Subject: Tech.inf 2018-09

Ship Handling & Management Knowledge For MWS- PART2

موضوع:اطلاعیه فنی ۰۹-۲۰۱۸

دانش مدیریت و کنترل کشتی برای بازرس تضمین عملیات- قسمت۲

Number: 32/96/0108

Date: 05.02.2018

شماره: ۳۲/۹۶/۰۱۰۸

تاریخ : ۱۳۹۶/۱۱/۱۶

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رضوان پناه
مدیر واحد کنوانسیون ها و مقررات دریایی
موسسه رده بندی ایرانیان

ترک دعوی: اگرچه در گردآوری کلیه راهنماهای فنی ارائه شده توسط موسسه رده بندی ایرانیان ،تا حد ممکن تلاش در دقت و صحت محتوا صورت گرفته است،این موسسه متحمل مسئولیتی در قبال هرگونه اشتباهات ،خسارت های احتمالی و جرائمی که ممکن است در ارتباط با بکار گیری مفاهیم و مطالب ارائه شده رخ دهد،نمیباشد.

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موسسه رده بندی ایرانیان
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NAUTICAL CHARTS

CHART FUNDAMENTALS

Definitions

A nautical chart represents part of the spherical earth on a plane surface. It shows water depth, the shoreline of adjacent land, topographic features, aids to navigation, and other navigational information. It is a work area on which the navigator plots courses, ascertains positions, and views the relationship of the ship to the surrounding area. It assists the navigator in avoiding dangers and arriving safely at his destination.

The actual form of a chart may vary. Traditional nautical charts have been printed on paper. Electronic charts consisting of a digital data base and a display system are in use and will eventually replace paper charts for operational use. An electronic chart is not simply a digital version of a paper chart; it introduces a new navigation methodology with capabilities and limitations very different from paper charts. The electronic chart will eventually become the legal equivalent of the paper chart when approved by the International Maritime Organization and the various governmental agencies which regulate navigation. Currently, however, mariners must maintain a paper chart on the bridge. The Integrated Bridge, for a discussion of electronic charts.

Should a marine accident occur, the nautical chart in use at the time takes on legal significance. In cases of grounding, collision, and other accidents, charts become critical records for reconstructing the event and assigning liability. Charts used in reconstructing the incident can also have tremendous training value.

Projections

Because a cartographer cannot transfer a sphere to a flat surface without distortion, he must project the surface of a sphere onto a developable surface. A developable surface is one that can be flattened to form a plane. This process is known as chart projection. If points on the surface of the sphere are projected from a single point, the projection is said to be perspective or geometric.

As the use of electronic charts becomes increasingly widespread, it is important to remember that the same cartographic principles that apply to paper charts apply to their depiction on video screens.

Selecting A Projection

Each projection has certain preferable features. However, as the area covered by the chart becomes smaller, the differences between various projections become less noticeable.

On the largest scale chart, such as of a harbor, all projections are practically identical. Some desirable properties of a projection are:

1. True shape of physical features.
2. Correct angular relationship. A projection with this characteristic is conformal or orthomorphic.
3. Equal area, or the representation of areas in their correct relative proportions.
4. Constant scale values for measuring distances.
5. Great circles represented as straight lines.
6. Rhumb lines represented as straight lines.

Some of these properties are mutually exclusive. For example, a single projection cannot be both conformal and equal area. Similarly, both great circles and rhumb lines cannot be represented on a single projection as straight lines.

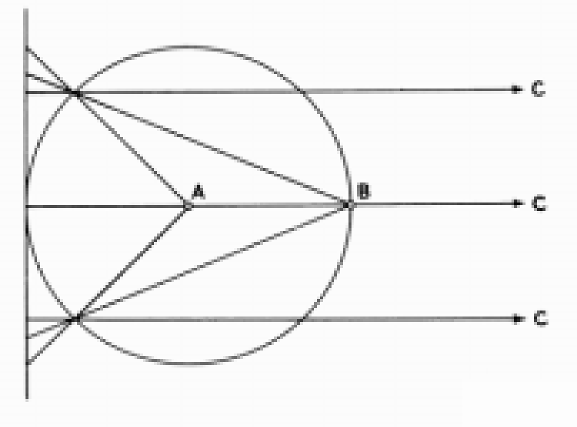
Types Of Projections

The type of developable surface to which the spherical surface is transferred determines the projection's classification. Further classification depends on whether the projection is centered on the equator (equatorial), a pole (polar), or some point or line between (oblique). The name of a projection indicates its type and its principal features.

