(B.A/B.Sc – 5th semester)

GEO-75P-302- Practical-I

(Geography)

Code of Course	Title of the Course	Level of the Course	Credits of the Course
GEO-75P-302	Practical-I	7	2
Types of the Course	Delivery type of the Course		
Major	60 contact hrs- Laboratory lectures and field study including diagnostic and formative assessments during lecture hours		
Prerequisites	Central Board of Secondary Education or Equivalent		
Objectives of the Course	To make the students understand about the relief features through scale and relief representation techniques.		

*** Note: - 1. Each practical batch of 30 students will be allotted a teaching of 4 hours per week for practical.**

2. It is compulsory for the Non-collegiate students to attend 48 hours practical training camp. One batch of practical training camp will comprise of maximum 30 students per batch.

Duration- 4 Hours **Max. Marks- 10+40**

Min. Marks- 4+16

Pattern of Examination	Bifurcation of Marks	Time
Written Test	20	2 Hours
Field Survey and Viva-Voce	7+3	2 Hours
Record Work and Viva-Voce	7+3	

**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*

अतिरिक्त कुलसचिव
राजस्थान विश्वविद्यालय, जयपुर

examinations.

2. *There will be 6 questions (3 questions from each unit) in written paper out of which student have to compulsorily attempt 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

Projection- Definition, Importance, Earth's Grid System and Scale of Projection, Classification-Conical Projection (One Standard, Two Standard, Bonne's, Polyconic), Cylindrical (Equal Area, Equidistant, Gall's, Mercator's)

प्रक्षेपण- परिभाषा, महत्व, पृथ्वी की ग्रिड प्रणाली और प्रक्षेपण का पैमाना, वर्गीकरण- शंक्वाकार प्रक्षेपण (एक मानक, दो मानक, बोन्स, पॉलीकोनिक), बेलनाकार (समान क्षेत्र, समदूरस्थ, गेल्स, मर्केटर)

Unit –II

Plane Table Survey- Introduction and Instruments, Process of Surveying, Methods of Surveying (Radiation and Intersection), Traversing (Open and Closed).

समतल तालिका सर्वेक्षण- परिचय और उपकरण, सर्वेक्षण की प्रक्रिया, सर्वेक्षण के तरीके (विकिरण और प्रतिच्छेदन), ट्रैवर्सिंग (खुला और बंद)।

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.
- Robinson, A.H. (2000). Elements of Cartography. U.S.A.: John Wiley& Sons.
- Sarkar, A. K. (2005). Practical Geography: A Systematic Approach. Calcutta: Oriental Longman.
- Sharma, J. P. (2010). Prayogik Bhugol. Meerut: Rastogi Publishers.
- Singh, R.L. and Dutt, P.K. (2010). Elements of Practical Geography. New Delhi: Kalyani Publishers.

Course Learning Outcomes:

By the end of the course, students should be able to the importance of projections for various countries and the importance of survey.

B.A./B.sc 5th Sem.

Geography

Practical Examination

M.M 20. P-A Time 2:00 Hours

प्रत्येक इकाई में से दो दो प्रश्न का चयन करते हुए कुल चार प्रश्न हल करें।

(Four questions are to be solved selecting two questions from each unit)

Unit-1

प्रश्न 1 प्रक्षेप की परिभाषा देते हुए, पृथ्वी की ग्रिड प्रणाली को समझाइए !

(Define of projections definition, Explain Earth gird system)

प्रश्न 2 निम्नलिखित विवरण के आधार पर एक मानक अक्षांश वाला साधारण शंकु प्रक्षेप बनाइये

मापनी 1:125,000,000 मानक अक्षांश 45 ' उत्तर क्षेत्र का विस्तार 0' से 75' उत्तरी अक्षांश तथा 60'

पश्चिम से 60पूर्वी देशान्तर, अंतराल 15'

(Conical projection construction-One standard parallel)

प्रश्न 3 1:350,000,000 मापनी एवं 30' अंतराल पर संसार का मानचित्र बनाने के लिए एक बेलनाकार

समक्षेत्र प्रक्षेप की रचना किजिए।

(Cylindrical projection Construction: equal are)

Unit -2

प्रश्न 4 प्लेन टेबल सर्वेक्षण के उपकरणों का सचित्र वर्णन कीजिए!

(Plane table survey Explain Req. instruments with diagram)

प्रश्न 5 प्लेन टेबल सर्वे की विकिरण या अरीय विधि को समझांइए !

(Plane table survey Explain Radiation method)

प्रश्न 6 प्लेन टेबुल सर्वेक्षण की प्रक्रिया का वर्णन किजिए?

(Plane table survey Explain Survey operation)

B.A/B.sc- Semister 5th

Geography

Practical Examination

M:20 P-B Time 2:00 H

प्रत्येक इकाई में से 2-2 प्रश्न का चयन करते हुए, कुल 4 प्रश्न हल करने है

Choose any 4Question from each unit ,Choose any 2 Question from each unit

Unit -1

प्रश्न 1 प्रक्षेपो के वर्गीकरण को रेखाचित्र द्वारा समझाइए।

(Classification of projection)

प्रश्न 2. 20' उत्तरी से 80' उत्तरी अक्षांश तथा 60'पश्चिम से पूर्वी देशांतर के मध्य स्थित क्षेत्र का 10 अंतराल तथा 1:125,000,000 मापनी पर मानचित्र बनाने के लिए दो मानक अक्षांश वाले शंकु प्रक्षेप की रचना कीजिए। प्रक्षेप में 40' उत्तरी तथा 60' उत्तरी अक्षांश वत्तोंको मानक अक्षाश मानिये

(Conical projection Construction: two standard parallel)

प्रश्न 3, 1:300,000,000 मापनी एवं 15 डिग्री अंतराल पर संसार का मानचित्र बनाने के लिए एक बेलनाकार समदूरस्थ प्रक्षेप की रचना किजिए।

(Cylindrical equidistant projection Construction)

Unit- 2

प्रश्न 4 प्लेन टेबल सर्वेक्षण के उपकरणों का सचित्र वर्णन कीजिए

(Plane table survey Explain Instruments with diagram)

प्रश्न 5. प्लेन टेबल सर्वे की प्रतिच्छेदन विधि का वर्णन कीजिए

(Explain plane table survey Intersection method)

प्रश्न 6 प्लेन टेबुल सर्वेक्षण चक्रमण विधि का वर्णन कीजिए।

(Explain plane table survey traverse method)

B.A. / B.sc Semester- 5th

Geography

Practical Examination

M. M 20 p-c Time - 2:00 H

प्रत्येक इकाई में से दो दो प्रश्न का चयन करते हुए कुल चार प्रश्न हल करने हैं

Unit -1

प्रश्न 1 1:125,000,000 मापनीएवं 15'अंतराल। मानक अक्षांश 45' उ; क्षेत्र विस्तार 15' से 75'उतरी अक्षांश तथा 15सी पूर्व से 165सी पूर्वी देशान्तर पर संसार का मानचित्र बनाने के लिए एक बोनप्रक्षेप की रचना कीजिए।

प्रश्न 2, 1:25,000,000 मापनीएवंअन्तराल 15' क्षेत्र का विस्तार 30' से 75' तथा 0,' से 180'पर संसार का मानचित्र बनाने के लिएबहु शकु प्रक्षेप की रचना किजिए!

प्रश्न 3 गॉल का प्रक्षेप के गुणधर्म, और उपयोग लिखिए

(Writes Gall's projection properties and uses)

Unit -2

प्रश्न 4 प्लेन टेबल सर्वेक्षण की विकिरण या अरीय रेखा विधिका वर्णन किजिए

(Explain plane table Surveying Radiation method)

प्रश्न 5 प्लेन टेबल सर्वेक्षण के उपकरणों का सचित्र वर्णन कीजिए

(Explain plane table Surveying Instruments)

प्रश्न 6 प्लेन टेबल सर्वेक्षण की प्रक्रिया का वर्णन कीजिए

(Explain Plane table Surveying: Survey operation)

B.A/B.Sc-Vth Semester
Geography Practical

DATE / /
PAGE NO.:

Unit-I

1. प्रक्षेप :- परिभाषा, वर्गीकरण, महत्व ⇒ 03-09, 04-09-2025
(Projection Definition. Classification. Importance)
2. पृथ्वी की ग्रिड प्रणाली, प्रक्षेप पैमाना ⇒ 10-09-2025
(Earth's Grid System), (Scale of Projection) ⇒ 17-09-2025
3. मानचित्र - प्रक्षेप रचना :- (Construction of Map-Projections)
(A) शंक्वाकार प्रक्षेप (Conical Projection)
(i) एक मानक शंक्वाकार प्रक्षेप (One Standard) - 24-09-2025
(ii) दो मानक शंक्वाकार प्रक्षेप (Two Standard) - 03-10-2025
(iii) बोन प्रक्षेप (Bonne's Projection) - 10-10-2025
(iv) बहुशंकुक प्रक्षेप (Polyconic Projection) - 25-10-2025
(B) बेलनाकार प्रक्षेप (Cylindrical Projection) -
(i) समक्षेत्र बेलनाकार प्रक्षेप (Equal area) - 06-11-2025
(ii) समदूरस्थ बेलनाकार प्रक्षेप (Equidistant) - 11-11-2025
(iii) मर्केटर बेलनाकार प्रक्षेप (Mercator) - 19-11-2025
(iv) गॉल का त्रिविम बेलनाकार प्रक्षेप (Gall's) - 26-11-2025

Unit-II

(1) प्लेन टेबुल सर्वेक्षण - परिचय और उपकरण - 03-12-2025
(Plane Table Survey - Introduction and Instruments)
(2) प्लेन टेबुल सर्वे की प्रक्रिया :- - 09-12-2025
(Process of Surveying)
(3) प्लेन टेबुल सर्वे की विधियाँ - (Methods of Surveying)
(i) अरीय या विकिरण विधि - (Radiation Methods)
(ii) प्रतिच्छेदन विधि - (Intersection Methods) - 10-12-2025
(iii) चंक्रमण या मालारेखा विधि - (Traverse) - 17-12-2025
(i) खुला (open) - 18-12-2025
(ii) बन्द (closed)

Teacher's Signature..............

Unit-I

Map-Projection

Q.1 Define of projections definition. Explain Earth gird system.

DEFINITION OF MAP-PROJECTION

Projection literally means to show by projecting a picture contained on a transparent paper or film on a wall or a drapper of cloth with the help of light. For example, the picture that we watch on a screen of cinema, is infact, a projection of picture shot on a film, which has been projected on screen with the help of a projector. Though every map-projection is not made with the help of light, term projection has gained so much popularity that the net of latitudes-longitudes made with geometrical method are called with this very name.

According to **F.J.Monkhouse**[1], A map projection is 'the representation of the earth's parallels and meridians as a net or graticule on a plane surface.'

John Bygott[2] said 'A map projection is some method of representing on a sheet of paper the lines of latitude and longitude of the globe.'

According to **J.A.Steers**[3] 'A map projection is a means of representing the lines of latitude and longitude of the globe on a flat sheet of paper.'

According to **Erwin Raisz**[4] 'A projection can be defined as.... any orderly system of parallels and meridians on which a map can be drawn.'

Studying the definitions given above, we reach to the conclusion that in order to making a map of the spherical earth or its large part on paper or other plane surface land-grid or net of latitude-longitude of the globe drawn with the help of light or any geometrical method is called map projection.

NECESSITY OF MAP-PROJECTIONS

The shape of our earth is like an oblate ellipsoid but the difference between earth's equatorial and polar radius is so little (21.5 km) that its shape is taken as approximately spherical or orange-shaped. This spherical shape of the earth can be seen and shown correctly only by a globe, neverthless the use of globes is less in comparison to maps, for the following reasons—

(1) The total part of the earth can not be seen together in a single sight on a globe.

(2) Measuring distances between two places is difficult.

(3) It is not possible to keep globe folded like map or put in a book etc.

(4) No globes of smaller parts of the earth can be made separately. So, if we wish to show a small part of the earth on a large scale, we shall have to make the globe's size so big that its use will become impossible.

(5) As compared to maps, the maintenance of globes and carrying them from one place to another is very difficult.

It is clear from the description given above that map is more useful than globe. In maps earth's spherical shape is represented on a plane surface of paper etc. For constructing maps, therefore, it is necessary to make a net of latitudes and longitudes or projection on a plane surface of paper so that the details of the globe could be marked at their proper places. It is worth mentioning here that as the skin of an orange can not be totally spread on a flat surface without cutting it at various places, in exactly the same way, it is difficult to spread flat the spherical surface of the globe. That is the reason why any projection is not totally perfect in its merits. So, according to need, any one of the merit of true area, true shape or true direction projection is constructed.

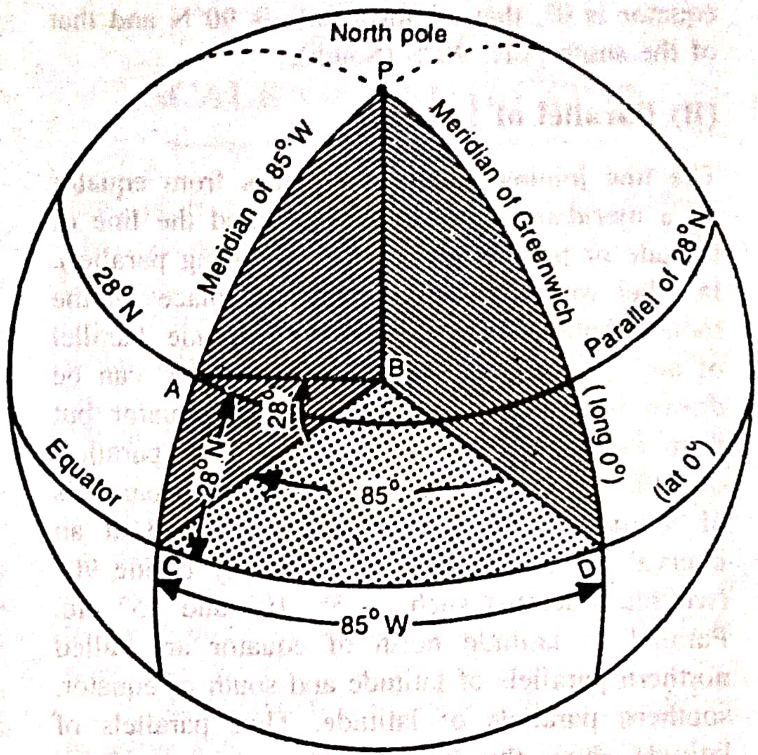

Fig 1

THE EARTH GRID

In the construction of projection according to a given scale, globe's net of latitudes and longitudes or the earth grid is drawn. It is therefore, necessary to understand well the net of latitudes and longitudes marked on the globe of the earth before studying construction-method of projections.

(A) Latitude

Angular distance of any place on a meridian (longitude) measured from the equator is called the latitude of that place. For example, in Fig.1 the angular distance of 'A' point from the equator on the arc of 85° west meridian is 28°. As 'A' point is located north of the equator, the latitude shall be called 28°N (North). The latitude of the equator is 0°, that of north pole is 90°N and that of the south pole, 90°S (South).

(B) Parallel of Latitude

The line joining equidistant places from equator on a meridian on the globe is called the line of latitude or parallel of latitude (all being parallel). In other words, circles representing places of the same latitude are called parallel of latitude. Parallel of any degree of latitude between 0°-90° can be drawn both north and south of the equator but from the view of simplicity, all possible parallels of latitude are not drawn and only such parallels of latitude are drawn according to need at an interval of such degrees as may fully divide 90° (without fraction) such as 5°, 10° and 15° etc. Parallel of latitude north of equator are called northern parallels of latitude and south of equator, southern parallels of latitude. Thus parallels of latitude show the location of a point north or south of equator. There are the following main characteristics of the parallels of latitude—

(1) All parallels of latitude are made parallel and mutually equidistant.

(2) All parallels of latitude intersect meridians at right angle except poles (being dots only and not circles).

(3) Parallels of latitude are always in the form of due east-west lines.

(4) Only the equator is the great circle (showing the circumference of the earth and thus is the biggest) and all remaining latitudes are small circles.

(5) The real length of parallels of latitude begins to get reduced from the equator towards the pole.

(6) Parallels of poles are in the form of dots.

(7) Each point on globe is located on one or the other parallel of latitude except poles.

(8) The equator which is a parallel of latitude is at equal distance from both the poles. The upper half part of the globe between the equator and the north pole is called the **northern hemisphere** and another half part south of equator is called the southern **hemisphere** (Fig. 2 A).

