Pattern of Examination	Bifurcation of Marks		Time
	Regular Students	NC Students	
Written Test	4 × 5 = 20	4 × 7.5 = 30	2 Hours
Field Survey and Viva-Voce	7+3	7+3	2 Hours
Record Work and Viva-Voce	7+3	7+3	
Total	**40**	**50**	**4 Hours**

B.A/B.Sc-I st Semester Geography (Practical) :- (प्रायोगिक भूगोल)

*Note-

1. *The students will have to prepare A3 Size **Record Book** which will be simultaneously checked by the Teacher in the class after teaching and evaluated during the examinations.*
2. *There will be 6 questions (3 questions from each unit) in written paper. The students have to attempt 4 questions in total (2 questions from each unit).*
3. *The student will have to prepare Survey Sheet **INDIVIDUALLY** during the examination.*
4. *Simple Calculator is permitted in practical examination.*

Unit – I

Definition and Conversion of Scale; Graphical Scale - Simple, Comparative & Diagonal; Methods of Relief Representation: Hachure, Hill-shading, Bench mark, Spot- Height, Form-lines & Contours.

मापनी की परिभाषा और रूपान्तरण; आलेखी मापक– सरल, तुलनात्मक और विकर्ण; उच्चावच निरूपण की विधियाँ– हैच्यूर, पर्वतीय छायाकरण, तल चिन्ह, स्थानिक ऊँचाई, आकृति रेखाएँ एवं समोच्च रेखाएँ।

Unit – II

Profiles: Definition and Types- Serial, Superimposed, Projected and Composite;

Surveying: Meaning, Classification and Significance; Chain and Tape Surveying: Open Traverse and Tie-line.

परिछेदिकाएँ–परिभाषा एवं प्रकार–संक्रम, अध्यारोपित, प्रक्षिप्त एवं मिश्रित;
सर्वेक्षण: अर्थ, वर्गीकरण एवं महत्व; जरीब–फीता सर्वेक्षण: खुली मालारेख विधि एवं योजक रेखा।

Recommended Readings:

- Monkhouse, F. J. and Wilkinson, H. R. (1973). Maps and Diagrams. London: Methuen.
- Rhind, D. W. and Taylor, D. R. F. (2000). Cartography: Past, Present and Future. International Cartographic Association.
- Robinson, A. H., (2009). Elements of Cartography. New York: John Wiley and Sons.

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Scale

MEANING AND DEFINITION OF SCALE

The meaning of scale can be understood very well by an example. Photograph of an object can be bigger or smaller than its real size, yet there is no difficulty in identifying that object by viewing the photograph. Since all the constituent details of that object are recorded smaller or bigger than the real size in one and the same ratio, the real shape of the object and the shape in the photograph are exactly the same despite difference in size. This **ratio** shall be called the scale of that photograph.

In the same way, the **ratio** in which a map shows the length and breadth, size and shape of mapped area reduced, is called scale of the map. In other words, scale is the ratio between straight distance between two points on a map and the real on horizontal distance between these corresponding points. This scale of a map is expressed in the form of a formulae as —

$$\text{Scale} = \frac{\text{Map distance of two points}}{\text{Horizontal ground distance of corresponding points}}$$

So, it is clear that scale of a map can be found out by above-mentioned formulae if the ground location of the two corresponding points shown on a map could be knwon. For instance, suppose there are two points A and B, the distance of which from each other on map and ground is 1 cm and 1 km respectively, then it clearly means that a ratio between distance on map and distance on ground is 1 and 1,00,000 (cm in a kilometre). This ratio, that is 1 : 1,00,000 is the scale of that map. This ratio can also be written as 1/1,00,000.

NECESSITY AND IMPORTANCE OF SCALE

Our earth is so huge that it is an impossible task to make a map of its real size. Supposedly, even if such map could be made, it would not only be meaningless and unsubstantial, but it will be also impossible to making use of it. Scale is that device whereby the whole earth or any of its parts can be correctly shown by making its map of required size. In addition, the area and real distances between points can be found out by a map of corresponding area made to a scale. Briefly speaking, any map made without a scale can not correctly show the size of the area and distances among places located on it. Thus, map and sketch map are infact, different from each other. A map is always made according to a scale, whereas a sketch map is drawn on judgement without using a scale. Things which should be paid attention to while choosing an appropriate scale for making a map of an area have been explained in the previous chapter. So they are not being repeated here.

METHODS OF EXPRESSING SCALE ON A MAP

As has been made clear in the previous chapter, a clear expression of scale is quite necessary on the map of an area whereby the readers may calculate the real length and breadth of that area or real distances among places marked on the map by consulting the map. There are three methods of expressing scale on maps—(i) statement method, (ii) representative fraction or R.F. method, and (iii) graphical method. The difference and comparative importance of these three methods should be understood well.

(A) Statement Method

In this method the scale of map is written on it in words as 1 cm = 1 km or 1 inch = 1 mile, etc. This method is, therefore, also called **literal interpretation** method. In cadastral maps of villages and plans of private buildings, scale is often expressed by this method in India. Though this is the simplest method of expressing scale, yet its use is very limited for two reasons—**firstly**, only those persons can calculate distances on such map, who understand words of language in which linear measurement system are expressed. For example, units of measurement such as *pel'ts* and '*versts*' can be used for measuring distances on map by a person who understands the meaning of these Russian words of linear measurement system. **Secondly**, maps on which scale is expressed in words, can not be printed in other size than the original one because the scale with different size will become erroneous.

(B) Representative Fraction or R.F. Method

The ratio between distances measured on map and on earth's surface expressed in fraction as 1/50,000 is called representative fraction or R.F. The numerator and denominator of this fraction represent map distance and ground distance respectively expressed in the same unit of a measurement system and the numerator of this fraction is always 1. For example, if representative fraction of a map is 1/50,000, then it means that there is a ratio of 1 and 50,000 between map and ground distances, that is, unit distance of a measurement system on the map represents 50,000 units of the same system on the earth's surface.

So, representative fraction(R.F.)

$$= \frac{\text{Distance of one unit of a linear measurement system}}{\text{Corresponding ground distance of the same units}}$$

The biggest merit of this method is that on the basis of this representative fraction, the actual distances of the ground shown in this map can be found out in any linear measurement system. As for instance, representative fraction 1/50,000 in metric system means 1 cm = 50,000 cm, in English linear measurement system, 1 inch = 50,000 inches and in Russian measurement system, 1 *pel'ts* = 50,000 *pel'ts*. This is important to mention here that this method can be used on the original maps but, if such map is later printed in different size, the scale of this newly printed map will be erroneous as is the case with statement method.

(C) Graphical Method

In this method, length of a line calculated according to representative fraction (R.F.) is drawn in a map at an appropriate place. This line is divided into main and secondary divisions and the value of actual distance is written on these dividing lines. On maps to be printed on different scales from the original map, only this method is successfully used for expressing scale. Various kinds of scales and their method of construction by graphical method on maps have been explained in detail in the following pages.

GRAPHICAL SCALE

For constructing a graphical scale, first of all the length of scale-line is calculated on the basis of the given R.F. Thereafter, this line needs to be divided into equal primary and secondary divisions.

It is, therefore, necessary to learn the method of dividing a straight line into equal divisions before knowing the methods of constructing graphical scales. This method is explained below.

(G-21 E)

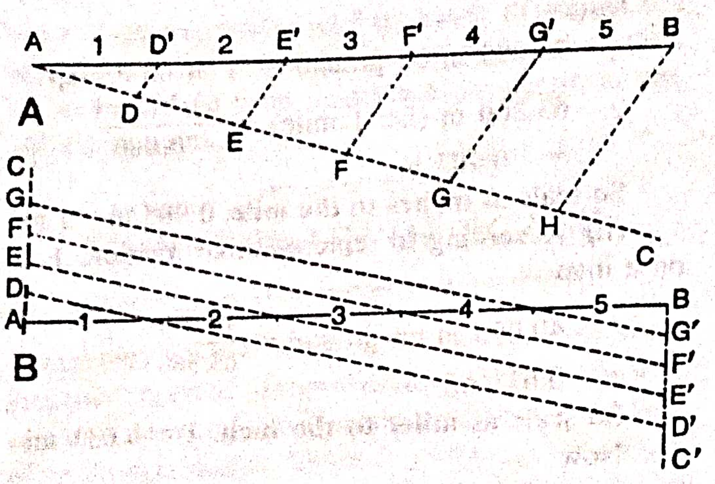


Fig 1

(A) Geometrical Methods of Dividing a Straight Line

There are the following two geometrical methods of dividing a straight line into equal parts.

First Method. Suppose AB is a straight line which is to be divided into 5 equal parts. As shown in figure 1 A, draw a line AC from A point with an acute angle. Now with a distance set in a compass, mark D, E, F, G and H at equal distance on AC line. Join H to B point and parallel to this HB line, draw DD', EE', FF' and GG' lines which cut AB line at points D', E', F', G'. These points divide AB line into five equal parts.

Second Method. As shown in figure 1 B, draw perpendiculars AC and BC' in opposite directions at the two ends of AB line. Now mark four equal dividing points at these perpendiculars with the help of a compass (i.e. D, E, F, G and D', E', F', G'). Draw lines DD', EE', FF', GG' joining these points. These lines will divide straight line AB into five equal parts.

(B) General Principles of Constructing a Graphical Scale

It is necessary to pay attention to the following general principles while constructing a graphical scale:

(1) According to the size of map, the length of graphical scale may be small or big. But for geography practical exercise book, 12 to 16 cm long graphical scale line is considered appropriate.

(2) Primary and secondary divisions should be divided by some geometrical method so that there is absolute accuracy in equal divisions.

(3) Graphical scale is divided in such a way that each division represents ground distance in rounded off figures (and not in fraction).

(4) As is shown in figure 2, primary divisions of a scale are marked towards the right from zero (which is at the first dividing point) and secondary divisions, which are sub-divisions of primary division, towards the left from zero.

(5) If the scale is divided only in primary divisions, zero is marked on the left end and primary divisions to the right are marked with ground distance they show. On the contrary, if primary and secondary both divisions have to be shown, then zero is marked after one primary division. The values they represent are written on divisions to the right as well as to the left from zero. This makes reading distances on the scale easy.

(6) Scale should be simple in reading and attractive in appearance.

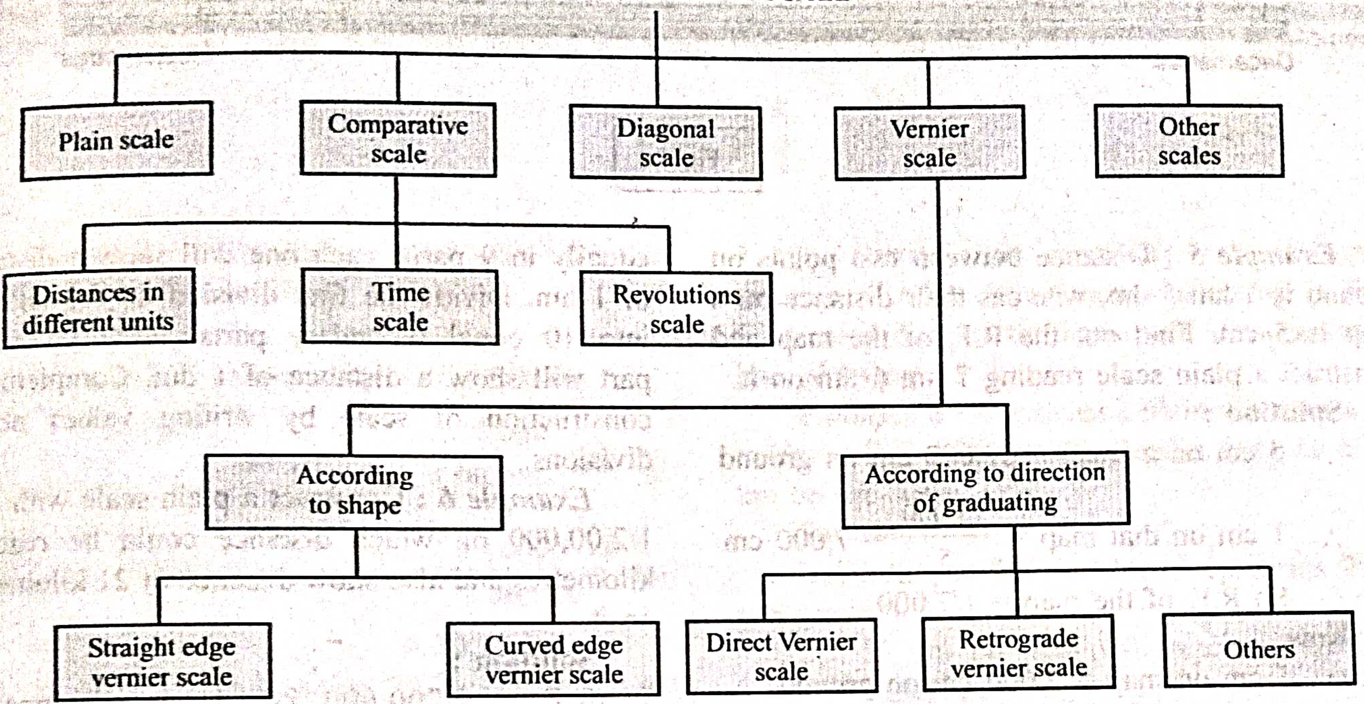
PLAIN SCALE

Plain scale is that kind of scale, on which maximum two units of length on ground, often of sequent

Kinds of Graphical Scale

Some of the main kinds of graphical scales and their sub-kinds are shown below:

KINDS OF GRAPHICAL SCALE



level, can be shown, such as kilometres and hectometres, hectometres and decametres, decametres and metres, miles and furlongs, furlongs and yards and yards and feet etc. The method of constructing plain scale can be understood very well by the following examples:

Example 4 : With R.F. 1/50,000 construct a plain scale. Read 5 km 7 hm on the scale.

Solution :

R.F. = 1/50,000

$\because$ distance of 1 cm on map = 50,000 cm on ground = 1/2 km

$\therefore$ 14 cm on map = $\frac{14 \times 1}{2}$ = 7 km on ground.

Now draw a straight line of 14 cm which will represent 7 km. Divide this line into 7 equal parts and again divide the first part on the left into 10 equal parts. Thus each bigger division or primary division will show a distance of 1 km of ground and each smaller division will show 1 hm. At meeting point of primary and secondary divisions, mark '0' (zero-the starting point of measuring on both primary and secondary parts of the scale). Mark 1, 2, 3..... 6 km on the primary dividing points to the right from 0 and 1, 2, 3,.....10 hm to the left on secondary scale dividing points. Draw a straight line above the scale at a little distance extending from fifth division towards the right of 0 and upto seventh division towards the left from 0. This straight line shows 5 km 7 hm of ground (Fig. 3).

R.F. 1 : 50,000

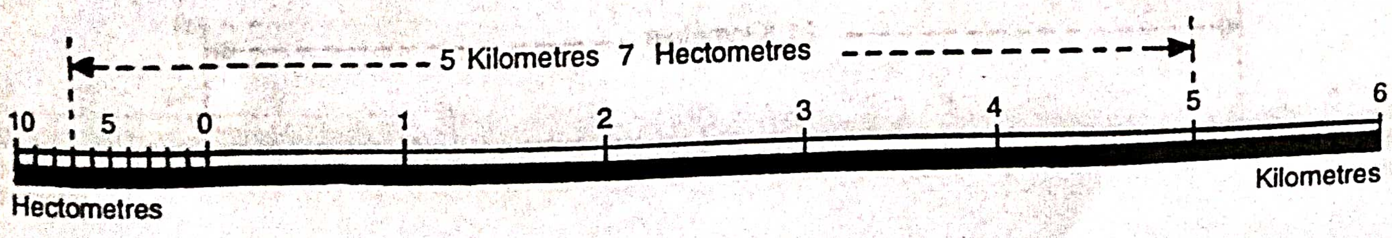


Fig 3

2. COMPARATIVE SCALE

Comparative scale is the graphical scale on which distances in more than one measuring system can be shown. The purpose of these scales is to facilitate measuring distances in more than one units of measurement.

Many facts are worth mentioning with regard to constructing comparative scale:

(1) All graphical scales representing distances in different measuring systems are made on one and the same R.F.

(2) These separate scales of different units of measure are arranged one above the other in such a way that zero of each scale is located on one straight vertical line.

(3) Sometimes, instead of separately making scales for separate units of measurement, one graphical scale is so divided that different units of measure could be read on it. For instance, in the time and distance comparative scale, the scale is divided in such parts according to the given R.F. as on the one hand, it may show ground distances and on the other, the time taken in travelling that distance. In these scales, generally the units of distance are marked on the upper side and time on the lower side of the scale. In scales of this kind it is essential that zero of both the scales are aligned in one straight vertical line.

(4) The remaining construction procedures of comparative scale, such as finding out the length of scale-line or determining the number of their primary and secondary divisions, etc. are like the construction procedure of plain scale.

There are three kinds of comparative scales—(i) comparative scale of distance in different units, (ii) time-scale, and (iii) revolution scale. Construction procedures of these three kinds of comparative scales are explained with examples below.

(A) Comparative Scale of Distance in Different Units

Example 15 : On R.F. 1/1,50,000, construct a comparative scale in which distances in miles and kilometres could be read.

Solution : It is clear that two separate scales showing distance in miles and kilometres are to be constructed in this comparative scale with R.F. 1/1,50,000. (Fig. 14).

For construction of scale of miles, according to the R.F.

$\because$ 1 in on map = 1,50,000 in on ground or $\frac{1,50,000}{63,360}$ mi

$\therefore$ 5 in distance on map = $\frac{1,50,000 \times 5}{63,360}$

= 11.83 mi on ground

As the nearest rounded off figure of 11.83 mi is 12 mi, so the length of scale line to show 12 mi shall be calculated thus:

$\because$ 11.85 mi distance on ground = 5 in on map

$\therefore$ 12 mi distance on ground = $\frac{12 \times 5}{11.83}$ = 5.07 in on map.