Mariners most frequently use a Mercator projection, classified as a cylindrical projection upon a plane, the cylinder tangent along the equator. Similarly, a projection based upon a cylinder tangent along a meridian is called transverse (or inverse) Mercator or transverse (or inverse) orthomorphic. The Mercator is the most common projection used in maritime navigation, primarily because rhumb lines plot as straight lines.

In a simple conic projection, points on the surface of the earth are transferred to a tangent cone. In the Lambert conformal projection, the cone intersects the earth (a secant cone) at two small circles. In a polyconic projection, a series of tangent cones is used.

In an azimuthal or zenithal projection, points on the earth are transferred directly to a plane. If the origin of the projecting rays is the center of the earth, a gnomonic projection results; if it is the point opposite the plane's point of tangency, a stereographic projection; and if at infinity (the projecting lines being parallel to each other), an orthographic projection. The gnomonic, stereographic, and orthographic are perspective projections. In an azimuthal equidistant projection, which is not perspective, the scale of distances is constant along any radial line from the point of tangency.



Azimuthal projections: A, gnomonic; B, stereographic; C, (at infinity) orthographic.

Cylindrical and plane projections are special conical projections, using heights infinity and zero, respectively.

A graticule is the network of latitude and longitude lines laid out in accordance with the principles of any projection.

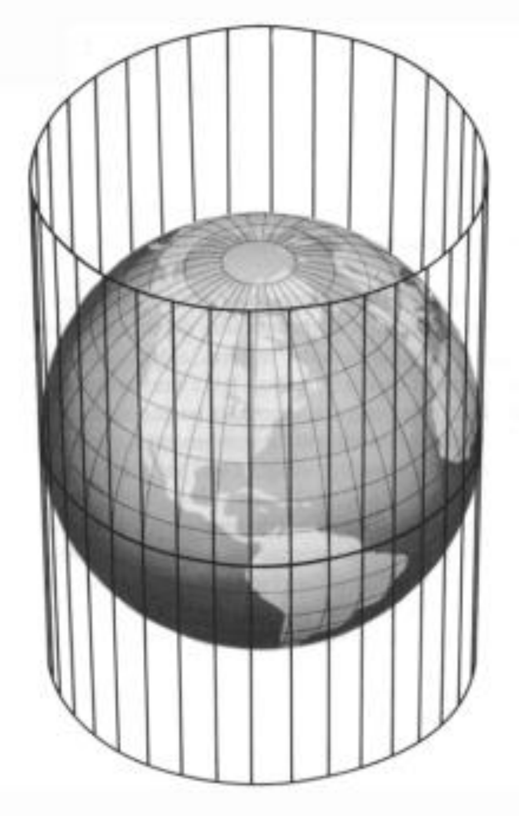
Cylindrical Projections

If a cylinder is placed around the earth, tangent along the equator, and the planes of the meridians are extended, they intersect the cylinder in a number of vertical lines. These parallel lines of projection are equidistant from each other, unlike the terrestrial meridians from which they are derived which converge as the latitude increases.

On the earth, parallels of latitude are perpendicular to the meridians, forming circles of progressively smaller diameter as the latitude increases. On the cylinder they are shown perpendicular to the projected meridians, but because a cylinder is everywhere of the same diameter, the projected parallels are all the same size.

If the cylinder is cut along a vertical line (a meridian) and spread out flat, the meridians appear as equally spaced vertical lines; and the parallels appear as horizontal lines. The parallels' relative spacing differs in the various types of cylindrical projections.

If the cylinder is tangent along some great circle other than the equator, the projected pattern of latitude and longitude lines appears quite different from that described above, since the line of tangency and the equator no longer coincide These projections are classified as oblique or transverse projections.



A cylindrical projection.

