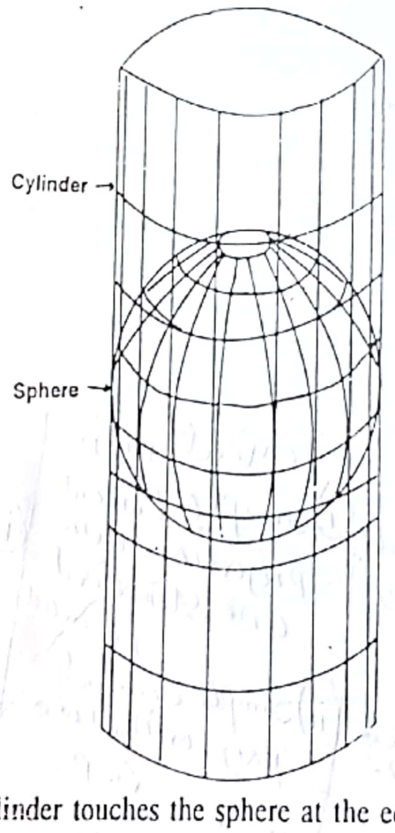
CHAPTER 6

Cylindrical Map Projections

IN these projections, the parallels and the meridians of a globe are transferred to a cylinder wh a developable surface. We take a cylinder the diameter of which is equal to the diameter of the and place the globe inside the cylinder in such a way that its equator touches the cylinder. We then the parallels and the meridians of the globe, by using certain methods, in contact with the inner s of the cylinder. On unrolling the cylinder, we get a flat rectangular surface. On this surface :



Cylinder touches the sphere at the equator.

Fig. 38

The parallels are straight lines. Each parallel is equal to the length of the equator. Thus, the pa are longer than the corresponding parallels on the globe. (ii) The meridians are straight lines. They int the equator at right angles and they are equi-spaced in all latitudes. (iii) The length of the equator cylinder is equal to the length of the equator on the globe. Therefore, these projections are quite s for showing equatorial regions.

We shall study the following cylindrical map projections:

(i) The Simple Cylindrical Projection.
(ii) The Cylindrical Equal-Area Projection.
(iii) The Mercator's Projection.

I. THE SIMPLE CYLINDRICAL PROJECTION

Let us draw a network of Simple Cylindrical Projection for the whole globe on the scale of 1 : 400,000,000, spacing parallels and meridians at 30° interval.

Construction

Radius of the earth = 635,000,000 cm.

$\therefore$ Radius of the globe on the scale of $\dfrac{1}{400,000,000}$

$$= \frac{1}{400,000,000} \times \frac{635,000,000}{1} \text{ cm.}$$

$$= 1.587 \text{ cm.}$$

Length of the equator on the globe $= 2\pi r$ (r = radius of the globe)