(C) Longitude

The longitude is a distance measured in degrees between the prime meridian (0° longitude) and a place on the arc of latiitude passing through that place. According to an international seminar held in 1884, almost all countries of the world, the meridian or longitude passing through Greenwich

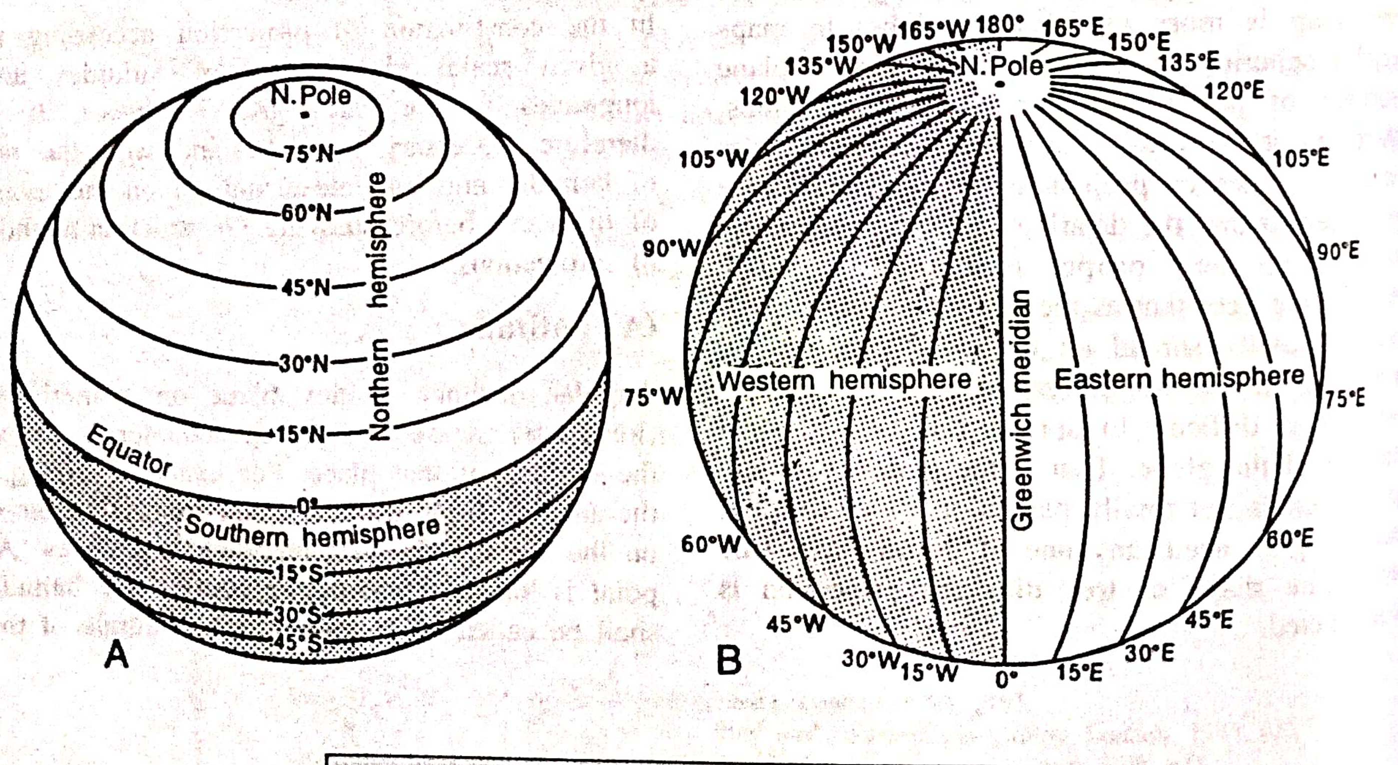

Fig 2. A. Parallels of latitudes, B. Longitudes or Meridians.

Royal Observatory close to London (England) has been adopted as prime meridian. Taking this longitude as 0° longitude, degrees of other longitudes both east and west of it are calculated. The degrees of longitudes east or west of 0° longitude can be between 0° to 180°. In Fig. 1, CD is an arc between A point on which PC longitude passes and 0° longitude (Greenwitch meridian) having a distance of 85°W (west). So the longitude (or meridian) is 85°W.

(D) Meridians

Imaginary lines joining places of the same longitude drawn between the two poles and therefore, north-south in direction are called meridians, polar circles or longitude. East and west meridians together make a great circle (the biggest circle that can be drawn on the earth and represents earth's circumference). The ends of these longitude merge at the north and the south poles. Thus, two longitudes located on just opposite sides of the earth make a full great circle. As there are 360° in a circle, the total number of longitude on the earth drawn at 1° interval is 360. Among these 360 longitudes, 180 are west of the prime meridian and remaining 180 are east of the prime meridian. Longitudes located in the east are called **East longitudes** and those in the west are called **West longitudes.** 180° E and 180°W longitude is one and the same longitude. The half part of the earth between 0°-180° E is called the eastern hemisphere and between 0°-180° W is called the western hemisphere (Fig.2B). Salient other features of longitudes are as follows—

(1) All longitudes are in due north-south direction and their length is equal.

(2) Distance between two longitudes is maximum at the equator and decreases north and south of the equator to become zero at poles.

(3) Many longitudes can be drawn on globe but in view of simplicity, generally they are drawn at such an interval of degrees as divides 180° fully.

(4) A longitude gives the perception of the location of a place east or west of the prime meridian.

(5) Each point on globe has one or the other longitude except poles.

SCALE OF PROJECTION

Each projection is constructed on a given scale. The average radius of the earth is 6,367·75 km (average of equatorial and polar radius) i.e. 636,775,000 cm or 3,956·75 miles i.e. 250,699,680 inches. But for the ease of calculation, these figures are taken as 635,000,000 cm or 250,000,000 inches (rounded off), the radius of the reduced earth according to given scale is calculated for making map projection, the method of which is given by one example below.

Suppose, the radius of the reduced earth is to be found out on a scale of 1/125,000,000, now,

∵ 125,000,000 cm represent 1 cm (according to above R.F.)

∴ 635,000,000 cm (earth's radius) will be represented by

$$= \frac{1 \times 635{,}000{,}000}{125{,}000{,}000} = 5{\cdot}08 \text{ cm}$$

If radius is to be found out in inches, then the radius of the reduced sphere of the earth = 250,000,000/125,000,000 = 2 inches. Thus, it is clear from the above example that if the radius of the reduced sphere of the earth is to be found out, then the denominator of the given R.F. is divided by the actual radius of the earth (250,000,000 inches or 635,000,000 cm).

Q·2 CLASSIFICATION OF MAP-PROJECTION

Map-projections are classified according to three bases—(i) According to the use of light, (ii) According to construction method, and (iii) According to merit.

(A) Classification of Projection According to the Use of Light

According to light, map projections are divided into the following classes—

1. Perspective map-projections. Projections constructed with the help of light are called perspective map-projections. In the construction of these projections, light is cast from a certain point on the net of parallels of latitude and meridians to tranfer its shadow on a plane surface. Thereafter, permanent picture of these shadows is acquired by pencil or photograph. Thus, the meaning of 'projection' in general parlance, perspective map-projections express that very meaning. These projections are also called geometrical projections.

2. Non-perspective projections. Non-perspective projections are those projections which are made with necessary modifications in perspective projection by mathematical methods. In these projections the method of construction and their limitations depend on purpose of map-projection. As these projections can be made, true-shape, true-area or true-direction according to need, these projections, therefore, are more important and useful in comparison to perspective map-projections.

(B) Classification of Projections According to the Method of Construction

On the basis of construction-method, map-projections can be divided into the following four classes—

1. Conical projections. Conical projections are based on the principle of transferring the earth-grid (network of latitudes and longitudes) on a sheet of paper shaped into a cone and thereafter spreading the sheet of plane surface (Fig. 3A). In the ocnstruction of these projections it is supposed that this cone of paper is kept on globe in such a way that it touches one selected latitude (except equator or poles, which are impossible situation) and the top of the cone is located exactly over the pole on some point of extended line of polar axis. In other words, the earth's centre, pole and the top of the cone are on one straight line. The parallel of latitude that the cone touches is known as the **standard parallel**. On the spread-out plane surface of this cone i.e. on the conical map-projection, the standard parallel is an arc of a circle and the longitudes are radiating lines at equal interval, which divides the standard parallel into arcs of equal length. Other latitudes are arcs of concentric circles. Scale is true, i.e. accurate at the standard parallel. The map of the whole world can not be drawn on these projections, but these projections are especially useful in making maps of temperate zones.

2. Cylindrical projections. The plane paper reshaped into a hollow cylinder and the earth-grid projected on it, when spread flat, then network of latitudes and longitudes thus acquired is called cylindrical projection (Fig. 3B). In normal position, this cylinder touches the equator and its axis is positioned at the polar axis of the earth. But in tranverse position, the cylinder of paper touches any of the great circles comprising of two antipodal (one in front and other on just the opposite side of the globe) latitudes; such as 0° longitude and 180° longitude. The characteristics of the cylindrical projections of normal position are as follows—

(1) All parallels of latitude are equal in length, straight and parallel lines. The scale therefore, is not true on all other latitudes except the equator.

(2) All longitudes are equal in length and straight parallel lines and distance between successive latitudes is equal.

(3) Each longitude intersects parallels of latitude at right angle (90°), consequently the shape of cylindrical projection is rectangular.

(4) The distance between parallel of latitudes is ascertained with mathematical methods according to the purpose of the projection.

Scale at the equator being true (accurate), cylindrical projection is especially useful for making maps of equatorial regions. Apart from this, Mercator's projection (cylindrical) is useful for making true-direction and true-shape maps of the world.

3. Zenithal projections. Network of latitudes and longitudes (graticule) projected on a plane flat surface touching the globe at one point results in zenithal projections (Fig. 3C). The point of zenithal projection that touches projection-surface (a plane paper) is called **centre of projection** and the point of the source of light is known as **eye point** or **point of origin**. The plane of the projection can touch a point on the equator, pole or between these two. Eye point can be located at the centre

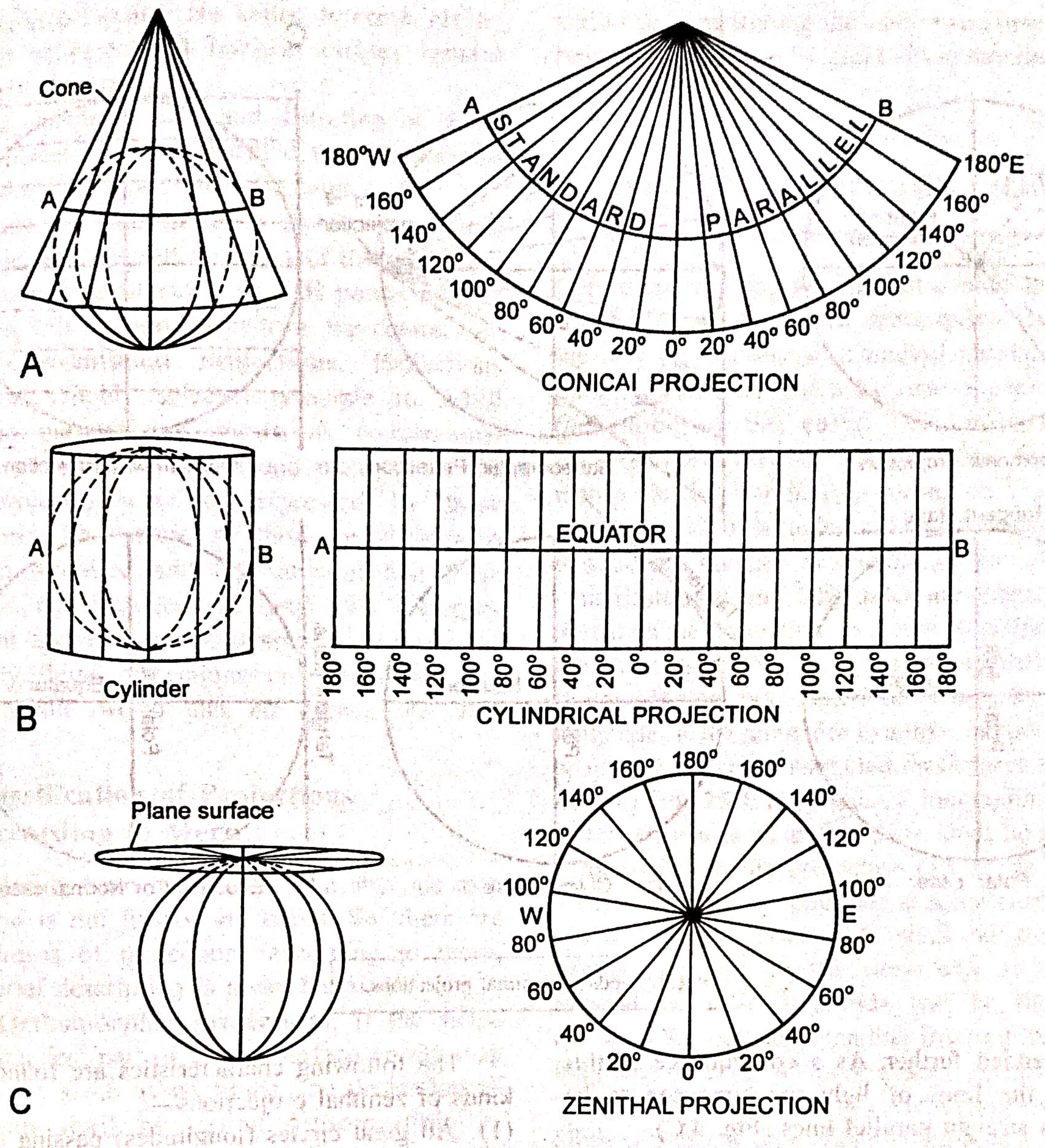

Fig 3

of the globe or anywhere at its circumference, or outside the globe at infinity. But in all cases centre of projection, centre of globe and eye point are on a straight line and the plane of projection touches the globe making right angle at this straight line.

On the bases of different positions of eye point and projection-plane, zenithal projections can further be divided in the following sub-classes—

(a) According to the position of eye point. According to the position of eye point or the source of light, zenithal projections have three kinds—

(i) Gnomonic projections. While constructing this kind of projections, the position of eye point is assumed at the centre of the globe (Fig. 4 A).

(ii) Stereographic projection. In stereographic projections, the eye point is assumed to be positioned at a point diametrically opposite to projection-centre (i.e. the point the projection-plane touches the globe) (Fig. 4 B).

(iii) Orthographic projection. In these projections, the eye-point is positioned at infinity on the line joining projection-centre and centre of

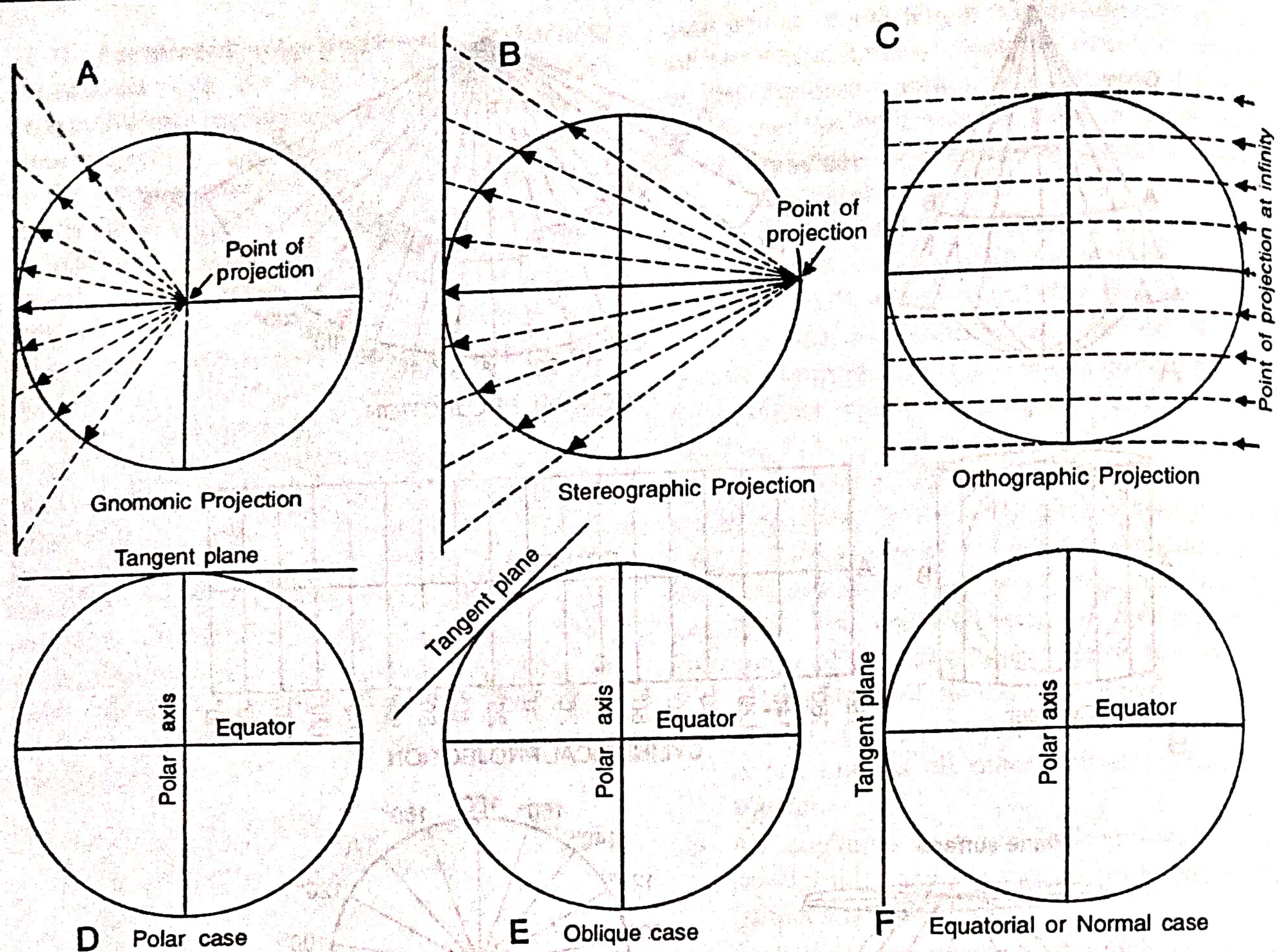

Fig 4. Kinds of zenithal projections.

globe extended further. As a consequence of this situation, the lines of light are supposed to be coming in straight parallel lines (Fig. 4 C).