Mercator Projection

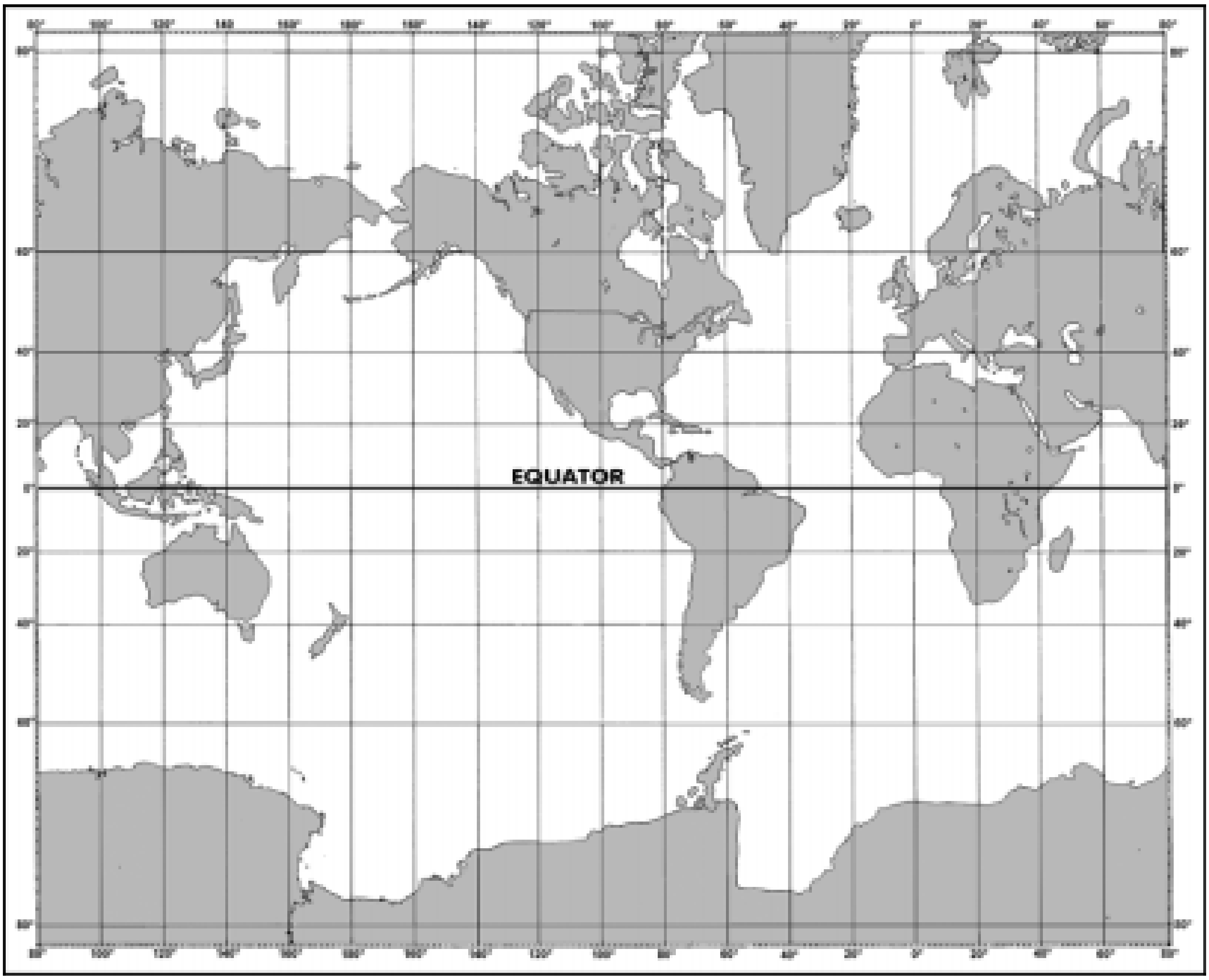
Navigators most often use the plane conformal projection known as the Mercator projection. The Mercator projection is not perspective, and its parallels can be derived mathematically as well as projected geometrically. Its distinguishing feature is that both the meridians and parallels are expanded at the same ratio with increased latitude. The expansion is equal to the secant of the latitude, with a small correction for the ellipticity of the earth. Since the secant of 90° is infinity, the projection cannot include the poles. Since the projection is conformal, expansion is the same in all directions and angles are correctly shown.

Rhumb lines appear as straight lines, the directions of which can be measured directly on the chart. Distances can also be measured directly if the spread of latitude is small. Great circles, except meridians and the equator, appear as curved lines concave to the equator. Small areas appear in their correct shape but of increased size unless they are near the equator.