So, draw a straight line of 5.07 in now and divide it into 4 equal divisions. Make 3 secondary

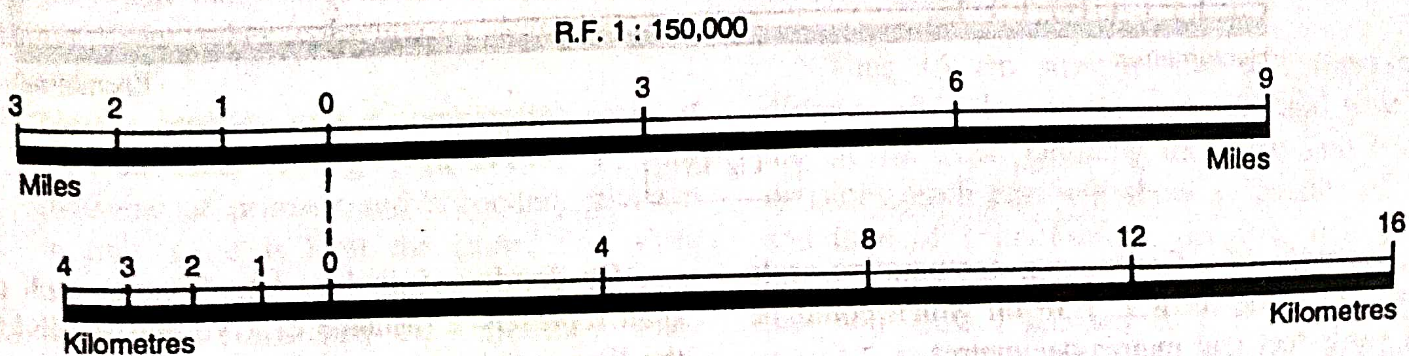


Fig 14

show 1 mm o...

3. DIAGONAL SCALE

The graphical scale in which secondary division is further divided into smaller units, is called diagonal scale. By plain scale, only **two** consecutive units such as mile-furlong, kilometre-hectometre or hectometre-decametre, etc. distances are read; whereas by diagonal scale **three** consecutive units such as mile-furlong-yard or kilometre-hectometre-decametre and so on distances can be read. In addition to this 100th part of an inch or centimetre can also be shown which is not possible on a plain scale.

Construction of a Diagonal Scale

As has been indicated above, in diagonal scale it is possible to read distances in three consecutive units. First two units are shown according to the method of plain scale and the third unit is shown by diagonals of rectangles drawn on sub-divisions. The length of sub-division, which is to be further subdivided, is the horizontal sides of the rectangle and its vertical sides may be kept as long as could be easily subdivided. The horizontal line is kept parallel to each other at as many places as its subdivisions are intended to be made. The diagonal drawn from top left to bottom right point of the rectangle divides each of horizontal sub-division in different ratio. For example, if the number of horizontal side are drawn 10 in number, the diagonal will divide the first line in ratio 1 : 9, second 2 : 8, third 3 : 7, fourth 4 : 6, fifth 5 : 5, sixth 6 : 4, seventh 7 : 3, eighth 8 : 2, ninth 9 : 1 and the tenth line will be the length of one full secondary division. Similarily, if the horizontal line or secondary part is one inch, then ten parallel lines will divide, each of them equal to 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8 and 0.9 inch which can be easily read. The last line will not be divided and shall be 1 inch. It should be remembered that the number of parallel lines drawn in the rectangle is as many as smaller divisions of secondary division is intended (Fig. 23).

From the account given above, it is clear that in diagonal scale the distances shown by the secondary divisions are subdivided equally in the desired number with the help of **diagonal** so that smalled distances could be read.

Construction of a diagonal scale is carried out according to the following rules—

(1) Perpendiculars from the marks of division of the primary and secondary scale are drawn with equal height. The height of these perpendiculars is often kept 3 to 4 cm and can be chosen according to ease of sub-dividing it. For the ease of construction, sometimes on the

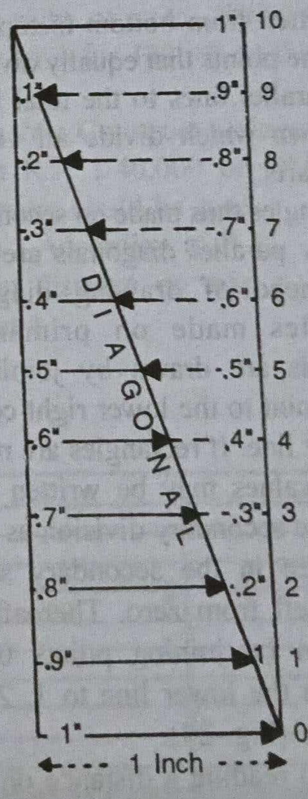


Fig 23

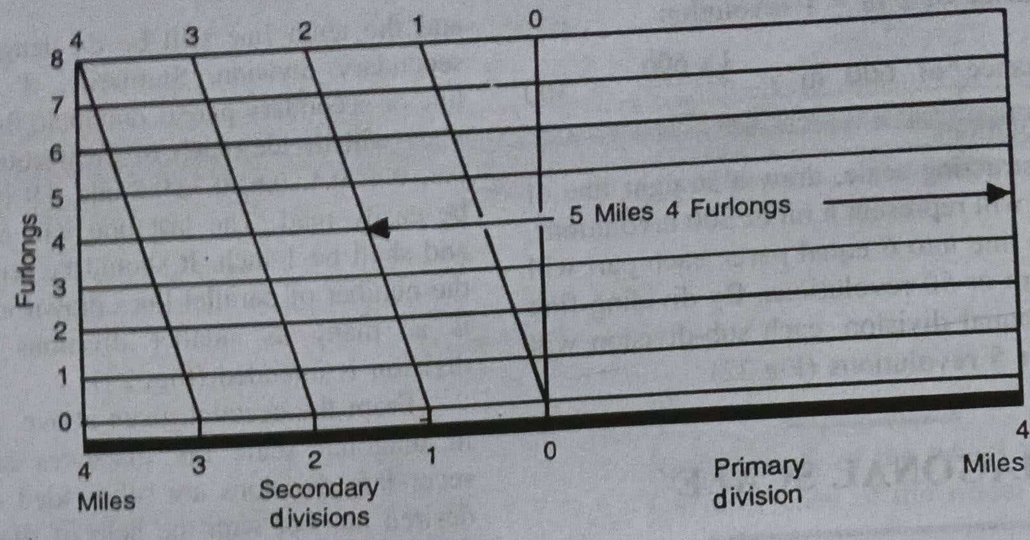


Fig 24

points dividing the scale into secondary parts, only diagonals are drawn without making the rectangles.

(2) The perpendicular drawn at the left end of the scale is subdivided at equal distance according to need and the valules of these dividing marks are written from bottom to top.

(3) From the points that equally divide the vertical line, parallel lines to the total length of scale are drawn which divide all vertical lines in equal parts.

(4) In rectangles thus made on secondary divisions, mutually parallel diagonals are drawn. There is no need of drawing diagonals in the rectangles made on primary divisions. Diagonals are drawn by joining upper left corner point to the lower right corner point by a straight line. If rectangles are not made, 1, 2, 3, 4..... values may be written on the upper side of the secondary division as 1, 2, 3, 4, etc. are written in the secondary scale, initially towards left from zero. Thereafter, diagonals are drawn by joining points 0, 1, 2, 3..... written on the lower line to 1, 2, 3, 4 on the upper side (Fig. 24).

(5) In order to reading a distance on the diagonal scale, an arrow or (×) sign is marked on concerned horizontal parallel line towards the right on a perpendicular and intersection point of the related diagonal. Between these two points, a dark ink line is drawn and the distance shown by it written above it. For example, suppose a distance of 5 miles 4 furlongs is to be shown, then vertical line showing reading of 4 miles and on the left the intersection point of second diagonal and fourth parallel lines will be marked by (×) signs. A line joining these points will show the desired distance (Fig. 24).

(6) The method of writing distances shown by primary and secondary divisions and finding length of scale is the same as in plain scale. Smaller divisions of the secondary parts are written on the perpendicular drawn on the extreme left of the scale from base to upwards at points where parallel lines meet this perpendicular.

Example 24 : Construct a diagonal scale at R.F. 1/50 for a plan of a house on which could be read distances upto 1 cm.

Solution : According to R.F.

∵ 1 cm on map = 50 cm on ground

∴ 14 cm on map = 50 × 14 = 700 cm or 7 m on ground.

Now draw a straight line of 14 cm which will represent 7 m on ground. Divide this line into 7 equal parts and draw a perpendicular at each point of division. Each part shows a distance of 1 m. Divide the part on the left into 10 subdivisions. each subdivision thus will represent 1 dm (i.e. 10 cm).

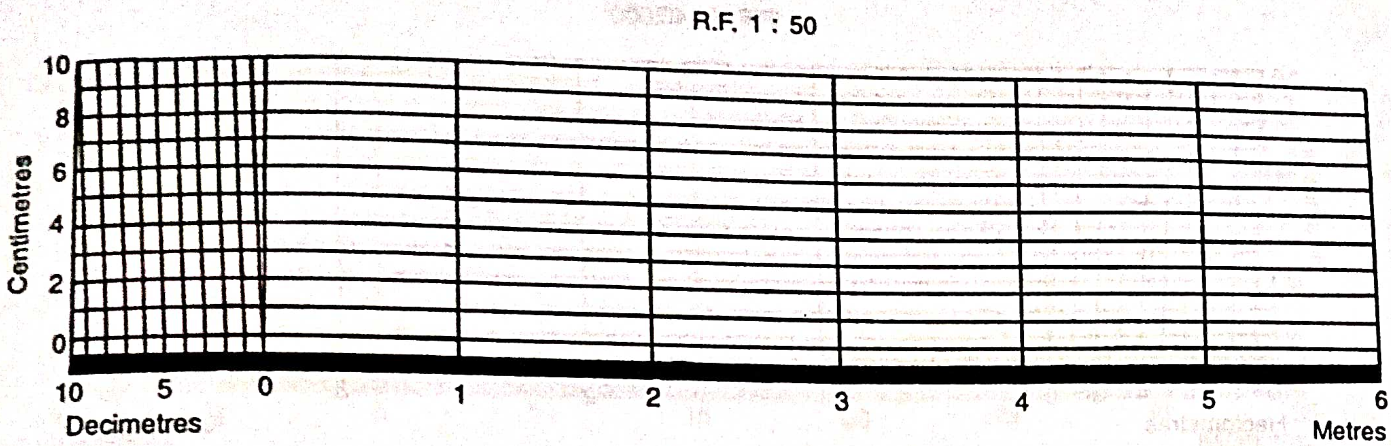


Fig 25

Mark 10 points at equal convenient distance on perpendicular drawn on left end and draw parallel lines of full length of scale from those points. Write 1 to 10 upwards from base on the extreme left perpendicular at ends of parallel lines. Draw diagonals at secondary divisions as shown in Fig.25.

Example 25 **:** Construct a diagonal scale for a map made on R.F. 1/63,360 and also read 3 miles 3 furlongs and 132 yards on this scale.

Solution : According to representative fraction,

∵ 1 in on map = 63,360 in on ground = 1 mi

∴ 5 in on map = 5 mi

Now draw any straight line 5 in long which will represent 5 mi. Make 5 equal parts of this line and each part will represent a distance of 1 km. Raise perpendiculars on points of division. For showing furlongs divide the first part on the left into eight equal parts. Divide the first perpendicular into 10 equal parts with a convenient spacing and draw parallel lines to the other end on the extreme right. Draw diagonals as shown in Fig.26. Reading 3 mi 3 fur on the main scale and 132 m on diagonal scale, draw a line between intersecting point of fourth diagonal (reading 3 fur) and sixth parallel line showing 132 yards to perpendicular representing 3 mi to the right of zero. Write the measured distance of 3 mi 3 fur 132 yd on this line making it prominent.

Example 26 **:** Construct a diagonal scale for a map made at R.F. 1/40,000 on which a distance upto 1 decametre could be read.

Solution : According to R.F.,

∵ 1 cm distance on map = 40,000 cm on ground

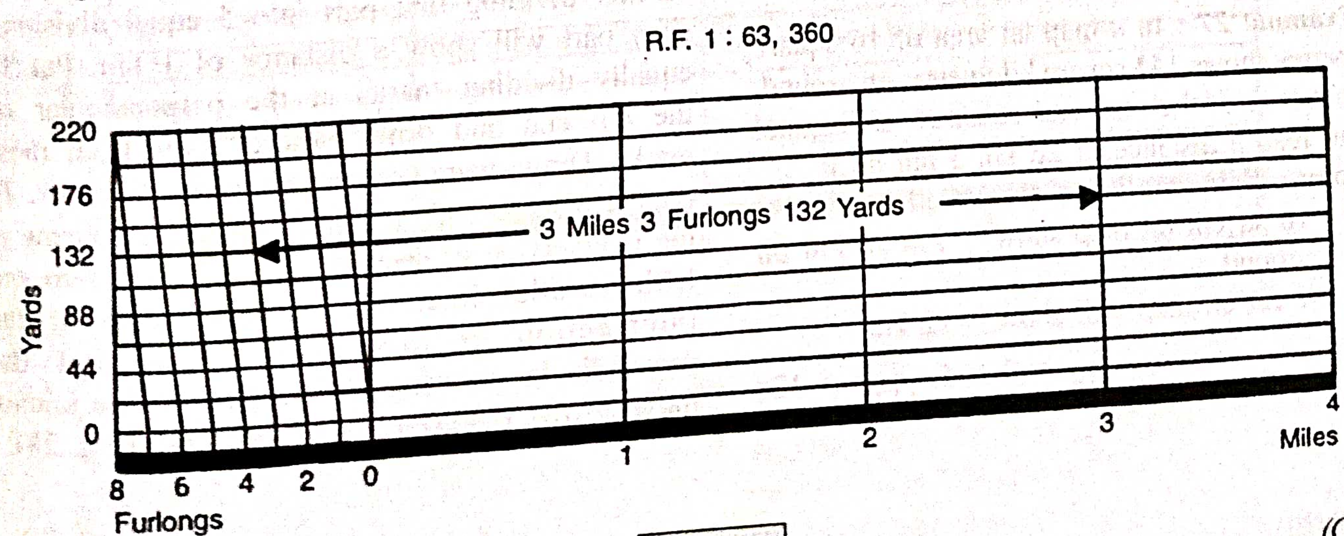


Fig 26

Representation of Relief : Contours and Profiles

INTRODUCTION

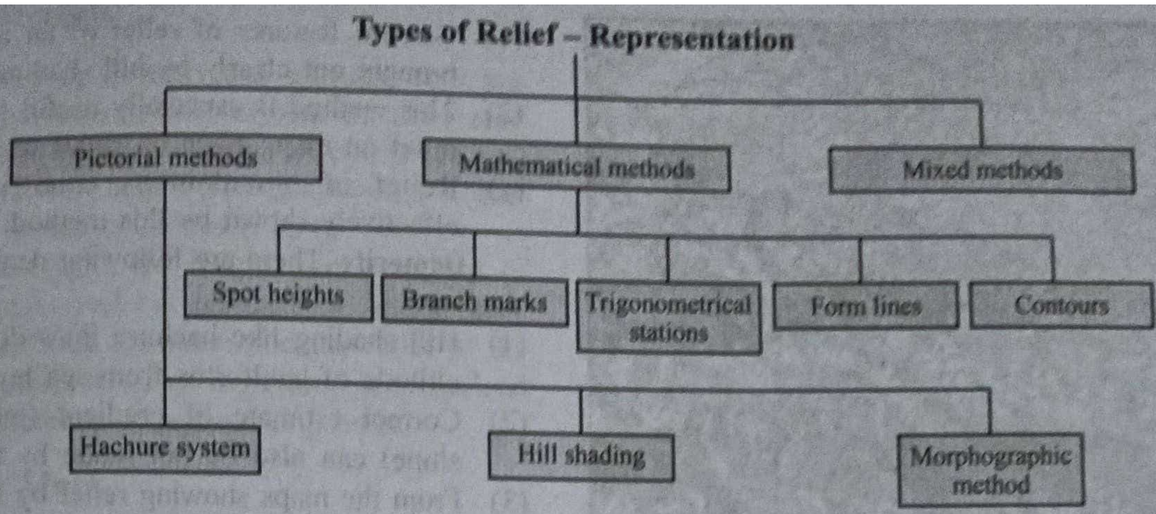
The term relief of English language is used in many senses. In physical geography vertical distance between two points on ground i.e. their difference of altitude is called relief. In the present chapter, representation of relief is meant by those methods of cartography by which actual three-dimensional form of any landmass or single landform is shown on plain surface of paper or piece of cloth. Here, the meaning of three-dimensional landform must be understood well. In a line there is only one dimension or measure i.e. only length. In a square or rectangle, there are two dimensions showing length and breadth. Different from it, in a shape of cube, there are three dimensions–length, breadth and height. There are three dimensions of all size of landforms responsible for real configuration of or relief of the earth's surface such as mountains, plateau, plain, ocean basin, spur, ridges, valleys, cliff, escarpment and so on. In all of them there are three dimensions of length, breadth and height which can be clearly seen and measured on the ground. It has always been a challenge to represent these three-dimensional land feature of the earth's surface or its constituent landforms on a two-dimensional plain surface of paper or cloth.

In ancient times landforms were shown on maps by pictorial symbols in the absence of refined surveying instruments and as the consequence of incomplete knowledge of cartographic techniques. By these symbols marked on a map, the location of the landform on the map could be guessed to some extent but it was very difficult to acquire the knowledge of their real three-dimensional form. To remove this difficulty new techniques of relief- representation were developed. The present chapter explains some of the common techniques of relief-representation.

METHODS OF REPRESENTING THE RELIEF

The main types of relief-representation are shown further ahead–

As is clear from the chart, methods of relief-representation can be divided into three classes–(i) Pictorial methods, (ii) Mathematical methods and (iii) Mixed methods.



Sub-kinds of these methods have been written in separate headings below–

(A) Hachure System

With the help of fine broken lines the method of showing relief on a map by hill shading is called hachure system. The credit of propounding the fundamental principle of this system goes to a military officer of Austria called **Lehmann**. In this method, broken lines are drawn in the direction of flowing water (i.e. in the direction of slope) and these lines are thickened and made darker in parts of greater slope. Thus, more slopy a part on surface is found, darker it appears in the map of hachure system (Fig.1).

Merits. There are following merits of hachure system–

(1) Hachures lines so clearly show elevations and depressions that all features of relief of the surface can be easily comprehended.

Fig 1. Hachure

(2) Smaller relief features such as river terraces, small ridges and sink holes, etc. can be shown more clearly by hachure system.

Demerits. There are following demerits in hachure method, which have reduced importance of this method–

(1) Though condition of slope is effectively represented by this method but hachure map does not give any information on altitude of landforms from sea level.

(2) This method is appropriate only for maps made on large scale. On a map with small scale it is extremely difficult to show relief by hachure lines.

(3) No clear representation happens by hachure lines of the relief of rolling land and hilly areas because the whole map becomes so black that the whole map appears unclear and foggy.