(b) According to the position of tangent plane. According to the position of tangent plane also, zenithal projections have three classes—

(i) Polar zenithal projection. In these projections tangent plane touches the globe at poles (Fig. 4 D).

(ii) Oblique zenithal projection. Tangent plane touches the globe at any one point between the equator and the poles in such projections (Fig.4E).

(iii) Equatorial zenithal projection. Tangent plane in these projection touches any one point on the equator (Fig. 4 F).

The following characteristics are found in all kinds of zenithal projections—

(1) All great circles (longitudes) passing through the centre of zenithal projections are shown by straight lines. In other words, each straight line drawn from the centre of projection is a great circle (great circle is the greatest possible circle that can be drawn on the earth's surface : equator and all longitudes are great circles) and their bearing or azimuth (direction) are accurate. In this projection, bearings or azimuths can be measured from central meridian.

(2) Points located at equal distance from the centre of projection are also equidistant on map. The circle made by joining these

equidistant points are called **horizon circle.** The shape of all horizon circles remain circular on map.

(3) The change in scale and distortion of shape of places at equal distance from the centre of the map also remain the same.

(4) If any one hemisphere is shown on zenithal projection, the outer margin of the projection will be a great circle and all points located on it will be equidistant from the centre.

4. **Conventional projections.** Projections drawn on suitably selected principle to fulfill a certain purpose are known as conventional projection. Generally understood meaning of the term 'projection' is not expressed by these projections. The shape of these projections is so much modified and conventional that these can not be included in any one category described above. Some conventional projections, especially those projections on which the map of the whole world can be drawn, are very useful.

(C) Classification of Projections According to Merit

It has already been made clear that any one map projection is not full of all merits. So, there are three classes of projections according to merit, whose brief description is given below—

1. **Orthomorphic projections.** If the shape of any smallest part of earth's surface on the map remains the same as on globe, the projection of such map shall be called orthomorphic or conformal. Mercator projection is the best example of orthomorphic projection.

2. **Homolographic projection.** The area on maps made on homolographic projection remains true or correct everywhere. In these projections scale is increased on one side and reduced on the other, as a result of which the area of any area remains true but there is change in its real shape. Mollweid's projection and Sanson-Flamsteed's sinusoidal projections are the examples of homolographic projections.

3. **Azimuthal projection.** Direction remains true in maps made on Mercator's projection and Zenithal projections. True direction means that the direction of a line joining two points on the map and of the line joining the same two corresponding points on the globe by great circle remains exactly the same.

CONICAL PROJECTIONS

Before constructing any kind of conical projection, four facts must be known necessarily—(i) Scale of the map-projection, (ii) Standard parallel i.e. that parallel of latitude which the cone of paper touches the globe of the earth, (iii) Latitudinal and longitudinal spread of the area for which map-projection is to be constructed, and (iv) Interval of the network of latitudes and longitudes in degrees, that is, the number in degrees at the interval of which latitudes and longitudes are intended to be drawn on the projection. In a conical projection that longitude should be selected as central meridian (longitude) on both sides of which the number longitudes is the same. For example, suppose conical projection is to be constructed for the area extending from 15°E to 75°E longitudes. If longitudinal interval is 15°, then it is clear that there shall be a total of 5 longitudes in the projection (15°E, 30°E, 45°E, 60°E and 75°E). So longitude at serial number three i.e. 45°E from either side shall be selected as central meridian. In the same way at the same interval (15°), 0° longitude will be the central meridian for the area extending from 60°W to 60°E longitude and 15°W for the area extending from 75°W to 45°W. Method of constructing some main kinds of conical projections is explained below.

(A) Simple Conical Projection with One Standard Parallel

In this projection, cone-shaped paper touches globe at any one latitude which is called standard parallel. Any circle of latitude except the equator and the poles can be selected as standard parallel according to the need. Its construction is very simple in comparison to other conical projections. This can be explained with the following example— Question ÷ 1

~~Example~~ 1 : On the bases of details given below construct one standard parallel simple conical projection :

Scale, 1 : 125,000,000; standard parallel, 45°N; extention of area, 0° to 75°N latitude and 60°W to 60°E longitude; interval, 15°.

Method of construction. According to the given scale, the radius of the reduced sphere of the earth, i.e.,

$$R = \frac{\text{Actual radius of the earth}}{\text{Denominator of R.F.}}$$

$$= \frac{635,000,000}{125,000,000} = 5.08 \text{ cm}$$

Now, according to Fig. 5 A, draw quarter of a circle ABO with radius (R) 5·08 cm. From point O of OB line, draw an angle DOB equal to the given interval of 15° latitude and angle COB equal to the standard parallel of 45°N latitude. Raise a tangent or right angle at O which intersects extended OA at P point. Now draw an arc with centre at O and radius of BD which intersects OC line at E point. From this E point draw a

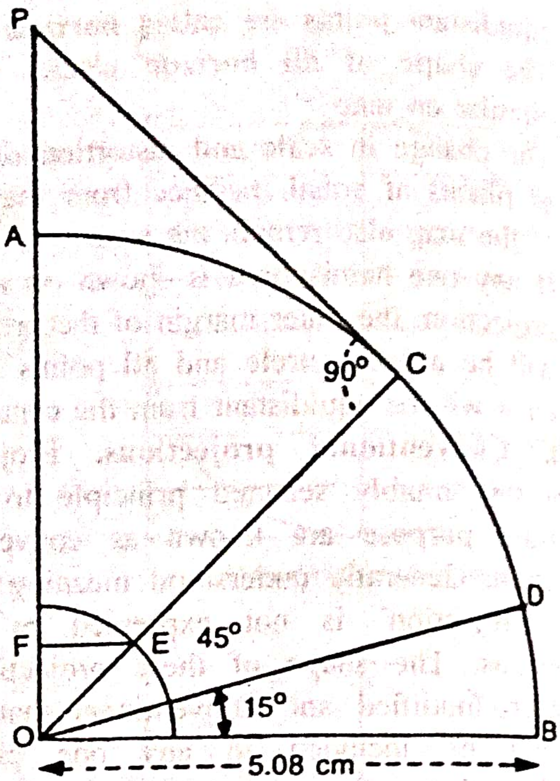

Fig 5 A.

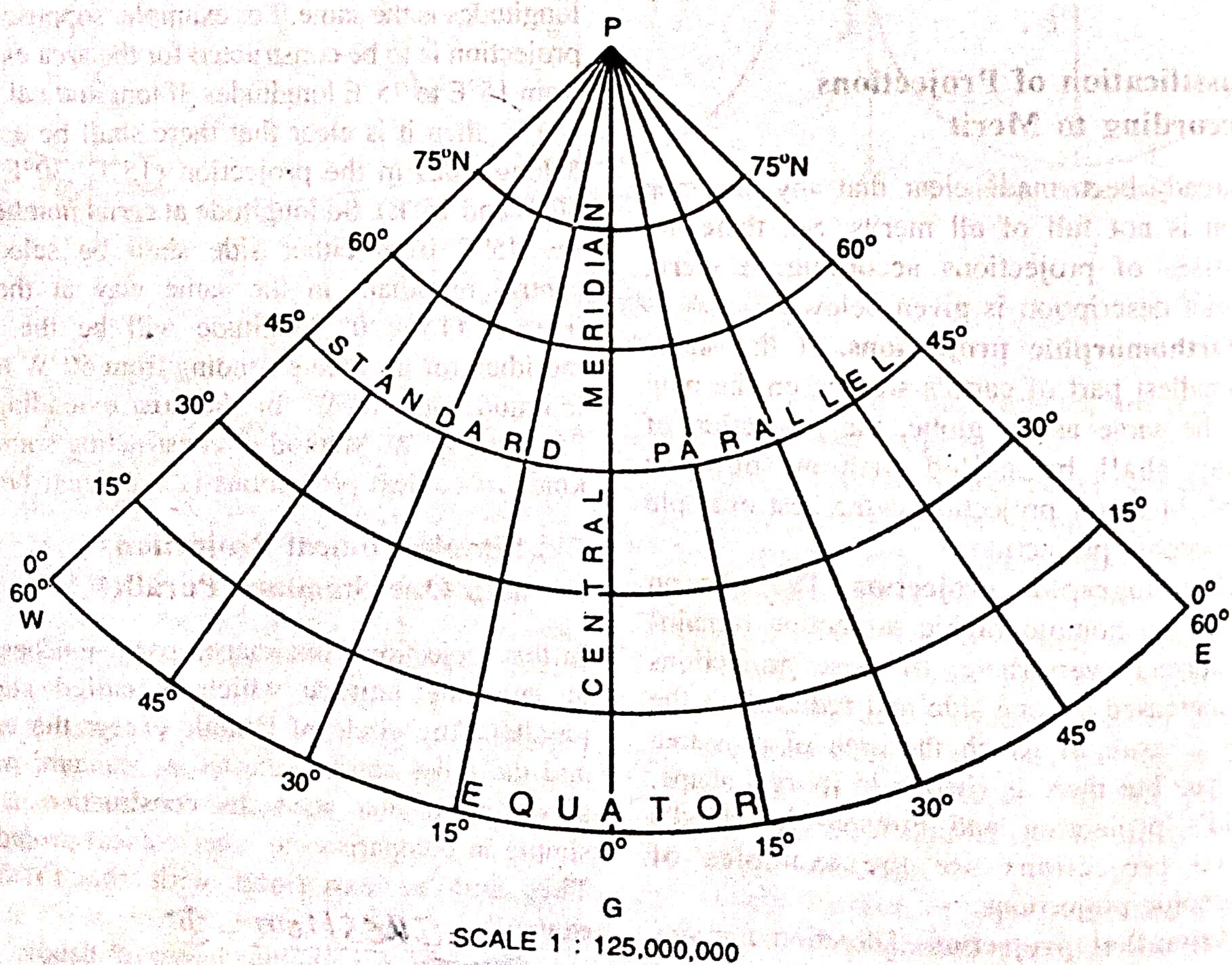

Fig 5. B. Simple conical projection with one standard parallel.

perpendicular EF on OA line which can also be drawn by making EF line parallel to OB line.

For constructing the projection, draw straight perpendicular line PG which will represent central meridian in the projection and according to the question, its value will be 0° longitude (Fig. 5 B). Now draw an arc with centre P and radius equal to PC which will be 45°N latitude, the standard parallel. For drawing other remaining latitudes, mark with BD distance at central meridian 2 points towards P and 3 points towards G. From centre P, draw areas passing through these 5 points and as in figure, write the latitudes they show.

Now mark 4 points on both sides of central meridian at standard parallel with distance of EF. Join all these points with P by straight lines. These straight lines represent longitudes of the projection. Write the degrees of these longitudes to complete the construction.

Identification

(1) All latitudinal areas or circles are concentric circles drawn from pole as centre and their spacing is equal.

(2) All longitudes are straight lines which merge at the top point of the cone.

(3) Pole is represented by an arc in the projection.

(4) Latitudes and longitudes intersect each other at right angle.

(5) Distance between longitudes increases from pole towards equator, but their distance at any one latitude remains the same.

Properties

(1) Scale is true (accurate) at the standard parallel, but does not remain true at other circles of latitudes.

(2) Scale is true at all longitudes. So this projection is also called **equidistant conical projection.**

(3) On the map made on this projection, farther a place from the standard parallel, more inaccurate the scale at the latitude of that place. So, with increasing distance from standard parallel, distortion in shape and area also increases in such far away areas.

(4) Shape and area at standard parallel is represented true to a great extent.

(5) Map of only one hemisphere (northern or southern) can be made on this projection.

Use. This projection is often used to make maps of small countries located in middle latitudes (temperate zone). In addition, maps of such areas whose latitudinal extent is limited are also made on this projection.

(B) Conical Projection with Two Standard Parallels

This projection is a modified form of one standard simple conical projection. The construction of this projection is based on the premise that paper-cone intersects globe along two circles of latitudes entering into the globe partially. Both of these latitudes are considered standard parallels. In case the standard parallels are not given in a question, then two such latitudes should be chosen as standard parallels as contain 2/3 part of the latitudinal extent of the area to be mapped.

Que [redacted] 2 : Construct a conical projection with two standard parallels for an area located between 20°N to 80°N latitude, 60°W to 60°E longitude with 10° interval (both latitudinal and longitudinal) on a scale 1 : 125,000,000. Take 40°N and 60°N latitudinal circles as standard parallels.

Method of construction. According to the given scale the radius of the sphere of reduced earth i.e.,

$$R = \frac{635,000,000}{125,000,000} = 5.08 \text{ cm}$$

Now according to Fig. 6 A draw a quadrant (quarter of a circle) ABO with a radius of 5.08 cm. Draw at O point ∠EOB of 10° which is the interval of the projection and also ∠COB of 40° and ∠DOB of 60° which are two standard parallels.

Draw a quadrant with the distance of arc EB at O point which intersect OC and OD at F and G respectively. Drop perpendiculars from F and G points on OA line (or draw lines parallel to OB from F and G upto OA).

As shown in Fig. 6 B, draw a perpendicular and mark C′ D′ distance equal to CD in Fig.6A.

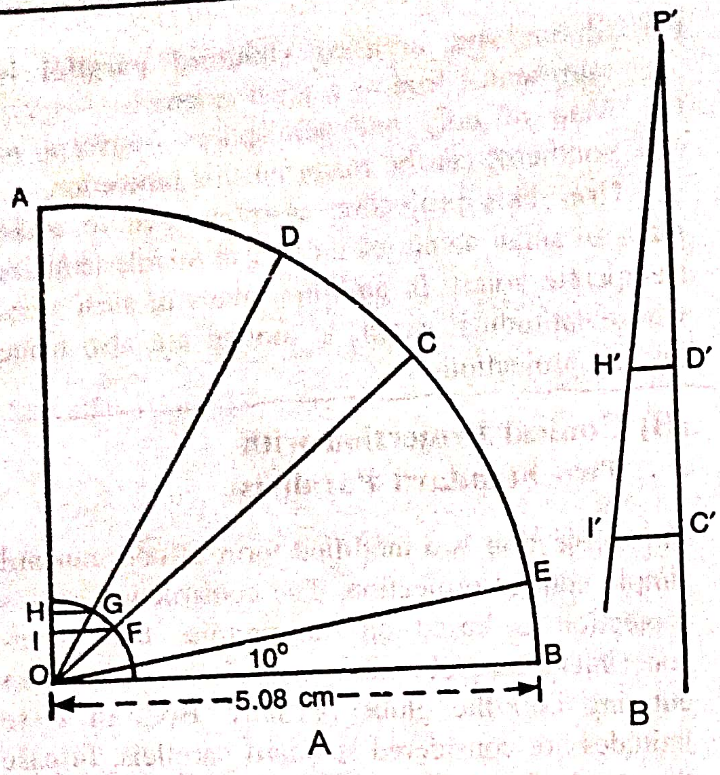

Fig 6 A., B.

Make C′ I′ and D′ H′ perpendiculars equal to FI and GH respectively. Joining I′ and H′ points, extend it to upper side which intersects C′ D′ extended line at point P′. In the projection, arcs drawn with P′ as centre and P′ C′ and P′ D′ as radius will represent latitudes 40°N and 60°N standard parallels.

