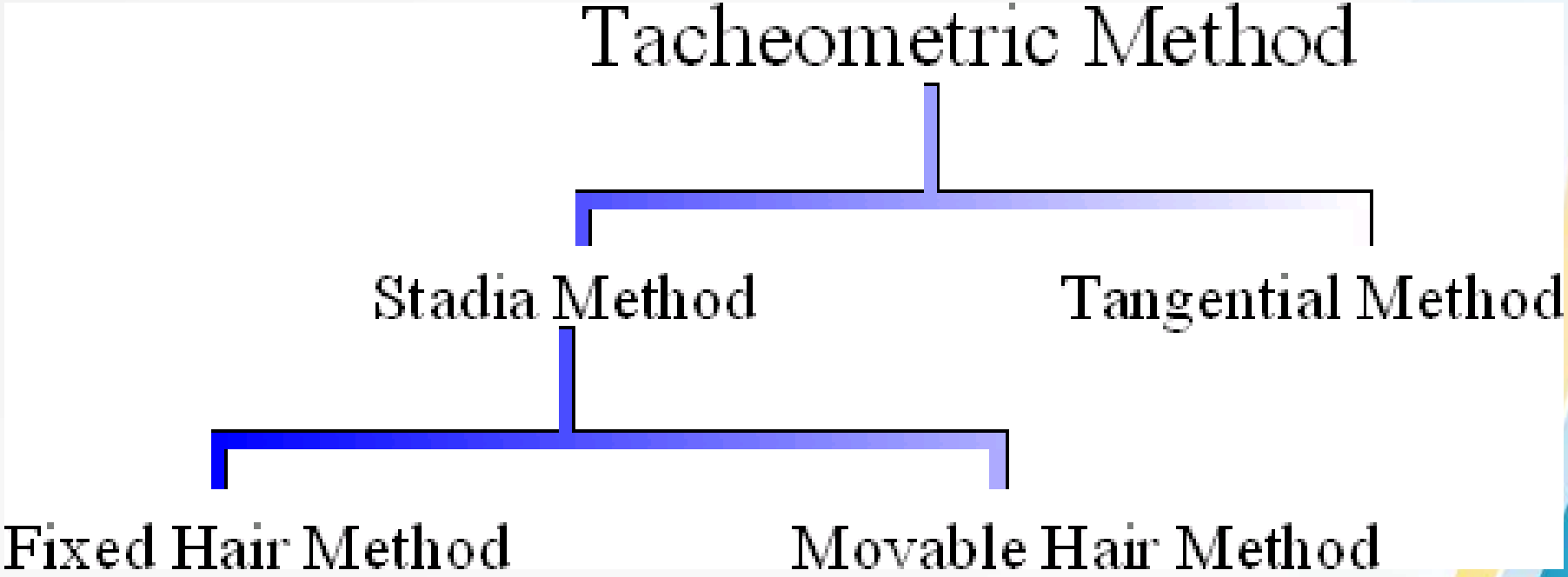
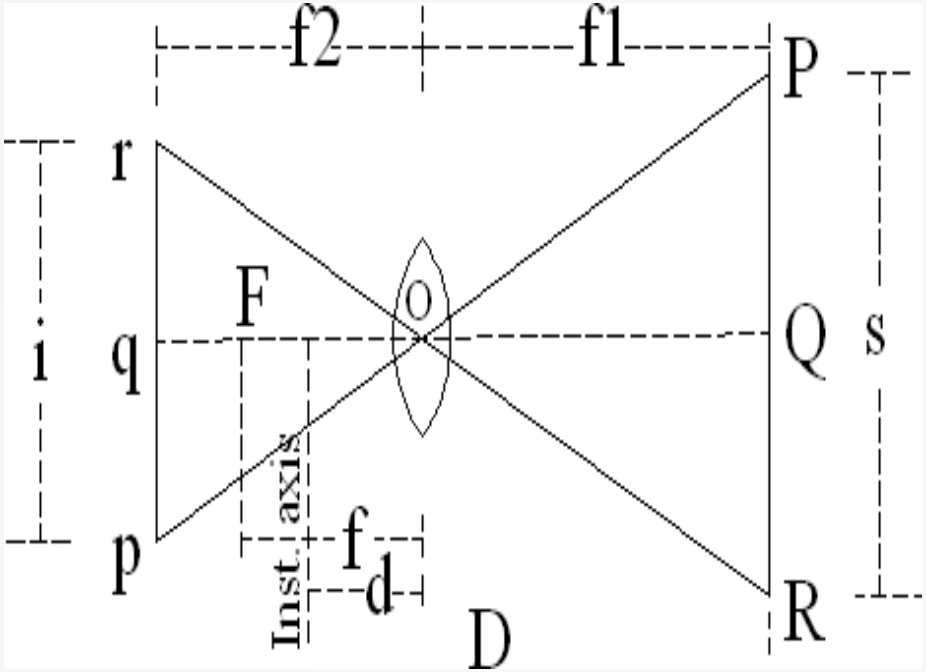

Tacheometric Method
Stadia Method
Tangential Method
Fixed Hair Method
Movable Hair Method

Fixed Hair Method

- In this method, the distance between two stadia hair is fixed.
- The reading corresponding to three cross hair is taken and difference between top and bottom hair is found out known as staff intercept.

Principle of stadia method



From similarity of triangle POQ & poq .
PR/pr =OQ/oq
S/i = f1/f2
By lens formula
1/f=
(1/f1)+(1/f2)
Multyplying f1 to both side
f1×(1/f) =
f1×(1/f1)+f1×(1/f2) F1/f =
1+(f1/f2)
Put values of (f1/f2) = S/i
f1/f = 1+ (S/i)
(f1/f)-1 =
S/i (f1-
f)/f = S/i
f1= S/i ×f+f eq 1
Now, D= f1+d or f1=D-
d

eq 2 Put values of equation 2 in 1
D-d = S/i×f+f
D=(f/i)×S+(f+d) eq 3
(f/i) =multiplying constant= m
(f+d)= additive constant =c **D=**
ms+ c

P, Q, R=Three line of sight on staff corresponding to three line. P, q, r=the stadia hairs

O= optical center of object glass. pr= i

= stadia interval.

PR= s = staff intercept.

f = focal length of object glass.

f_1 = horizontal distance between center of object glass to the staff station.

f_1 = horizontal distance of diaphragm from ‘o’

D= horizontal distance of staff station from vertical axis of taceometer.

d= horizontal distance between vertical axis of tacheometer & center bof object glass.

Fixed Hair Method

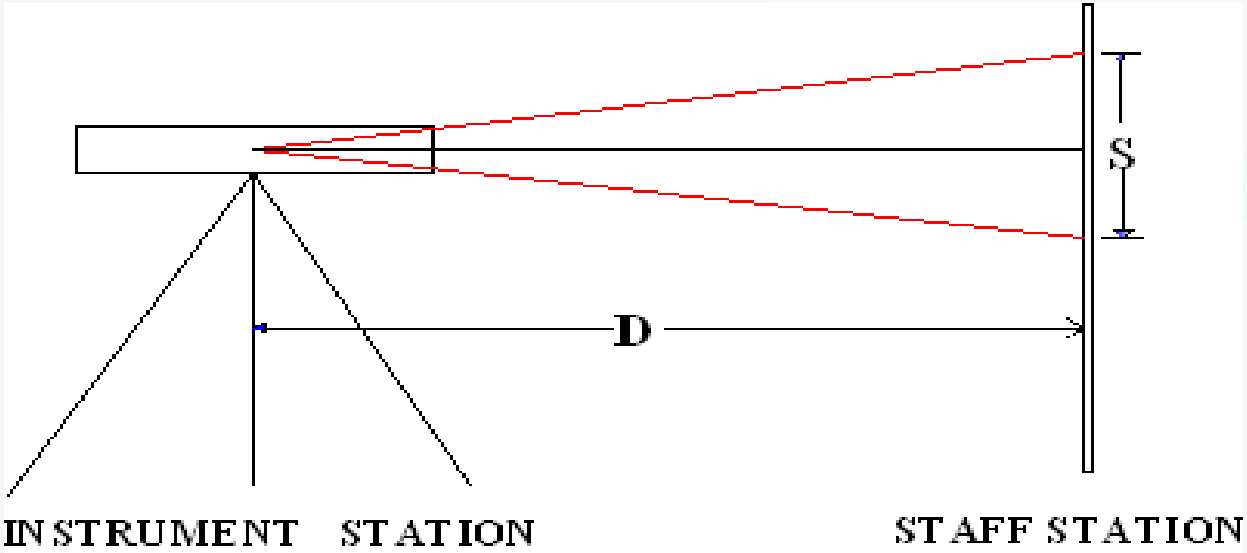
There are three different cases used.