(4) For making hachures, enough practice and proper knowledge about landforms is essential with the result that the use of this method is limited only to experienced cartographers.

(B) Hill Shading

Hill shading is also called **plastic shading.** A map made with this method appears as a photograph of relief model taken from above (Fig. 2). This method is based on the imagination that light is falling on landforms or ground from above or from northwest corner. So these parts which are in darkness are shaded black and remaining parts are left blank. For example, if it is imagined that light is falling from above, then slopy parts will

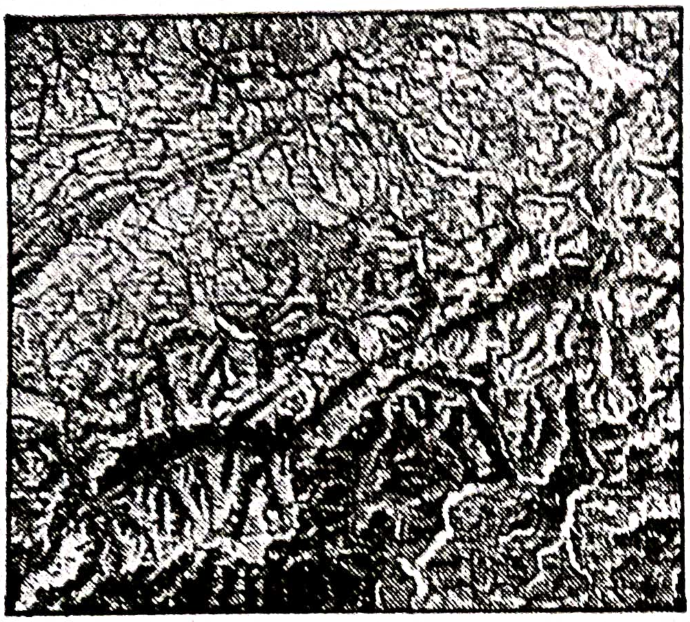


Fig 2. Hill shading.

be dark and flat parts lighted. So, in such a situation more slopy a part is, darker its shading is done whereas ridge-crests, plateau, valley bottoms and the parts that are plain shall be devoid of shading.

Merits. There are following merits of hill shading–

(1) General features of relief of an area can be brought out clearly by hill shading.

(2) This method is especially useful for showing relief on maps made on small scale.

(3) Relief of mountainous countries can be effectively shown by this method.

Demerits. There are following demerits of hill shading–

(1) Hill shading like hachure lines do not reveal altitude of landforms from sea level.

(2) Correct estimate of gradient (magnitude of slope) can also be not made by these maps.

(3) From the maps showing relief by hill shading, it is often difficult to ascertain as to which part is elevated and which one is depressed. It is, therefore, hard to differentiate valley and spur or a plateau and a plain.

(C) Morphographic Method

Showing relief features by symbols similar to them in shape on a physical landscape is called morphographic method. The symbols used in this method are based on aerial photograph of relief features at 45° angle (Fig. 3). Thus in morphographic method the type of landscape is shown and not slopes or altitude on a map.

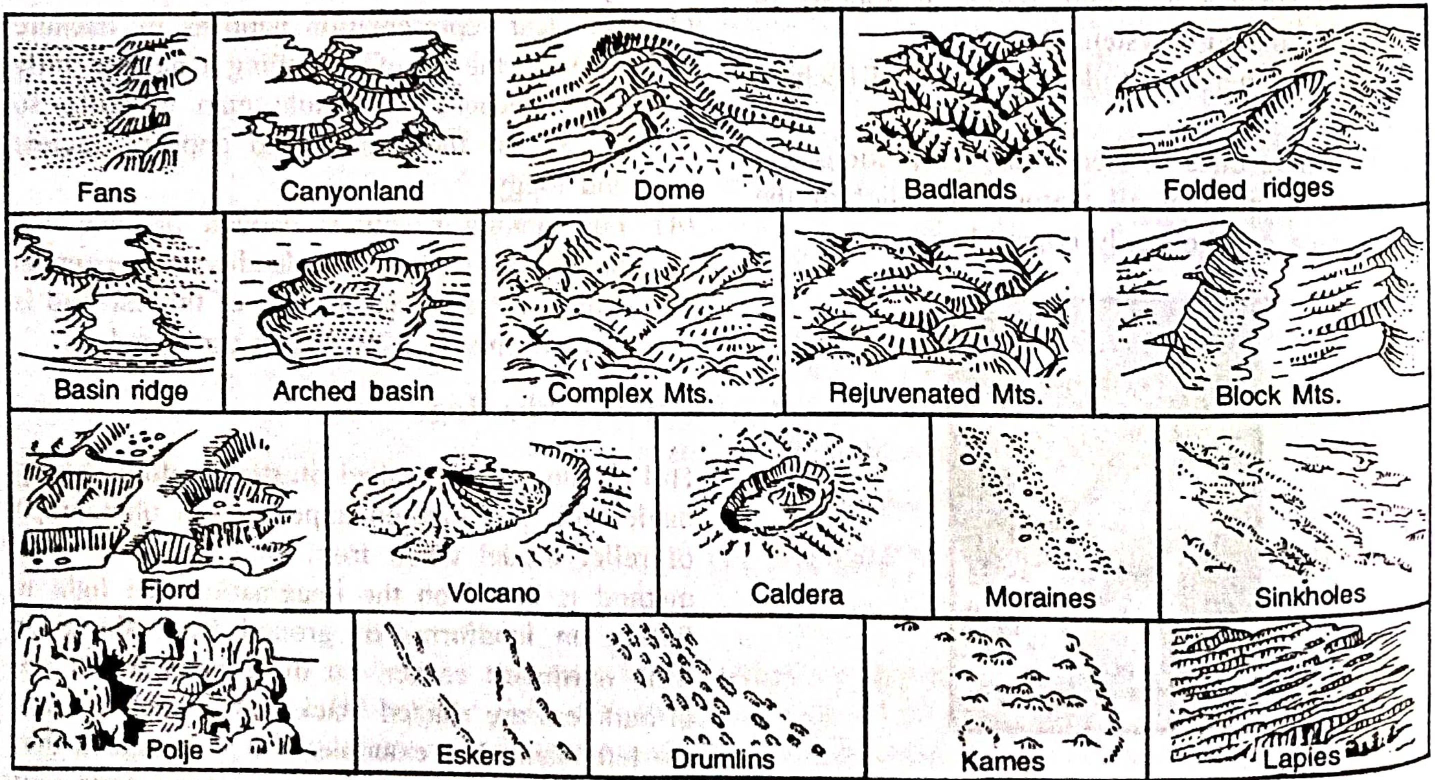


Fig 3. Morphographic symbols.

(D) Spot Heights

A point showing location and altitude from sea level of a particular place on map is called spot height. In this method, location of places on map is shown and their height from sea level is written in its front in feet or metres (Fig.4).

By spot height, the height from sea level of a place is perceived but seeing spot heights on a map, it is difficult to understand the relief of the concerned area. Its use, therefore, is beneficial with other methods of representing relief.

(E) Bench Mark

The marks showing altitude from sea level according to actual survey put on walls of buildings, bridges of canals and rivers and iron poles are called bench marks. Understanding difference between bench mark and spot height is necessary. The altitude of a place on the earth's surface shown on a map is perceived by spot height whereas bench marks show altitude from sea level on a mark made on wall etc. On a map bench mark is shown by letters B.M. and near these letters altitude of that mark from sea level is written in feet or metres.

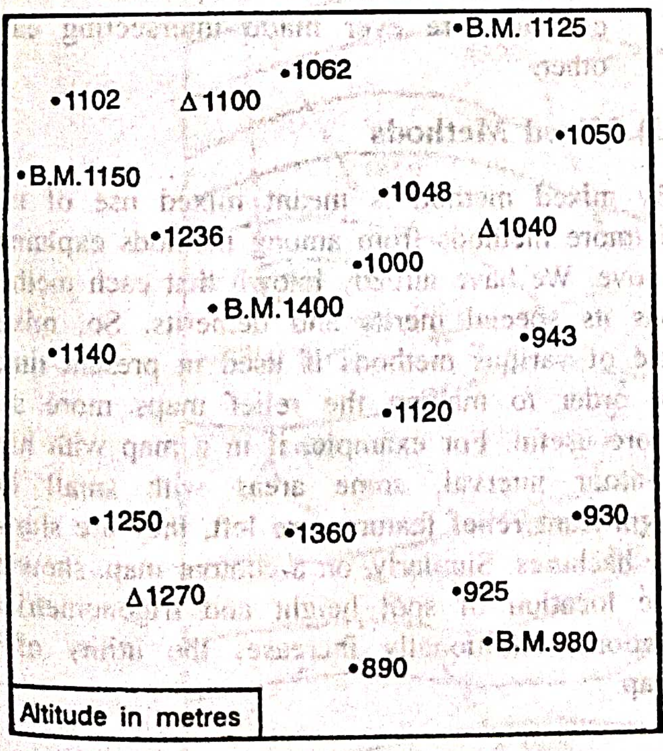


Fig 4. Spot heights, bench marks and trigonometrical stations.

(F) Trigonometrical Stations

Trigonometrical stations mean those points on a map which were used for measuring angles in triangulation method of surveying. The location of a trigonometrical station is indicated on map by a small triangle and near this triangle, altitude of that point from sea level is written (Fig. 4).

(G) Form Lines

Approximate contours drawn between countour lines on a map are form lines. The main difference between contours and form lines is that whereas, contours are drawn by interpolation of spot heights determined by actual surveying, the form lines are drawn on the basis of seen land form in an area of relief features. Thus, contours give a perception of real altitude of a place from sea level whereas form lines give an approximate idea of the altitude of a point in between two contours. Form lines are made as broken lines for easy identification in map.

Form lines are especially useful to bring out small relief features on contour maps of relatively low relief region with high contour interval.

(H) Contours

The method of showing relief on map with the help of contours is considered the best. This is a standard method of representing relief on which are based many other methods of relief-representation. These regular lines are drawn by interpolation (explained ahead) of spot heights determined on a map by surveying. Contours therefore, show on map the points of equal altitude on ground from sea level. In simple words, contours are imagined lines joining adjoining points of equal altitude on ground. If on a certain landform, some lines are marked joining points of equal altitude from sea level and the shape of these lines is drawn on a plain surface of paper, etc. as seen vertically on sea level from above towards below, then this will be contour map of that landform (Fig. 5).

On a contour map, the difference of the values of two successive contours is called **contour interval**. Generally, only one contour interval is kept in contours drawn on a map, but sometimes

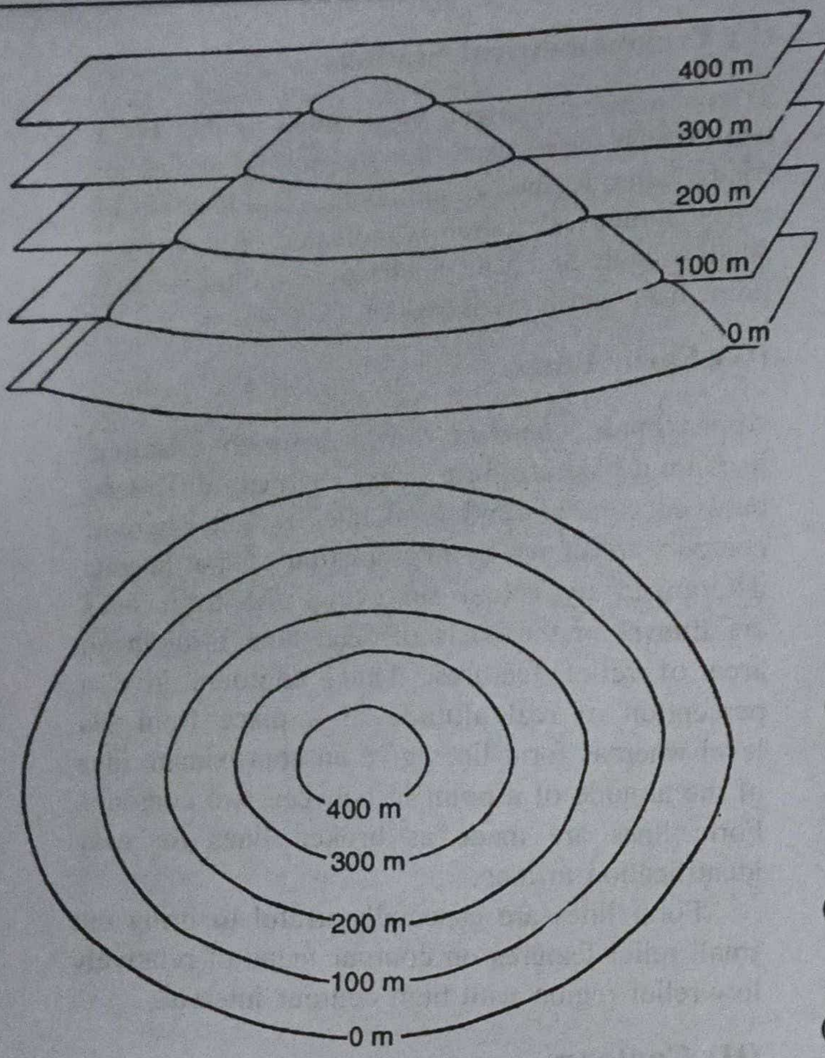


Fig 5. Contours.

varied intervals are also used. In mountainous areas, contour interval is sometimes increased after a certain altitude.

Gradient, that is, the magnitude of slope is easily visualised by looking at a contour map. As contours show places of various altitude from sea level, so it is clear that in areas where contours are close to each other, the gradient is high. On the contrary, in parts of low gradient, the spacing of contours is relatively more.

While drawing contours on a map, the following things should be paid absolute attention–

(1) Contours should be drawn as smooth curves devoid of wavey lines or small bends.

(2) Prior to drawing contours, drainage system should be made on the map so that contours could be passed through correct points.

(3) Contour interval should be kept a little larger while representing relief of high altitude to avoid the congestion of contours.

(4) Contour interval should be written at the bottom of a contour map.

(5) The value of each contour is written one above the other in a straight line upwards. Sometimes, values of contours are written on contour line itself by breaking the line to make space for writing attitude they show.

(6) If a contour map is to be reduced later, the values of contours and spot heights should be written in a little larger size so that they are read easily.

(7) If there happens a depression as a crater in an area encircled by a contour with high value, the inner part of the contour showing it should be shaded by small lines all pointing towards the deepest point.

(8) Contours should be drawn from one border to the other as closed ends, i.e. they should not be left hanging on the map.

(9) Though contours of different values merge on one line at vertical slope, but no two contours are ever made intersecting each other.

(I) Mixed Methods

By mixed method is meant mixed use of two or more methods from among methods explained above. We have already known that each method has its special merits and demerits. So, mixed use of various methods is used in present times in order to making the relief maps more and more useful. For example, if in a map with high contour interval, some areas with small but significant relief features are left, they are shown by hachures. Similarly, on a contour map, showing the location of spot height and trigonometrical stations, additionally increases the utility of a map.

Unit-II

PROFILE

For showing characteristics of the slope of a landform, profiles or cross section of the contour map are drawn. Meaning of profile can be understood by an example. Suppose a landform or geomorphic feature is vertically cut downward and one piece of the two parts is removed from its location, then a new vertical surface of the inner part will appear. The upper ground line reveals the profile and the straight line along which this landform was cut is called the line of section of the profile. It is, therefore, clear that by selecting various lines of section, many profiles can be acquired. Thus the upper or surface line of newly exposed plane after its vertical section along a given line of section is called a profile. Two facts deserve special mention regarding profile–First, line of section is always drawn as a straight line on contour map. Secondly, line of section can be drawn in any direction according to the need. In other words, it can be horizontal, inclined or vertical or any other kind.

METHOD OF DRAWING A PROFILE

Two methods of drawing profiles have been given below. First method among the two can be used

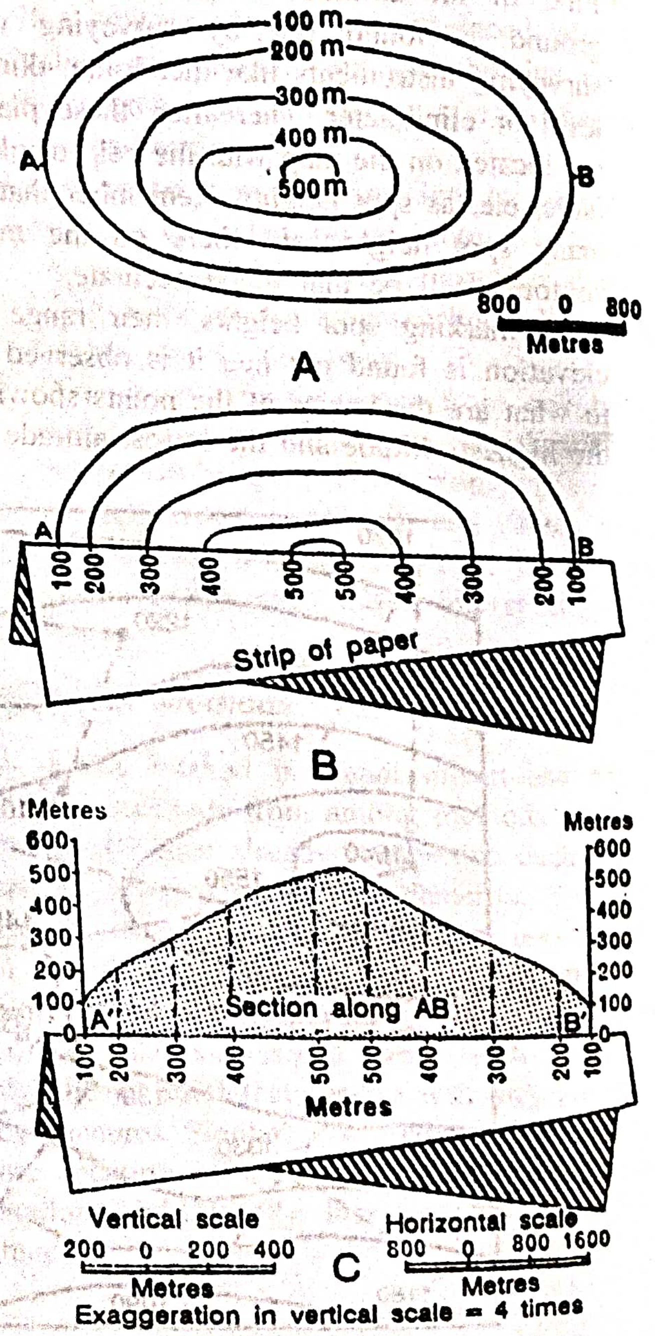


Fig 7

for any kind of line of section but the second method should be used only in condition when the line of section is fully horizontal otherwise the cross-section and profile will assume oblique shape on paper. Here, it should be kept well in mind that the base line of cross-section should be exactly equal to the line of section. If the base line of cross-section and the line of section are not equally long as has been shown by oblique line of section by mistake in some geography practical books, then the profile will be definitely inaccurate and erroneous.