$$= 2 \times \frac{22}{7} \times 1.587 \text{ cm.}$$

$$= 9.975 \text{ cm..}$$

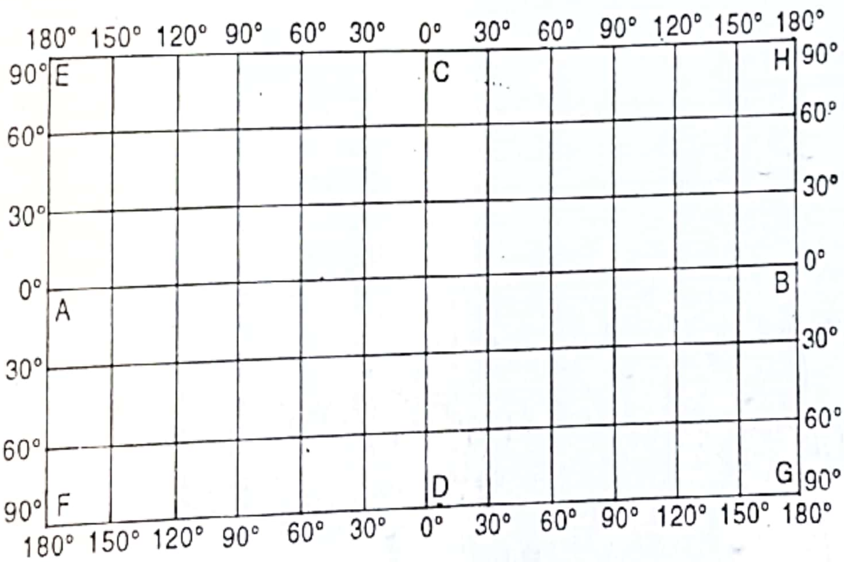


Fig. 39

Draw a line AB, 9.975 cm. long to represent the equator (Fig. 39). The equator is a circle on the globe and is subtended by 360°. Since the meridians are to be drawn at an interval of 30° divide AB into 360/30 or 12 equal parts.

The length of a meridian is equal to half the length of the equator.

$\therefore$ A meridian of the globe $= \dfrac{9.975}{2}$ or 4.987 cm.

To draw meridians erect perpendiculars on the points of divisions of AB.* Take each of these lines equal to the length of a meridian, *i.e.* 4.987 cm., long keeping half of it *i.e.* 2.493 cm. on either side of the equator.

*See foot-note at page 54.

A meridian on a globe is subtended by 180°. Since the parallels are to be drawn at an interval of divide the central meridian (CD) into $\frac{180}{30}$, *i.e.* 6 equal parts. Through these points of divisions lines parallel to the equator. These lines will be parallels of latitude. Mark the equator and the ce meridian with 0° and the parallels and other meridians as shown in Fig. 39. EFGH is the required gra

Properties

(1) Parallels and meridians are straight lines.

(2) The meridians intersect the parallels at right angles.

(3) The distances between the parallels and those between the meridians remain the same throug the projection.

(4) All the parallels are of the same length and every one of them is equal to the length of the equ

(5) The length of the equator on this projection is equal to the length of the equator on the gl Therefore, the scale along the equator is correct. The other parallels are longer than the correspon parallels on the globe. For example, 30° parallel, 60° parallel and 80° parallel on this projection are 1 times, 2.000 times and 5.758 times longer than the corresponding parallels on the globe respectivel pole which is a point on the globe is equal to the length of the equator on this projection. The scale a the parallels is, therefore, exaggerated, the exaggeration increasing away from the equator.

(6) All the meridians are of the same length and every one of them is equal to half the length of equator on this projection. Therefore, scale is correct along all the meridians.

(7) The projection is neither equal-area nor orthomorphic.

Limitations

Since the parallels increase in length towards the poles, areas away from the equator are enlar Near the poles the exaggeration is much pronounced. It is only near the equator that the areas are correctly represented.

Uses

(1) A narrow belt along the equator can be shown fairly correctly on this projection. Since it is ne equal-area nor orthomorphic, maps on this projection are used for general purposes only.

(2) Scale along the meridians is correct. Therefore, a narrow strip of land running in the north-s direction and crossing the equator is shown fairly correctly on this projection. This projection can be for showing a railway or a road connecting Cairo (Egypt) with Durban (Republic of South Africa) be both of these towns are located near 31° E. meridian.

II. CYLINDRICAL EQUAL-AREA PROJECTION

(A) Let us a draw a network of Cylindrical Equal-Area Projection for the whole globe on the of 1 : 450,000,000 keeping the parallel interval at 15° and the meridian interval at 30°.

Construction

Radius of the earth=635,000,000 cm.

∴ Radius of the globe on the scale of $\frac{1}{450,000,000}$

*See also Kazi S. Ahmed, *Simple Map Projections*, S. Chand & Co., 1969.

$$= \frac{1}{450,000,000} \times \frac{635,000,000}{1} \text{ cm.}$$

$$= 1.411 \text{ cm.}$$

Length of the equator on the globe $= 2\pi r$ (r=radius of the globe)

$$= 2 \times \frac{22}{7} \times 1.411 \text{ cm.}$$

$$= 8.869 \text{ cm.}$$

Towards the left-hand side of the drawing sheet, draw a circle (Fig. 40) with radius equal to the radius of the globe, *i.e.* 1.411 cm.* This circle represents the globe. Let NS the polar diameter and WE the equatorial diameter intersect each other at right angles at O the centre of the circle. Since we are required to draw the parallels at an interval of 15°, draw radii of the circle at an interval of 15° as shown in Fig. 40.