Case I): Line of sight is horizontal and the staff held is vertical.

Case II): Line of sight is inclined and the staff held is vertical.

Case III): Line of sight is inclined and the staff held is normal to the line of sight.

Case I): Line of sight is horizontal and the staff held is vertical.



HORIZONTAL DISTANCE(D)=(f/i)S+(f+d)

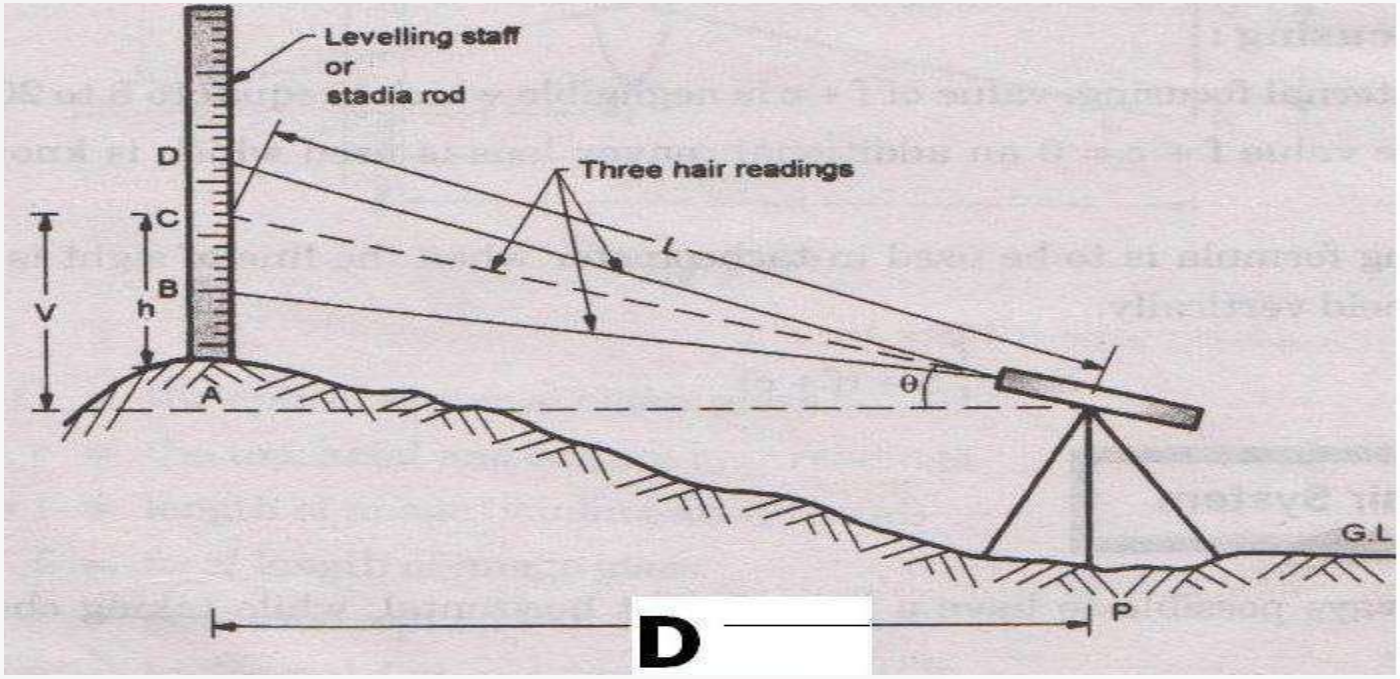
(D)=mS +c

Where , m=Multiplying Constant(f/i)

S= staff intercept

c= additive constant (f+c)

Case II): Line of sight is inclined and the staff held is vertical.



Vertical Distance $V=(f/i)S \frac{\sin 2\theta}{2} + (f+c)\sin\theta$

Horizontal Distance $D=(f/i)S\cos^2\theta + (f+c)\cos\theta$

Where, θ is angle between horizontal line of sight & central reading0

THANK YOU..

SURVEYING

UNIT- 5 MODREN SURVEYING EQUIPMENTS & PHOTOGRAMMETRIC SURVEYING

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CONTENTS

- Modern Surveying Methods
- Principle and types of E.D.M.Instruments
- Total station- Advantages and Applications
- Field Procedure for total station survey
- Errors in Total Station Survey
- Global Positioning System- Principle and Applications.
- Photo Grammetry Surveying: Introduction
- Basic concepts

CONTENTS

- Perspective geometry of aerial photograph
- Relief and tilt displacements
- Terrestrial photo grammetry
- Flight planning.

MODREN SURVEYING EQUIPMENTS

- By the 1970's, relatively small, lightweight and easy-to-use electronic distance measuring devices, called **EDM's** were in use.
- The advance of technology and miniaturization of electronic components enabled the building of theodolites that measure angles electronically, called **Electronic Theodolite**
- Combination of an electronic theodolite and electronic distance meter, and software running on an external laptop computer known as a data collector, called **Total Station**
- **The Global Positioning System (GPS)** was designed for military applications. Its primary purpose was to allow soldiers to keep track of their position and to assist in guiding weapons to their targets
- A computerized data base management system for capture, storage, retrieval, analysis, and display of spatial data, called **GIS**

MODREN SURVEYING EQUIPMENTS

- Electronic Theodolite
- EDM – Electronic distance measurement eqp.
- Auto Level.
- Digital Level.
- Laser Level.
- Laser Distance meter
- Total station.
- GPS – global positioning system.


MAGELLAN
Laser Instrument
Surveying Equipment
Soil/Bitumen/Concrete
Testing Equipment
Magellan MobileMapper 6
Measuring Wheel
Water Level Measure, Measuring Tape,
Diameter Tape,Surveyor Rope
Leica Disto D2, Disto D3,
Disto A5 - Laser Distancemeter
GARMIN
Leica
SUUNTO
DAVIS
Optek
TRIMBLE
OmniSTAR

ELECTRONIC THEODOLITE

1. For precise surveys the vernier theodolites are replaced by modern theodolites such as optical and electronic theodolites.
2. The electronic theodolites have optical system to scan both horizontal and vertical circles and display them digitally on a screen

Electronic Distance meter

1. **EDM** is Electronic Distance meter
2. Measurement of distance is done by a modulated **microwave** or **infrared** carrier signal
3. The distance is determined by emitting and receiving multiple frequencies, and determining the integer number of **wavelengths** to the target for each **frequency**

DIGITAL LEVEL

- They are not popular instead auto levels are more extensively used.
- The Trimble DiNi Digital Level : Determine accurate height information 60% faster than with automatic leveling
- Eliminate errors and reduce rework with digital readings
- Transfer data to the office easily
- Measure to a field of just 30 cm