Drop straight vertical line P′ G for making projection (Fig. 6 C). Draw standard parallels of 40°N 60°N with P′ centre and P′ C′ and P′ D′ as radii respectively. Find out the middle point of both standard parallels on the central meridian. Its distance from either of the two standard parallels will be equal to EB and concentric circle passing through it will be circle of 50°N latitude. Mark points with EB length on central meridian like in example 1 in required number according to latitudinal extent of the map. Draw arcs from centre P′ passing through marked points on the central meridian. Make six marks on both sides of the central meridian equal to the distance of GH and join these points to P′ with straight lines which shall represent longitudes in the projection. Remember that in case marks are made on 40°N standard parallel, then F1 shall be the distance for making marks. Complete

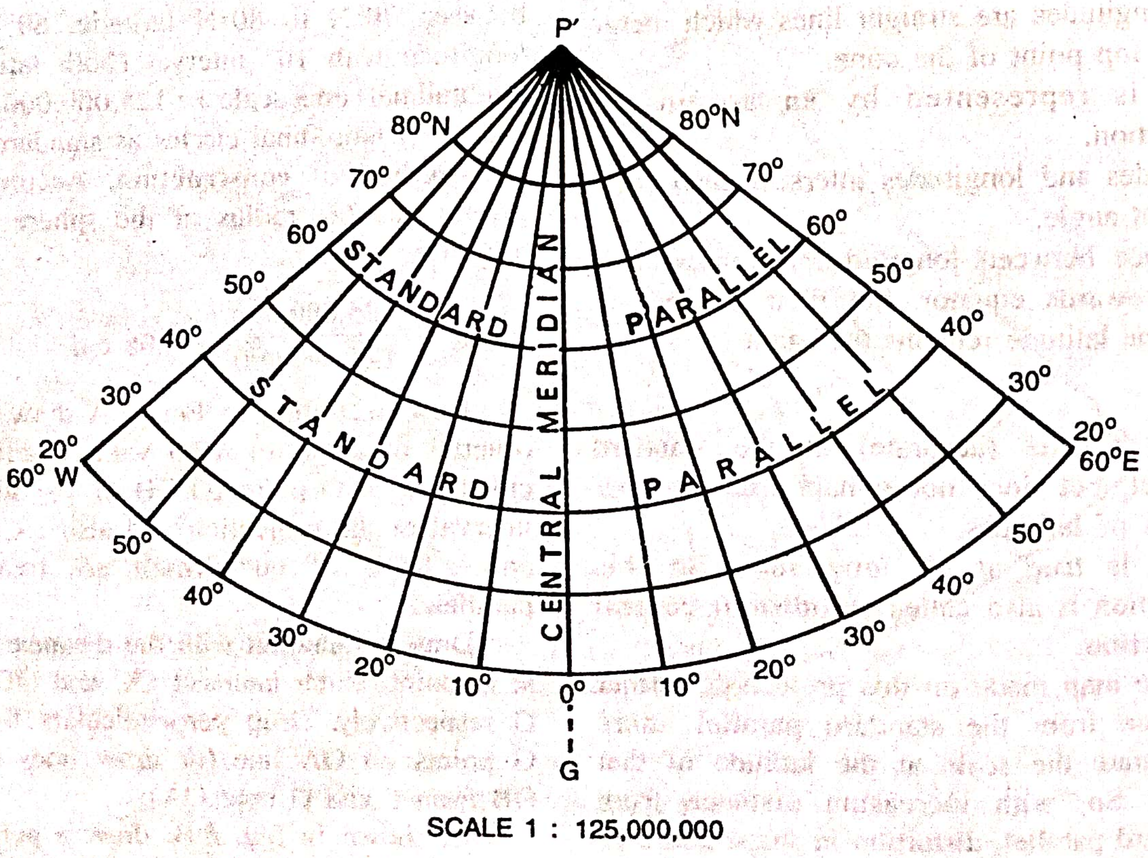

Fig 6 C. Conical projection with two standard parallels.

construction of projection by writing degrees on latitudes and longitudes and also its scale as R.F. just beneath it.

Identification

(1) All circles of latitudes are arcs of concentric equidistant circles.

(2) All longitudes are straight lines from the top of the cone.

(3) Pole is shown by an arc on the projection.

(4) Parallels of latitude and lines of longitudes intersect each other at right angle.

(5) Spacing of longitude decreases towards the pole but at any one parallel of latitude interspacing of longitudes is equal.

Properties

(1) Scale is true at both the standard parallels, but scale is not true at other parallels of latitudes.

(2) Scale is true at all the longitudes.

(3) As scale remains true only at standard parallels and all longitudes, this projection is, therefore, neither orthographic (true shape) nor homolographic (true area) projection.

(4) As there are two standard parallels in this projection, it is more accurate in comparison to simple conical projection with one standard parallel.

(5) The map of the whole world can not be made on this projection.

(6) Since pole is shown by a point in this projection, it is not suitable for making maps of polar regions.

Use. Since the shape and area of these projections begins to increasingly distort as the distance from standard parallels increases, so maps of countries with large latitudinal extent are not made on these projections. In the atlases of Europe and Australia, this projection is used very much for making maps of their countries or their provinces.

(C) Bonne's Projection

This is a modified conical projection which was made first by **Rigobert Bonne.** Being an equal-area projection, this is also called **Bonne's equal-area projection.** Its method of construction is very much similar to that of simple conical projection with one standard parallel. The only difference is that whereas only standard parallel is equally divided in simple projection with one standard parallel to draw longitudes, it is necessary to equally divide all parallels of latitudes for drawing longitudes in Bonne's projection. The graticule of Bonne's projection can be compared with Samson-Flamsteed homolographic projection.

Example 3 : Draw a graticule of Bonne's projection with the help of the following description—

Scale, 1 : 125,000,000; interval 15°; standard parallel 45°N; extension of area, 15°N to 75° N latitude and 15°E to 165°E longitude.

Method of construction. According to the given scale, radius of the reduced earth, i.e.,

$$R = \frac{635,000,000}{125,000,000} = 5.08 \text{ cm}$$

In keeping with the Fig.7A, draw a quadrant ABO of 5·08 cm radius. At point O of OB line, draw lines OC, OD, OE, OF and OG at an interval of 15°. Draw a tangent at E point which intersects extended AO line at P point. Now O

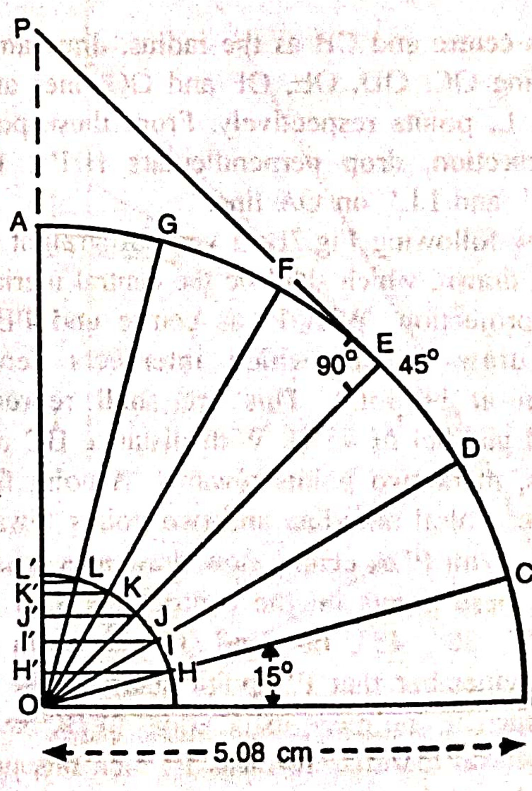

Fig 7 A.

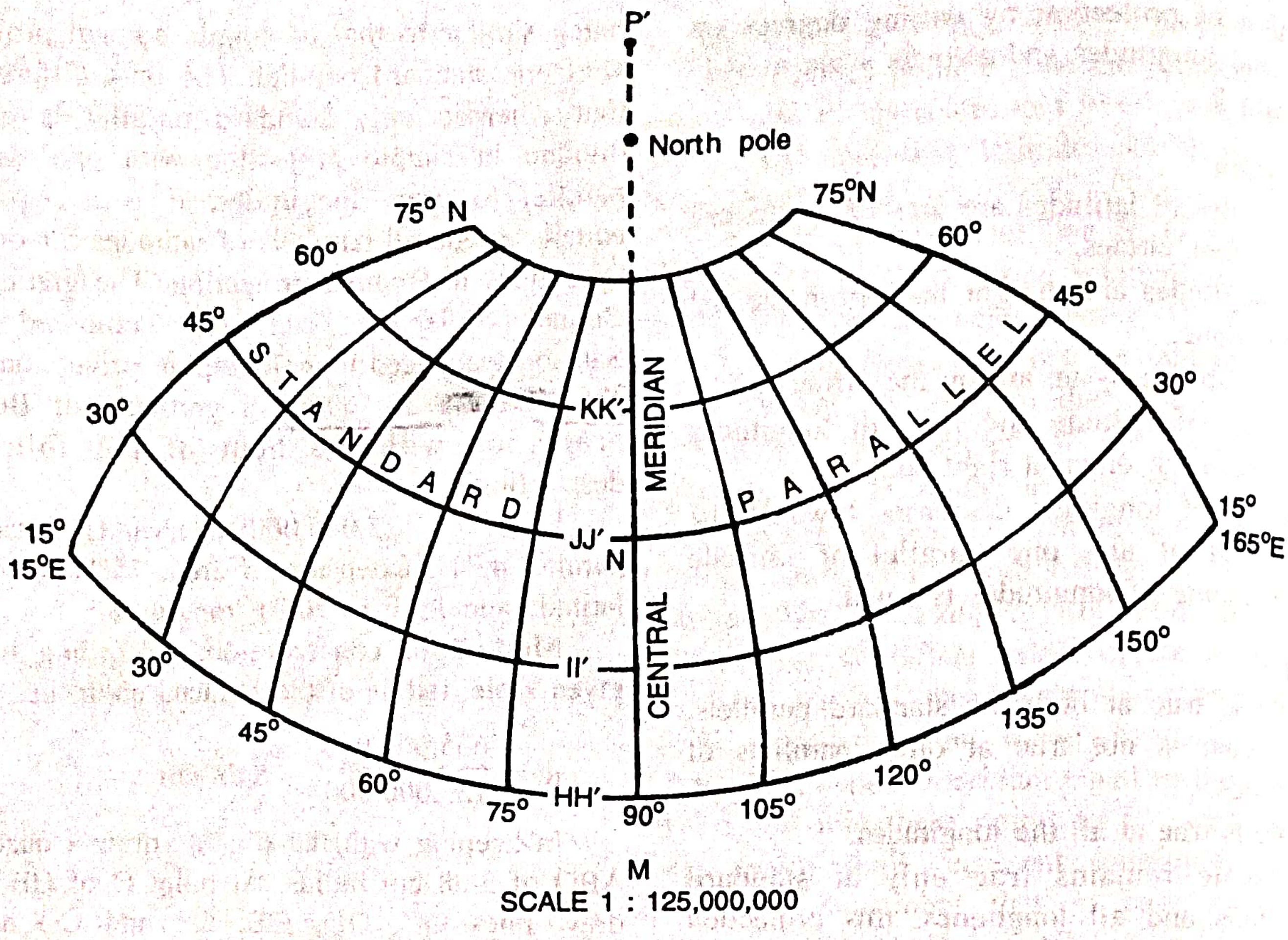

Fig 7 B. Bonne's projection.

point as centre and CB as the radius, draw an arc intesecting OC, OD, OE, OF and OG lines at H, I, J, K, L, points respectively. From these points of intersection, drop perpendiculars HH′ , II′ , JJ′, KK′ and LL′ on OA line.

Now following Fig.7B, a vertical straight line P′M be drawn, which shall be the central meridian in the projection. With P′ as centre and PE as radius draw an arc which intersects central meridian at N point. This arc shall represent standard parallel of 45°N. With distance BC on a compass, mark two points towards M point from N on the central meridian and two points towards point P′. With P′ as centre, now draw arcs passing through these points on the central meridian and write 15°, 30°, 45°, 60° and 75° N as in the figure. Remember that P′ point shall not be the pole. Infact, if one more mark equal to BC is put on the central meridian towards P′, then this point will be the north pole.

For drawing longitude divide 15° latitude by HH′ interval, 30° latitude by II′ interval, 45° latitude by JJ′, 60° latitude by KK′ and 75° by LL′ interval and mark the dividing points. As the longitudinal extent of the area is 15°E to 165°E, 90°E will be in the centre of all longitudes and hence, the central meridian. Five marks on both sides each shall be put on all latitudes. Complete drawing longitudes by joining the marks of the same serial number put on each latitude and write degrees of longitudes.

Identification

(1) All parallels of latitudes are drawn as arcs from the top of the cone as centre and therefore, they are arcs of concentric circles with equal spacing.

(2) Central meridian is a straight line and all remaining longitudes are of the shape of curves.

(3) All parallels of latitudes intersect central meridian at right angle but with increasing distance east and west from the central meridian and intersections of parallels of latitudes and longitudes become more and more inclined.

(4) As the length of all parallels of latitudes is true (correct), hence as opposed to conical projections with one or two standard parallels, pole is shown by a point.

(5) Distance between longitudes on different parallels of latitudes is equal.

Properties

(1) Scale on all parallels of latitudes and on central meridian remains true.

(2) With increasing distance from central meridian, scale on longitudes goes on increasing, as the result of which the shape of areas near eastern and western margins is very much distorted.

(3) As scale remains true at parallels of latitudes and each latitude is at true distance from adjoining latitude, the merit of equal area, therefore, remains maintained.

(4) At the most only one hemisphere can be shown on this projection.

Use. Bonne's projection is in much use for making maps of large areas like Europe, Asia, North America, South America, Australia and other large areas in atlases, but this projection is especially useful for making maps with less longitudinal extent. For example, if 70°W longitude is selected as central meridian, an ideal map of Chile can be made on it. Its reason is that alongwith true area, shape of the map also remains largely correct along central meridian. Despite increasing distortion of shape farther away from the central meridian, this projection is widely used for showing distributions and for statistical maps of middle latitudes. In addition to this geomorphological maps of France, Switzerland and Belgium are also made on this projection.

(D) Polyconic Projection

This is a modified conical projection, in which each parallel of latitude is a standard parallel. While constructing this projection the premise is taken that separate cones are kept on various parallels of latitudes. That is why this projection is called polyconic projection. Since the apex of these cones are not on the same point, parallels of latitudes are not arcs of concentric circles and longitudes are curvature-shaped. In brief, each parallel of latitude is made in the same way as the standard parallel is made in simple conical projection with one standard parallel and the method of drawing longitudes is the same as in Bonne's projection.

Example 4 : Construct a polyconic projection on the basis of the following description—

Scale, 1 : 125,000,000; interval 15°; extension of the area, 30° to 75° N and 0° to 180°E.

Method of construction. According to the given scale, the radius of the sphere of reduced earth, i.e.,

$$R = \frac{365,000,000}{125,000,000} = 5{\cdot}08 \text{ cm}$$

As in Fig. 8A, draw a quadrant ABO with a radius of 5·08 cm. Draw a line OC of 30° angle at O point of OB line. Thereafter, draw OD, OE and OF lines all at the difference of 15° angle.

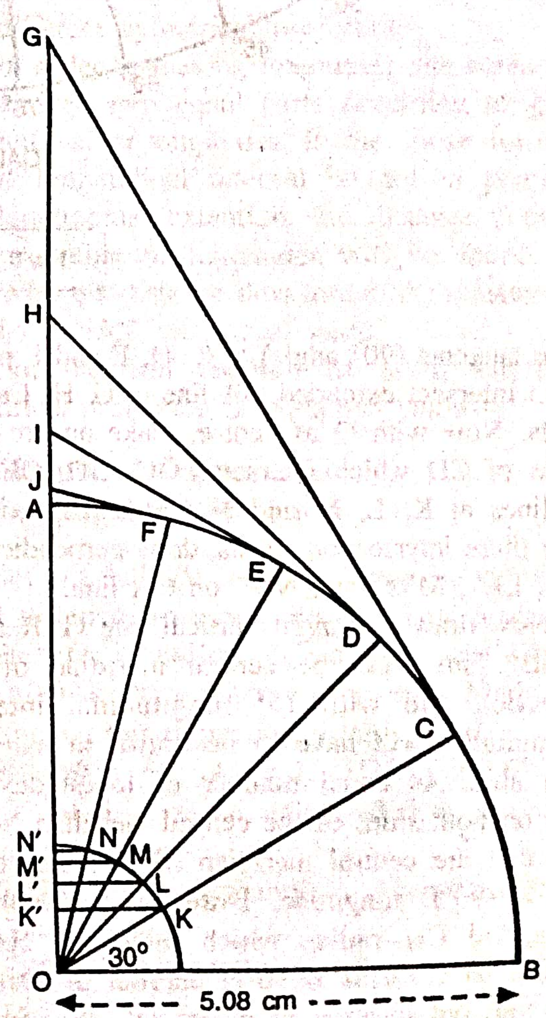

Fig 8 A.