First method. Suppose there are two points A and B on a contour map along which profile of ground is to be drawn (Fig.7A). Join points A and B with a straight line and put a strip of straight-edged paper or graph along AB line. Now carefully mark on this paper-edge the location of all those points including A and B where contours touch the strip between A and B. On each mark, write the altitude of the concerned contour (Fig.7B). Now draw a straight A′ B′ line on some other paper equal to A B and carefully transfer all points marked on the strip. From each transferred point raise a perpendicular equal to its altitude on the basis of a selected vertical scale. Draw a smooth curve joining points of the head of those perpendiculars. This curve will represent profile of land between points A and B on map (Fig.7C).

Second method. Suppose a profile on ground is to be drawn between points A and B located on a contour map. Joining A and B, draw a straight line which will intersect contours between these two points at C, D, E, F, G and H (Fig.8). Drop down two perpendiculars AX and BY of equal length. Join X and Y. Straight line X and Y will be the base line for drawing the profile. This line shall be equal to AB line of section and will represent sea level. Assuming the value of X and Y as zero, put marks of altitude on some scale on XA and YB perpendiculars. The difference of the value of these marks should be equal to

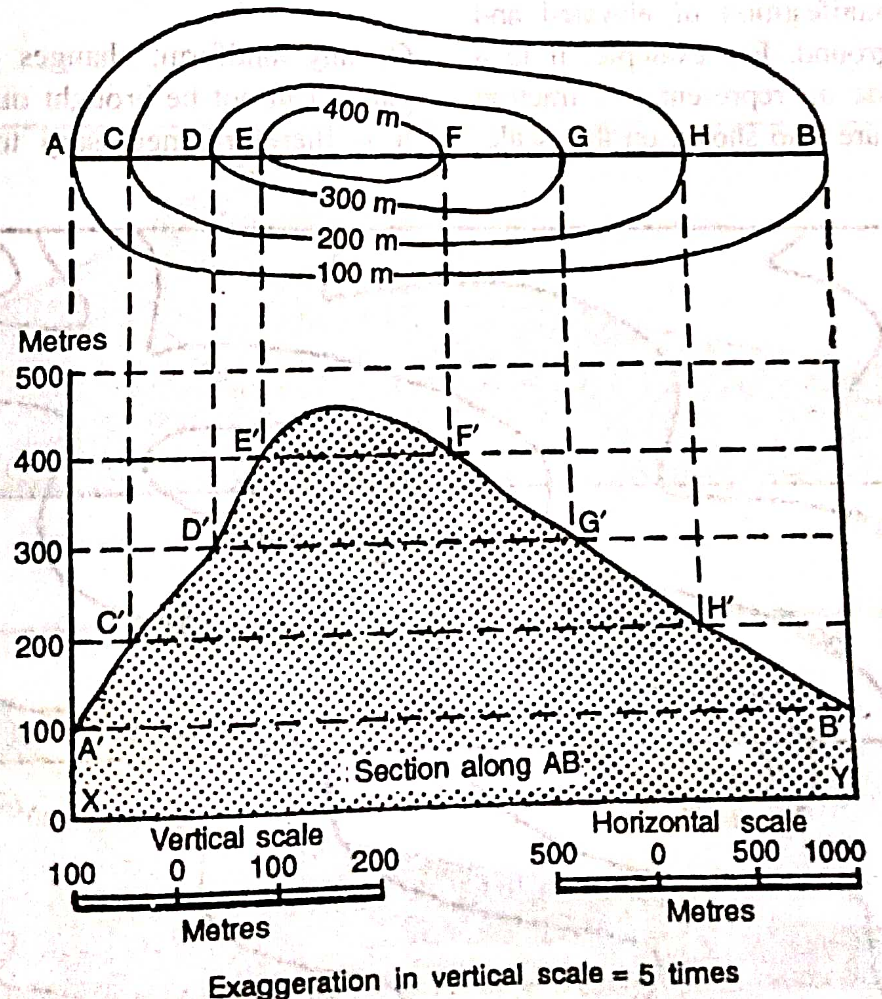


Fig 8

contour interval. From each point draw parallel lines to XY. These lines will represent different altitude from sea level. Now as shown in the Fig, from A, C, D, E, F, G, H and B drop down perpendiculars AA′, CC′, DD′, EE′, FF′, GG′, HH′ and BB′ upto parallel lines belonging to the altitude of the contour. Smooth curve passing through points A′, C′, D′, E′, F′, G′, H′ and B′ shall be the intended profile.

HORIZONTAL AND VERTICAL SCALES OF A PROFILE

As we have studied above, horizontal and vertical distances in a profile are shown according to different scales. The real magnitude of slope on ground is, therefore, not represented by profile. For showing real magnitude of slope it is absolutely necessary that horizontal and vertical scales should be one but by doing so there is difficulty in clear manifestition of elevated and depressed parts on ground. For example, if in a profile of a map made on representative fraction 1 : 1,00,000, heights are also shown on this scale, then a 2,000 metre mountain peak raising profile only 1/5 cm (or 2mm) will be enough and it will be very difficult even to recognise clearly this mountain peak in the profile. In order to remove this difficulty vertical scale is selected larger than the horizontal scale of profile and the exaggeration effected in vertical scale is written below the profile.

Exaggeration in vertical scale is found out according to the following formula :

$$\text{Exaggeration of vertical scale} = \frac{\text{Vertical Scale}}{\text{Horizontal Scale}}$$

As for example, if horizontal scale of a profile is 1 : 1,50,000 and vertical scale is 1 : 25,000, then the exaggeration of vertical scale shall be,

$$= \frac{1/25,000}{1/1,50,000} = \frac{1}{25,000} \times \frac{1,50,000}{1} = 6 \text{ times}$$

KINDS OF PROFILES

On any landform, changes occurring at different places can not be brought out by only one profile. It is therefore, necessary to draw some straight

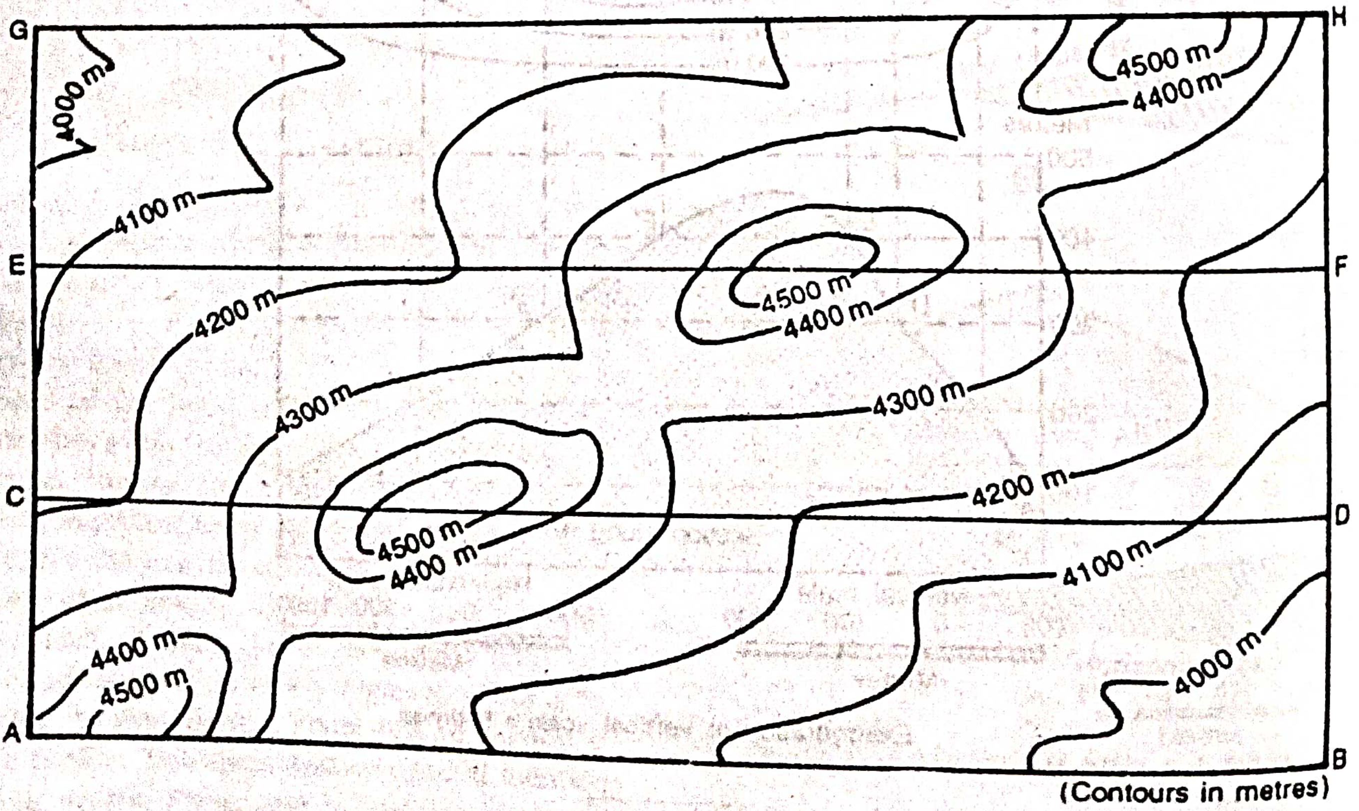


Fig 9

parallel lines at equal mutual distance on the contour map of that landform and according to each parallel line, draw separate profiles. In Fig. 9 for example, on a contour map of an area AB, CD, EF and GH four straight parallel lines of section are drawn. As per method already described, profiles of separate parts of ground can be acquired. Profiles drawn along these four lines of section can be presented in four forms or kinds–(I) Serial profile, (II) Superimposed profile, (III) Projected profile and (IV) Composite profile. The difference of above mentioned four kinds of profiles is explained below–

(A) Serial Profiles

If profiles drawn on different lines of section on a contour map are arranged in a series, this serial of profiles will be called serial profiles. In order to making serial profiles, some parallel lines of section in required number is drawn and then profiles made along these lines are arranged in a sequence in the form of a serial (Fig. 10). For identification name of related line of section as AB, CD, or EF, etc. must be written.

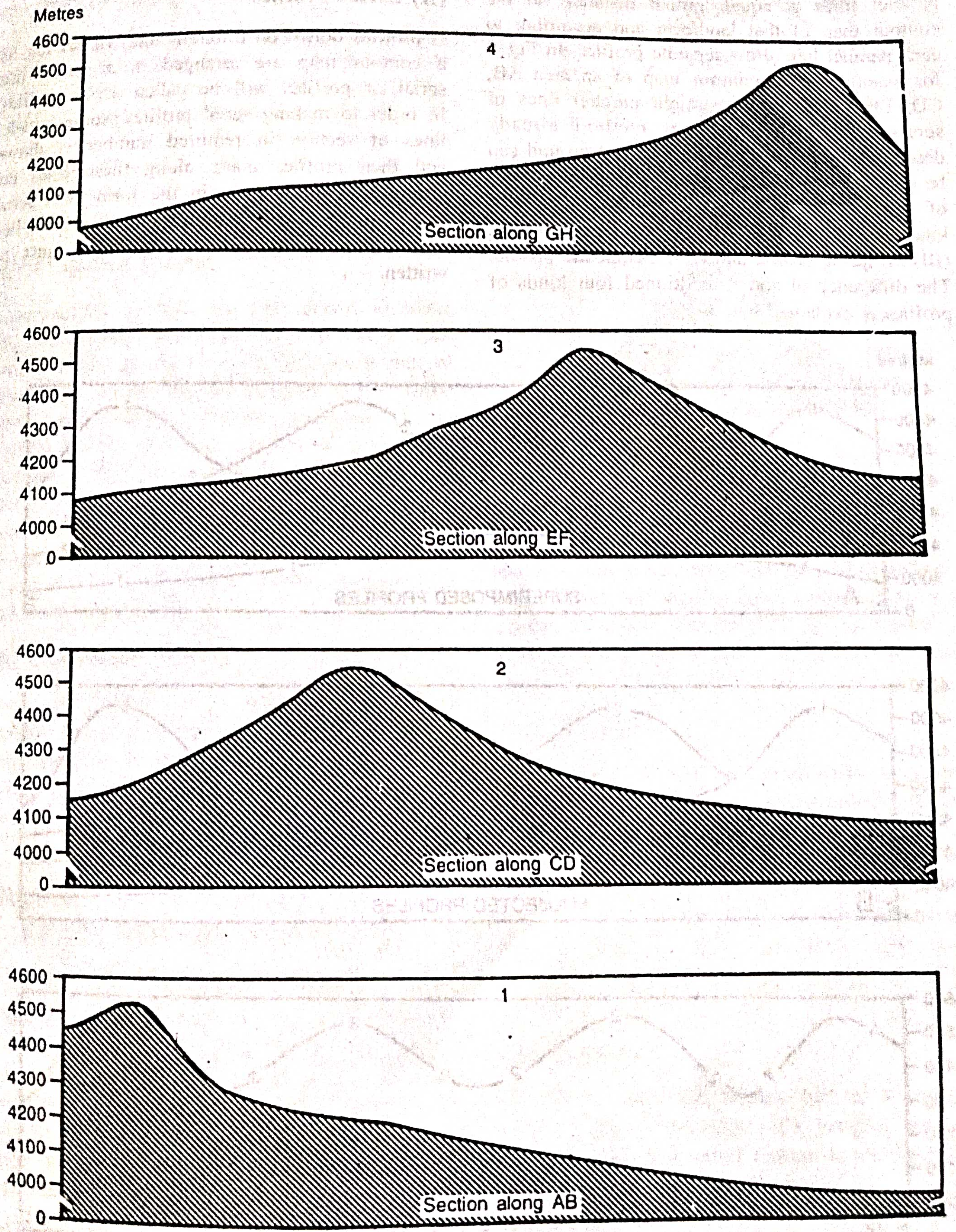


Fig 10. Serial profiles.

(B) Superimposed Profiles

If various profiles are drawn along various lines of section in a single box on a single base line putting instead of each separately, these profiles will be superimposed profiles. In Fig.11A, profiles of Fig.10 have been shown as superimposed profiles and on each of them a serial number has been written for their identification.

(C) Projected Profiles

Superimposed profiles are first drawn to make projected profiles and thereafter, that part of each profile is erased which is invisible lower part of that profile. In other words, that part of any profile which are concealed behind previously drawn profiles are not drawn in a projected profile. For example in Fig.11B, profile at serial number 1 is shown totally and those parts of profile at serial number 2 are left undrawn which are below profile number 1. Similarly those parts of profile number 3 and 4 which fall below profile number 1, 2 and 3 are not shown.

(D) Composite Profiles

Composite profiles show only sky line of all profiles. In order to draw these profiles, therefore, only the line showing the highest part of any profile in superimposed profile is drawn and all remaining parts are erased (Fig. 11 C).

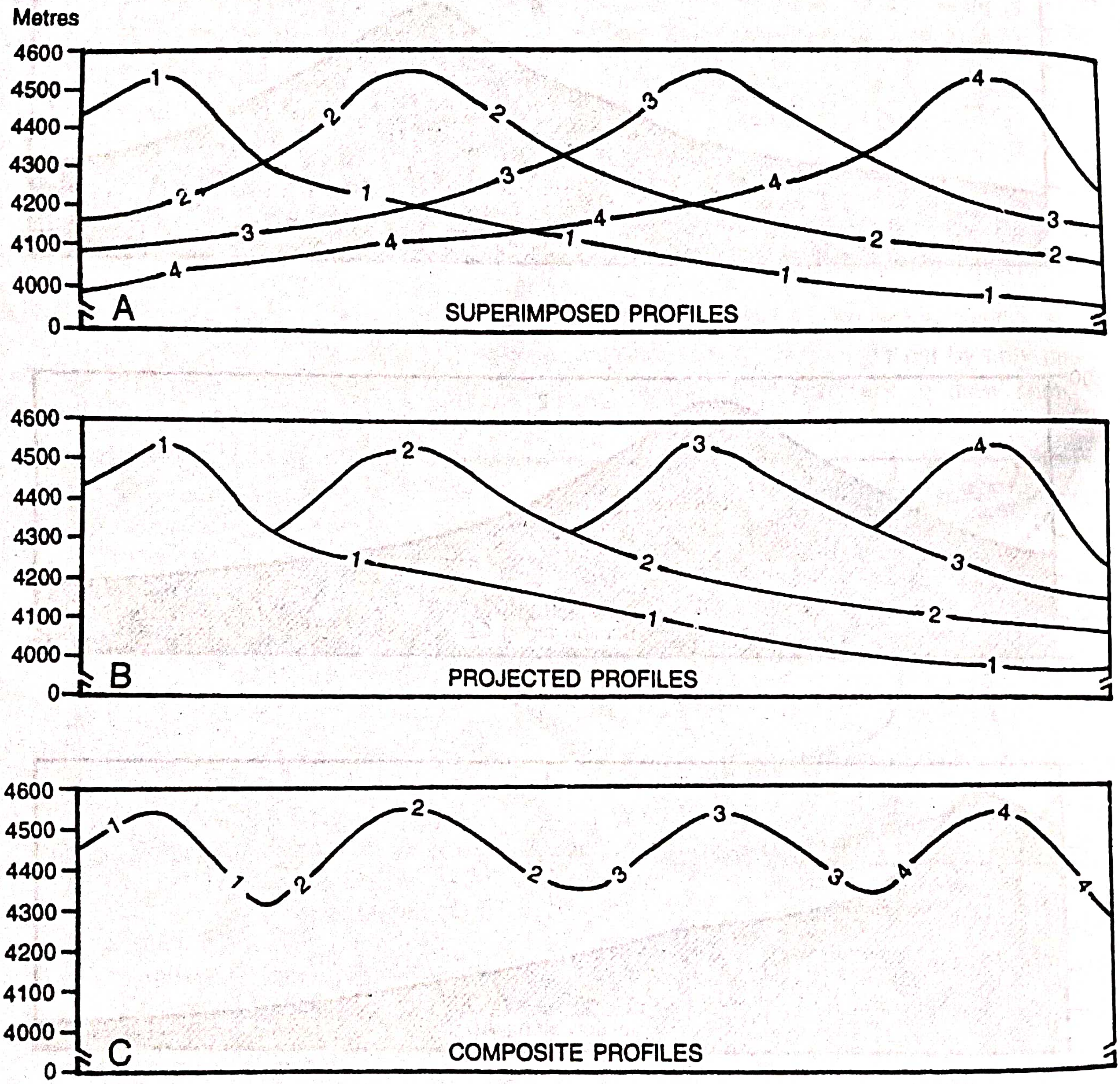


Fig 11 A. Superimposed profiles, B. Projected profiles, C. Composite profiles

CHAPTER 11 SURVEYING

Surveying is the art of making observations and measurements in order to determine the relative position of points on the earth's surface. Obviously it includes linear and angular measurements and the determination of the relative levels or heights of objects.