Produce WE to A so that EA is equal to the length of the equator, i.e. 8.869 cm. The equator is a circle on the globe and is subtended by 360°. Since we have to draw the meridians at an interval of 30°, divide EA the equator into 360÷30 or 12 equal parts.

Through the points where the radii drawn at an interval of 15° touch the circle, draw lines parallel to the equator EA. These lines are parallels of latitude. To draw meridians erect perpendiculars on the points of divisions marked on the equator and produce them so that they meet the parallels representing the poles. Mark the equator and the central meridian with 0° and the parallels and other meridians as shown in Fig. 40. JKLM is the required map projection.

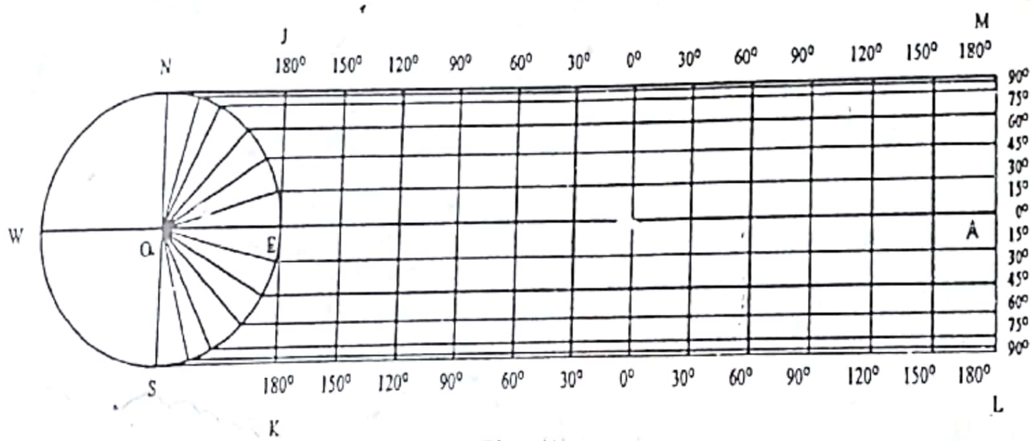


Fig. 40

Properties

(1) Parallels and meridians are straight lines.

(2) The meridians intersect the parallels at right angles.

(3) The distances between the parallels go on decreasing towards the poles but the distances between the meridians remain the same.

(4) All the parallels are of the same length and every one of them is equal to the length of the equator.

(5) The length of the equator on this projection is equal to the length of the equator on the globe. Therefore, the scale along the equator is correct. The parallels are longer than the corresponding parallels on the globe. For example, 30° parallel, 60° parallel and 80° parallel on this projection are 1.154 times, 2.000 times and 5.758 times longer than the corresponding parallels on the globe respectively. A pole which

*See foot-note at page 16.

is a point on the globe is equal to the length of the equator on this projection. The scale along the p is, therefore, exaggerated, the exaggeration increasing away from the equator.

(6) All the meridians are of the same length and the length of each meridian is equal to the of the diameter of the globe but their lengths between the parallels go on decreasing towards the pole the meridians on this projection are shorter in length than the corresponding meridians on the glob lengths have been shortened in the same ratio in which the parallels are made longer with the re area of a strip lying between any two parallels on this projection is equal to the area between the corres parallels on the globe. Thus, equal-area property is maintained over the entire projection. Therefo projection is an equal-area one and useful for showing distribution of products.

Limitations

In the polar areas, the parallels are markedly stretched in the east-west direction and the me are shortened greatly in the north-south direction. Consequently the countries are stretched in the ea direction and compressed in the north-south direction. Thus, the shapes of the countries are d increasingly towards the poles. The distortion in the shapes of tropical countries is almost neglig

Uses

(1) This projection is used for showing tropical countries.

(2) Being an equal-area projection, it is drawn mainly for showing the world distribution of t products such as rubber, coconut, rice, cotton, groundnut, etc.