LASER LEVEL

- The word ***laser*** is an acronym for Light Amplification by Stimulated Emission of Radiation and is the name applied to an intense beam of highly monochromatic, coherent light.
- Laser rangefinders use these relationships to calculate Distance
- **Distance = speed of light * (time/2)**
- The time refers to time of pulse to go from the instrument to the tree and back again

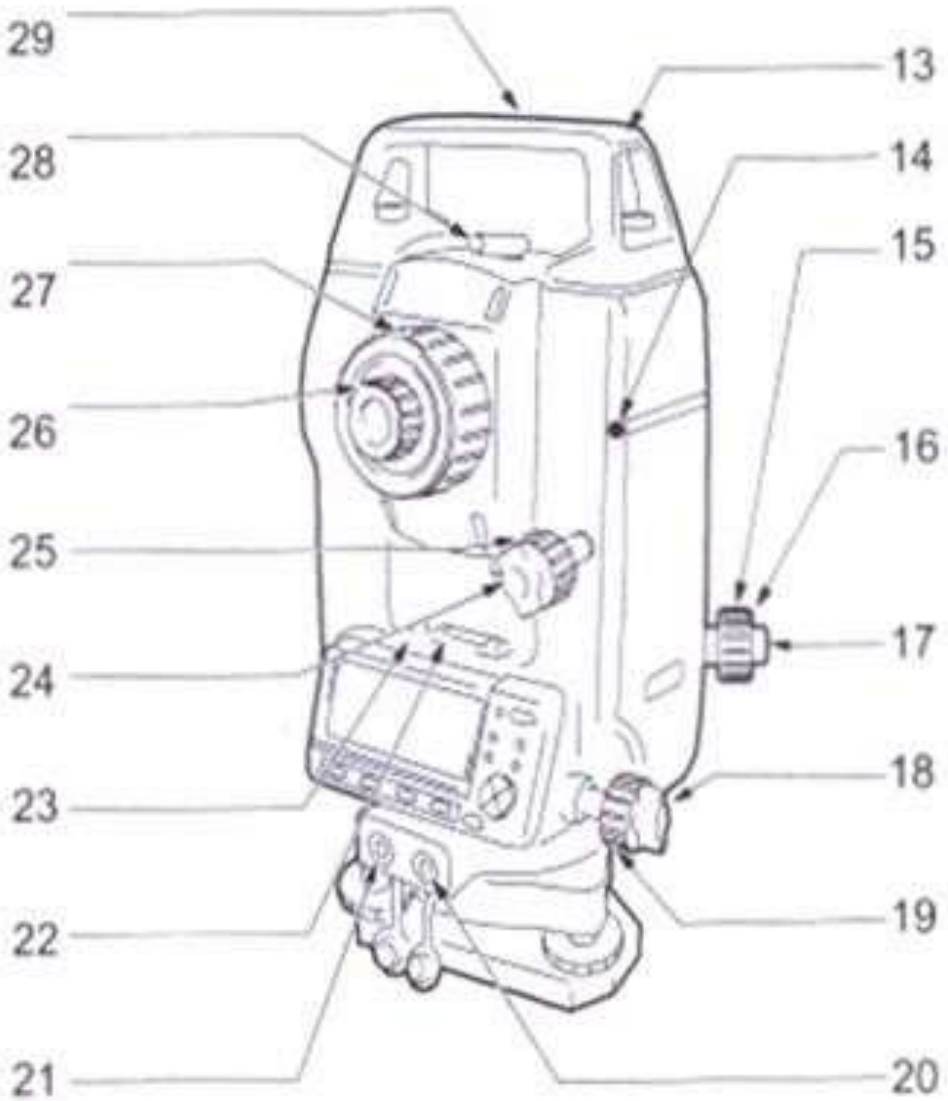
EDM+ THEODOLITE

- EDM is used to measure the horizontal distances.
- Some EDM are attached with electronics theodolite which has the adapter system.
- Some are advanced models which itself reads the distance without theodolite

TOTAL STATION

- A **Total station** integrates the functions of a **Electronic theodolite** for measuring angles, an **EDM** for measuring distances, digital data and a data recorder
- Angles and distances, coordinates and height differences and many other items can be computed, displayed and stored into internal memory.

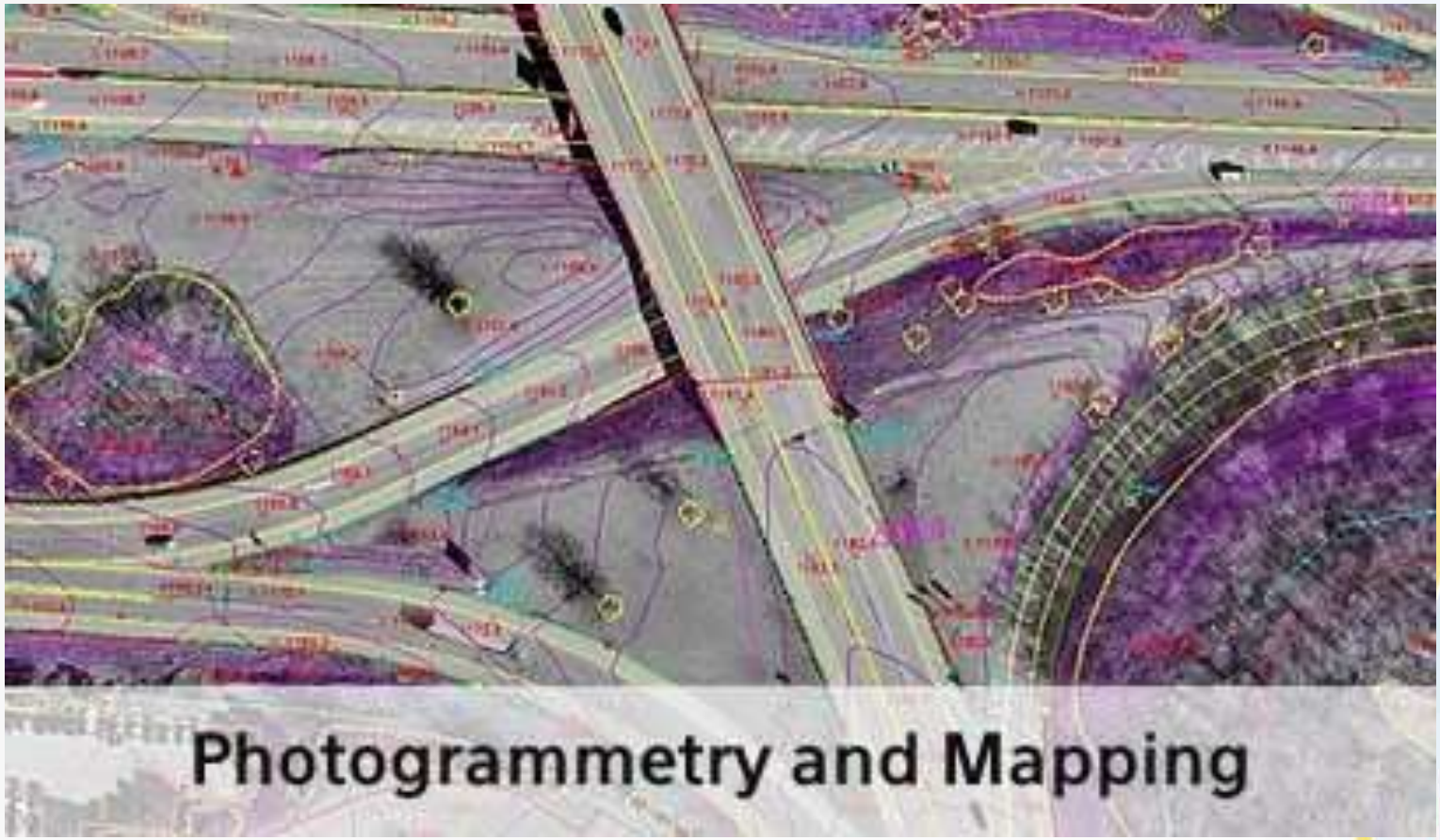
TOTAL STATION



13 Tubular compass slot
14 Beam detector for wireless keyboard (Not included on SET620/620S)
15 Optical plummet focussing ring
16 Optical plummet reticle cover
17 Optical plummet eyepiece
18 Horizontal clamp
19 Horizontal fine motion screw
20 Data input/output connector (Beside the operation panel on SET620/620S)
21 External power source connector (Not included on SET620/620S)
22 Plate level
23 Plate level adjusting screw
24 Vertical clamp
25 Vertical fine motion screw
26 Telescope eyepiece
27 Telescope focussing ring
28 Peep sight
29 Instrument center mark