In *plane surveying* the curvature of the earth is not taken into consideration and all measurements are taken or reduced to a horizontal or vertical plane surface. In *geodetic surveying* the curvature of the earth is taken into account which amounts to about 1 foot in 34.5 miles. For ordinary surveys extending upto say 100 sq. miles, plane surveys do not involve much error.

The accuracy of the survey depends on the purpose for which the survey is being undertaken. Depending on the accuracy aimed at surveying may be grouped under two heads :

1. Triangulation, or an accuate and elaborate work.
2. Traversing, or a rapid and less careful work.

Surveying may also be characterised as topographical surveying, cadastral surveying, geological surveying, military surveying, etc. according to the purpose of the survey.

Survey involves :

(A) Field work

(B) Office works

(C) Care and adjustment of instruments.

(A) **Field work.** Essentilly field work consists of (*i*) measuring distances and angles, (*ii*) recording field notes.

(B) **Office work.** The indoor work consists chiefly of (*i*) Computing, (*ii*) drawing, and (*iii*) finishing up the map.

(C) **Cure and adjustment of instruments.** A surveyor should be throughly acquainted with the instruments, their case and adjustment.

Field Notes

These are written records of field work taken when the survey is done in the field. Field notes must be taken with great care. The office work entirely depends on a legible field note. Field notes essentially consist of the following aspects :

1. Sketches

Showing an outline of the area to be surveyed. Generally sketches are necessary when measurements cannot be described easily. It always helps in the interpretation of notes.

(*a*) A sketch is never made to scale. The sketch should always be large and clear, even it may be necessary to make separate exaggerated sketches of small portion to get a clear understanding.

(*b*) Straight edges should as far as possible be shown by a straight line; for this a small scale or a small triangle may be used.

(*c*) No time should be spent in attempting to draw the angles of a sketch accurately.

2. Numerical Notes

The recording of measurements both distances and angles.

(*a*) The figures should be plain and large.

(*b*) No attempt should be made to overwrite. It is best to delete the incorrect value with a line and write the correct figure near it.

3. Explanatory Notes

This helps to expalin the numerical notes and sketches. The complete field book should be such that any surveyor who was not in the field could draw up the map correctly from the field notes.

General Hints

Field Notes

(*a*) A note book with a stiff cover should be used.

(*b*) The pencil used should be hard enough not to blur.

(*c*) A surveryor should know what data he would require in the office for drawing the map and should in no case leave any data to memory.

सर्वेक्षण के प्रकार
(Types of Surveying)

सर्वेक्षण को भिन्न-भिन्न आधारों के अनुसार निम्न प्रकार से वर्गीकृत किया जा सकता है :

(1) सर्वेक्षण का प्राथमिक (primary) वर्गीकरण :
- (i) भूगणितीय सर्वेक्षण (geodetic surveying), तथा
- (ii) समतल सर्वेक्षण (plane surveying) ।

(2) सर्वेक्षण की विधि के अनुसार वर्गीकरण :
- (i) त्रिभुजन सर्वेक्षण (triangulation surveying), तथा
- (ii) चंक्रमण सर्वेक्षण (traverse surveying) ।

(3) प्रयुक्त सर्वेक्षण उपकरण के अनुसार वर्गीकरण :
- (i) ज़रीब एवं फीता सर्वेक्षण (chain and tape surveying),
- (ii) प्लेन टेबुल सर्वेक्षण (plane table surveying),
- (iii) दिक्सूचक अथवा कम्पास सर्वेक्षण (compass surveying),
- (iv) सेक्सटैन्ट सर्वेक्षण (sextant surveying),
- (v) थियोडोलाइट सर्वेक्षण (theodolite surveying),
- (vi) डम्पी लेविल (dumpy level) द्वारा तलमापन (levelling),
- (vii) भारतीय क्लाइनोमीटर (Indian clinometer) द्वारा प्रवणता की माप, तथा
- (viii) हवाई सर्वेक्षण (air surveying) ।

(4) सर्वेक्षण की वस्तु (object of surveying) के अनुसार वर्गीकरण :
- (i) स्थलाकृतिक सर्वेक्षण (topographical surveying),
- (ii) पुरातात्विक सर्वेक्षण (archaeological surveying),
- (iii) भूवैज्ञानिक सर्वेक्षण (geological surveying),
- (iv) सैन्य सर्वेक्षण (military survey),
- (v) भूसम्पत्ति सर्वेक्षण (cadastral survey),
- (vi) शहर सर्वेक्षण (city survey),
- (vii) इंजीनियरी सर्वेक्षण (engineering survey),
- (viii) अन्य सर्वेक्षण (other surveys) ।

(5) सर्वेक्षण-क्षेत्र की प्रकृति के अनुसार वर्गीकरण :
- (i) भू-सर्वेक्षण (land survey),
- (ii) समुद्री (marine) अथवा नौसंचालन (navigation सर्वेक्षण, तथा
- (iii) खगोलीय सर्वेक्षण (astronomical survey) ।

Chain and Tape Surveying

INTRODUCTION

There are many methods of making plan of any area by plane surveying in which the surface of the spherical earth is assumed to be totally plane. On the basis of main instrument or set of instruments used for surveying, methods of plane surveying may be divided into five main parts—(i) Chain and tape surveying, (ii) Plane-table surveying, (iii) Prismatic compass surveying, (iv) Sextant surveying, and (v) Theodolite surveying. Among above five methods chain and tape surveying is considered to be the easiest for these four reasons—**First**, the instruments used in this surveying are very simple and their use can be learned with a little practice. **Secondly**, with a little care these instruments don't become bad for use soon. **Thirdly**, dependence on weather condition is the least in this surveying. **Fourthly**, for making plan according to this method, only distances are measured in the field and measuring angles is not required. It is for this reason that chain-tape surveying is sometimes called **linear survey**.

Before making plan of an area by chain and tape method, the following facts should be paid attention to —

(1) The area given for surveying should be plain, so that no additional labour is required to measure horizontal distances correctly.

(2) The area should be open and free from all kinds of obstacles. Less the obstacles like waterbodies, buildings, pits, rivers or similar other obstacles, which cause difficulty in measuring distances, simpler the surveying work.

(3) In this surveying the given area is divided in triangles and all three sides are measured. So the given area should be such as may be fully divided in the least number of triangles for surveying.

(4) The boundary of given area should not be much zig-zag, otherwise surveying will become very difficult.

(5) Area to be surveyed should be relatively small. That is why this method is often chosen for making plan of playing fields, property or fields, etc. on a large scale.

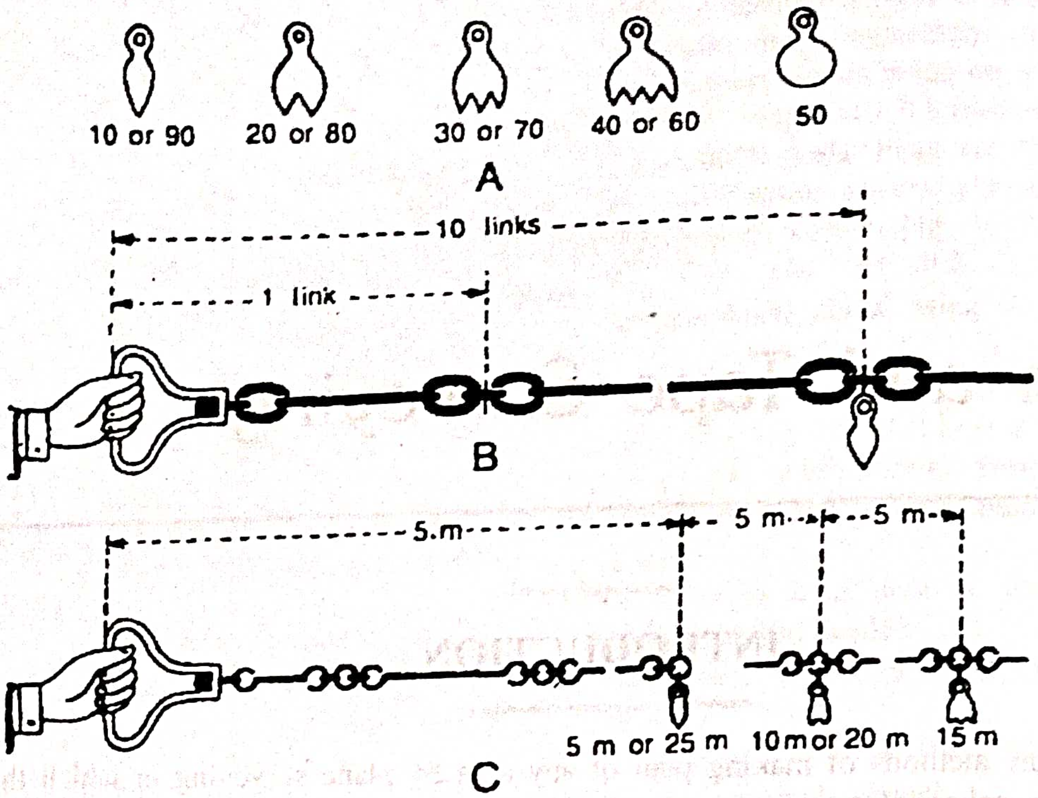


Fig 1 A. Tag, B. Engineeri's Chain, C. Metric Chain.

INSTRUMENTS REQUIRED FOR CHAIN AND TAPE SURVEYING

The following instruments are needed for chain and tape surveying—

(A) Chain

Chain is the main instrument of measuring distance. This is made of iron or steel wires and brass handles are attached at its both ends. In each chain, there are 100 links whose ends are bent in the form of knob and a ring is put in each knob which is joined with the ring of next link with another ring so that the chain can be kept by easily turning. For the ease of counting brass-tags with one, two, three and four tips are tied at the interval of 10 links which give an idea of 10 or 90, 20 or 80, 30 or 70 and 40 or 60 links. In the middle of the chain, that is after 50 links, the brass tag is round-shaped. These pieces of brass are called **tags** or **tellers** (Fig. 1A). As the shape of tags of 40 and 60 is the same counting from any end of the chain, so tags of same shape juxtaposed sometimes causes error in counting. To avoid this probable error, the position of central round tag should be seen well.

It has been already stated that links of chain are joined together by round rings. So, the length of one link is measured from the middle of the ring of one side to the middle of the ring of another side. In the first and last link the length of handle is also included (Fig. 1B). Chains are of 4 kinds on the basis of measurement system, length and utility—(i) Metric chain, (ii) Engineer's chain, (iii) Gunter's chain, and (iv) Steel band chain.

1. Metric chain. Distances are measured by metric chain in countries of metric system of measurements. After adopting metric system, India also uses metric chains. Metric chains are often 10m, 20m and 30m long (Fig. 1C). Chain of 10m length is also called **decameter chain**. Each metric chain has 100 links. A brass tag is attached after every 10 links counting from any end of the chain. Thus the length of a link is 1, 2 or 3 decimetre (10, 20 or 30 cm) in metric chain of 10m, 20m and 30m length respectively.

2. Engineer's chain. For finding out distances in miles, furlongs, yards and feet, Engineer's chain is used. This kind of chain was used in India before adopting metric system of measurements in 1956, but now trend of its use is diminishing. There are 100 links in Engineer's chain and length of each link is equal to one foot. Thus, engineer's chain is 100 feet in length and brass tags are attached at every 10 feet (i.e. after every 10 links) (Fig. 1B). While using this chain, distance of 100 feet is called the distance of one chain and measured total distance is expressed in chains and feet. Since chain is a heavy instrument, it is convenient to use 50 feet chain for measuring shorter distances for the sake of ease in carrying and using it in hilly areas.

3. Gunter's chain. This chain was made by an astronomer called **Edmund Gunter** in the early years of seventeenth century and that is why it is called Gunter's chain. This chain is 66 feet or 22 yards in length and it also has 100 links. Thus one link in Gunter's chain is 0·66 foot or 7·92 inches in length. This chain is especially useful in measuring distances in Miles-Furlongs and finding out area in acres. For example, there are 1,760 yards in one mile or 8 furlongs and an acre is equal to 4,840 square yards, so—

(i) 80 Gunter's chain = 80 × 22 = 1760 yards = 1 mile.

(ii) 10 Gunter's chain = 220 yards = 1 furlong.

(iii) 10 square Gunter chain = 220 × 22 = 4,840 square yards = 1 acre.

Like other chain Gunter's chain also has a brass-tag at every 10 links for having an idea of numbers.

4. Steel band chain. In surveying of a town etc. where accuracy is the most important consideration, steel band chain is used in place of above mentioned general chains. This chain is made of steel band and at both the ends of the chain, brass handles are attaches as in other chains (Fig.2). Steel band chain is as long as other general chains. After measuring distances, steel band chain is wrapped up on an iron spool.

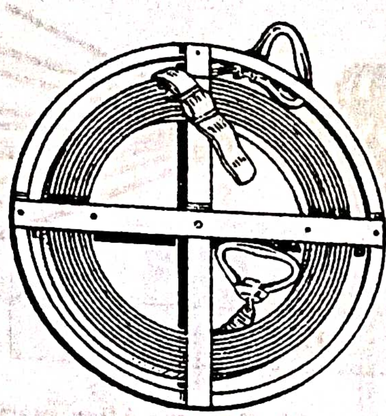


Fig 2. Steel band chain.

(B) Tape

Tapes for measuring distances are of different length but for conducting surveying, generally 100 feet or 30 metre tapes are mostly used (Fig.3). On one end of the tape is fixed a brass ring and the other end is tied to a rod under a strong cover made of leather etc. This rod is connected to a hook outside the cover. Turning this hook clockwise, the tap is wrapped up around the rod within the cover. On the basis of material of make, tapes are of the following five kinds—

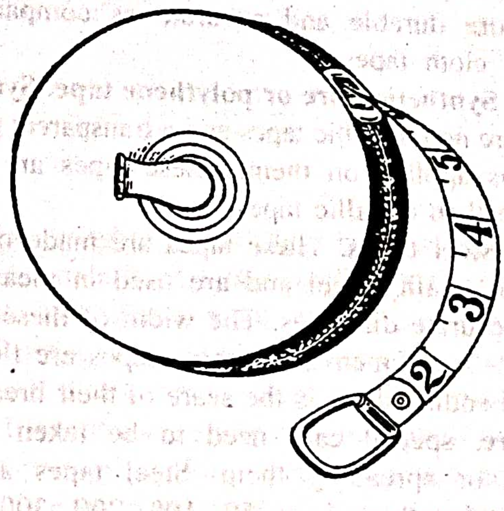


Fig 3. Tape.

1. Cloth or linen tape. Cloth or linen tapes are considered inappropriate for field surveying operations because there is probability of their turning or contracting. So their use is limited only to domestic use.

2. Metallic tape. By the term metallic, students may mistake this tape of being totally metallic. Infact, these tapes are made of a special kind of cloth in which copper or brass thin wire

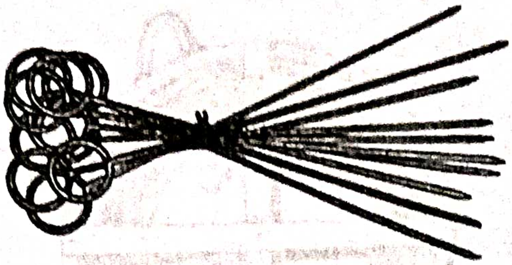


Fig 4. Arrows of chain

is also woven with threads. After marking inch-feet or centimetre-metre signs on these tapes, a thin paste of good warnish is applied on them, whereby no adverse effect on the cotton of the tape is exerted at being wet. Thus metallic tapes are more durable and accurate as compared to simple cloth tapes.

3. Synthetic fibre or polythene tape. Synthetic tapes are non-metallic tapes and a transparent plastic paste is applied on them. These tapes are more durable than metallic tapes.

4. Steel tapes. These tapes are made of thin sheet of quality steel and are used in measuring more accurate distances. The width of these tapes is 7 to 13 millimetres. As these tapes are flexible and at bending there is the scare of their breaking, therefore, special care need to be taken while folding or spreading them. Steel tapes are of different length such as 50, 100, 200, 300, 500 feet or 25, 30, 50 or 100 metres.

5. Invar tape. Invar tapes are made by nickel mixed thin steel sheet, so in comparison to steel tapes invar tapes have the least influence of the change in temperature. In high precision surveying, as for measuring base-line in a town's surveying, invar tape is used. Invar is soft metal, so tape can break at bending. Being very costly and made of soft metal, invar tapes are not used in ordinary surveying.

(C) Chaining Arrows or Pins

When chain or tape has to be spread many times to measure a long distance, an arrow or pin has to be burried on ground at the forward end of the chain. This gives two benefits—**First**, for measuring next chain distance, it helps holding the backward end of the chain at right point and **Secondly**, by counting the total number of arrows burried in the ground, it becomes clear after surveying as to how many times the chain or tape was spread. Arrows of chain are made of thin rod of iron or steel and length of each arrow is between 25 to 30 centimetres. Upper end of the arrow is shaped as knob and the lower end is pointed so that it can be easily burried in the ground.