(B) Draw a Cylindrical Equal-Area Projection on the scale of 1 : 200,000,000 for the area ext from 10°S parallel to 50°S parallel and from 20°W meridian to 100°E meridian and spacing the p at an interval of 10° and the meridians at 20°.

Hint

Radius of the earth=250,000,000 inches

∴ Radius (r) of the globe on the scale of 1 : 200,000,000

$$= \frac{250,000,000}{200,000,000} \text{ inches}$$

$$= 1.25 \text{ inches}$$

Length of the equator on the globe = $2\pi r$

But the projection extends from 20°W meridian to 100°E meridian.

∴ Length of the equator between 20°W and 100°E meridians

$$= 2\pi r \times \frac{20+100}{360}$$

$$= 2 \times \frac{22}{7} \times 1.25 \times \frac{120}{360} \text{ inches}$$

$$= 2.62 \text{ inches.}$$

Divide this line (2.62 inches) into $\frac{20+100}{20}$ or 6 equal parts. ABCD is the required map projection (Fig. 40A).

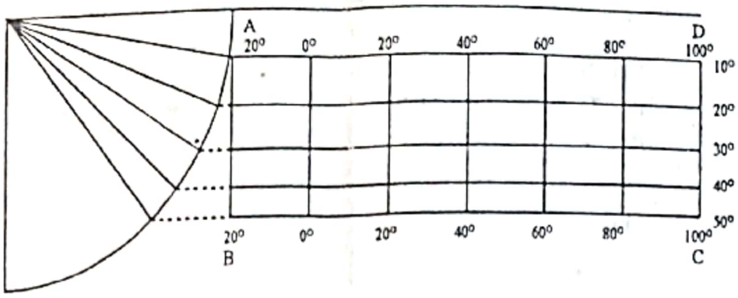


Fig. 40A

III. MERCATOR'S PROJECTION

This projection named after its inventor, was devised by Gerardus Mercator, a Dutch, in 1569. We have seen that the meridians on the Simple Cylindrical Projection and the Cylindrical Equal-Area Projection do not converge towards the poles. They are equidistant throughout these projections, i.e. the distances between the meridians increase towards the poles in these projections. Mercator devised a mathematical formula by virtue of which he placed the parallels increasingly farther apart towards the poles thereby increasing the lengths of the meridians but taking care that the increase in the lengths of the meridians was in the same proportion in which the lengths of the parallels increased. By doing so he got a true orthomorphic projection. The projection is, therefore, also called the *Cylindrical Orthomorphic Projection.*

Let us construct a graticule for Mercator's Projection on the scale of 1 : 460,000,000 spacing parallels and meridians at 20° interval.

Construction

Radius of the earth=250,000,000 inches.

$\therefore$ Radius of the globe on the scale of $\frac{1}{460,000,000}$

$$= \frac{1}{460,000,000} \times \frac{250,000,000}{1}$$

$$= 0.543 \text{ inch}$$

Length of the equator on the globe $= 2\pi r$ (r = radius of the globe)

$$= 2 \times \frac{22}{7} \times 0.543$$

$$= 3.413 \text{ inches.}$$

Draw a line AB 3.413 inches long to represent the equator (Fig. 41). The equator is a circle on the globe and is subtended by 360°. Since the meridians are to be drawn at an interval of 20°, divide AB into $\frac{360}{20}$ or 18 equal parts. Draw lines CAD and FBE perpendicular to *AB*.

Use the following Table for drawing the parallels

Latitude	*Distance of parallel from the equator (r is the radius of the globe)*
10°	0.175 × r
20°	0.356 × r
30°	0.549 × r
40°	0.763 × r
50°	1.011 × r
60°	1.317 × r
70°	1.733 × r
80°	2.436 × r
90°	∞