PHOTOGRAMMETRY

Photogrammetry or photographic surveying is a method of surveying in which plans or maps are prepared from photographs taken from suitable camera stations



Two Types

1.Terrestrial or ground

photogrammetry 1.Aerial

photogrammetry

Terrestrial Photogrammetry:

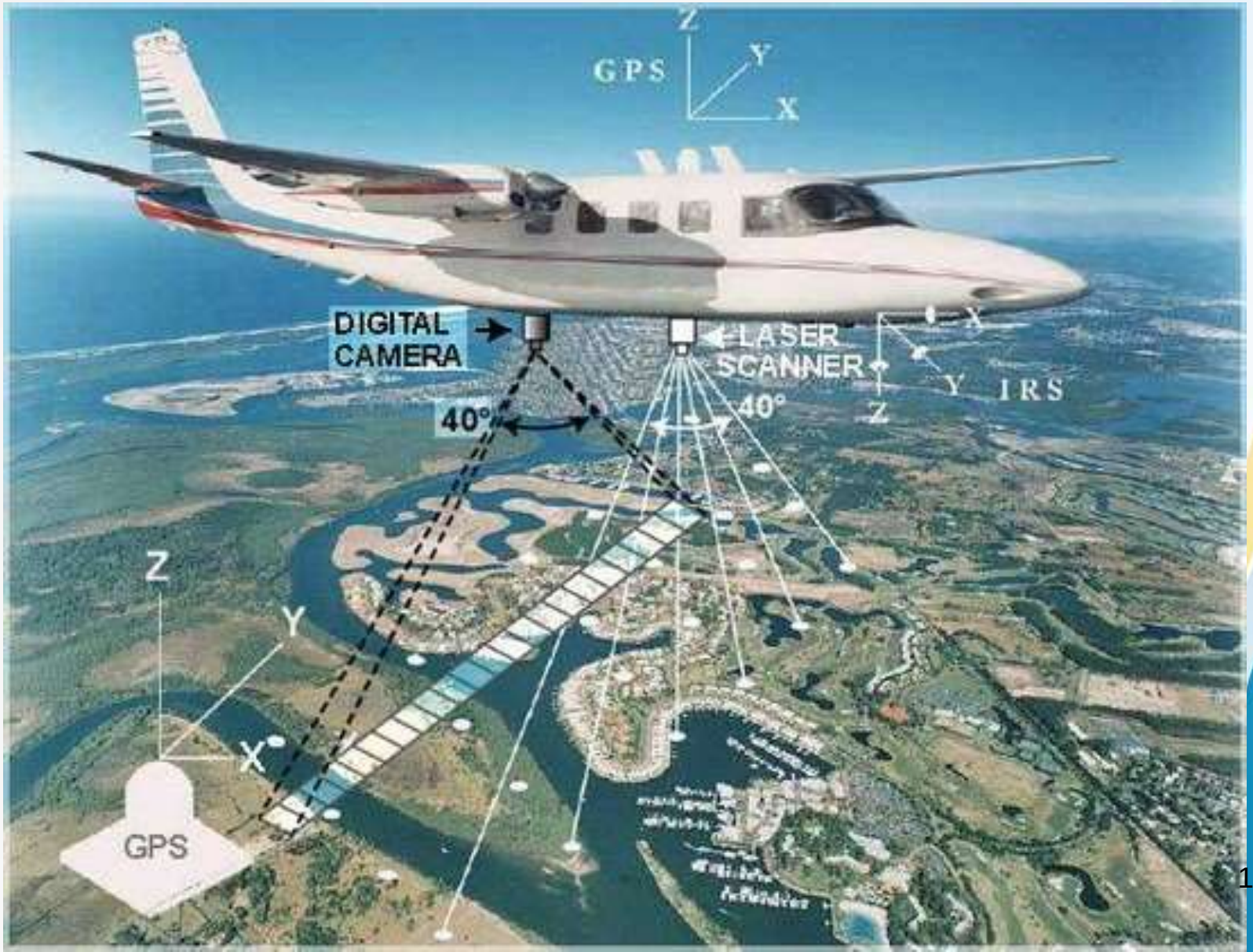
Maps are prepared from photographs taken from some fixed positions on or near the ground with camera axis horizontal

Terrestrial Photogrammetry:

Used for-

- Small scale mapping of open hilly or mountainous countries
- Reproduction of plan and elevation views of buildings and structures
- Motion picture photography
- For furnishing supplementary ground control for aerial photography

Aerial Photogrammetry:



Aerial Photogrammetry:

Maps are prepared from photographs taken by a precision camera mounted in an aircraft flying over the area with camera axis vertical.

Used for-

- country's reconnaissance and preliminary surveys
- Survey of rivers, roads and railways
- Survey of inaccessible regions like deserts and wooded countries
- Survey of power schemes and transmission lines
- Acquisition of land

- Town and village planning
- Flood control, irrigation, drainage and soil conservation
- Harbors, navigation channels and coastal defense
- Mining prospects
- Study of geology
- Soil and agricultural studies
- Military installations, camping and forbidden zones

Definitions

Static Photographs: photographs of still or static objects; such as building

Quasi- Static Photographs: A series of photographs taken in fairly rapid sequence in order to picture the positions of a slow moving object at various circumstances;

such as movement of ships near a port or traffic flow after a regular interval of time

Dynamic Photographs: Photographs of an object which changes its size, shape and position or orientation from one instant to another

Taken by motion picture camera

Definitions

- **Primary or main camera station:** control point over which the photo theodolite is centred.

Definitions

Eccentric camera station: when it is not possible to get a greater photo coverage from the main camera station the photo theodolite is placed over a position eccentric to the main camera station

Side camera station: neither the main nor the eccentric camera station is found suitable to obtain a greater photo coverage, the photographs are taken with the photo theodolite centered over a point remote from the primary or eccentric camera station

Definitions

Vertical Photograph: It is an aerial photograph taken with the camera or optical axis coinciding with the direction of gravity

Tilted photograph: It is an aerial photograph taken with the camera or optical axis unintentionally tilted from the vertical by a small amount, usually less than 3 degree

Oblique Photograph: It is an aerial photograph taken with the camera or optical axis intentionally tilted by about 30 degree to the forward direction

Definitions

Exposure station: It is a point in space, in the air, occupied by the camera lens at the instant of exposure

Flying height or flight altitude: It is the elevation of the exposure station above the mean sea level or any other selected datum

Stereoscopy : If two overlapping aerial photographs containing the same objects, taken from different positions, are viewed through a stereoscope, the corresponding objects will fuse and the terrain will appear in three dimensions.

Terrestrial Photogrammetry

Basic Principle:

•Similar to plane table surveying.