(D) Ranging Rod

Ranging rod is also called, **flag, lining rod** or **flag pole**. This is about 5 cm (2 inches) diameter round or octagonal cross-section wooden or iron pipe straight rod 2 to 3 m or 8 to 10 feet long at whose top a red-colour cotton flag is tied. At the lower end of the rod a pointed cover or **iron shoe** is mounded, which helps burry it in the ground easily (Fig. 5). Ranging rod is coloured in alternate bands of black and white or red and white colour. As the result of these bands, on the one hand, the ranging rod is clearly visible and on the other, small offset distances can be measured by such rods in case

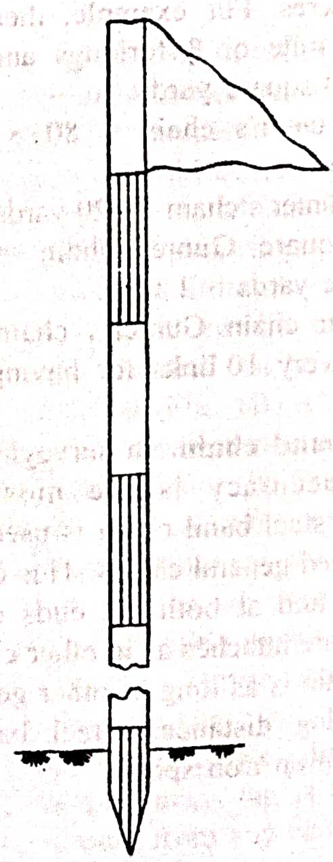


Fig 5. Ranging rod.

the need arises. While not in use, ranging rods are kept on their stand or with support of wall upside down so that 'iron shoe' remains unaffected. In addition, if the ground is hard ranging, rod can be used with the support of its stand. Various points or locations are shown by ranging rods.

(E) Cross Staff

This is a simple instrument made of brass, iron or aluminium, which is used by putting it on the opposite end of pointed 'iron shoe' end of a wooden staff. In this instrument, four arms making right angle to one another, a vertical vane or **sight vane** is fixed. A slit is cut vertically as a straight line in the middle of each vane. In some of the cross staff only wider slit with a fine thread or wire tied in between of two vanes only is made and in the remaining two vanes round holes are cut for sighting (Fig. 6). These round holes are called **eye holes.** Cross staff put on the staff can be turned horizontally in any direction. In chain and tape surveying, there are two uses of this instrument— **First,** when the chain needs to be spread more than one time for measuring a distance, then the help of cross staff is taken in spreading chains aligned between two points being measured. To accomplish this function, the staff of cross-staff is burried at chain line and the thread is aligned to the flag staff positioned at the second end by viewing from sight vane. Hereafter, the person holding the back-end of the chain directs with indication of one hand to the person holding forward end to align the chain in line with the flag

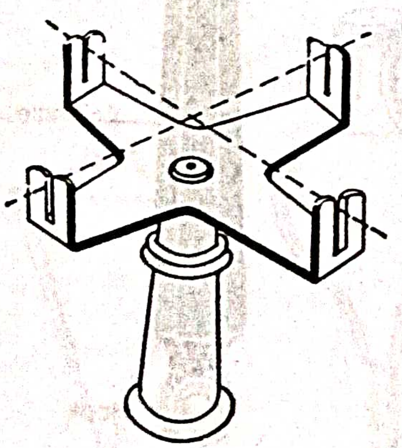


Fig 6. Cross staff.

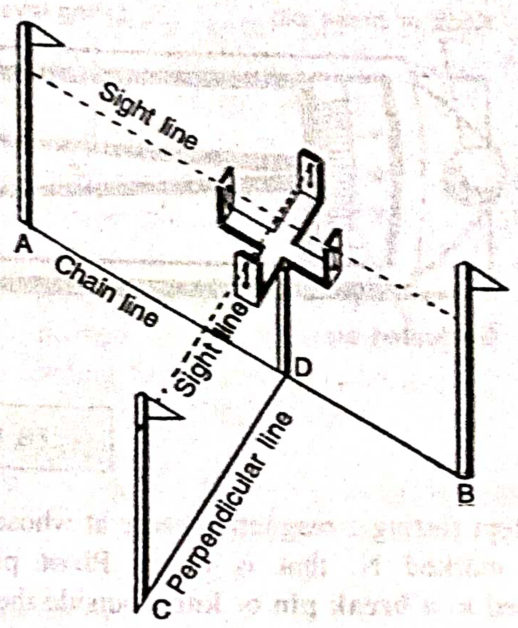


Fig 7

ahead by watching this flag from sight hole. Secondly, sometimes cross staff is also used to find out intersection point of the perpendicular drawn from a point of object. For this cross-staff is moved along chain line till the point of intersection of perpendicular is found out by aligning one edge along chain line and another right angle edge to the point of object. For example, in Fig.7, D is the point of intersection on AB chain line making perpendicular from point of object C. Thus CD is perpendicular on AB.

By another kind of cross staff objects to be surveyed located at 45° angle from chain line can also be marked on chain line when such need arises. This is called **octagonal cross staff** (eight vaines each at 45° angle from the neighbouring vain).

(F) Trough Compass

Trough compass is used to ascertain magnetic north in chain and tape surveying. This instrument is made of brass, aluminium or some other non-ferrous metal like an oblong box which has a glass (transparent) cover.

The opposite sides of the box are mutually parallel and at the tip of centrally located **pivot**

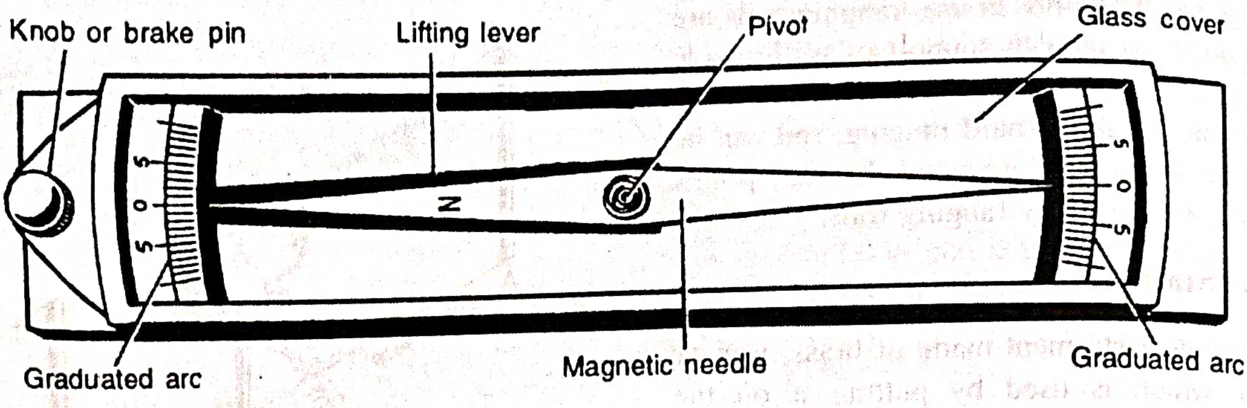


Fig 8. Trough compass.

pin is kept resting a magnetic needle at whose one end is marked N, that is north. Pivot pin is connected to a **break pin** or **knob** outside the box at tightening which the needle stops moving left or right and at loosening the needle by this breaking pin, both pointed tips of needle begin to move freely indicating at graduated arcs inside the box (Fig. 8). While using this compass, the needle is allowed to move freely. Trough compass is moved towards the side to which the needle touches until it becomes stable a 0° in the middle of graduated arc. As the axis of the needle is parallel to the long sides of the box, a line drawn on the side of this box will indicate north-south line, north being towards the N of the needle.

(G) Optical Square

This instrument made of brass is a wedge-shaped hollow box in whose inclined sides have two mirrors inside making 45° angle with each other. Above each mirror, a slit is cut so that across both sides can be seen. A hook is attached to the bottom of the handle of optical square for hanging plumb bob (Fig. 9).

By optical square it is ascertained as to where on the chain line a perpendicular will intersect it from the point of an object located on the left or right sides of the chain line. As is stated earlier also, this can also be done by simple cross staff, but from the consideration of accuracy, use of optical square is more appropriate. With the help of optical square, in order to find out right angle position of an object (suppose C), a surveyor first keeps the open side of the optical square towards C (Fig.10). He will stop keep seeing through slits at that point of chain line (D here), where he sees C point's image on mirror (Q mirror) just below flag staff put on the other end of chain line (B point here). So, D is the intended point from

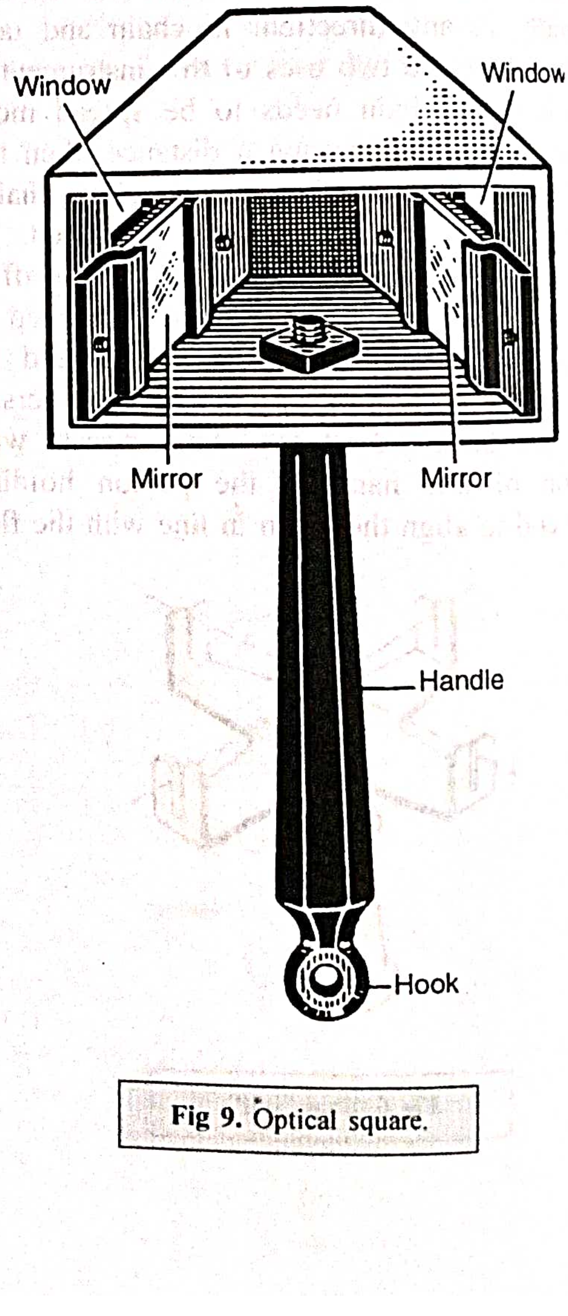


Fig 9. Optical square.

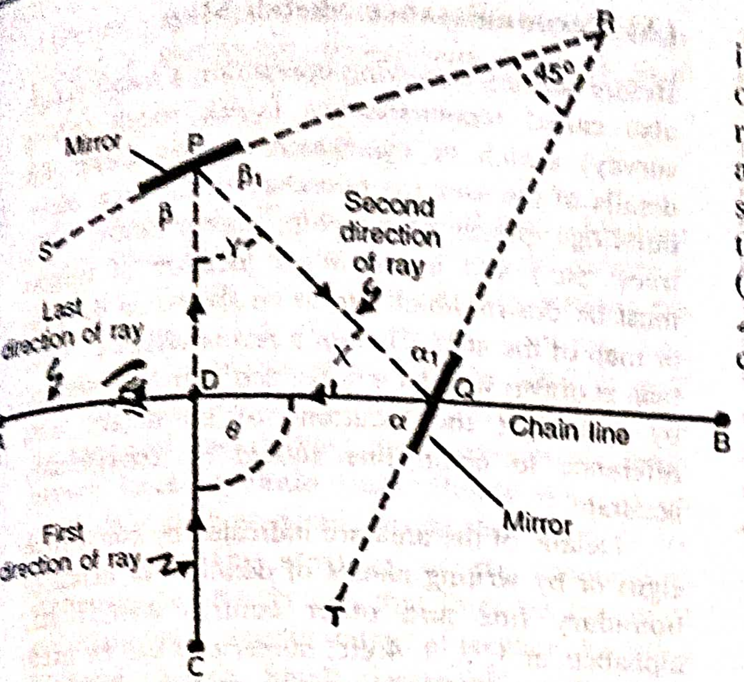


Fig 10

where a perpendicular line will pass through C point.

Optical square is devised on the principle that if a light-ray is reflected successively from two plane mirrors, the angle between the first direction of the ray and the last direction is double the angle of the two mirrors (Fig.10). In this figure AB is the chain line and D is that point of chain line where the surveyor sees the image of C point under just B point in the optical staff. As the image of C point first is reflected from P mirror and falls on Q mirror and again reflected from there is seen by the surveyor standing at D point. So, according to the above principle, the first direction of the ray (i.e. CP) and last direction (i.e. QD) making $\angle QDC$ should be double of the $\angle QRP$, which can be proved in the following way—

According to the rule of reflection—

$\angle\alpha = \angle\alpha_1$, and $\angle\beta = \angle\beta_1$

In ΔQPD,

$\angle\theta = \angle X + \angle Y$ ($\because \theta$ is exterior angle)

$= (180° - 2\alpha) + (180° - 2\beta)$

$= 360° - 2(\alpha + \beta)$ .....(i)

In ΔQPR,

$\angle\alpha + \angle\beta = 180° - \angle QPR$ .....(ii)

($\because$ sum of all three interior angles of $\Delta = 180°$)

Putting values of (ii) in (i),

$\angle\theta = 360° - 2(180° - \angle QRP)$

$= 2 \times \angle QRP$

$\because \angle QRP = 45°$

($\because \angle$ between both mirrors $= 45°$)

$\therefore \angle\theta = 2 \times 45° = 90°$

So, CD line is perpendicular on AB chain line.

(H) Plumb Bob

Plumbs or plumb bobs may be of different shapes but the lower tip of each plumb is pointed in

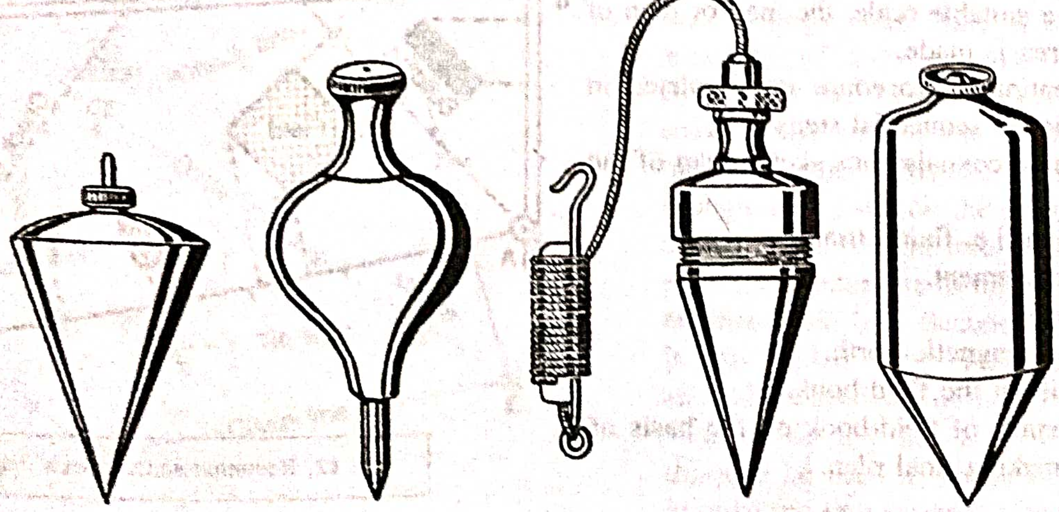


Fig 11. Kinds of plumb bobs.

the shape of a point. Arrangement of a hook or screw in the middle upper part is made for a thread. Normal kind of plumbs are reverse cone-shaped solid piece of iron. Since the point of plumb and the upper end of thread are in a vertical line, so this instrument is used to find out the accurate position of a point on the ground located above it. In the chain and tape surveying, the location of optical square held in surveyor's hand is found out on the chain line. In addition to this, while measuring distance between two points on a sloppy land by horizontally spreading tape or chain, another end's location on ground is also found out by its use. Different kinds of plumb bobs are shown in Fig.11.

METHOD OF CHAIN AND TAPE SURVEYING

The summary of the method adopted in chain and tape surveying is that in order to ascertain the location of a point, its vertical distance from such a straight line is measured which itself is a side of a triangle. These vertical distances are called **perpendicular** or **offset** and the side of the triangle from which offset is measured is called **chain line**. Thus, first of all the given area for chain and tape surveying, is divided into triangles. The length of the sides of triangle and distances of offset are recorded in a field-book. Thereafter, these distances are plotted on a suitable scale, the map or plan of the surveyed area is made.

Above mentioned procedure is completed in the following seven sequential steps—

(1) Making the reconnaissance sketch map of the area.
(2) Triangulation i.e. fixing triangles.
(3) Chain measurement.
(4) Fixing offsets.
(5) Finding out magnetic north.
(6) Enter details in the field-book.
(7) Drafting details of field-book on the basis of scale and making final plan.

(A) Reconnaissance Sketch Map

Before starting surveying operations, a rough sketch also called reconnaissance (quick rough outline survey) sketch or eye-sketch map is drawn. All details of the area (as boundary of the area, paths, buildings, places of worship, plains, fields, wells, trees, etc.) and approximate location of centres must be drawn which are to be shown on the plan or map of the area. Though a reconnaissance sketch map is drawn without a scale, and only by observing by eyes, yet the locations of all details with reference to chain line should be considerably accurate.

Details of the area are indicated by convention signs or by writing names of details. For bends of boundary line and other centres ABCD etc. alphabets or 1, 2, 3, 4 etc. numericals can be used. In short, on all details, centres or lines should be

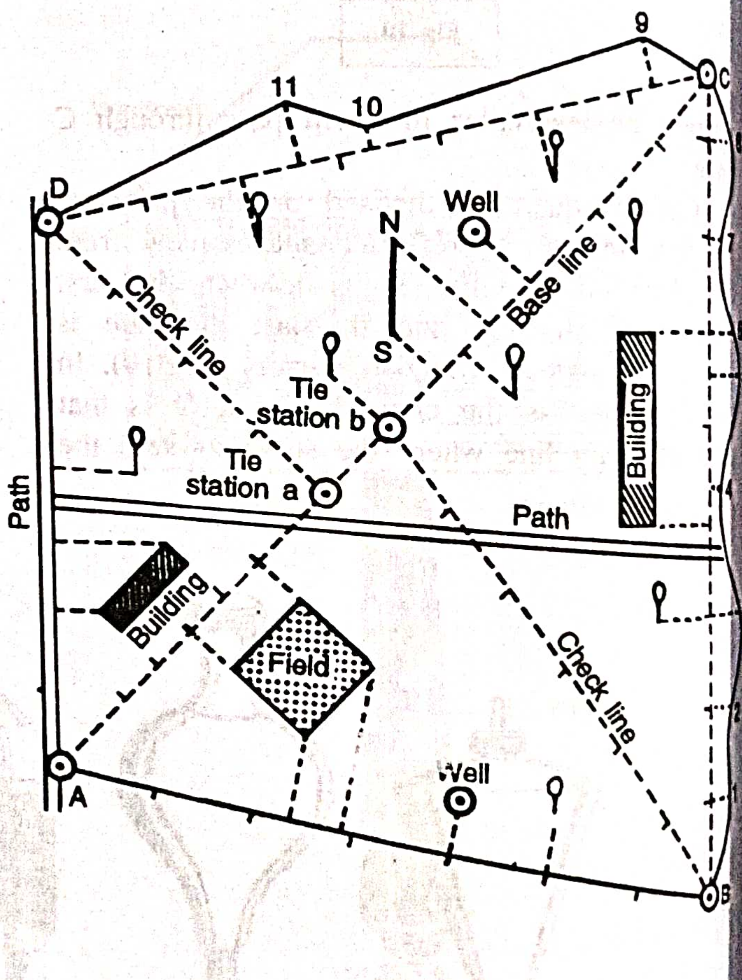


Fig 12. Reconnaissance sketch map.

made such an indication, as could be identified on ground at seeing the reconnaissance sketch map (Fig.12).