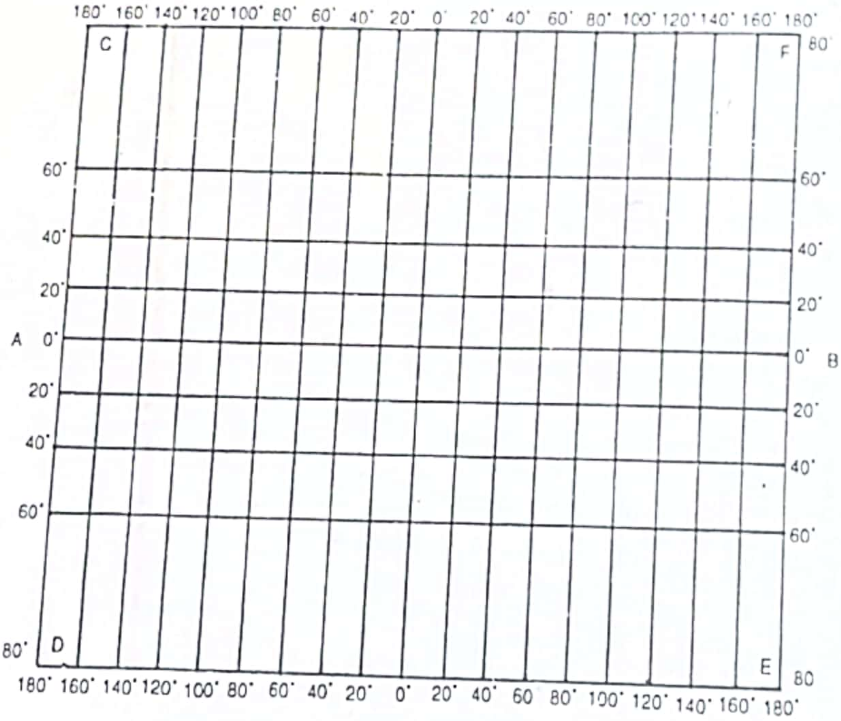


Fig. 41

Now we are required to draw 20°, 40°, 60° and 80° parallels.

Therefore distance of 20° parallel from the equator = 0.356 × r = 0.356 × 0.543 = 0.1

Distance of 40° parallel from the equator = 0.763 × r = 0.763 × 0.543 = 0.

Distance of 60° parallel from the equator = 1.317 × r = 1.317 × 0.543 = 0.

Distance of 80° parallel from the equator = 2.436 × r = 2.436 × 0.543 = 1.3

Mark off points along the lines AC, and BF, the distance of the points from the equator bein to 0.193". A line joining these two points will mark 20°N parallel. Again mark off points along t AC and BF, keeping the distance of the points from the equator now equal to 0.414". A line joini two points will mark 40°N parallel. Similarly draw other parallels.

To draw the meridians, erect perpendiculars on the points of divisions except points A & B equator and produce them so that they meet 80°N and 80°S parallels.

Mark the equator and the central meridian with 0° and parallels and other meridians as shown in Fig. 41.

CDEF is the required graticule.

Properties

(1) Parallels and meridians are straight lines.

(2) The meridians intersect the parallels at right angles.

(3) The distances between the parallels go on increasing towards the poles but the distances between the meridians remain the same.

(4) All the parallels are of the same length and every one of them is equal to the length of the equator.

(5) The length of the equator on this projection is equal to the length of the equator on the globe. Therefore, the scale along the equator is correct. The parallels are longer than the corresponding parallels on the globe. For example, 30° parallel, 60° parallel and 80° parallel on this projection are 1.154 times, 2.000 times and 5.758 times longer than the corresponding parallels on the globe respectively. The poles cannot be shown on this projection because exaggeration in the scales along the 90° parallel and the meridians touching them is infinite.

(6) The meridians are longer than the corresponding meridians on the globe. They are made longer so as to make the scale along the meridians at any point equal to the scale along the parallels at the same point. The following three examples illustrate this point :

(a) As the length of 1°N parallel is 1.0002 times the length of the 1°N parallel on the globe, the length of the meridian between 0° (equator) and 1°N parallel is 1.0002 times longer than the corresponding meridian on the globe.

(b) 20°N parallel on this projection is 1.064 times the length of the 20°N parallel on the globe. Therefore, the length of the meridian between 19°N and 20°N parallels is 1.064 times longer than the corresponding meridian on the globe.