Meridional Parts

At the equator a degree of longitude is approximately equal in length to a degree of latitude. As the distance from the equator increases, degrees of latitude remain approximately the same, while degrees of longitude become progressively shorter. Since degrees of longitude appear everywhere the same length in the Mercator projection, it is necessary to increase the length of the meridians if the expansion is to be equal in all directions. Thus, to maintain the correct proportions between degrees of latitude and degrees of longitude, the degrees of latitude must be progressively longer as the distance from the equator increases.

The length of a meridian, increased between the equator and any given latitude, expressed in minutes of arc at the equator as a unit, constitutes the number of meridional parts (M) corresponding to that latitude. Meridional parts, given in Table 6 for every minute of latitude from the equator to the pole, make it possible to construct a Mercator chart and to solve problems in Mercator sailing. These values are for the WGS ellipsoid of 1984.

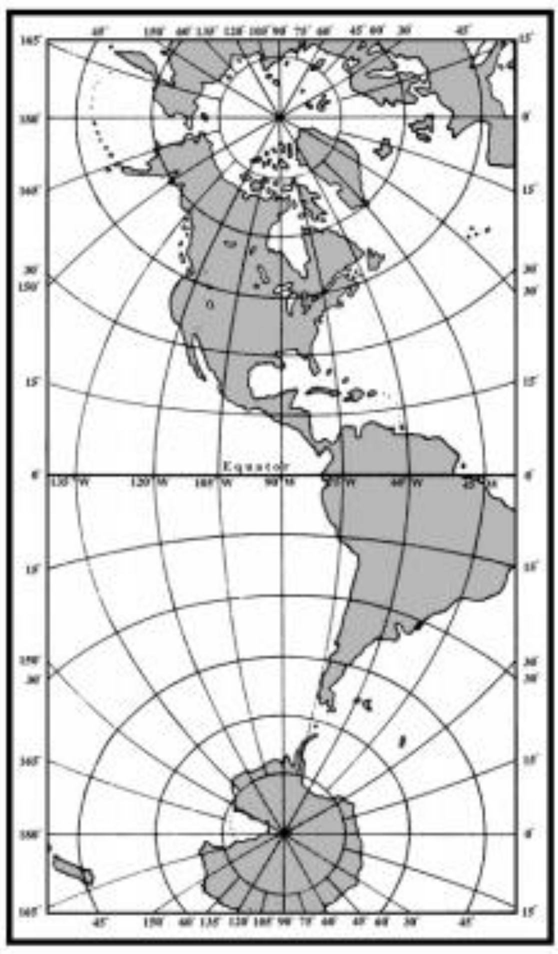


A Mercator map of the world.

Transverse Mercator Projections

Constructing a chart using Mercator principles, but with the cylinder tangent along a meridian, results in a transverse Mercator or transverse orthomorphic projection. The word “inverse” is used interchangeably with “transverse.” These projections use a fictitious graticule similar to, but offset from, the familiar network of meridians and parallels. The tangent great circle is the fictitious equator. Ninety degrees from it are two fictitious poles. A group of great circles through these poles and perpendicular to the tangent great circle are the fictitious meridians, while a series of circles parallel to the plane of the tangent great circle form the fictitious parallels. The actual meridians and parallels appear as curved lines.

A straight line on the transverse or oblique Mercator projection makes the same angle with all fictitious meridians, but not with the terrestrial meridians. It is therefore a fictitious rhumb line. Near the tangent great circle, a straight line closely approximates a great circle. The projection is most useful in this area. Since the area of minimum distortion is near a meridian, this projection is useful for charts covering a large band of latitude and extending a relatively short distance on each side of the tangent meridian. It is sometimes used for star charts showing the evening sky at various seasons of the year.