(B) Fixing the Triangles

After drawing reconnaissance sketch map, the given area is divided into triangles for which pre-selection of survey stations is necessary. Survey stations are of two kinds—(i) main survey stations, and (ii) secondary stations or tie stations. Vertices used for delimiting boundary of the area are **main survey stations** and lines joining these vertices are **main survey lines** or **chain lines**. Points selected on chain lines to show details inside the boundary are called **secondary stations** or **tie** (connector) **stations**. The straight line that joins tie station of one chain line to the tie station of another chain line is called **tie line**. Small circles with a dot at its centre A (Fig.13) are used to indicate survey centres.

For selecting appropriate survey centres and for ascertaining (fixing) triangles in an area, the following things should be kept especially in mind—

(1) First of all a straight line is selected in the middle of the area passing through the centre of the area and extending to the whole area in order to divide the given area into triangles. This straight line is called **base-line**.

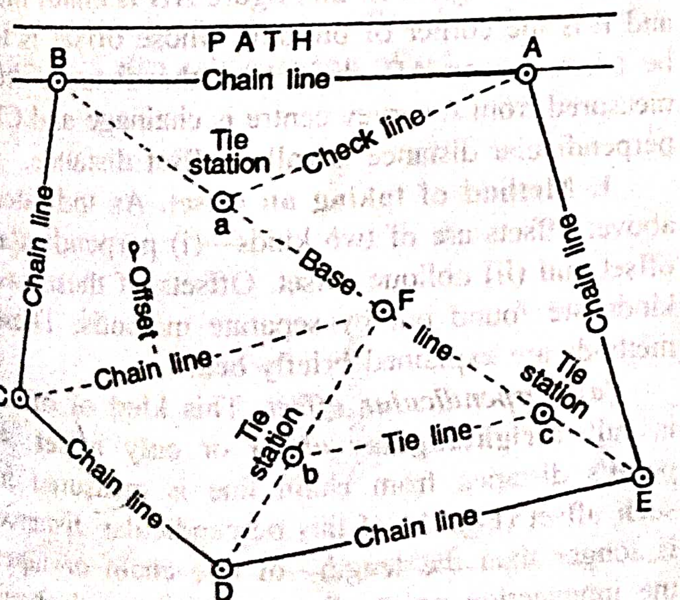


Fig 13

In comparison to other chain lines, base-line is longer and the most important because the framework of all triangles is based on this line. There should be no obstacle in the course of a base-line. There is the need of special attention while measuring the length of base-line because on the accuracy of its measurement depends the accuracy of the whole survey.

(2) All triangles of the area should be large, as far as possible. In this survey each side of these triangles is chain line. So large triangles mean lesser number of chain lines. This enables avoiding unnecessary labour in filling field-book and drawing chain lines.

(3) Each triangle should be kept an equilateral triangle, as far as possible. That means the value of each of three angles of triangles should be about 60°. Any triangle with more than 120° angle or less than 30° angle being an ill-conditioned triangle is not appropriate for measuring distances.

(4) The sides of triangles should be closest possible to the area's boundary line as a result of which the length and number of offsets drawn upto boundary line are minimised.

(5) Chain line should be obstacle-free, as far as possible. This means that there should not be buildings, ponds, rivers, hillocks, pits or the like obstacles in the course of a chain line, otherwise extra time and labour will be needed in measuring chain lines.

(6) Each triangle must have a check line. The accuracy of survey work is checked by comparing the length on the plan with the actual length of this line. A **check-line** is the line that either joins the point of apex of a triangle to a point on the opposite side of the triangle or a straight line joining a secondary point of a chain line to the secondary point of another chain line. Second type of check line is also called a tie line. With the help of check line, accuracy of the survey is examined. whereas tie line has a double utility—**first**, this can be used as check line and secondly, in open traverse surveying, the angles between two adjoining chain lines are fixed with the help of tie lines,. Another use of tie line is

that by measuring offsets from this line, details located far away from chain lines can also be drawn.

According to above method centres, chain lines, offsets, tie lines and check lines fixed for survey should be drawn at appropriate place in reconnaissance sketch map.

(C) Chaining

Two persons are required for measuring distances by chain. The person moving forward holding the fore-end of the chain is called **head chain-man** or **leader** and the one holding the back-end is called **rear chain-man** or the **assistant.** While measuring long distances covered by more than one chain, the assistant directs the leader to take chain in the direction of another point of the chain line with the help of viewing by the cross-staff. When the chain is straight in the desired direction, the leader burries an arrow at the outer end of the handle and pulls the chain forward. For measuring next chain length the assistant holds the rear-end at the arrow and directs the leader to straighten the chain towards the end of chain line. The leader having straightening the chain burries another arrow on the ground. Repeating this process, the entire chain line is measured. The assistant collects and keeps with him these arrows while moving forwards, so that it could be found out at the end as to how many times the full chain-length was measured. This helps avoid any error in the measurement of total length of chain line. This is worth remembering well that the chain or tape must be spread tightly straight between tweo centres while measuring distances. Distances of chain-line or tie lines thus measured are entered in the field book instantly.

Sometimes chain-measuring becomes relatively difficult because of the obstacles like river, pond or building falling in the course of chain line. The remedial methods to resolve such difficulties in the course of chain lines have been explained in the following sections.

(D) Fixing the Offsets

Location of details on the right or left side of a chain line or tie line are found out by offsets, so that those details could be included in the plan of

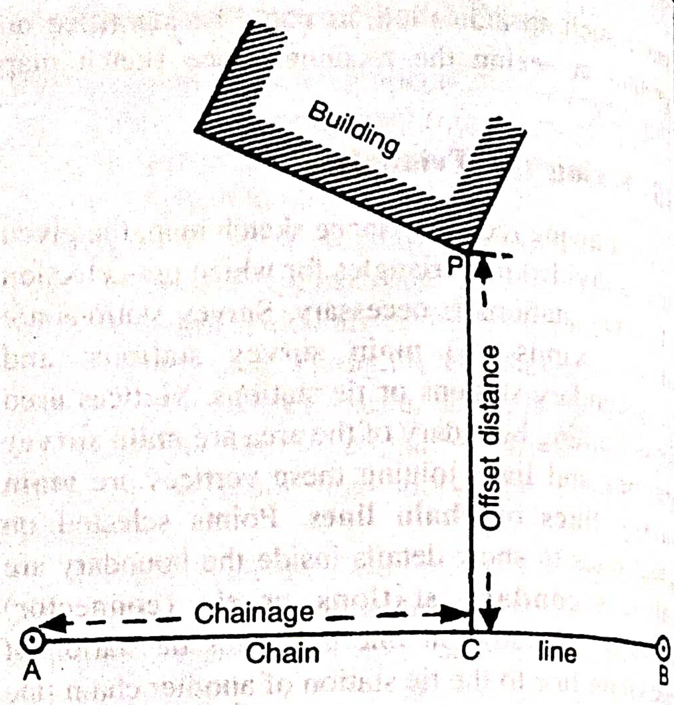


Fig 14

that area. The real meaning of offset is perpendicular distance. But in chain and tape survey, oblique distance measured from chain line to a point is also called offset. While taking an offset of any place or object, two distances are entered in the field-book after measuring them—(i) chainage (distance at chain) and (ii) offset distance. The difference of these distances is explained in Fig.14. In this figure AB is chain line and P is the corner of building whose offset is to be taken. So on AB chain line, the distance AC measured from A survey centre is chainage and CP perpendicular distance is called offset distance.

1. Method of taking an offset. As indicated above, offsets are of two kinds—(i) perpendicular offset and (ii) oblique offset. Offsets of these two kinds are found out by separate methods. These methods are explained briefly below—

(a) Perpendicular offset. This kind of offset is called **rightangular offset** or only **offset.** A point's distance from chain line is measured in such offset (Fig.15). If this perpendicular distance is longer than the length of one chain or tape, the intersection point of perpendicular and chain line is found first with the help of cross-staff or optical square. Thereafter, chain distance and offset

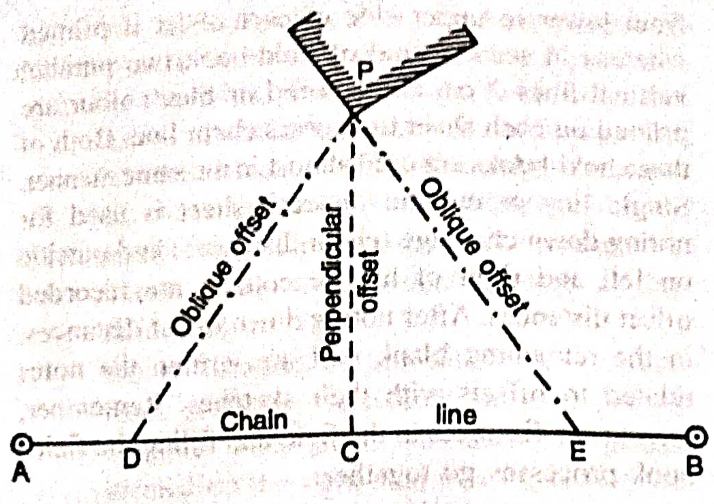


Fig 15.

distance are filled in the field-book after measuring them. The method of using these instruments has already been explained.

Those perpendicular distances which are smaller than one chain or tape, those can be measured by using tape only without taking the help of cross-staff. For example, suppose from AB chain line offset of P is to be measured, then the leader will hold the starting end of tape at P and the assistant will find that point on chain line by moving (swinging) tightly held tape along an arc and finding the point where the distance is the least (C point here) (Fig.16). After C point is found out AC chain distance and CP offset distance is measured. Perpendicular offset found out by this method is also called **swing offset.**

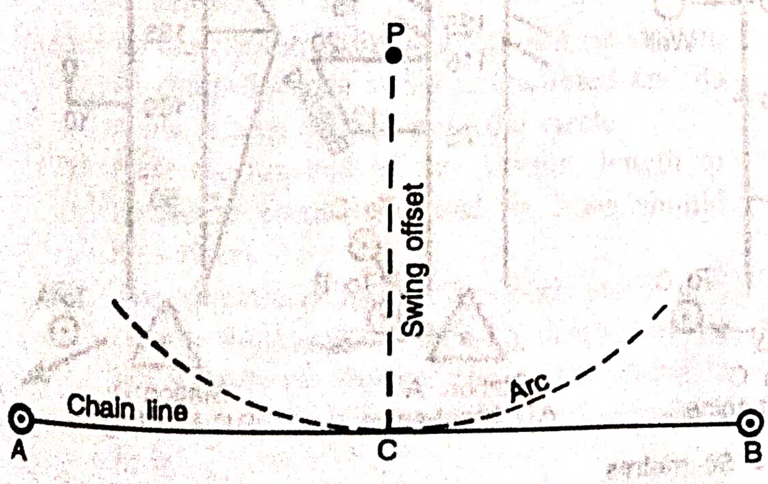


Fig 16

(b) Oblique offset. Those offsets in which distance of a place or object is measured oblique from chain line, are called oblique offset or **tie-line offset**. For example, in Fig.15, DP and EP show oblique offsets measured from P point to the chain line. For taking oblique offsets of a place, two such points on chain line are selected which, when joined to the place don't make a badly bound triangle (i.e. ΔPDE). Such offsets are often measured for locating places or corners of a building as are far away from chain line. Sometimes oblique offsets are also taken to check the accuracy of perpendicular offsets.

(E) Determining the Magnetic North

It is compulsory to show north direction in a plan or map of an area. Magnetic north is found out with the help of trough compass in chain and tape surveying. As is shown in Fig.17, trough compass is placed on a plain ground near a chain line and its break pin is loosened to allow free movement of magnetic needle on its pivot. Now move trough compass gently to right or left as required to bring the needle to halt on the 0 of graduated arcs of the compass. Now tighten the screw of break pin and spread tape or straight wooden ranging rod (NS in Fig.17) along the side of trough compass. Precaution should be taken that trough compass should not be shaked even the least by

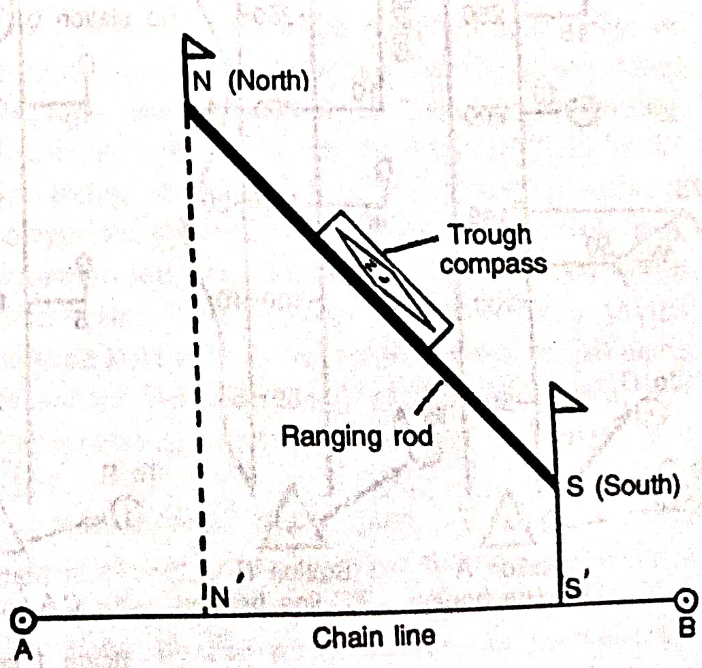
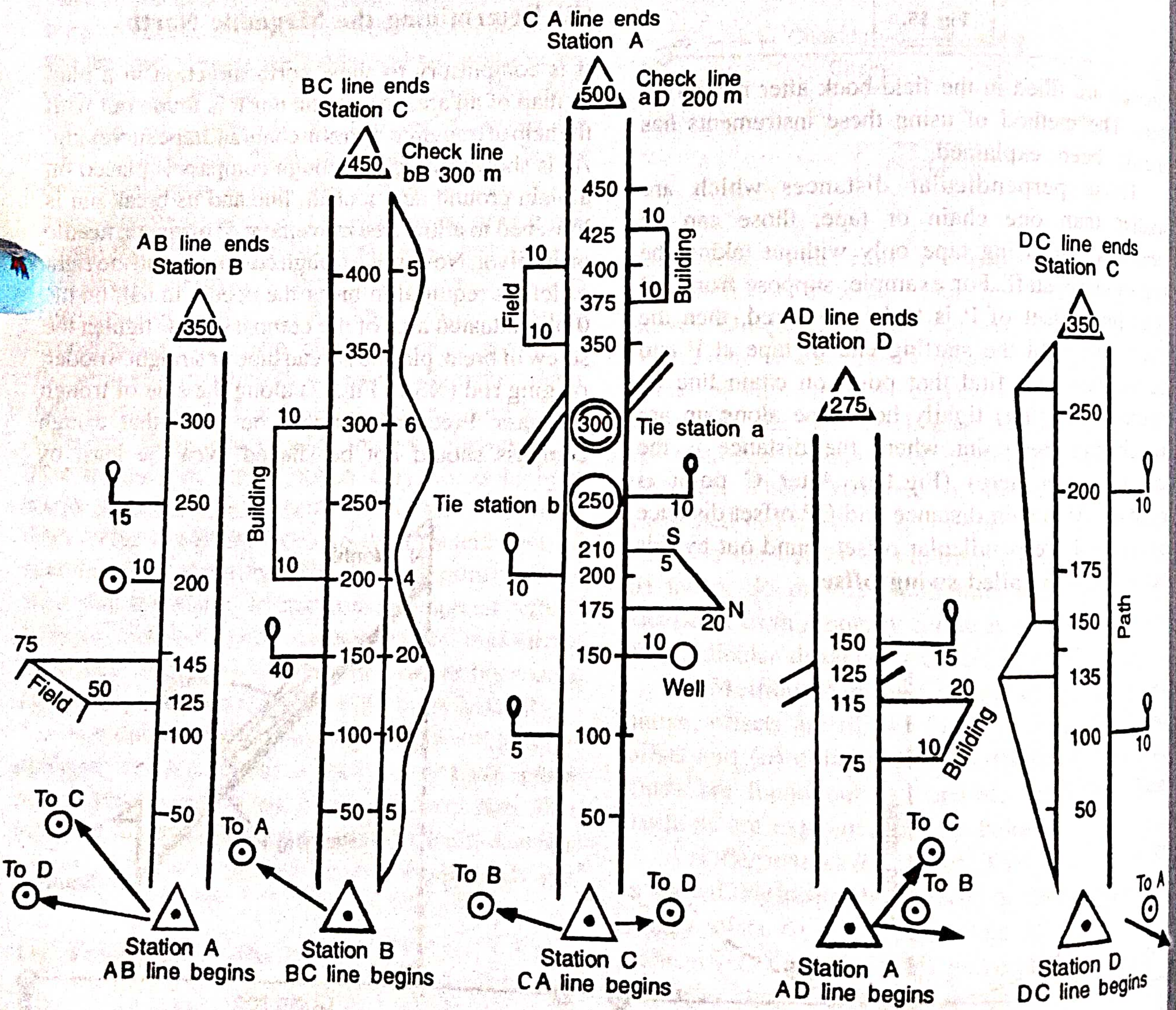


Fig 17

spreading tape or pole. The end of the pole towards N of the compass is the north direction of the area and the opposite side, the south. Now burry flag rods at N and S. Take offsets NN' and SS' from AB chain line of these points. Line joining N and S points shall be the line showing north-south line.