•The difference between the plane table surveying and terrestrial photogrammetry is that in plane table surveying all the detailing is done in the field, while in terrestrial photogrammetry the photographs are taken in the field but their subsequent plotting is done in the office.

Terrestrial Photogrammetry

Photo Theodolite:

•Combination of a terrestrial camera and an ordinary theodolite

•**Principal point:** intersection of the images of the horizontal and vertical heirs

Terrestrial Photogrammetry

Field Works in Terrestrial Photogrammetry:

1. **Reconnaissance:** The following factors are to be consider

- Considered in selecting the camera stations and the base lines.
- The stations are chosen so as to give as much coverage of the terrain as possible
- The station should be located on points of higher elevation than the surrounding terrain
- It should be a good triangulation station
- Stations should be so fixed that the object to be plotted on the map can be clearly and easily recognized on at least two photographs taken from different stations
- Base line should be nearly horizontal or uniformly sloping
- Slope of a base line should not exceed 9 degree.

Terrestrial Photogrammetry

Field Works in Terrestrial Photogrammetry:

2. Triangulation: – A method of surveying in which the stations are points on the ground at the vertices of a chain or network of triangles. The angles of the triangles are measured instrumentally and the sides are derived by computation from selected sides or bases, whose lengths are obtained by direct measurement on the ground or by computation from other triangles.

3. Camera Work

Aerial Photogrammetry

Equipments Required-

1.An aeroplane

2. An aerial camera: The aerial camera requires

a.Fast lens

b.High speed and efficient shutter

c.High speed emulsion for the film

3. A magazine to hold large rolls of film

4.Accessories required for interpretation and plotting maps


ZS-HFD
www.bassair.co.za

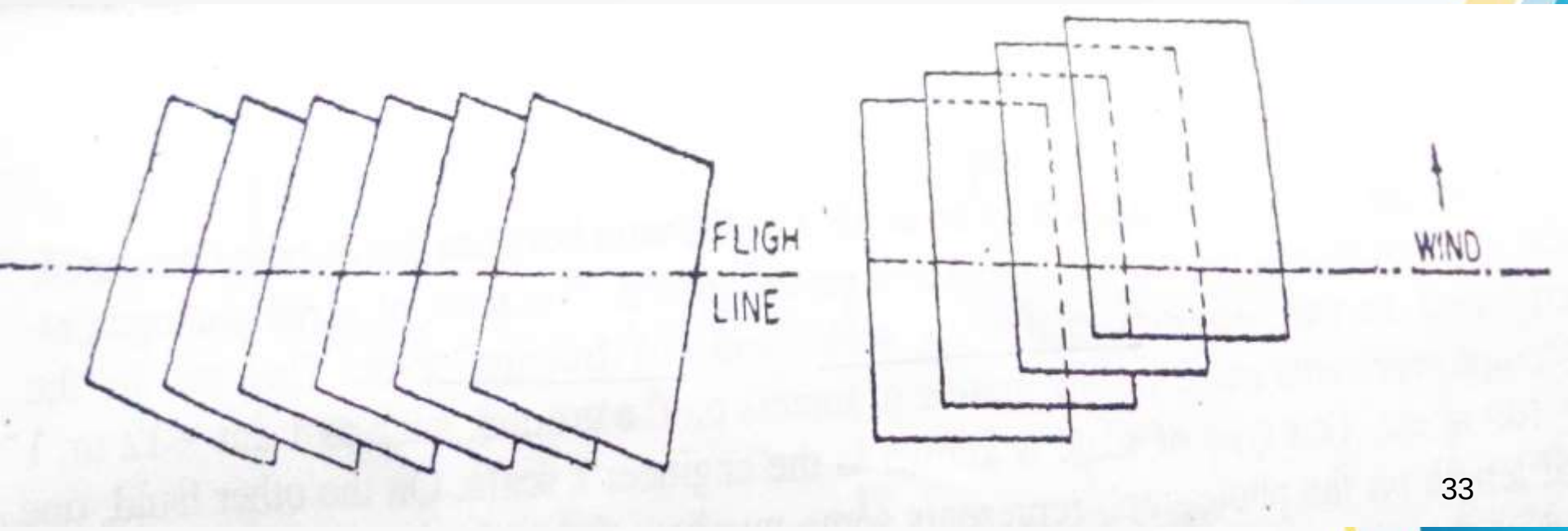
Aerial Photogrammetry

Aerial Photogrammetry consists of five operations-

1.Advanced planning
2.Flying
3.Photography
4.Ground control
5.Compilation or mapping

Crab: Crab is the term given to designate the angle formed between the fight line and the edges of the photograph in the direction of flight

Drift: Drift is caused by the failure of the aircraft to stay on the predetermined flight line.

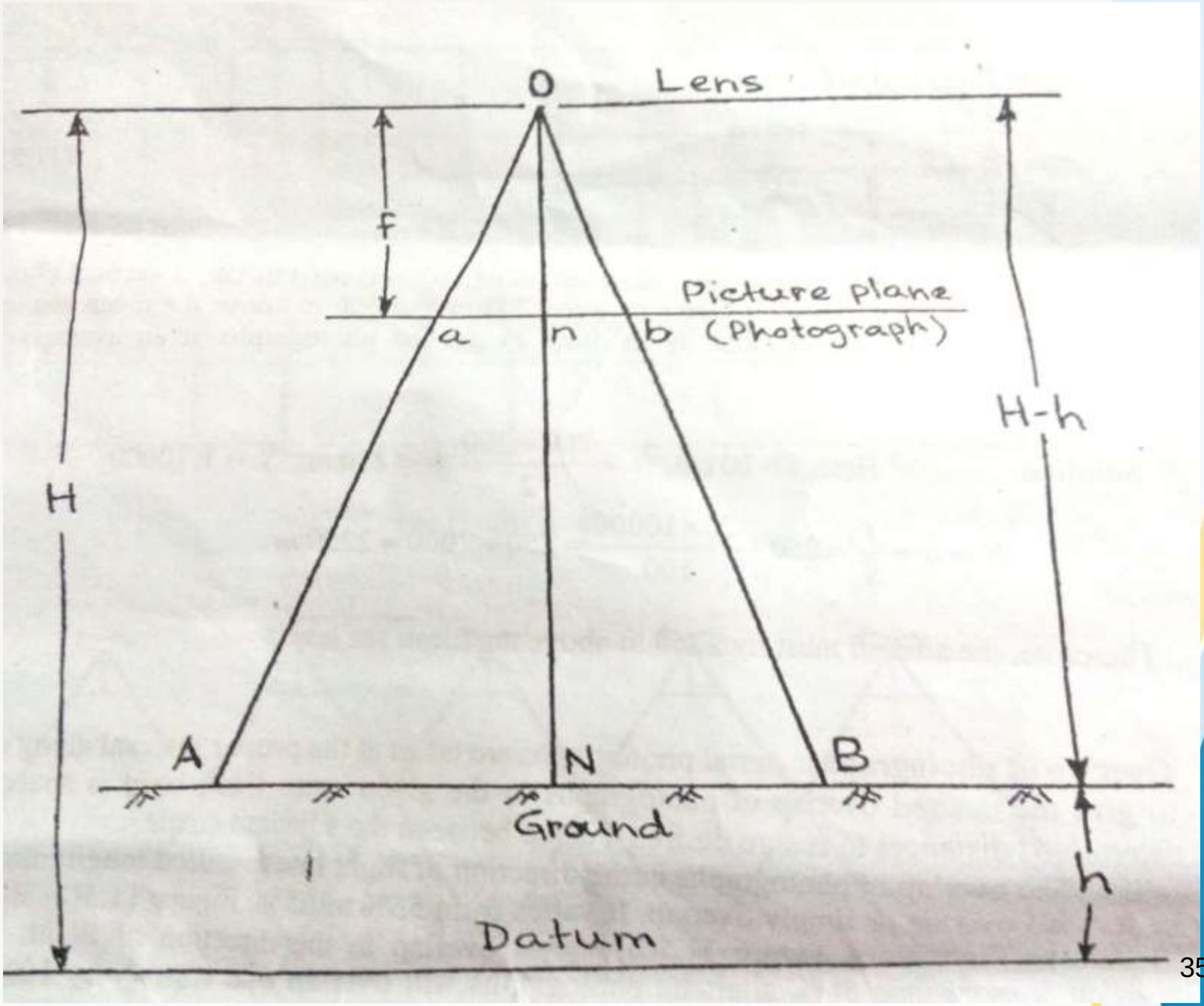


Scale: the ratio of the distance between two points on a photo to the actual distance between the same two points on the ground (i.e. 1 unit on the photo equals "x" units on the ground).