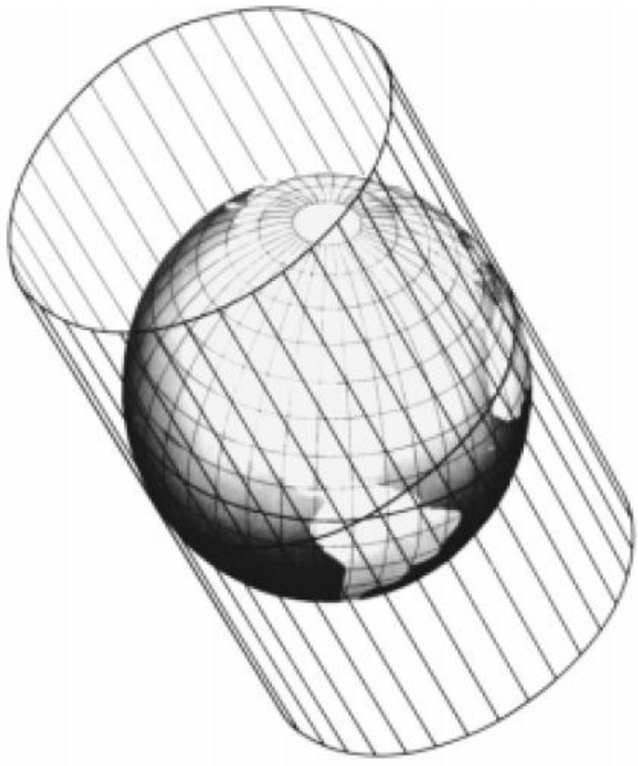
A transverse Mercator map of the Western Hemisphere.

Universal Transverse Mercator (UTM) Grid

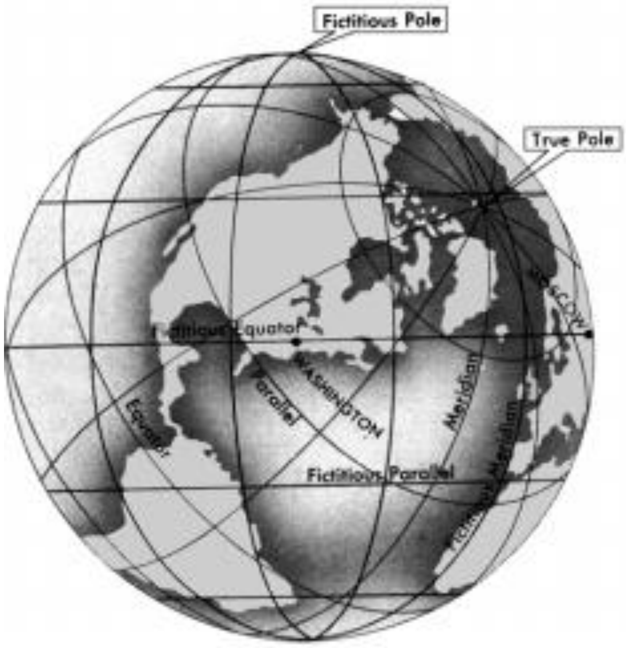
The Universal Transverse Mercator (UTM) grid is a military grid superimposed upon a transverse Mercator graticule, or the representation of these grid lines upon any graticule. This grid system and these projections are often used for large-scale (harbor) nautical charts and military charts.

Oblique Mercator Projections

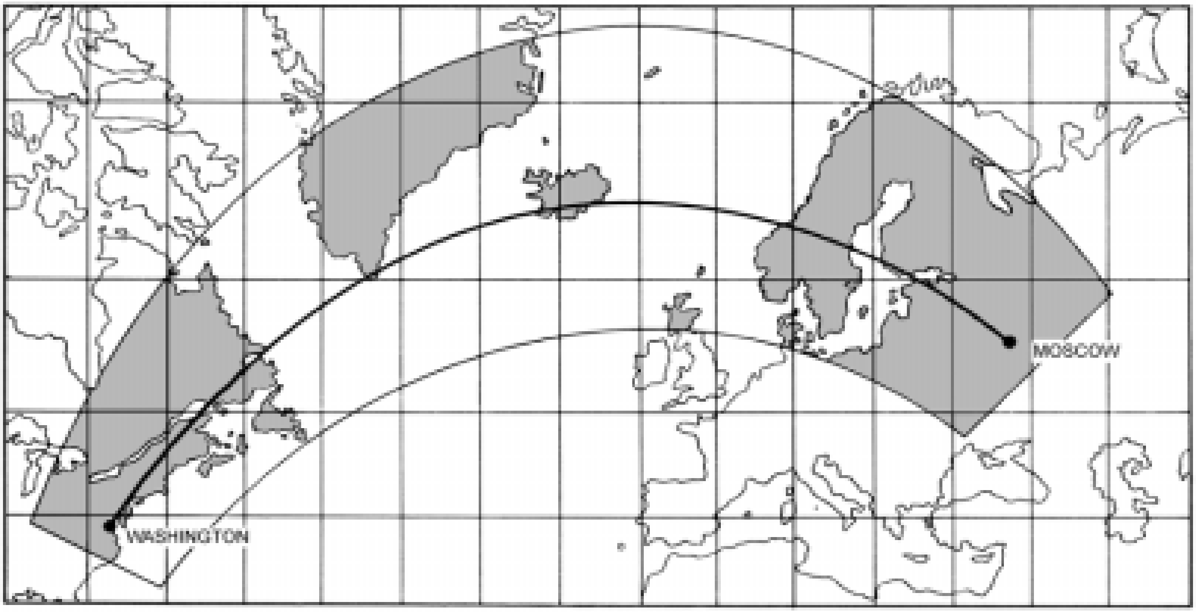
A Mercator projection in which the cylinder is tangent along a great circle other than the equator or a meridian is called an oblique Mercator or oblique orthomorphic projection. This projection is used principally to depict an area in the near vicinity of an oblique great circle. For example, shows the great circle joining Washington and Moscow. Below figure shows an oblique Mercator map with the great circle between these two centers as the tangent great circle or fictitious equator. Note the large variation in scale as the latitude changes.