(c) 80°N parallel on this projection is 5.758 times the length of the 80°N parallel on the globe. Therefore, the length of the meridian between 79°N and 80°N parallels, is 5.758 times longer than the corresponding meridian on the globe.

Thus, the east-west stretching is accompanied by an equal north-south stretching at every point over the entire projection. It should, however, be borne in mind that the actual amount of stretching will vary from one latitude to another. The result of this stretching is that sizes of countries in high latitudes are enlarged many times more than their actual sizes. The exaggeration in the sizes of the countries within the tropics is very small. Most of Greenland lies within the polar areas and most of South America within the tropics. Greenland which is about one-ninth of the size of South America appears as large as South America on Mercator's Projection.

(7) The parallels and meridians also intersect each other at right angles. Therefore, the shape of countries is represented truly at every point. Since the scale varies from parallel to parallel and is much exaggerated towards the poles, the shape of a large-sized country is distorted; it is larger on the poleward side and relatively small on the equatorward side. Therefore, shapes of small areas are preserved on this projection but of large countries distorted.

(8) At a point, the scale along the meridian is equal to the scale along the parallel. The projection is, therefore, orthomorphic.

(9) A straight line drawn on this projection makes the same angle with the meridians (Fig. 42). A

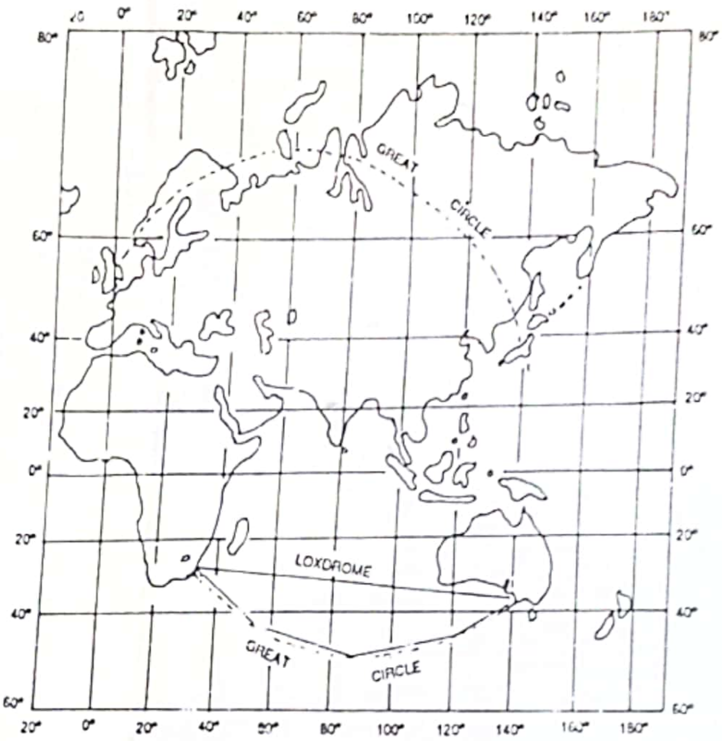
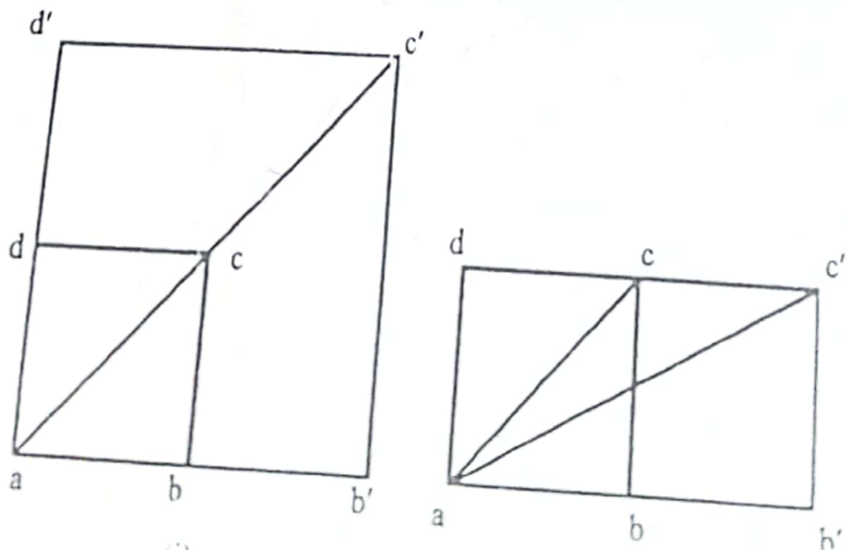