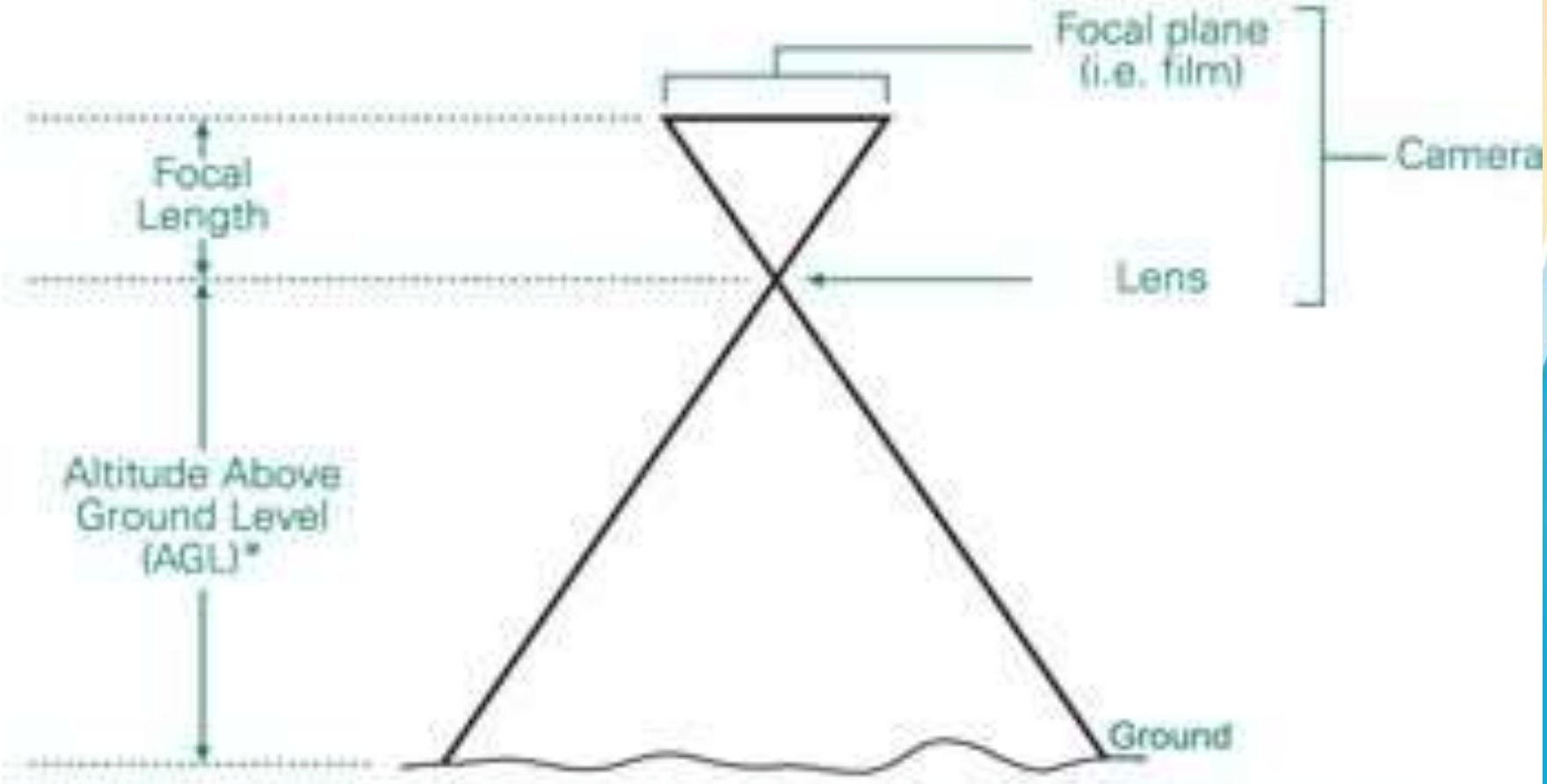
If a 1 km stretch of highway covers 4 cm on an air photo, the scale is calculated as follows:

$$Scale = \frac{Photo\ Distance}{Ground\ Distance} = \frac{4\,cm}{1\,km} = \frac{4\,cm}{100000\,cm} = \frac{1}{25000}$$

$$S = \frac{Distance\ on\ the\ photograph}{Distance\ on\ the\ ground} = \frac{ab}{AB} = \frac{2an}{2AN} = \frac{On}{ON} = \frac{f}{H-h}$$


O
Lens
f
Picture plane
(Photograph)
a
n
b
H
H-h
A
N
B
Ground
h
Datum

Another method used to determine the scale of a photo is to find the ratio between the camera's focal length and the plane's altitude above the ground being photographed.



If a camera's focal length is 152 mm, and the plane's altitude Above Ground Level (AGL) is 7 600 m, using the same equation as above, the scale would be:

$$Scale = \frac{Focal\ Length}{Altitude\,(AGL)} = \frac{152\,mm}{7600\,m} = \frac{152\,mm}{7600000\,mm} = \frac{1}{50000}$$

Scale may be expressed three ways:

- Unit Equivalent
- Representative Fraction
- Ratio

A photographic scale of 1 millimeter on the photograph represents 25 meters on the ground would be expressed as follows:

- Unit Equivalent 1mm = 25 m
- Representative Fraction 1/25 000
- Ratio 1:25 000

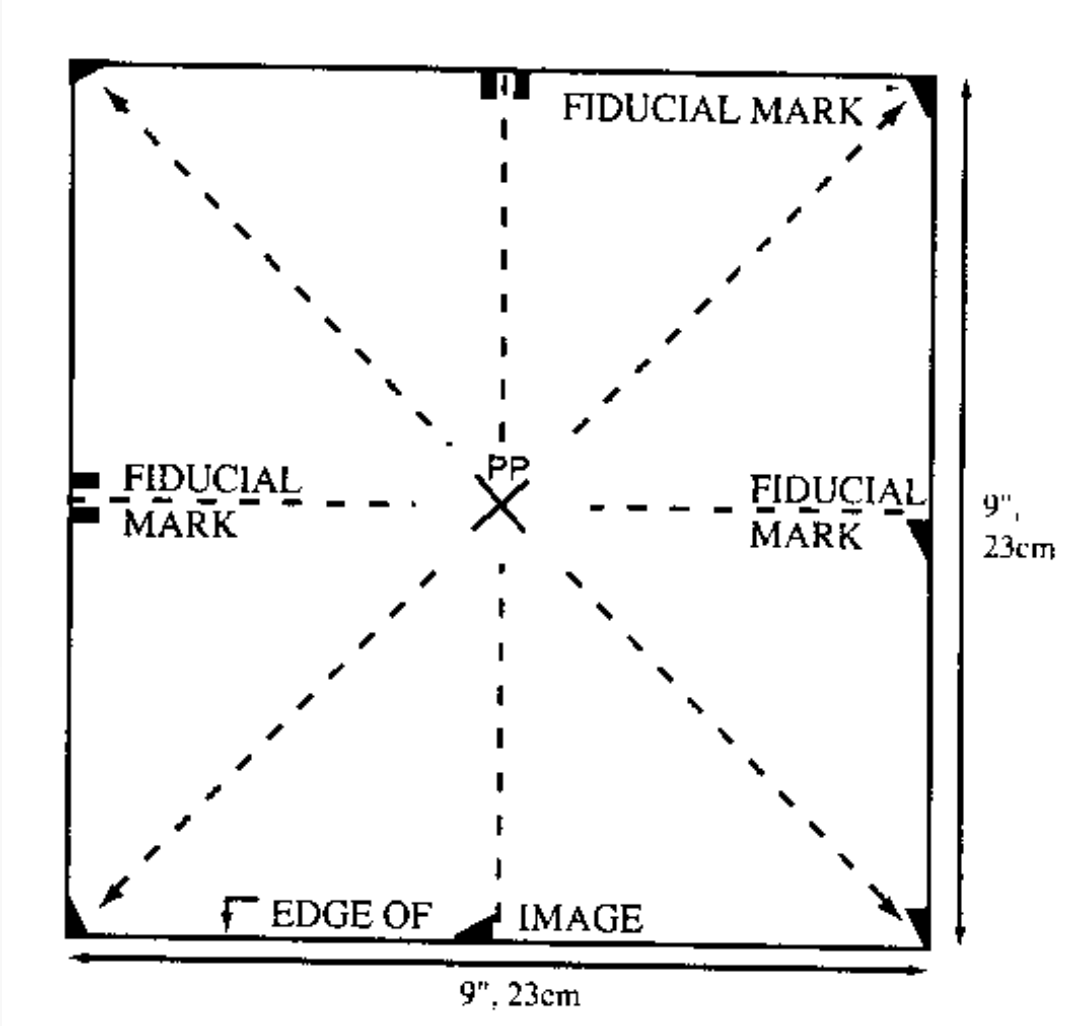
Two terms that are normally mentioned when discussing scale are:

•**Large Scale:** Larger scale photos (e.g. 1/25 000) cover small areas in greater detail. A large scale photo simply means that ground features are at a larger, more detailed size. The area of ground coverage that is seen on the photo is less than at smaller scales.

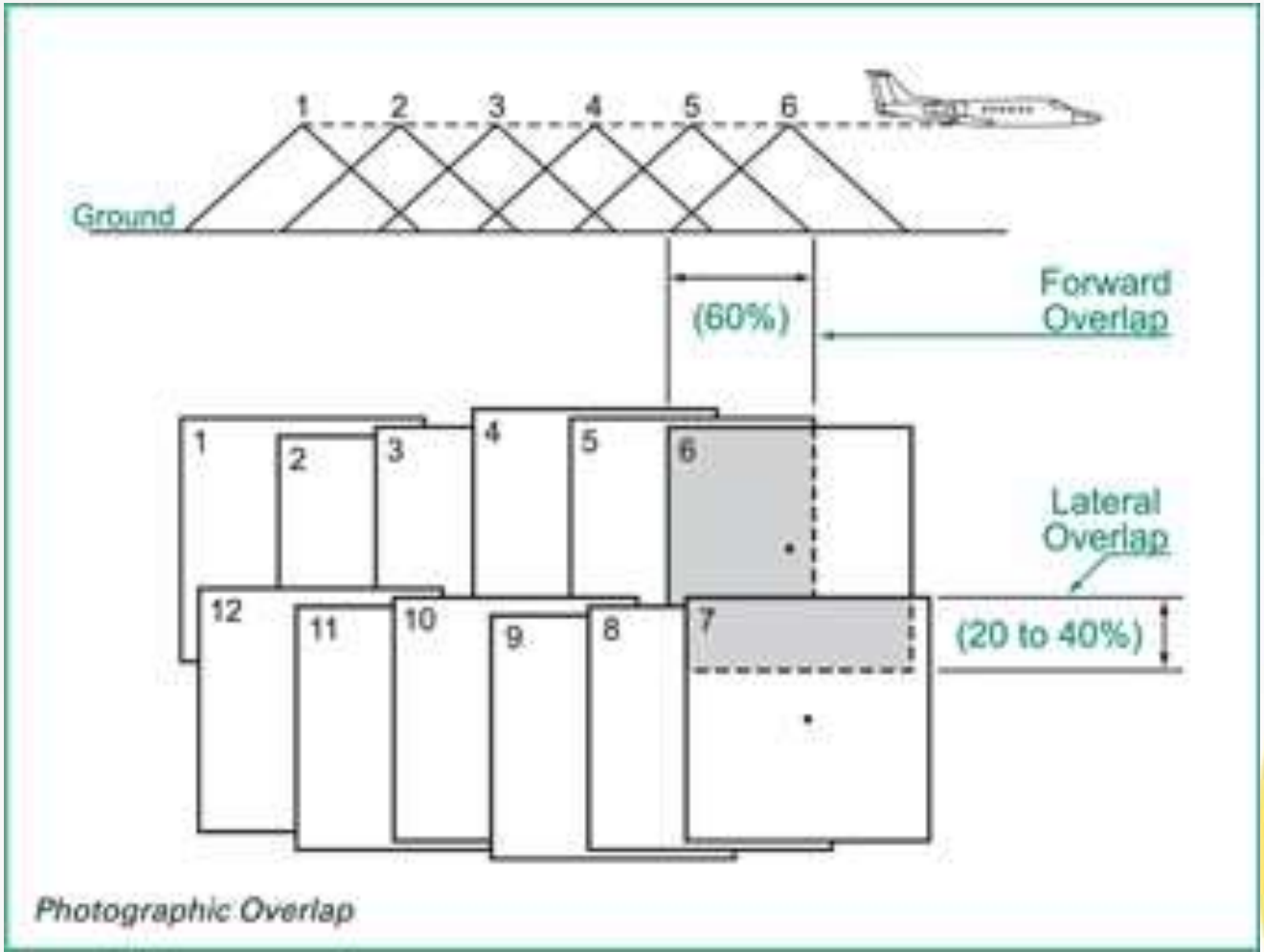
•**Small Scale:** Smaller scale photos (e.g. 1/50 000) cover large areas in less detail. A small scale photo simply means that ground features are at a smaller, less detailed size. The area of ground coverage that is seen on the photo is greater than at larger scales.

The National Air Photo Library has a variety of photographic scales available, such as 1/3 000 (large scale) of selected areas, and 1/50 000 (small scale).

Fiducial marks: small registration marks exposed on the edges of a photograph. The distances between fiducial marks are precisely measured when a camera is calibrated, and this information is used by cartographers when compiling a topographic map.