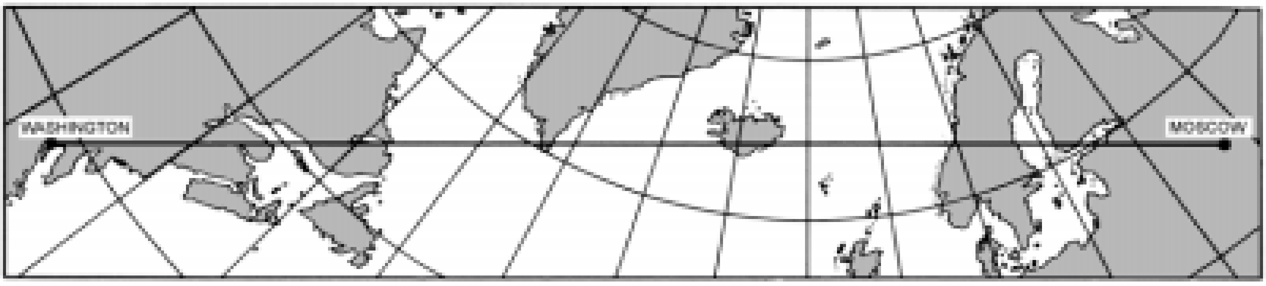
An oblique Mercator projection.



The fictitious graticle of an oblique Mercator projection.



The great circle between Washington and Moscow as it appears on a Mercator map.



An oblique Mercator map based upon a cylinder tangent along the great circle through Washington and Moscow. The map includes an area 500 miles on each side of the great circle.

Rectangular Projection

A cylindrical projection similar to the Mercator, but with uniform spacing of the parallels, is called a rectangular projection. It is convenient for graphically depicting information where distortion is not important. The principal navigational use of this projection is for the star chart of the Air Almanac, where positions of stars are plotted by rectangular coordinates representing declination (ordinate) and sidereal hour angle (abscissa). Since the meridians are parallel, the parallels of latitude (including the equator and the poles) are all represented by lines of equal length.