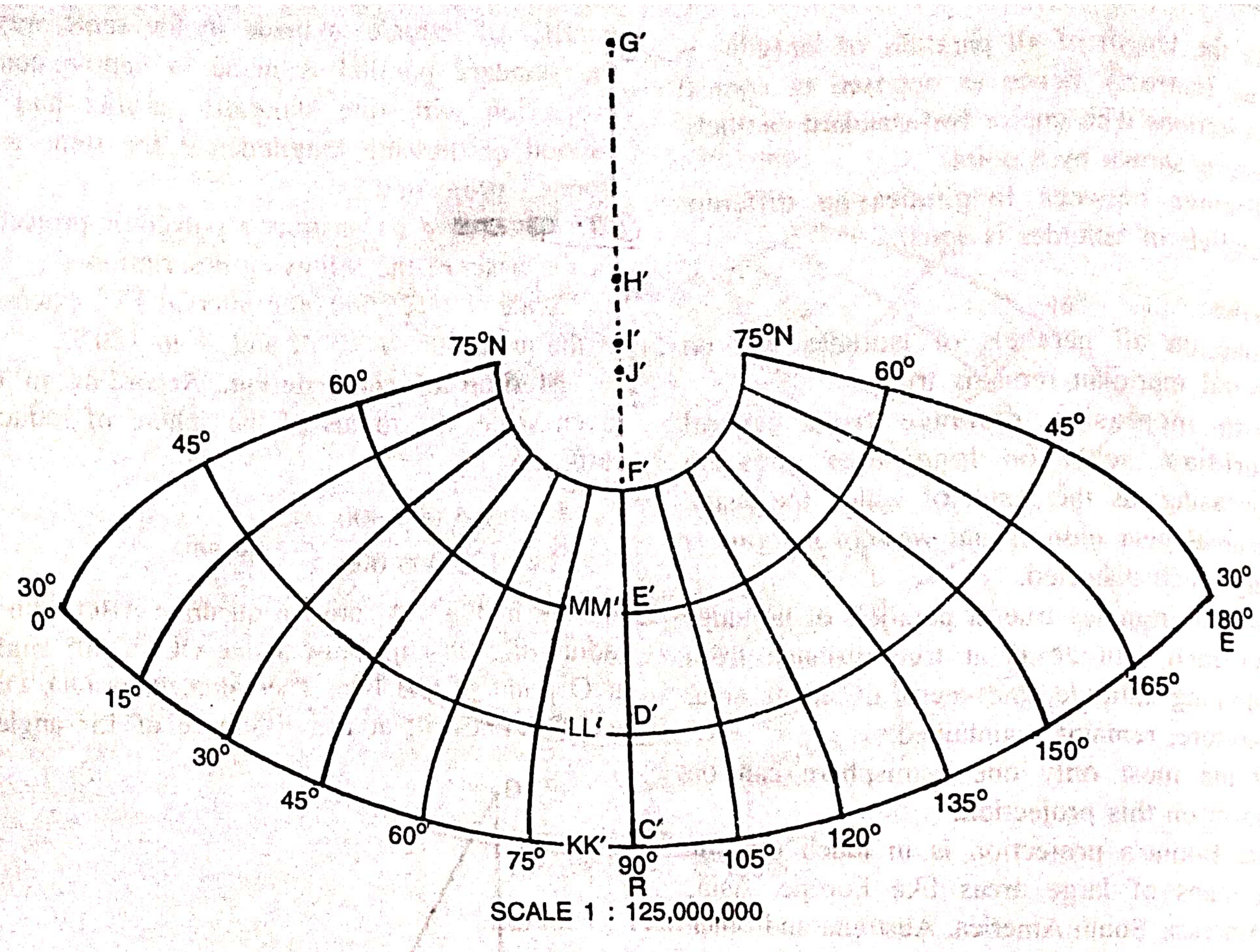

Fig 8 B. Polyconic projection.

Make tangents (90° angle) at C, D, E and F points which intersect extended OA line at G, H, I and J points. Now with O as centre, make an arc with radius of CD which intersects OC, OD, OE and OF lines at K, L, M and N points respectively. From these intersection points, draw perpendiculars KK′, LL′, MM′ and NN′ on OA line.

Now draw a straight vertical line G′ R as in Fig.8B. This shall be central meridian of the projection and with 15° longitudinal interval 13 longitudes will have to be drawn to map the given area. As equal number of longitudes are made on both sides of the central meridian, so its clear that the central meridian of this projection shall be 90°E longitude. Draw an arc with G′ centre and CG radius which intersects central meridian at C′. This is 30°N parallel of latitude. Now find out location of points D′, E′ and F′ points on central meridian from C′ towards G′ with equal distance of CD. Draw arcs of such circles as pass through D′ E′ and F′ with radii of DH, EI and FJ respectively. These arcs will be 45°, 60° and 75°N latitudes respectively. Thus, it is clear that different latitudes are drawn from different centres (as in Fig. G′, H′, I′ and J′).

For making longitudes, six points each of equal distance at one latitude on both sides of the central meridians shall be marked. These equal distances shall be KK′ for 30°, LL′ for 45° and MM′ for 60° and NN′ for 75° latitudes. As shown in Fig. 8 B, draw longitudes joining points of equal division with the same serial number at all latitudes with a smooth curve and write degrees each longitude shows.

Identification

(1) As latitudes are arcs of circles drawn from different centres, parallels of latitude are not concentric arcs but in the projection equator is a straight line.

(2) Distance between parallels of latitude is equal at the central meridian but eastward or

westward the difference between parallels of latitude continously keeps on increasing.

(3) Central meridian is a straight line and remaining longitudes are curve-shaped.

(4) Central meridian intersects parallels of latitudes at right angle, whereas other longitudes intersect parallels slanting. This slanting of the intersection of parallels of latitude and longitudes increases progressively away from central meridian.

Properties

(1) Scale is true along all parallels of latitudes and central meridian in this projection.

(2) Parallels of latitude not being concentric arcs, this projection does not have the merit of true area (homolographic).

(3) This projection is also not orthomorphic (true shape) projection because of rapid increase in the scale of longitudes from the central meridian.

(4) Distortion in shape and area increases very much in the marginal areas away from the central meridian.

(5) Equator is shown as a straight line in this projection.

Uses. This projection is not suitable for making maps of large areas because shape and area both are incorrect. It is especially useful for making maps of small areas with less east-west extention. Many kinds of landform maps are made on this projection in the U.S.A.

CYLINDRICAL PROJECTIONS

The following facts are especially worth mentioning about the construction of cylindrical projections—

(1) In cylindrical projections the length of all parallels of latitude including the equator is equal. So, the length is calculated according to the following formula and all parallels of latitudes are made of equal to that length,

Length of the equator = $2\pi R$ (earth's circumference).

In this formula π means 22/7 and R is the radius of reduced sphere of the earth according to given scale (R.F.). By calculating according to this formula, the total length of equator is found out. If distance between two longitudes is to be found at the equator, the above formula is written in the following form—

Distance between two longitudes at the equator

$$= 2\pi R \times \frac{\text{Longitudinal extension (in degrees)}}{\text{Earth's circumference (in degrees)}}$$

For example, at a scale of 1 : 250,000,000, between 10°W to 80°E longitude,

$$\text{Length of equator} = \frac{2 \times 22 \times 2.54 \times 90}{7 \times 360}$$

$$= 3 \cdot 99 \text{ cm}$$

(2) Though the length of all parallels of latitude is equal in these projections, yet spacing between them is calculated differently in different cylindrical projections.

(3) In order to making longitudes, the equator is divided into equal parts according to given interval of longitudes. In the above formula, if longitudinal interval be put in place of longitudinal extention, the distance between two adjacent longitudes will be found out.. With the distance thus found, the equator can be divided into equal parts.

Construction method of main kinds of cylindrical projection is explained below—

(A) Simple or Cylindrical Equidistant Projection

Parallels of latitude and longitude are drawn at equal distance from one another. This projection is, therefore, called equidistant cylindrical projection or **Plate Carree** projection. Method of constructing this projection is very simple.

Example 5 : At R.F. 1/300,000,000 and interval of 15°, make an equidistant projection for the world map.

Method of construction. According to the question,

(1) Radius of the reduced sphere of the earth, i.e.,

$$R = \frac{635,000,000}{300,000,000} = 2 \cdot 1 \text{ cm}$$

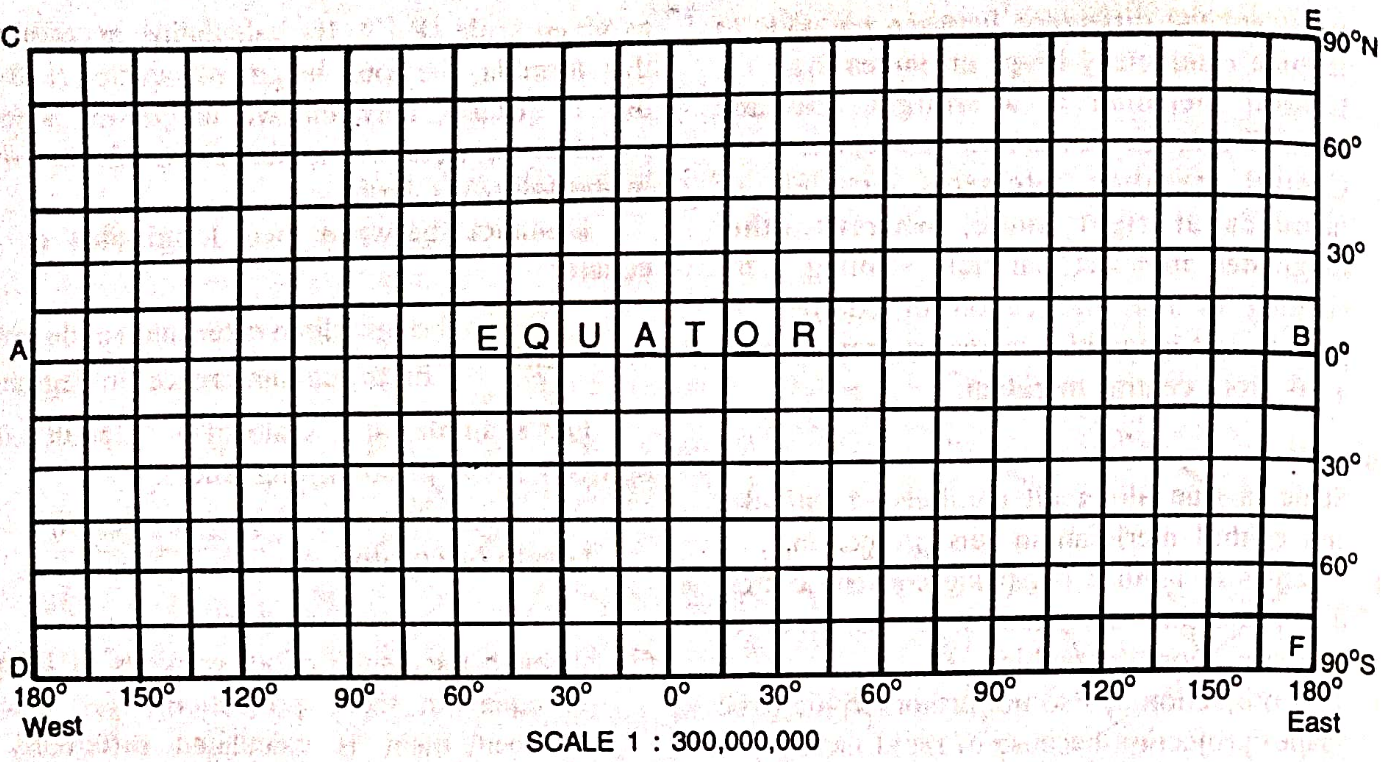

Fig 9. Equidistant cylindrical projection.

(2) Length of equator = $2\pi R$

$$= \frac{2\times22\times2.1}{7} = 13\cdot2 \text{ cm}$$

(3) Distance between two longitudes

$$= 2\pi R \times \frac{\text{Interval (degrees)}}{360°}$$

$$= \frac{13.2\times15°}{360°} = 0\cdot55 \text{ cm}$$

After completing above-stated calculation, draw a straight line AB measuring 13.2 cm in length (Fig. 9). This will be the equator in the projection. At A point of this line, make a perpendicular CD and EF at point B. Now, either by geometrical method or by measuring 0·55 cm in a compass, divide AB line in 24 equal parts (for quick and correct division, first, 2 equal divisions of AB be made followed by two equal divisions of each of the 2 parts; again two equal parts of each of 4 divisions and finally 3 divisions of 8 equal parts each obtained till now by using compass now.) and from these points of division, draw perpendiculars like CD perpendicular on both sides of equator. These perpendicular lines will represent longitudes in the projection. On both sides of A at CD line mark equal division points at an interval of 0·55 cm and from these marks draw straight lines parallel to the equator and thus complete making parallels of latitudes.

Identification

(1) Parallels of latitude and longitudes being made at equal distance the projection is like a network made up of squares.

(2) Each parallel of latitude is equal to equator in length. All parallels of latitudes are straight and parallel lines.

(3) All longitudes are straight parallel lines and they intersect parallels of latitude at right angle.

(4) Each longitude is half of the length of the equator in projection.

Properties

(1) All parallels of latitude are at correct distance from the equator, so scale at every longitude is true.

(2) At the equator where a cylinder is considered as touching the globe, the scale remains true.

(3) All parallels of latitude except the equator, are larger than their real length, so scale on

Table 1. **Distance of different parallels of latitudes from the equator.**

Latitude	Distance	Latitude	Distance	Latitude	Distance
5°	0·087×R	35°	0·652×R	65°	1·505×R
10°	0·175×R	40°	0·763×R	70°	1·735×R
15°	0·265×R	45°	0·880×R	75°	2·025×R
20°	0·356×R	50°	1·010×R	80°	2·436×R
25°	0·450×R	55°	1·154×R	85°	3·131×R
30°	0·549×R	60°	1·317×R	90°	Infinity

(R = Radius of reduced sphere of the earth at given scale.)

them is not true. Error of scale keeps increasing on parallels of latitude towards pole from the equator, that is the scale is more erroneous in higher latitudes in comparison to the lower latitudes.

(4) Even poles (which are just points) are shown by lines equal to equator in length which helps easily understand the error of scale at parallels of latitude.

Uses. This projection is neither orthomorphic (true shape), nor has the merit of being a homolographic (true area) projection. Shape and area is somewhat correct near the equator in this projection. Its limited use is, therefore, made for making maps of equatorial areas. This projection is not suitable for making maps of high latitude areas on the map of the world.

(B) Cylindrical Equal-area Projection

This projection was first made by **Johann Heinrich Lambert**. So it is also called **Lambert's cylindrical equal-area projection.** As is obvious by its name, this projection has the merit of representing true area. Method of constructing cylindrical equal area projection has been explained by an example below—

Example 6 : At a scale of 1 : 350,000,000 and an interval of 30° of the graticule, construct a cylindrical equal-area projection for a map of the world.

Method of construction. According to the question,

(1) $R = \dfrac{635,000,000}{350,000,000} = 1{\cdot}8$ cm

(2) Length of the equator = $2\pi R$

$= \dfrac{2\times 22\times 1{\cdot}8}{7} = 11{\cdot}3$ cm and

(3) Distance between two adjoining longitudes,

$= 11.3 \times \dfrac{30}{360} = 0{\cdot}94$ cm

For constructing the projection, draw a semi-circle ABC with centre O and radius of 1·8 cm in which AC is the polar diameter (Fig. 10). Join points O and B and extend it further. Mark

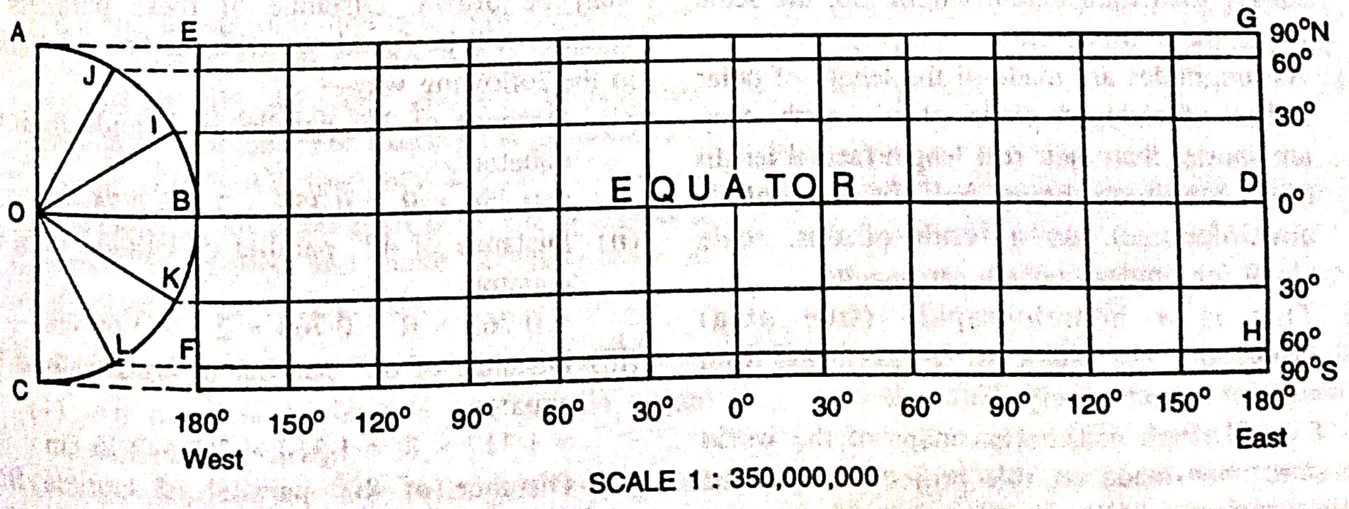

Fig 10. Cylindrical equal-area projection.

BD equal to 11·3 cm (i.e. equator) on this extended line. Draw EF perpendicular at point B and GH perpendicular at D point. These perpendicular lines represent 180°W and 180°E longitude. Now draw angles at 30° interval from O point of OB line and draw lines OI and OJ towards upper side. Similarly, draw OK and OL lines downwards. By making parallel lines to BD line from A, J, I, K, L and C complete drawing parallels of latitude 90°N, 60°N, 30°N, 30°S, 60°S and 90°S. For making longitudes divide BD line at 0.94 cm interval or by some geometrical method into 360°/30° = 12 equal parts and draw perpendiculars from these dividing points parallel to EF.

Identification

(1) Parallels of latitude are straight and parallel lines. The length of each parallel of latitude is equal to the equator in length.
(2) Space between parallels of latitudes keeps decreasing towards poles.
(3) Longitudes are also parallel and equal lines, but space between all of them is equal.
(4) Parallels of latitude and longitudes intersect one another at right angle.
(5) Pole, which is a point on the globe is represented by as long straight line as the equator.

Properties

(1) The equator is equal to its actual length and therefore, scale at equator remains true. (R = At given scale, radius of reduced sphere of the earth)
(2) Other than equator, parallels of latitude are longer than their actual length. So, the scale along them is not true.
(3) As longitudes are made of the length of polar radius of reduced globe of the earth, they are shorter than their real length (actual length of a longitude being half of the earth's circumference). As a result of this, scale along longitudes becomes erroneous.
(4) This is a homolographic (true area) projection, but shape of areas away from equator becomes very distorted.