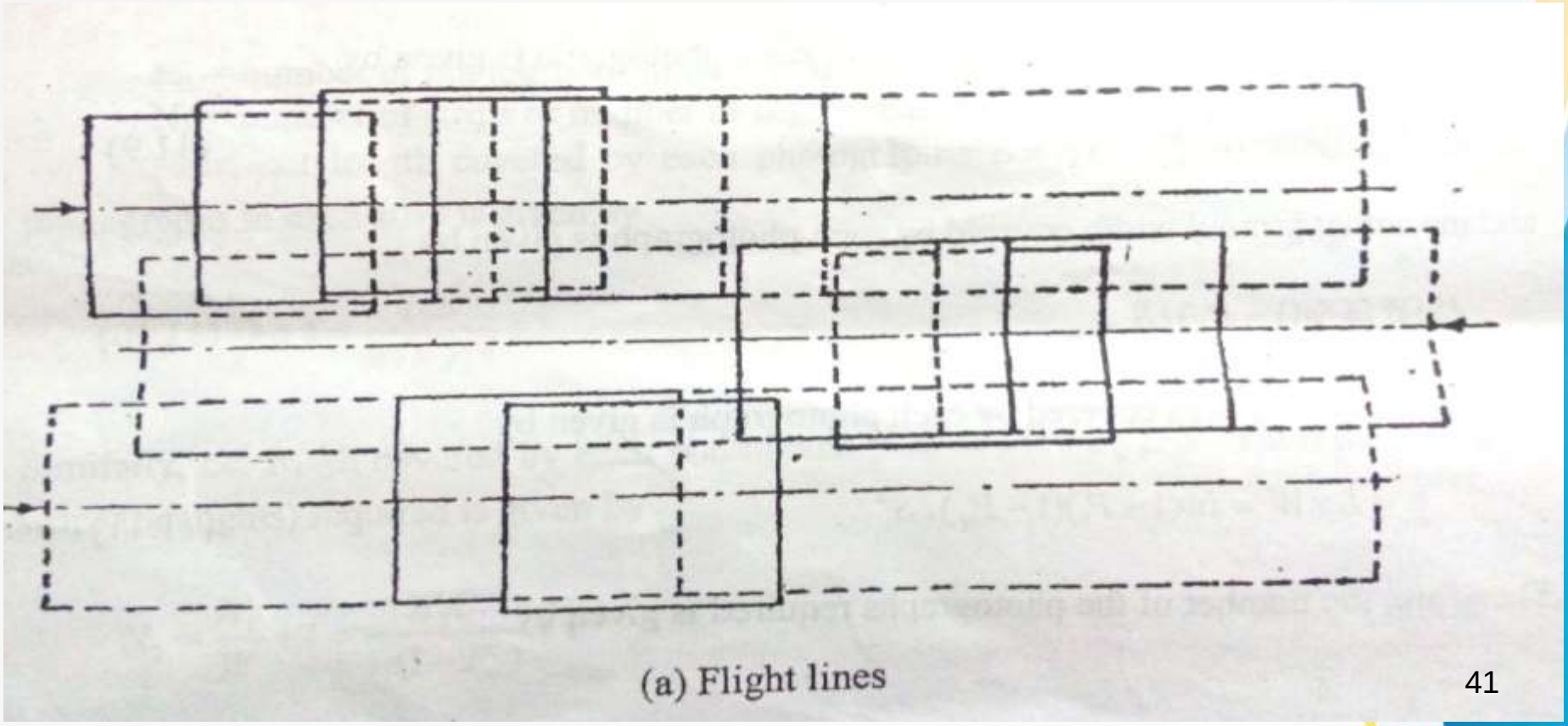


Overlap: is the amount by which one photograph includes the area covered by another photograph, and is expressed as a percentage. The photo survey is designed to acquire 60 percent forward overlap (between photos along the same flight line) and 30 percent lateral overlap (between photos on adjacent flight lines).



Photographic Overlap

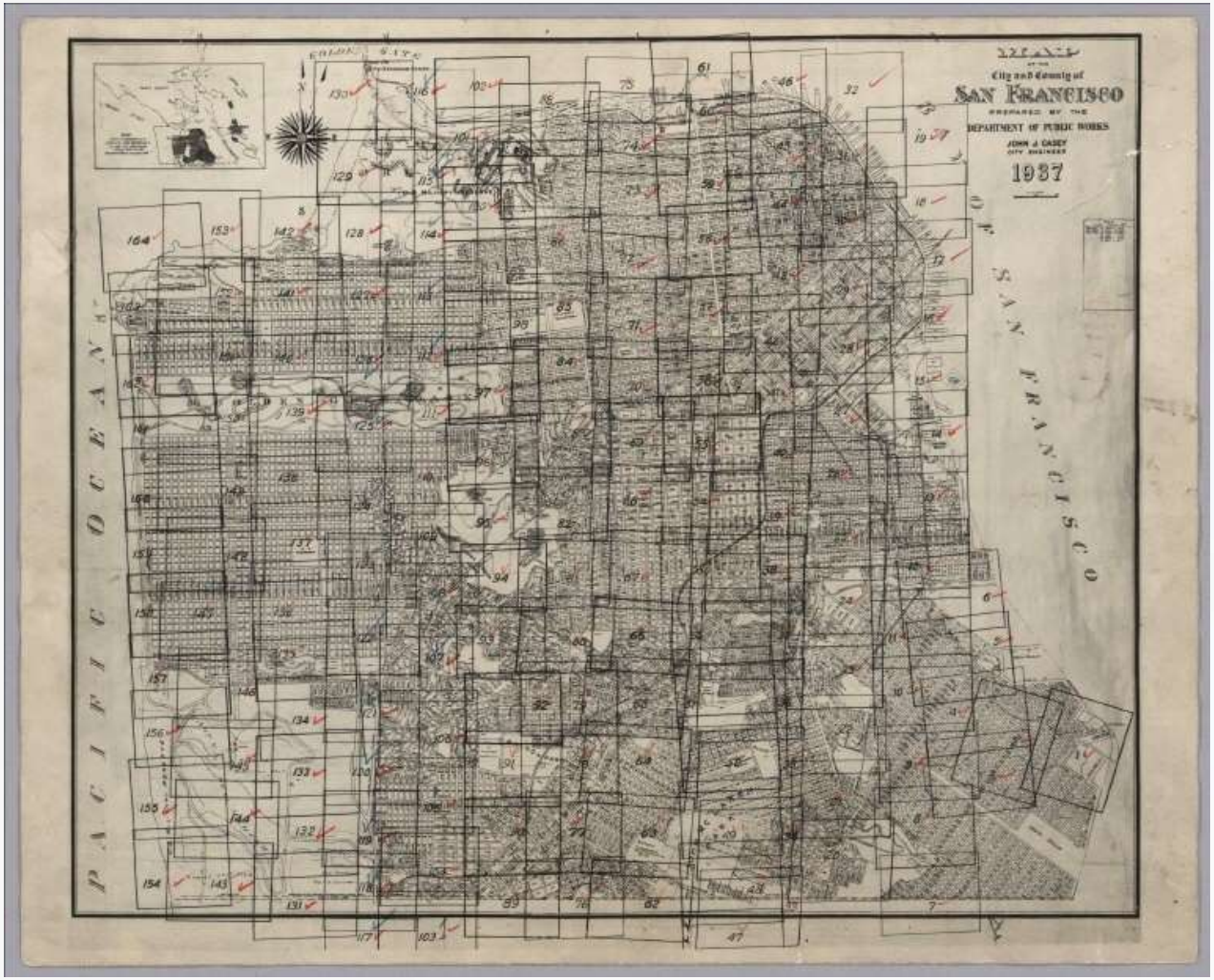
Flight Lines and Index Maps: at the end of a photo mission, the aerial survey contractor plots the location of the first, last, and every fifth photo centre, along with its roll and frame number, on a National Topographic System (NTS) map. Photo centres are represented by small circles, and straight lines are drawn connecting the circles to show photos on the same flight line.



(a) Flight lines


FLIGHT DIRECTION
FLIGHT DIRECTION
FLIGHT DIRECTION
staples
Photo ID = QS-2V-153
Visible portion of photo
Portion of photo overlapped by adjacent photos

The graphical representation is called an air photo index map, and it allows you to relate the photos to their geographical location. Small scale photographs are indexed on 1/250 000 scale NTS map sheets, and larger scale photographs are indexed on 1/50 000 scale NTS maps.



THANK YOU..