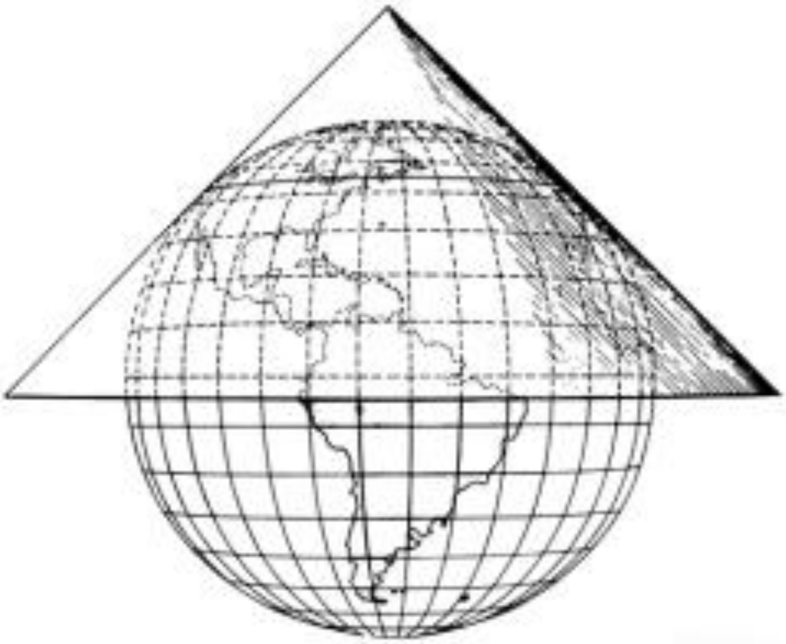
Conic Projections

A conic projection is produced by transferring points from the surface of the earth to a cone or series of cones. This cone is then cut along an element and spread out flat to form the chart. When the axis of the cone coincides with the axis of the earth, then the parallels appear as arcs of circles, and the meridians appear as either straight or curved lines converging toward the nearer pole. Limiting the area covered to that part of the cone near the surface of the earth limits distortion. A parallel along which there is no distortion is called a standard parallel. Neither the transverse conic projection, in which the axis of the cone is in the equatorial plane, nor the oblique conic projection, in which the axis of the cone is oblique to the plane of the equator, is ordinarily used for navigation. They are typically used for illustrative maps. Using cones tangent at various parallels, a secant (intersecting) cone, or a series of cones varies the appearance and features of a conic projection.