Uses. Though distribution maps of the world are sometimes made on this projection, yet this projection is especially useful for distributions in areas close to the equator.

(C) Mercator's or Cylindrical Orthomorphic Projection

This projection was first made by a Dutch cartographer **Gerardus Mercator** in 1559. This is why this projection is called Mercator's projection. This is an orthomorphic (true shape) projection whose maximum use is made in constructing navigation charts.

Distance of various parallels of latitude can be found out with the help of Table-1 above. Method of drawing longitudes is the same as in other cylindrical projections.

Example 7 : At a scale of 1 : 300,000,000 construct cylindrical orthographic projection or Mercator's projection for a map of the world. Interval of projection is 20°.

Method of construction. According to the question,

(1) $R = \dfrac{635{,}000{,}000}{300{,}000{,}000} = 2{\cdot}1$ cm

(2) Length of the equator = $2\pi R$

$= \dfrac{2 \times 22 \times 2.1}{7} = 13{\cdot}2$ cm

(3) At given interval of the projection, distance between two adjoining longitudes,

$= \dfrac{2\pi R \times 20}{360} = \dfrac{13{\cdot}2 \times 20}{360} = 0{\cdot}73$ cm

As in Fig. 11, draw the equator AB 13·2 cm long. Make perpendicular CD at A point of AB line and perpendicular EF at B point. According to interval given in the projection, north and south parallels of latitudes of 20°, 40°, 60° and 80° shall be drawn. Distance of these parallels of latitudes will be found out with the help of Table-1 in the following way—

(i) Distance of 20° parallel of latitude from the equator,
$= 0{\cdot}356 \times R = 0{\cdot}356 \times 2{\cdot}1 = 0.75$ cm

(ii) Distance of 40° parallel of latitude from the equator,
$= 0{\cdot}763 \times R = 0{\cdot}763 \times 2{\cdot}1 = 1.60$ cm

(iii) Distance of 60° parallel of latitude from the equator,
$= 1{\cdot}317 \times R = 1{\cdot}317 \times 2{\cdot}1 = 2{\cdot}76$ cm

(iv) Distance of 80° parallel of latitude from equator,
$= 2{\cdot}436 \times R = 2{\cdot}436 \times 2{\cdot}1 = 5{\cdot}10$ cm

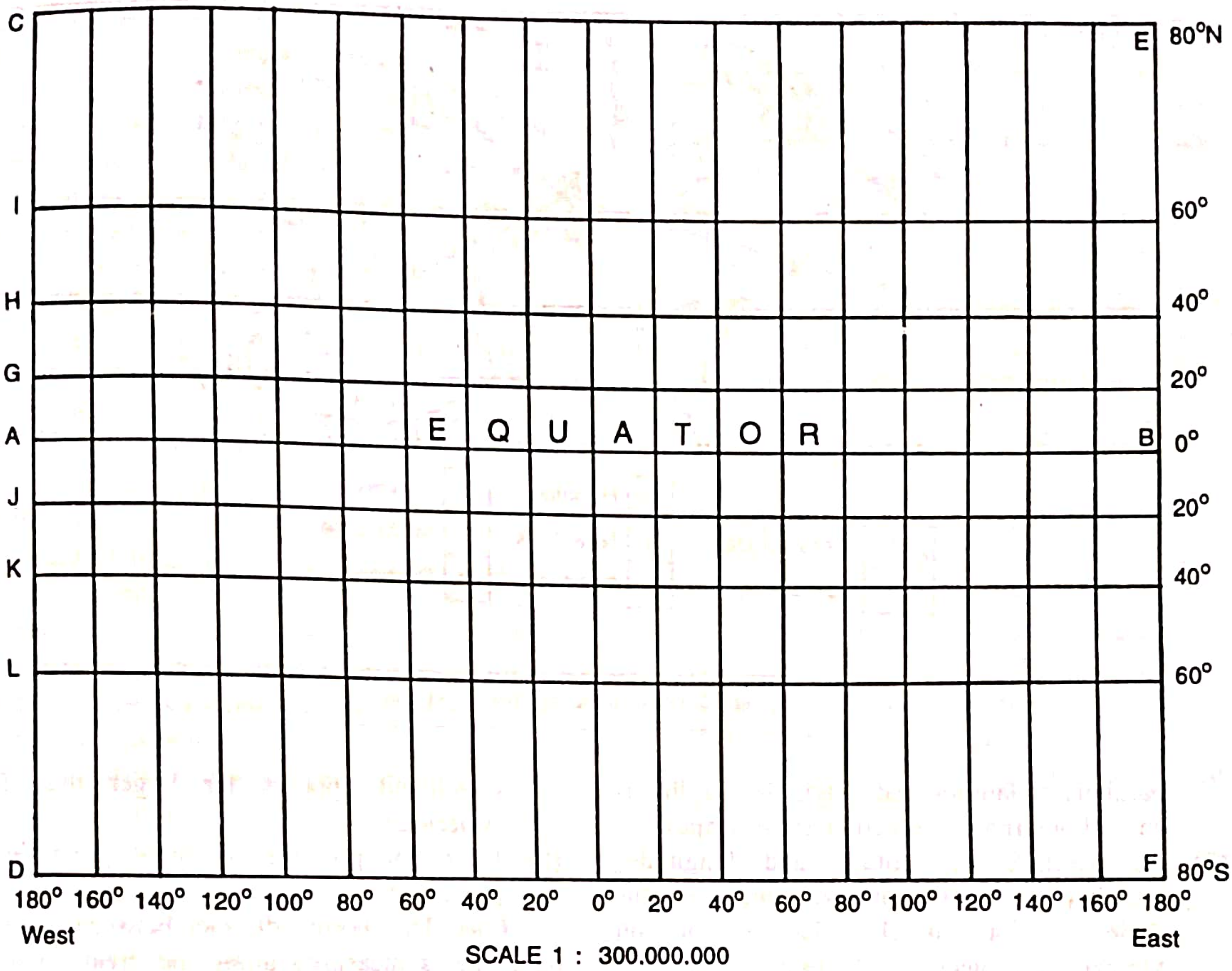

Fig 11. Mercator's projection.

Now mark points G, H, I, and C from A point on AC line and points J, K, L and D on AD line at 0·75, 1·6, 2·76 and 5.1 cm respectively. From the points thus marked, draw parallel lines to AB line for North and South parallels of latitudes of 20°, 40°, 60° and 80° to complete drawing of latitudes. For making longitudes at 20° interval, divide AB line into 360/20 = 18 equal parts either at an interval of 0·73 cm or by some geometrical method and make perpendiculars on both sides of the equator AB.

Identification

(1) All parallels of latitude are straight, equal and parallel lines.

(2) Longitudes are also straight, equal and paralles lines.

(3) Parallels of latitude and longitude intersect each other at right angle.

(4) Longitudes are at the same and equal distance but the distance between parallels of latitude increases from the equator to poles continuously.

Properties

(1) Scale is true at the equator. Scale at other parallels of latitude is exaggerated as all of them are drawn equal to the equator in length.

(2) The ratio in which scale increases east-west along parallels of latitude, in the same ratio scale increases north-south along longitudes. Due to this property, scale remains the same on all sides from the intersection points of

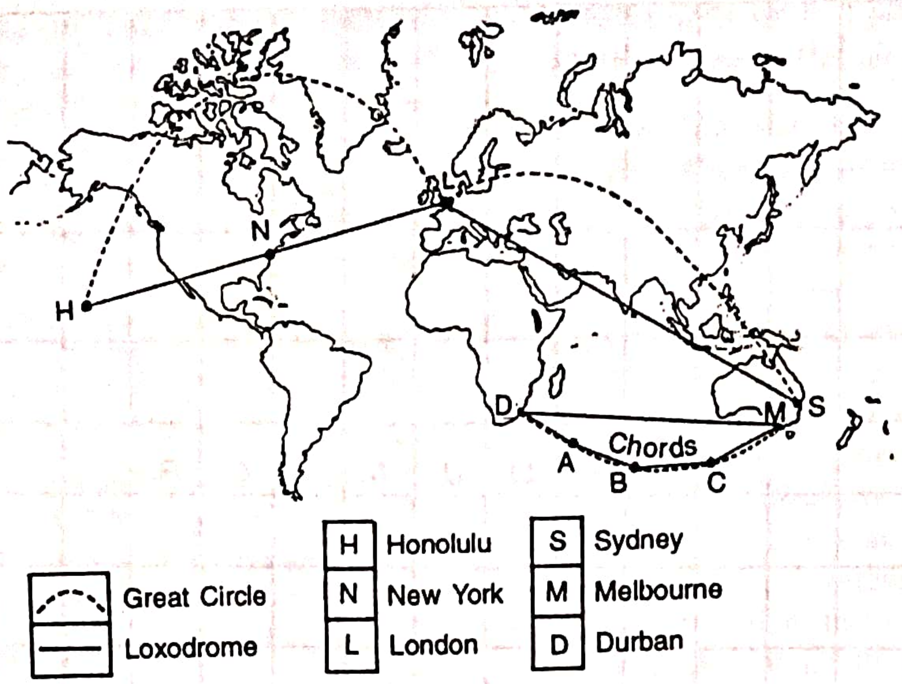

Fig 12. Great circle and the loxodrome.

parallels of latitude and longitude. So, this is an orthomorphic projection (true shape).

(3) As parallels of latitude and longitudes intersect each other at right angle in this projection, a straight line drawn on Mercator's projection intersects all parallels of latitude at one constant angle. Similarly along longitudes also this line intersects with constant angle. Such straight line drawn on Mercator's projection is known as **rhumb line or loxodrome** (Fig. 12). As the direction of longitudes is in geographical north-south direction, each straight line intersecting them, also known as rhumb line, is line of constant bearing. In other cylindrical projections the shape of longitudes and parallels of latitude is largely similar to Mercator's projection, but they don't possess the merit of showing true direction. Due to the merit of true direction in this projection, it is very much used in navigation.

(4) Though it is a true-direction and true shape projection, yet the area progressively increases from the equator towards the poles. For example, the area of Greenland in reality is 1/10 part of South America, but the size of Greenland appears far larger than South America.

(5) It is not possible to show poles in this projection.

Uses. The shortest distance between two points on globe is measured along the great circle (the greatest circle that can be drawn on earth's surface, its plane passing through earth's centre and shall therefore, be the circumference of the earth) passing through those points. On a Mercator's projection it assumes the shape of a curve (and appears longer than the straight line joining those two points but actually is the shortest distance between them). This curve is bent towards north in the northern hemisphere and towards south in the southern hemisphere. So, it is clear that if the great circle is not the part of the equator (lone great circle among all parallels of latitude) or a longitude (all of which are great circles), then to follow the great circle, which is the shortest distance but curved route on the map, a navigator will keep on changing the direction of his ship every now and then. It is practically very-very difficult task. To resolve this difficulty, small chords of this curve are drawn keeping them as close to the curve as possible. These chords being straight lines on the projection are small loxodromes/rhumlines with a fixed direction. So navigation along these chords, a navigator need to change the direction of the ship only at points where two cords meet. For example, in Fig. 12, four chords DA, AB, BC and CM are drawn of the great circle route passing through Durban (South Africa) and Melbourne (Australia). Now changing the direction of ship only at A, B and C points will be enough. Though a little longer distance has to be navigated while undertaking voyage through these loxodromes, yet the problem of impracticable constant change in the direction is resolved. Thus, the great circle route and loxodromes are plotted on Mercator's projection for navigation.

Besides navigation, this projection is of paramount importance for showing wind directions and ocean currents, as their direction should also be true on a map. In brief, almost all maps made to show true shape and true direction are made on Mercator's projection.

As the area increases very much in high latitudes, this projection is unsuitable for other areas except equatorial region. Though political maps are made on this projection, yet the root cause of making those maps is to show small European countries enlarged.

(D) Gall's Stereographic Projection

This is a modified cylindrical projection, which is made on the following three postulates—

First, the cylinder touches the globe intersecting it at 45°N and 45°S parellels and not at equator as is supoosed in other cylindrical projections. So, all parallels of latitude including the equator are made of the length of 45° parallel of latitude. There are two following formulas of finding out the length of 45° parallel of latitude—

First formula. Length of 45° parallel of latitude = $2\pi R \cot 45°$ (i.e. cotangent 45°). The value of cot 45° is 0·7071. Thus, the length of 45° parallel of latitude is found out by multiplying the length of equator according to given scale by 0.7071 (Example-8).

Second formula. A simple formula of finding out the length of 45° parallel of latitude is the following—

Length of 45° parallel of latitude = $2\pi r$.

In this formula the value of r is found out by measuring OG on equatorial radius of the reduced globe according to the scale (in Fig.13). OG line is 1.8 cm. According to the formula, the length of 45° parallel of latitude

$$= 2\pi r = \frac{2 \times 22 \times 1{\cdot}8}{7} \quad (r = 1{\cdot}8) = 11{\cdot}3 \text{ cm}$$

Thus in a Gall's projection, the length of parallels of latitudes is 0·7071 times shorter than the length of parallels of latitude in other cylindrical projections.

Distance of parallels from the equator is found out stereographically. In this method the source of light is supposed positioned at the opposite end of equatorial diameter, i.e. opposite of the side on which projection is constructed and then parallels of latitude are projected on the cylinder.

Longitudes in the Gall's projection are drawn at equal distance from each other by dividing the latitudes in equal parts according to given interval, i.e. space between two adjoining longitudes

$$= \frac{\text{Length of } 45^{\circ} \text{ parallel of latitude} \times \text{interval}}{360^{\circ}}$$

Example 8 : Construct a Gall's projection for making a world map at 1 : 250,000,000 scale and 15° projection interval.

Method of construction. According to the question,

(1) The radius of the sphere of reduced earth, i.e.,

$$R = \frac{635{,}000{,}000}{250{,}000{,}000} = 2{\cdot}54 \text{ cm}$$

(2) Length of 45° parallel of latitude

$$= 2\pi R \cot 45°$$

$$= \frac{2 \times 22 \times 2{\cdot}54 \times 0{\cdot}7071 \text{ cm}}{7}$$

(at replacing the values) = 11·29 cm

(3) Inter-longitude distance

$$= \frac{\text{Length of } 45^{\circ} \text{ parallel of latitude} \times \text{interval}}{360^{\circ}}$$

$$= \frac{11{\cdot}29 \times 15}{360^{\circ}} = 0{\cdot}47 \text{ cm}$$

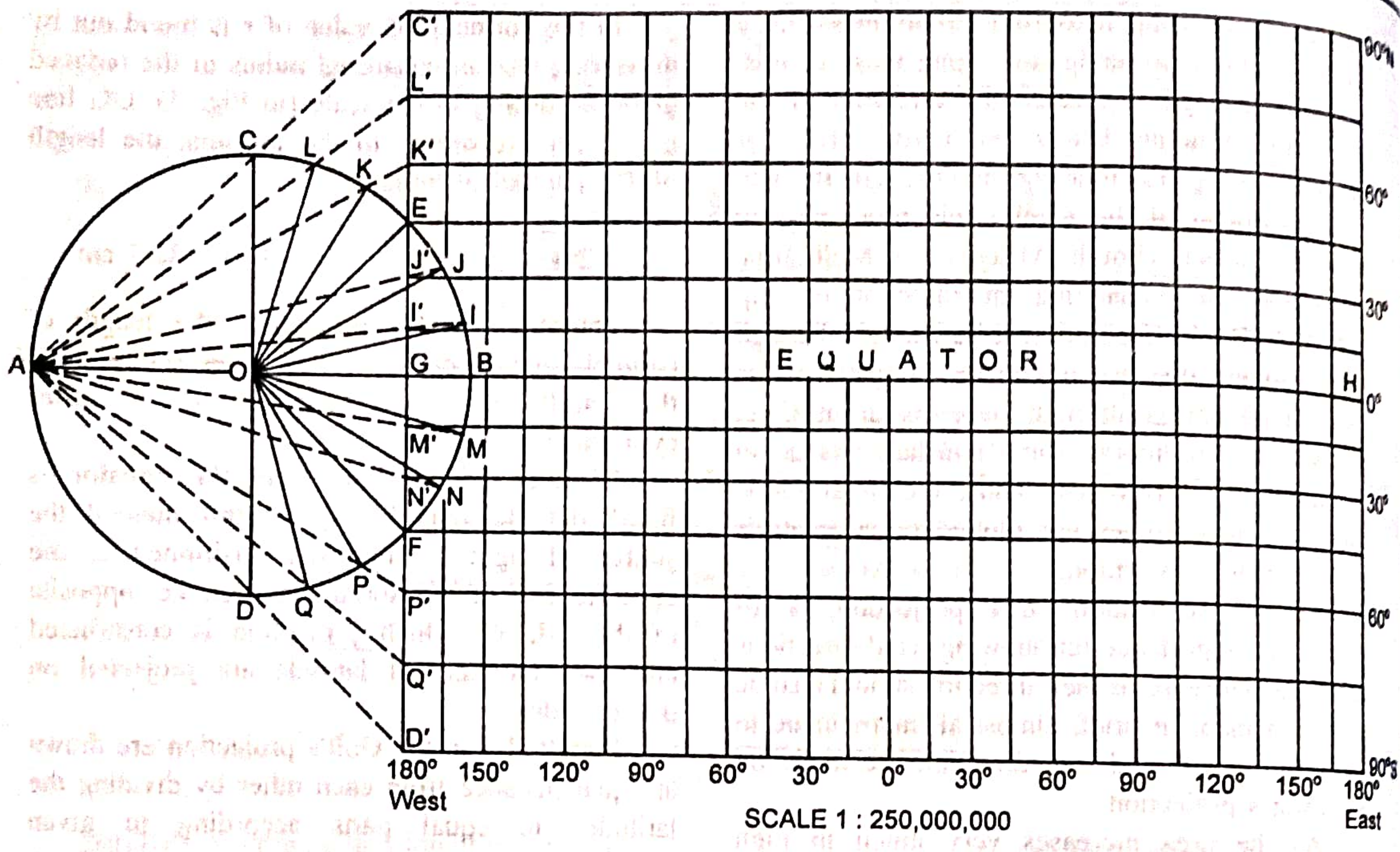

Fig 13. Gall's projection.