Fig. 42

straight line drawn on this projection is, therefore, a line of constant bearing. Such a line is called a *loxodro* or a *rhumb-line*. Thus, compass directions are shown by straight lines and correctly maintained in t projection. Owing to this property, Mercator's Projection is of great value for navigational purposes b on the sea and in the air.

It may be noted here that a line drawn on Cylindrical Equal-area Projection is not a rhumb-line beca the scale along a meridian at a particular point is not equal to the scale along the parallel at that point properties of the projection). This point is further elaborated as below.

In Fig. 43 (i), the side a b of rectangle abcd is produced to b′ and ad to d′ keeping the ratio of lengths ab′ and ad′ equal to the ratio of the lengths ab and ad. Complete the rectangle ab′c′d′. The an cad is equal to the angle c′ad′ and c′ lies on the diagonal ac produced. Thus, the direction of ac′ is the sa as that of ac.



(i)

In Fig. 43 (ii), the side ab of rectangle abcd is produced to b′ without increasing the length of ad. Thus, the ratio of the lengths of ab and ad is not maintained in this diagram. The angle cad is not equal to the angle c′ad. Thus, increase in the length of ab without increase in the length of the line ad has resulted in the change of direction from ac to ac′.

Limitations

(1) As already pointed out, the scale along the parallels and the meridians increases rapidly towards the poles. There being a great exaggeration of scale along the parallels and the meridians in high latitudes, the sizes of the countries on this projection are very large in the polar areas. For this reason, the polar areas cannot be shown satisfactorily on this projection.

(2) Poles cannot be shown on this projection because the exaggeration in the scales along the 90° parallel and the meridians touching them is infinite.

Uses

(1) This projection is commonly used for navigational purposes both on the sea and in the air. The distance along a rhumb-line between any two points is greater than the distance along the great circle between the same two points, on the earth. A rhumb-line on this projection is a straight line but a great circle running more or less in the east-west direction is a curved line. A great circle bends towards the poles—northwards in the Northern Hemisphere and southwards in the Southern Hemisphere (Fig. 42). A rhumb-line and a great circle, however, run together as a straight line along the equator and the meridians on this projection.

The mariner gets his direction by the rhumb-line but tries to remain as near the great circle as possible to follow the shortest route. Lines indicating the great circles are marked on the maps (drawn on this projection) with the help of Gnomonic Projection. He breaks up the great circle into a number of sections and joins the points of divisions (on the great circles) by lines which serve as various legs of the rhumb-line. The mariner follows the first leg until he reaches the great circle. He then changes his bearing to follow the next leg of the rhumb-line. Thus, he goes on changing his bearings till he reaches his destination.

(2) Ocean currents, wind directions and pressure systems are shown on this projection as the directions are maintained truly on this projection.

(3) Maps of tropical countries are shown on this projection when they are to be used for general purposes. The reason is that exaggeration in the size of an area is small within the tropics and the shapes of the countries are preserved without much distortion.

QUESTIONS

1 (a) Explain the principle underlying the construction of cylindrical projections.

(b) Draw a graticule for a Cylindrical Equal-Area Projection on the scale of 1 : 200,000,000, spacing parallels and meridians at an interval of 30°.

2 Explain how you would determine (a) the shortest route and (b) the bearings to be followed for an ocean navigation route from Durban (Africa) to Melbourne (Australia).

3 For what purposes would you use the following projections :

(i) Simple Cylindrical Projection

(ii) Cylindrical Equal-Area Projection

(iii) Mercator's Projection

4 Compare and contrast the properties and uses of Cylindrical Equal-Area Projection with those of Mercator's Projection.