(F) Entering Details in the Field-book

Field-book or field ledger means a booklet in which the surveyor notes down survey work in the field itself in the form of—(i) linear measurements, (ii) diagrams and (iii) notes. Field-books are of two kinds. First kind of field-book has a red line drawn from lower to upper side of each sheet is printed whereas in second kind of field-book two parallel vertical lines 2 cm apart in red or blue colour are printed on each sheet to express chain line. Both of these field-books are used almost in the same manner. Single line or column on each sheet is used for noting down chainage (chain-distances) and outside on left and right of line or column are recorded offset distances. After noting down offset distances, in the remaining blank part are written the notes related to offsets with their sketches. Remember, measuring distances in the field and filling the field-book processes go together.



Scale 1 cm = 50 metres

Fig 18. Field-book.

While filling details in the field-book, special attention must be paid to the following facts—

(1) In the initial sheets of the field-book, the name of the area, date of surveying, full reconnaissance sketch and page numbers of chain lines should be recorded.

(2) Each chain line and its offsets should be noted down on a separate sheet of the field-book.

(3) Offset distances of a chain line are written from bottom to upside in singular line or column. Thus offset distances of places located on the right side of a chain line are written on the right of the column and those located on the left side are written on the left of the column.

(4) At the lower end of the column, the name of the chain line and the name of its initial station and its location should be indicated by Δ sign. Similarly, at the upper end of the column the name of the chain line and name of its terminal station should be written near Δ sign. For example, on a chain line AB, if distances of chain (chainages) are measured from A to B, then at the lower end of the column name of A station and 'AB line begins' phrase should be written. Similarly at the top end of the column, the name of B station and 'AB line ends' phrase is written (Fig.18).

(5) Within Δ0 is written at the bottom end of the column and within the top Δ total measured length of the concerned chain line is written.

(6) To clearly show the location of a tie station, its chain-distance value is encircled and its name is also written near the circle.

(7) Near the top end of the column, length of measured check-lines and tie lines should be written.

(8) The directions should be necessarily and clearly indicated by making arrows of all chain lines or check lines at the point at which they begin or terminate after coming to it.

(9) If any path obliquely cuts the chain line, then distance of the path at any side should [illegible] the [illegible]ame on both the parallel lines of the column and the path should not be shown intersecting the column.

(10) From the viewpoint of cleanliness, it is beneficial to write chain distances at least 1 cm apart. In the same way the values of offset distances are written at the concerned place or near the sketch of an object (as building) and towards the chain-line.

(11) Symbols or sketches of the places whose offsets are taken should be shown to make their shape clear at appropriate place in the field-book. Short notes may also be written for offsets of complex forms.

(12) All the entries in the field-book must be so neat, complete and clear that even a person, other than the surveyor, who has not seen that area could correctly show the location of places on the basis of field-book.

Earlier made reconnaissance sketch's (Fig.12) field-book of chain lines are presented in Fig.18.

(F) Construction of Plan

If the lengths of all the three sides of a triangle are known, then making that triangle will be an easy task. So, for constructing plan, first of all the base-line is drawn on a suitable scale. After this the framework of triangles made-up by various chain lines is drafted. While drawing the base-line it is kept in mind that the north direction of the plan is towards the upper side of the drawing sheet. After preparing the framework of triangles, remaining details are filled in it on the basis of field-book. For testing the accuracy of the surveying work, a comparison should be made between the check-lines drawn on the plan with their lengths entered in the field-book. After making the plan, these things must be shown on it—(i) name of the area, (ii) name of survey instrument and method, (iii) scale, and (iv) indicating north direction by an arrow is a must.

Sometimes, some part of plan remains undrafted due to taking larger than a suitable scale or not drawing base-line at appropriate place on the sheet. So the whole labour put in preparing plan goes was[illegible] The plan is first made on a tracing pap[illegible] [illegible]oid this difficulty. Thereafter, tracing pap[illegible] [illegible]t over drawing paper and ends of lines and other details are transferred on drawing paper with the help of pin and then the plan is traced.

OPEN TRAVERSE SURVEYING BY CHAIN AND TAPE

Open traverse method is used for surveying a river, canal, road or railway, etc. Open traverse method is different from the above described triangulation method in two respects—(i) given area is not divided in triangles in open traverse method and (ii) the turn in the course of traverse line is found out by making a tie line. Rest of the surveying procedure, such as making a reconnaissance sketch, measurement of chain lines, taking offsets, finding out north direction, recording details in field-book and construction of plan, etc. is completed according to the method described above. Open traverse method is explained below by giving an example.

Reconnaissance sketch of a path (dark thick line) is shown in Fig.19 A. Keeping bends in the path, traverse stations A, B, C and D are selected. Lines AB, BC and CD chain lines joined together shows traverse line. Fixing tie stations a, b, c and d,

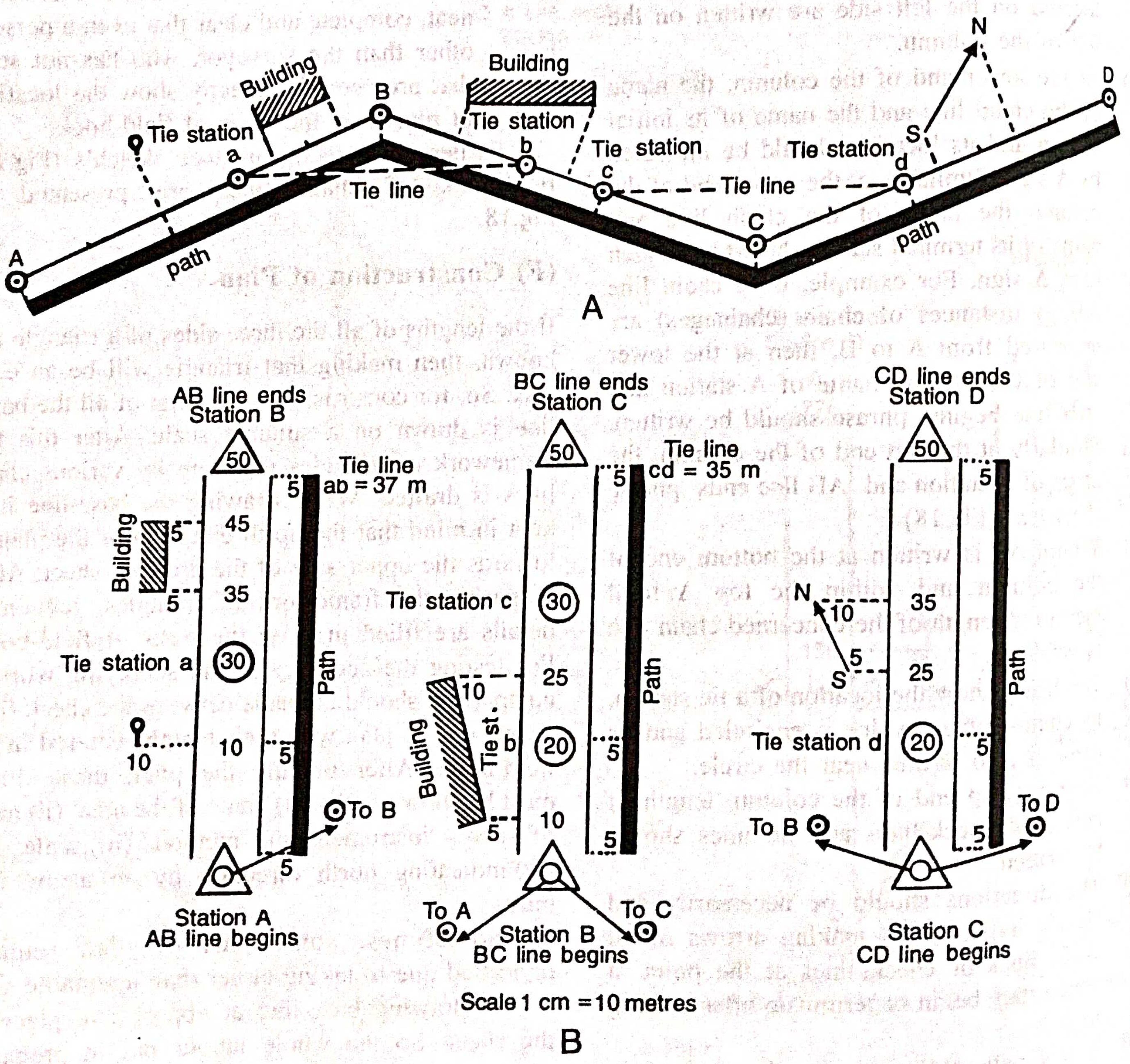


Fig 19

two tie lines ab and cd are drawn. While constructing plan after drafting abB and cdC triangles, direction of next chain line at B and C is found out. NS line in reconnaissance sketch indicates north direction. Now, according to the method explained in earlier paragraphs, measure each chain line. Chain distances and offset distances of details shown in the reconnaissance sketch may now be entered in field-book of concerned chain line (Fig. 19 B). Chain distances of tie stations and length of tie lines should be measured with special precaution. After completing field-book, draw AB chain line first on a suitable scale. Taking a and B points of this line as centre and ab and Bb as radius, mark two arcs which intersect each other at b point. Join B and b and extend it further. Measure the length of next chain line (BC) and fix point C. Next chain lines will be plotted repeating this process. Once the traverse line is plotted, draw other details of field-book in the plan. Tracing the whole plan on drawing sheet, write the name of area and instruments used, etc. and indicate scale and north direction.

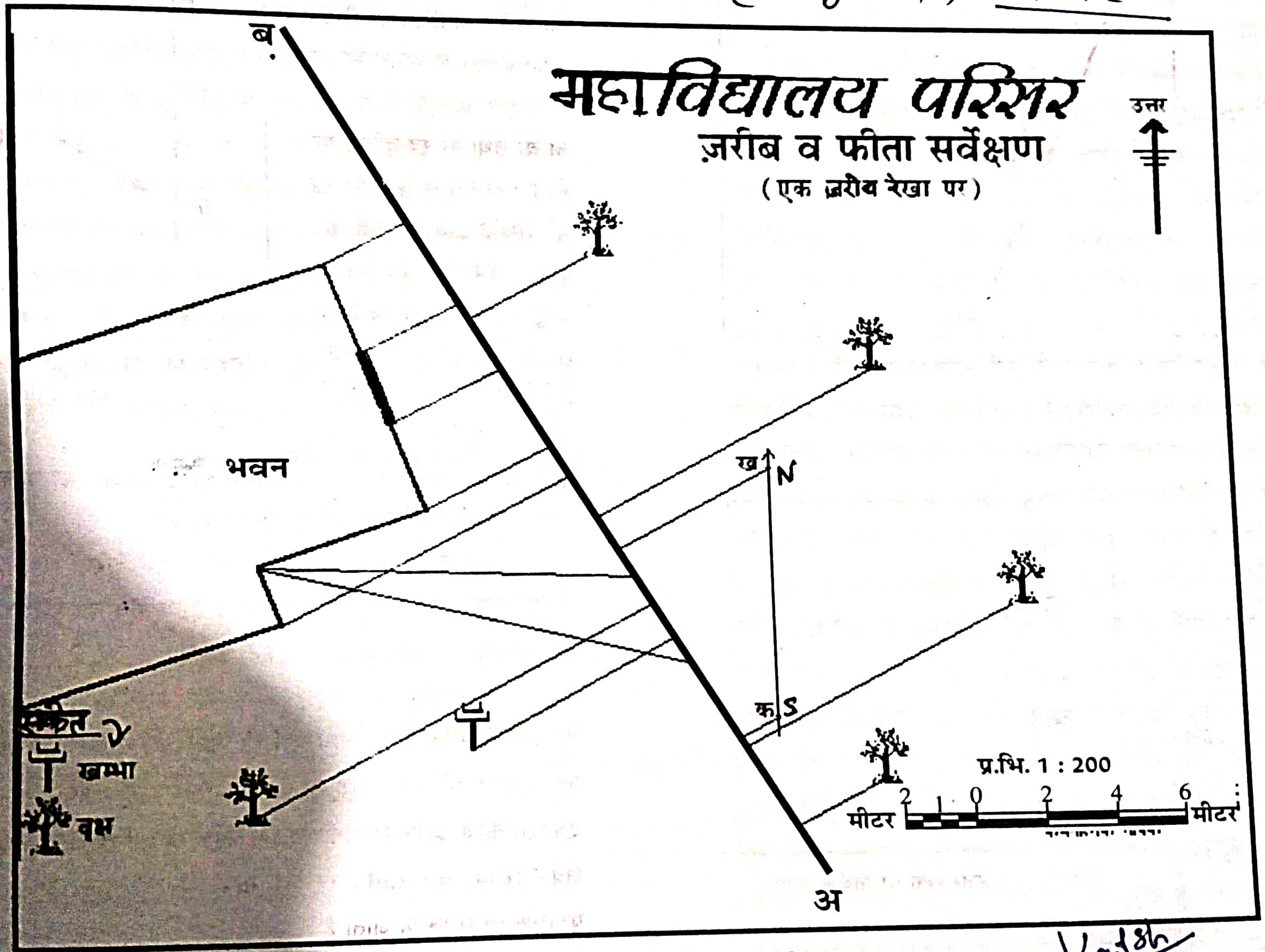
Owing to the following difficulties, open traverse surveying by chain and tape is not considered very useful—

(1) If any surveyor commits even the smallest negligence in measuring tie line or while plotting it, inaccuracy in next traverse stations located further ahead and the locations of details will increase progressively.

(2) As the consequence of not dividing the area into triangles, its area has to be found out by some other method.

⇒ इस चित्र को वाइट चार्ट पर बनाना है, फाइल में नहीं।, (चार्ट के दूसरी तरफ)

B.A/B.Sc - Part-I[st] (Geography) सर्वे-चार्ट



- सर्वेक्षण क्षेत्र का मानचित्र

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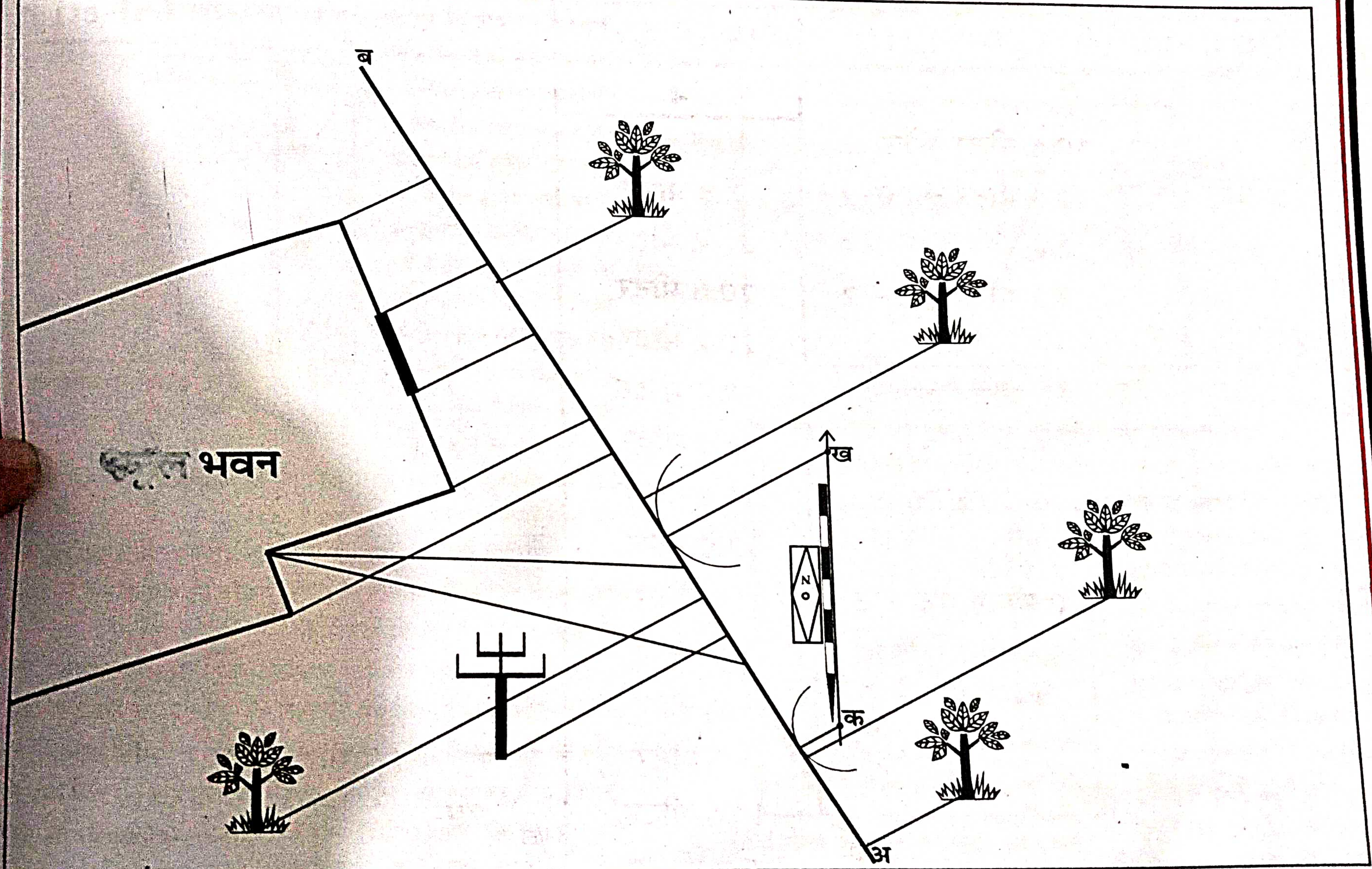

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	ब	
10.6 मीटर कोना-2	10.8 मीटर	
12.6 मीटर कोना-2	7.8 मीटर	
2.8 मीटर कोना-4	23.6 मीटर	
3.2 मीटर द्वार - 2	20.8 मीटर	
	20.2 मीटर	वृक्ष-5 - 4.4 मीटर
3.6 मीटर द्वार - 1	18.4 मीटर	
4.0 मीटर कोना - 3	15.6 मीटर	
9.4 मीटर कोना - 1	14.4 मीटर	
	13.0 मीटर	वृक्ष-4 - 9.2 मीटर
13.0 मीटर वृक्ष - 3	9.8 मीटर	
6.6 मीटर खम्भा	8.8 मीटर	
	4.8 मीटर	वृक्ष-2 - 9.2 मीटर
	2.0 मीटर	वृक्ष-1 - 3.0 मीटर
	11.8 मीटर	उत्तर ↗ ख - 5.0 मीटर
	5.2 मीटर	क - 1.2 मीटर
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