For constructing the projection, first draw a circle with 2·54 cm radius, in which AB and CD lines are equatorial and polar parameters respectively (Fig. 13). Draw lines at 15° angle on both sides of OB. These lines intersect the earth's radius at I, J, E, K, L and C above OB line and at M, N, F, P, Q and D below this line. Now join lines of 45°N and 45°S by a straight line extending upto C′ D′ which intersect OB line at G point. This vertical line is 180°W longitude in the projection. Extend OB line towards B and measure GH line equal to 11·29 cm (which is the length of 45° longitude and all latitudes are made of this length) GH line is the equator in the projection. Draw lines from E and F parallel to GH which will be 45°N and 45°S respectively.

For drawing remaining parallels of latitude, join A point with straight lines to points I, J, K, L, C, M, N, P, Q and D located at the circumference of the circle. At extending these lines, they intersect C′ D′ perpendicular line at I′, J′, K′, L′ C′, M′, N′, P′, Q′ and D′ points respectively. Draw lines parallel to the equator GH from I′, J′, K′, L′ and C′ and complete making parallels of latitude of 15°, 30°, 60°, 75° and 90° north respectively. Similarly, draw lines from M′ N′ P′ Q′ D′ parallel to the equator and complete making southern parallels of latitude. In order to making longitude, divide the equator (GH line) into 24 equal parts of 0·47 cm (or divide GH first into two equal parts; again divide each of these two parts into two equal parts and once again divide each of four parts into two equal parts thus getting eight equal parts. Now divide each part into 3 equal parts of 0·47 cm. This makes the process of division simple and probability of error the least in equality of 24 divisions). From these points draw perpendiculars on both sides of the equator.

Identification

(1) Parallels of latitude are parallel lines of one and the same length.

(2) Each parallel of latitude in this projection is equal to the length of 45° parallel of latitude.
(3) Longitudes are also straight lines parallel to each other and equal in length.
(4) The spacing between adjoining longitudinal lines is equal but spacing between successive parallels of latitude keeps increasing towards the poles.
(5) Parallels of latitude and longitudes intersect each other at right angle.

Properties

(1) Scale remains correct only at 45°N and 45°S parallels of latitude. From these parallels of latitude, scale keeps on becoming smaller as parallels of latitude are made smaller than their actual length. For example, the equator is only 7/10 of its real length. On the contrary, towards poles from 45° parallels of latitude, they are made longer than their real length and, therefore, scale on them becomes larger. This becomes clear from the fact that even poles are made as long as other parallel of latitudes.
(2) Scale of longitudes keeps on increasing from equator towards the poles as their distance along parallels of latitude increases. But scale is very much increased towards poles and scale is reduced towards the equator. For example, in Fig.13 the perpendicular distance between the equator I′ G is smaller than the arc IB; so the scale is reduced there. Opposed to this, the distance C′ L′ between 75°N latitude and 90°N latitude is greater than CL arc; so scale is very much increased there.
(3) This projection is not orthomorphic. Area and direction are also not correctly represented. But because of two standard parallels, area in this projection does not increase as much as in Mercator's projection. Infact, this projection is considered a good projection with median conditions because of limited distortion in shape and area.

Uses. Gall's projection is especially useful for general maps of the world.

Unit-II

Plane Table Surveying

Q. Explain plane table survey Instruments with diagram.

INTRODUCTION

The work of making a plan of any area is completed in two steps. In the first step, reconnaissance sketch-map of the given field is prepared and the field-book of measured distances or angles is made. In the second step, the plam of the area is plotted on a suitable scale on the basis of measurements entered in the field-book. Plane table surveying is the only method in which both surveying work and plan construction are completed at the same time. There are many benefits of the plan having been completed without making field-book—**First**, without the necessity of making field-book, surveying consequently becomes simpler. **Secondly**, the whole survey operation is completed soon. **Thirdly**, if any detail remains to be plotted by mistake, it is instantly found out and completed without the difficulty of carrying all survey instruments in the field once again.

The method of preparing a plan of a field with the help of plane table is called by many names such as **plane table surveying**, **table/board surveying** and **plane tabling**, etc. Though invention and first use of this instrument was made in 1570, yet its use and popularity has remained the same despite so much period of time has passed away.

INSTRUMENTS REQUIRED FOR PLANE TABLE SURVEYING

The following instruments and equipments are required for plane-table surveying—

(1) Plane table and tripod stand,
(2) Alidade,
(3) Spirit level,
(4) Plumbing fork,
(5) Plumb bob,
(6) Trough compass,
(7) Chain or tape,
(8) Ranging rods,
(9) Arrows of chain,
(10) Drawing sheet,
(11) Drawing pins and alpins,
(12) Drawing instruments.

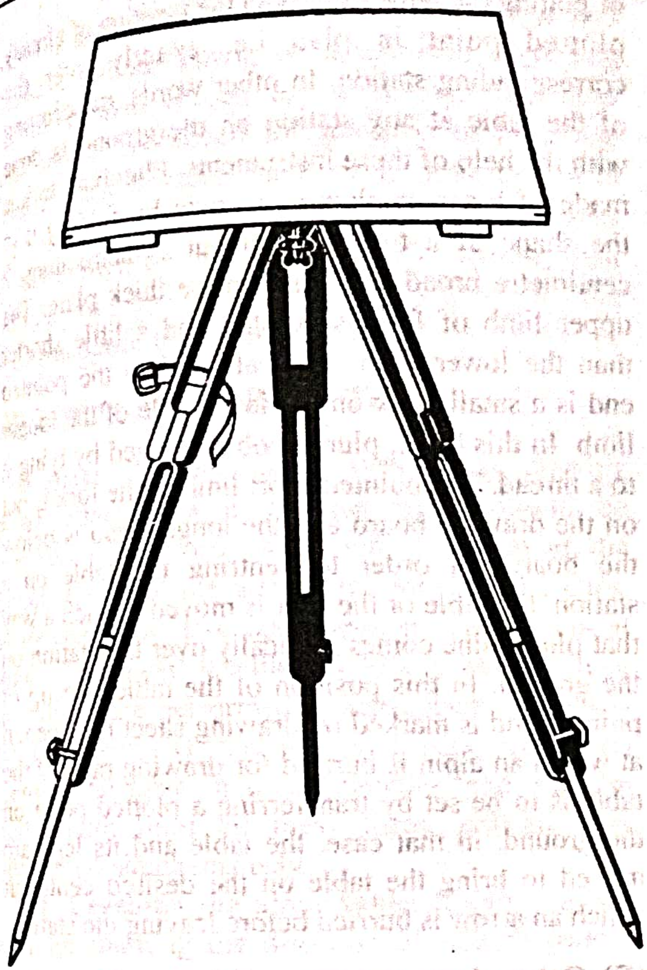

Fig 1. Plane table and its tripod-stand.

(A) Plane Table and Tripod Stand

Plain table is the main instrument of this surveying. It has two components—(i) Drawing board and (ii) Tripod stand. Since drawing board can be rotated on tripod stand in horizontal plane, or can be fixed in the desired direction, it is called plane table (Fig. 1).

The drawing board of plane table is made by joining very well seasoned pine wood planks 2·5 cm in width. These boards are of different size as 40 × 30 cm, 70 × 60 cm, 45 × 45 cm and 60 × 60 cm and so on. To make it strong, two batten of teak wood are fixed on the bottom plane of the board. Slotted strips are made on the lower surface of the board so that the board's upper surface is not affected by changing temperature. A circular plate of brass or aluminium is fixed on the lower surface of the board in its centre, which is called **pivot plate.**

Drawing board is used after tightening it on about 1·5 m high tripod stand. There are three legs in tripod stand, as a result of which even on the uneven ground the board can be set up on a plane level. These legs are made of twin strips of teak and their upper ends are joined together by fly-nuts to a brass or aluminium plate which is known as tribrach plate. At the lower end of each leg, a pointed piece or cover of any mettle other than iron is mounted which prevents tripod from slipping on ground. The boss head of pivot plate is inserted into tribrach hole of tribrach plate to attach drawing board with the tripod and are tightened together by clamping screw put with tribrach plate.

(B) Alidade

With the help of alidade, a line or ray is drawn towards a station on the drawing sheet. Alidade is a scale of parallel edges made of brass or hard wood like teak. On both its ends are fixed immovable or movable vertical vanes (Fig. 2). On one vane is a thin slit in whose top and bottom are small round holes or **eye holes** and on the slit of the other vane a thin wire or thread is tied in the middle of the slit. The vane with eye holes is called **eye vane** or **sight vane** and vane with thin wire/thread is called **object vane.** The line of sight which is an imaginary line aligning eye hole and the wire/thread is totally parallel to the edges of alidade. As a result, the direction of line drawn on drawing sheet along the edge is the same as that of the line of sight. The right edge

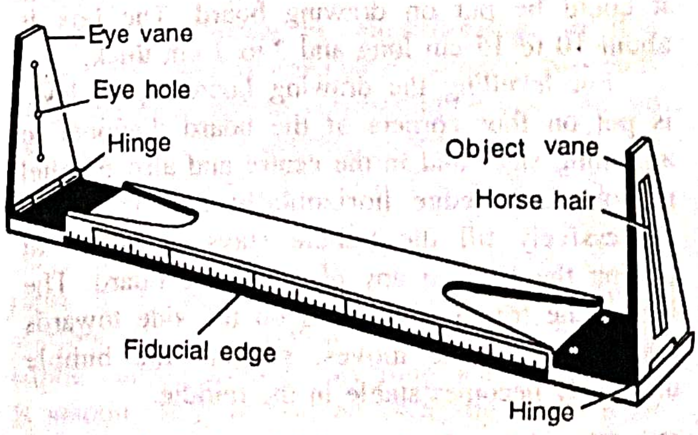

Fig 2. Alidade.

of alidade is made a little slopy so that ray could be drawn along that edge. This edge of alidade is called **fiducial edge** or **working edge**.

Alidades are often 40 to 50 cm in length. In good quality alidade's fiducial edge, a scale in centimetres etc. is marked. On its upper surface, a trough compass and round shaped spirit level is attached. The working edge of alidade is put adjacent to the alpin burried on the board at point showing the location of table. Positioning eye at the eye hole, the thread of the object vane is aligned to the ranging rod standing at a distance. When eye hole, thread of object vane and the ranging rod are in one straight line, a ray is drawn towards the ranging rod along fiducial edge of the alidade. While aligning, both the vanes of adilade must be in vertical position.

(C) Spirit Level

This is a simple instrument with the help of which levelling (parallel to sea level) of drawing board attached to tripod stand is examined. In the glass tube of spirit level is filled spirit or alcohol (which does not evaporate fast by heat). As some space is left empty within it while filling spirit or alcohol in the tube a air bubble is formed, which always moves towards height. On the top of the glass tube, transverse line marks are made on both side from the centre at equal distance. In some levels, two transverse parallel lines are drawn in the centre. When the bubble becomes stable in the centre of the tube, drawing board is levelled. The tube of spirit level is fitted inside a rectangular cover of wood, brass or aluminium with plane base, so that it could be put on drawing board. The box is about 10 to 15 cm long and 2 to 3 cm thick.

For levelling the drawing board, spirit level is put on four corners of the board diagonal to adjoining sides and in the centre and also parallel to long side edge horizontally and vertically successively till the bubble stays at centre at putting the level at any place on the board. The leg of the tripod is lowered on the side towards which the bubble moves, so that the bubble ultimately becomes stable in the middle.

(D) Plumbing Fork and Plumb Bob

These instruments are used for finding out the location of a point of ground on the drawing board or putting the table exactly in the position of already plotted point in plan i.e. exactly over the corresponding station. In other words, the centring of the table at any station on the ground is done with the help of these instruments. Plumbing fork is made of brass or aluminium strip by folding it in the shape of a fork. It is about 1 metre long, 2 centimetre broad and 2 milimetre thick plate. The upper limb of fork is pointed and a little shorter than the lower limb. Vertically below the pointed end is a small hook on the lower side of the longer limb. In this hook, plumb bob is hanged by tying it to a thread. The pointed short limb of the fork is put on the drawing board and the longer limb is below the board. In order to centring the table on a station, the table or the fork is moved in such a way that plumb line comes vertically over the station on the ground. In this position of the table, the tip of pointed end is marked on drawing sheet by a pencil at which an alpin is burried for drawing rays. If the table is to be set by transferring a plotted point on the ground, in that case, the table and its legs are moved to bring the table on the desired centre at which an arrow is burried before leaving the station.

(E) Other Instruments

Among other instruments necessary for plane table surveying, chain or tape, trough compass, ranging rod and arrows of chain, etc. deserve special mention. In addition to the above instruments, a high quality drawing sheet, drawing pins, ink, pencil and drawing instruments are required.

Q. Plane ~~table~~ survey

Explain SURVEY OPERATIONS-

As will be discussed later, there are many methods of plane table surveying and in almost all methods the following operations are carried commonly out—

(A) Reconnaissance Sketch Map

Before starting the actual surveying, the field given for surveying should be observed well. At features not visible from a distance, ranging rods should be burried; such as at bends of boundary line, etc. for identification. Thereafter, a base line and traverse stations should be determined according to the method chosen for surveying. The facts that should be heeded for selection of base line and traverse stations have been described with the respective methods in the following paragraphs. It is followed by marking details by writing their names or by conventional signs in the reconnaissance sketch map.

(B) Setting up the Plane Table

After making reconnaissance sketch map, drawing board attached with drawing sheet should be clamped with tripod stand and is set up at the initial station of the area at the level of the chest of the surveyor. Two operations are carried out at initial station—(i) levelling and (ii) centring. Three operations are performed at subsequent stations—(i) levelling, (ii) centring, and (iii) orientation (setting the table in north direction and marking north-south line) all these three activities are performed simultaneously.

1. Levelling the plane table. Before drawing rays for marking the direction of objects from a station, plane table is necessarily set-up at horizontal position (which means parallel to sea level). This levelling is done by moving the legs of tripod stand forward and backward and lifting and lowering them for levelling drawing board and is tested by spirit level.

2. Centring. The location of a survey station is found out on the drawing board sheet in centring. Plumb bob is used for centring, the method of which has already been explained.

After finishing work at initial station, plane table is carried and put at the next station whose location is already marked on the drawing sheet. Keeping the point of the fork intact at the new station, centring is done by moving the table slowly and carefully. Even then levelling is disturbed and therefore, drawing board should be levelled once again. After one or two trials, the centring and levelling of the plane table is achieved successfully.

3. Orientation. While drawing plan or map, the procedure of setting lines (as base-line) parallel to their corresponding position on the field, so

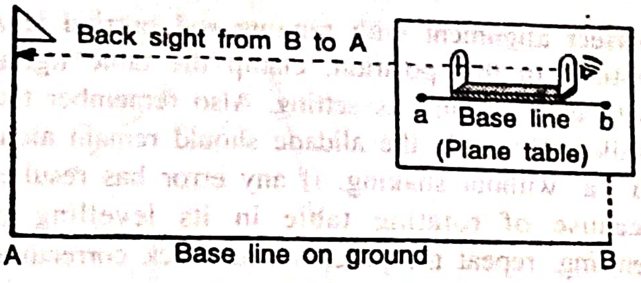

Fig 3

that all drawing is with reference to the magnetic north is called orientation. Subsequent to each station from initial station simultaneous centring, levelling and orientation accurately is absolutely necessary, otherwise all details plotted on the sheet will be different from their real position. There are the following two methods of orientation—

(a) Orientation by trough compass. The table is accurately levelled and centred by loose clamping of the board on tripod at the station where orientation is to be done. Putting trough compass edge on line showing north-south direction, table is so rotated as to enable magnetic needle marked by 'N' (north) to precisely indicate '0' (zero) on the graduated arc of trough compass; then plane table is very carefully tightly clamped on the tripod by gently pushing the table in the centre by all fingers of left hand and clamping it by right hand, so that the table is not disturbed the least in this process. Orientation by this method requires setting up line of north-south direction beforehand.

(b) Orientation by backsighting. In this method the table is oriented by aligning two ends of drawn base line to corresponding base line on the ground. For example, suppose A an B are two survey stations. The base line between A and B is represented by 'a' and 'b' on the drawing sheet (Fig. 3). Now, for the orientation of the table at B station, burry a ranging rod at A station. Loosely clamping drawing board on tripod, make accurate levelling and centring at B station. Thus b shall be vertically above B on ground. Now put fudial/working edge of alidade along 'b' 'a' base line and rotate the table so much as to bring the wire of object vane in perfect alignment with ranging rod burried at A station. In this position, clamp the table tightly without disturbing its setting. Also remember that while sighting A, the alidade should remain along 'b' 'a' without shaking. If any error has resulted because of rotating table in its levelling or centring, repeat the process and check correctness of orientation by backsighting A.

Orientation by backsighting is considered as more reliable and authentic. So, this method is often used for orientation.

(C) Drawing of Rays

After setting the plane table at initial station and then at next stations, the features of the field around the station and also the next stations of traversing, are sighted and straight lines which are also called **rays** are drawn from these stations with the help of alidade. For drawing rays an alpin is burried at the station on the drawing sheet and working edge of alidade is kept tightly attached to this alpin while sighting an object on the field (like corner of a building or a tree etc.). Before drawing rays from A station, a line indicating north should be drawn to the left or right upper part of the sheet with the help of trough compass.

(D) Completing the Plan

After drawing all features and boundary line, the scale of the plan should be drawn on the lower side of the plan. On each plan, the name of the area and the method of surveying used should be written within bracket below the area's name.

METHODS OF PLANE TABLING

Main methods of surveying by plane table are explained below. The figures made in explaining various methods, it should be remembered that capital English letters represent ground locations and small letters, their corresponding location on plan.

(A) Intersection Method

In order to making a plan, this method requires drawing rays from two stations, intersection points of the two rays being the location of objects with the help of which the plan is finalised. The line joining two carefully chosen stations wherefrom rays are drawn is called **base line.** This method is especially useful for plotting inaccessible places in open areas (facilitating sighting and raying). In addition, intersection method's use is beneficial for filling up the details in the plan of an area and for mapping river banks and broken boundary lines.

The accuracy of the plan of an area very much depends on correct selection of base line and its measurement. The following things, therefore, should be kept in mind while selecting a base line—

(1) All details and objects should be visible from both ends of the base line.

(2) The angle between the base line and a ray should neither be very small (acute angle) on very big (obtuse angle). In other words, intersection of rays should not be very oblique.

(3) Base line should be selected on a plain ground without intervening obstacles, so that the line could be measured easily with chain or tape.

Procedure. Following Fig. 4, suppose ABCD is an area. Survey procedure of this area will be completed in the following steps—

(1) Having carefully observed the field, choose the details to be shown on the plan. At the bends of boundary line, fix ranging rods to be sighted by alidade. If needed, ranging rods may be put at other details also for clear sighting by alidade.

(2) Following the necessary instruction given above, choose an appropriate base line and measure its length by chain or tape. In the present example AB line is the base line.

(3) Having levelled the plane table at A station, mark magnetic north at the upper side of

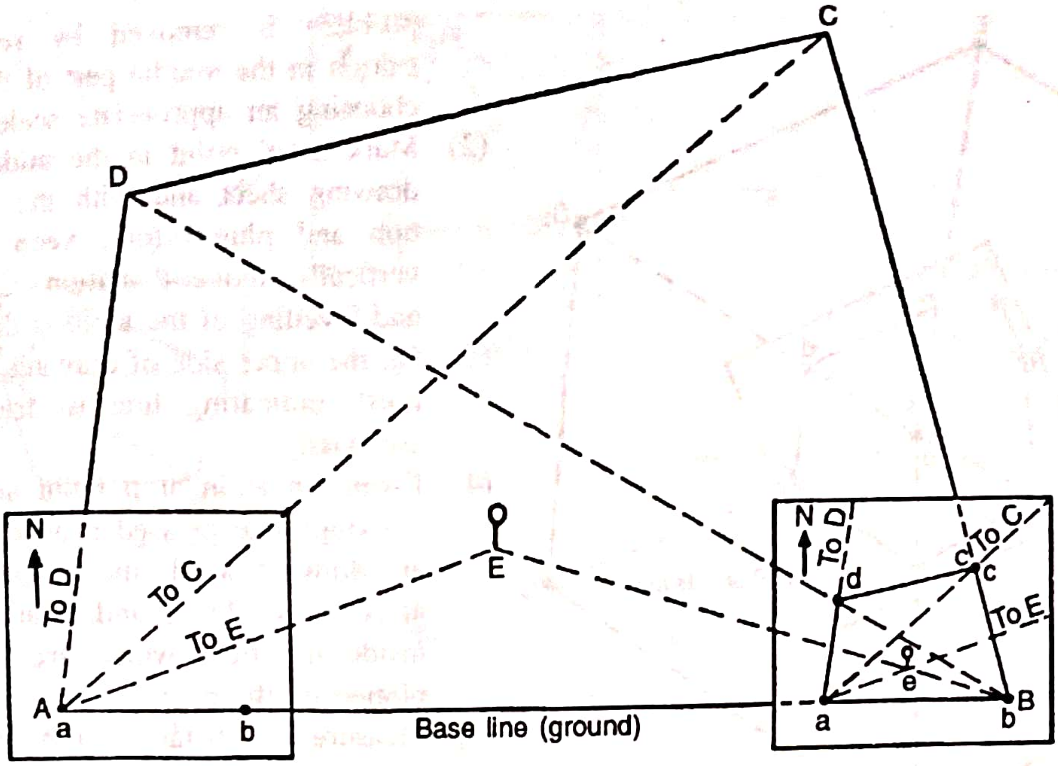

Fig 4. Intersection method.

drawing sheet with the help of trough compass.

(4) By the use of plumb bob, find 'a' point on the drawing sheet corresponding to the A station on ground and fix an alpin at 'a'.

(5) Pushing the working edge of alidade against the alpin hold it and sight the ranging rod at B station and draw a ray. From this ray measure the distance 'a' 'b' according to a decided scale as corresponding distance of AB on ground.

(6) Draw rays sighting other chosen objects in the field from 'a' and write their names or indications for identification as To C, To D, To E etc. on the rays.

(7) Finishing all procedures mentioned above, shift the plane table to B station. Setting the table at B station requires enough time which should be given to simultaneously levelling, centring and orientation of the table. At this stage 'b' must be just above B station, table should be levelled and putting alidade along 'b' 'a' line of sight must pass through ranging rod at A station.

(8) Now alidade be put pressed against alpin at 'b' and one by one the rays be intersected from here sighting them. Any object of field details must be sighted from any two stations and intersected to mark the intended point on ground.

(9) Plan should be prepared hand in hand with the help of intersection points. Lines of plan such as a wall of building, or a boundary of crop field or well etc. should be made a little darker in comparison to rays and other pencil work.

(10) After making all details of the plan, write the name of the area surveyed as caption, surveying method below it and also make graphical scale and index at the bottom of the map.

(B) Radiation or Radial Line Method

Objects of the details of the field are located from only one station in this method. After setting the table, rays are drawn towards the objects and their length measured and marked on the drawing sheet according to pre-determined suitable scale. So,

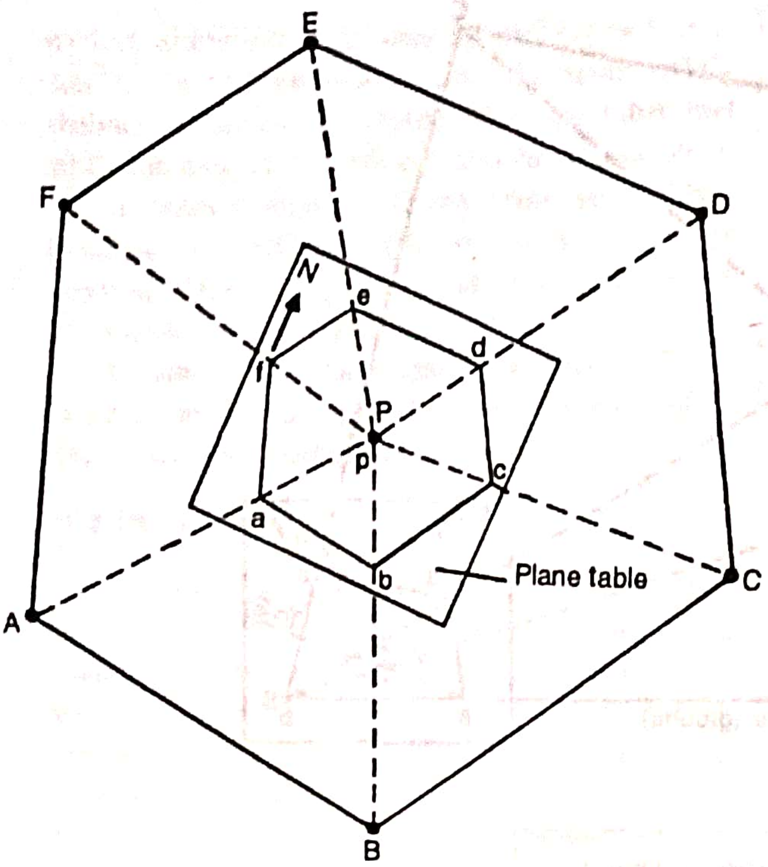

Fig 5. Radiation method.

measuring of distance of an object from plane table station becomes necessary. Since all rays are radiated from one station towards various directions in making plan with this method, it is called **radiation method** or **radial line method**. Open small plain areas are surveyed by this method. In addition, this method is best suited to making plan of smaller areas around one plane table station in a surveying carried out by some other method.

Procedure. Suppose ABCDEF is a plain open area (Fig.5). The surveying of this area will be conducted by radiation method in the following way—

(1) First of all, select a survey station as P in this case, in the middle part of the area from where all details to be mapped are visible. If survey station is chosen in a corner or out of the field, sometimes details to be mapped can not be plotted within the limits of drawing sheet and the whole surveying procedure has to be repeated once again. This problem is removed by selecting survey station in the middle part of the field and by choosing an appropriate scale.

(2) Mark a 'p' point in the middle part of the drawing sheet and with the help of plumb bob and plumb fork, keep 'p' point just vertically above P station. Correct centring and levelling of the table is done.

(3) On the upper side of drawing sheet, magnetic north indicating line is drawn by trough compass.

(4) Fixing an alpin at p point and keeping the working edge pressed against the alpin, rays are drawn towards the ranging rods burried at A, B, C, D, E and F and other objects inside the field which are intended to be plotted on the plan.

(5) Measure the distance of A, B, C, D, E, F etc. from P station on the field with the help of chain or tape and mark a, b, c, d, e and f points on the corresponding rays on the basis of a scale already decided. Similarly, other details are also marked in the field and plan prepared. To avoid mistakes in marking distances on rays, such distances should be marked immediately after drawing a ray.

(6) Make the boundary line of the field by joining a, b, c, d, e and f and other details and finish the work by writing the name of the area, method of surveying and scale at appropriate places on the drawing sheet.

(C) Traverse Method

A traverse line by joining the series of survey stations is drawn and survey of area around a station is conducted and plan is made according to a chosen scale. So, in this method accessibility between the stations of traversing should be a must, so that distances between the survey stations are measured easily on the field. This method is very useful for surveying an area along a road or a river.

Procedure. Plane table surveying by traverse method is completed in the following steps—

(1) Inspecting the field well, selection of any suitable traverse is made and ranging rods

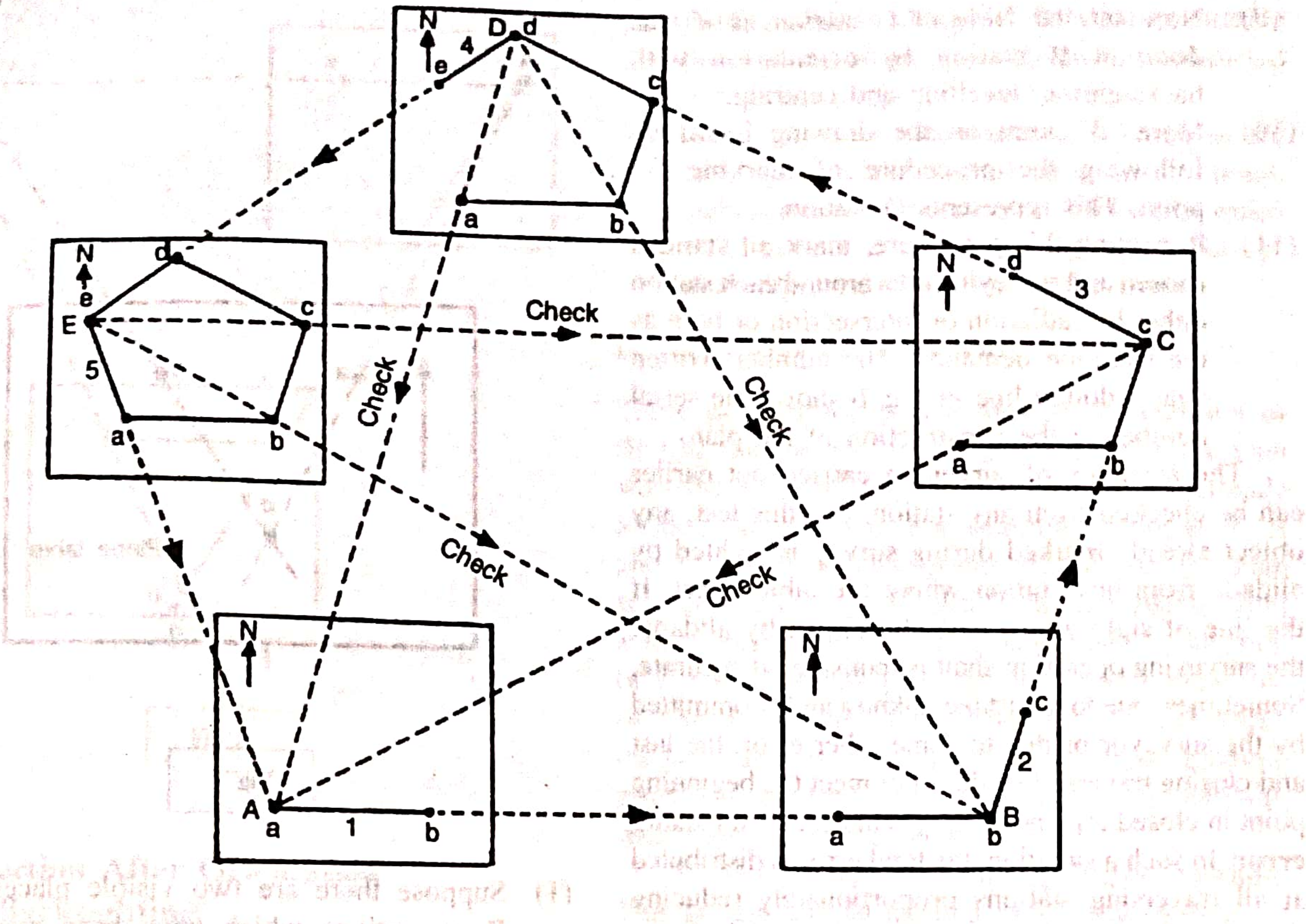

Fig 6. Traverse method.

are burried at survey stations A, B, C, D and E (Fig. 6).

(2) Put the plane table at A station to begin the traversing and plot A on drawing sheet as 'a' with the help of plumb bob and do the centering of the plane table i.e. put 'a' point exactly above A station and do the levelling of plane table.

(3) Fixing an alpin at 'a' and keeping alidade's working edge pressed against alpin, draw a ray to B station.

(4) Measure the distance between stations A and B and mark this distance according to scale to find out 'b' which represents B station.

(5) Draw the line showing magnetic north. If certain objects around A station and on both sides of traverse line have to be mapped, their location is also marked by radiation method. Distant objects should be ... intersection method. For intersection two successive stations may be chosen.

(6) Now take the plane table to B station and pitch a ranging rod at A station again. Putting the 'b' point of table exactly above B station, complete levelling and orientation of plane table. For orientation, backsighting of ranging rod at A station with the help of alidade is preferred. When backsight line is aligned to ranging rod at A, the table is clamped and its levelling and centring should be tested once more before drawing rays from 'b'.

(7) From 'b' point on the table C station is sighted and a ray drawn. The distance measured between stations B and C is marked on this ray and point 'c' marked representing C station.

(8) At B, locate ... ects around this station either by radiati... ntersection method and then take the ... ible at C station.

(9) Now set the lable at C station as it was done at B station by orientation with backsighting, levelling and centring.

(10) Mark 'd' point on the drawing board by following the procedure of marking 'c' point. This represents D station.

(11) Repeating this procedure, mark all stations chosen and surveying area around each station either by radiation or intersection or both as the situation demands. The number written near a dotted line in Fig. 6 shows the serial number of the construction of the plan.

The accuracy of surveying carried out earlier can be checked from any station. For this test, any object already marked during survey is sighted by alidade from any station where the table is set. If the line of sight aligns with the object by alidade, the surveying operation shall be considered accurate. Sometimes, due to a mistake unknowingly committed by the surveyor or due to some other error, the last and closing traverse line does not meet the beginning point in closed traverse survey. This is called **closing error**. In such a situation, the total error is distributed at all traversing stations proportionately reducing (1)
the error backwards and a new corrected closed traversing frame is achieved, which is used as the basic frame for plotting all details. The graphical method of removing closing error is explained in the next chapter on prismatic compass surveying. (2)