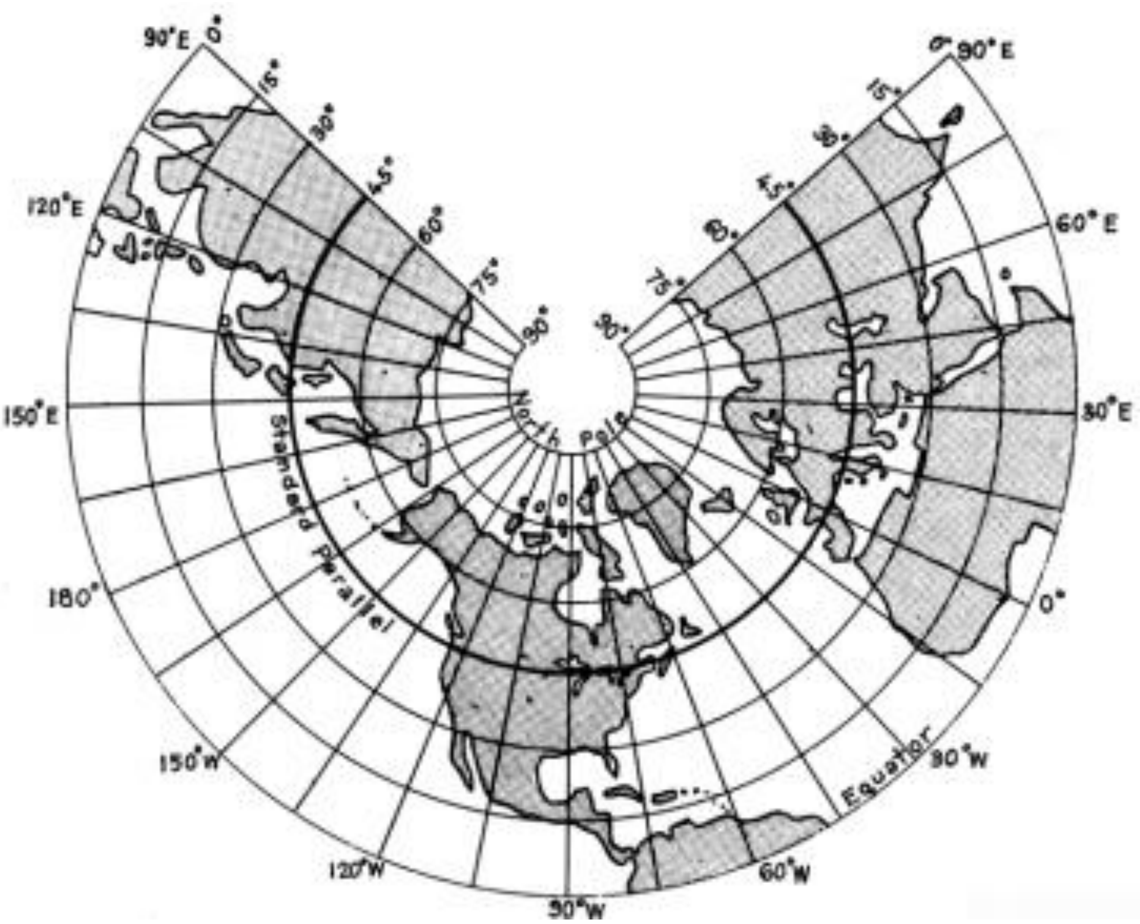
Simple Conic Projection

A conic projection using a single tangent cone is a simple conic projection. The height of the cone increases as the latitude of the tangent parallel decreases. At the equator, the height reaches infinity and the cone becomes a cylinder. At the pole, its height is zero, and the cone becomes a plane. Similar to the Mercator projection, the simple conic projection is not perspective since only the meridians are projected geometrically, each becoming an element of the cone. When this projection is spread out flat to form a map, the meridians appear as straight lines converging at the apex of the cone. The standard parallel, where the cone is tangent to the earth, appears as the arc of a circle with its center at the apex of the cone. The other parallels are concentric circles. The distance along any meridian between consecutive parallels is in correct relation to the distance on the earth, and, therefore, can be derived mathematically. The pole is represented by a circle. The scale is correct along any meridian and along the standard parallel. All other parallels are too great in length, with the error increasing with increased distance from the standard parallel. Since the scale is not the same in all directions about every point, the projection is neither a conformal nor equal-area projection. Its non-conformal nature is its principal disadvantage for navigation.

Since the scale is correct along the standard parallel and varies uniformly on each side, with comparatively little distortion near the standard parallel, this projection is useful for mapping an area covering a large spread of longitude and a comparatively narrow band of latitude. It was developed by Claudius Ptolemy in the second century A.D. to map just such an area: the Mediterranean Sea.



A simple conic projection



A simple conic map of the Northern Hemisphere.

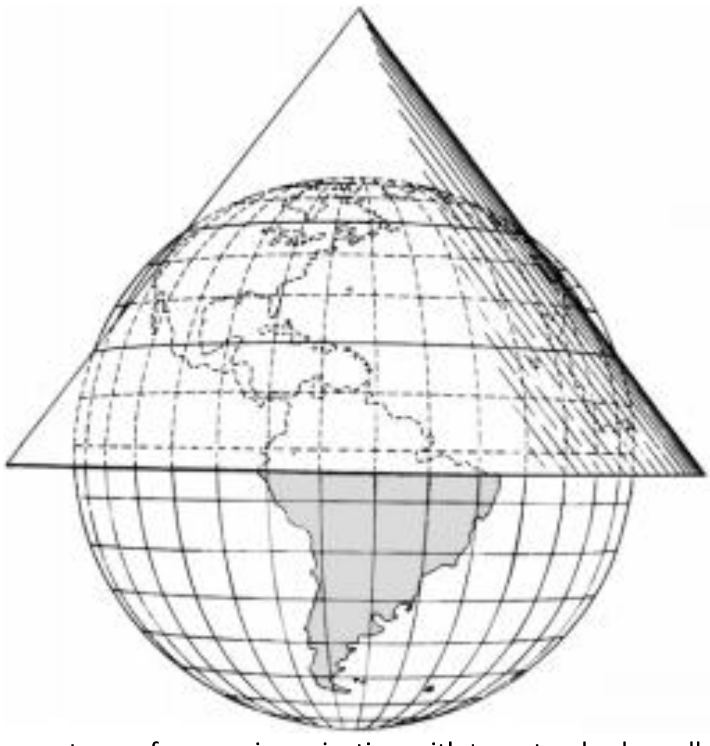
Lambert Conformal Projection

The useful latitude range of the simple conic projection can be increased by using a secant cone intersecting the earth at two standard parallels. The area between the two standard parallels is compressed, and that beyond is expanded. Such a projection is called either a secant conic or conic projection with two standard parallels.

If in such a projection the spacing of the parallels is altered, such that the distortion is the same along them as along the meridians, the projection becomes conformal. This modification produces the Lambert conformal projection.

If the chart is not carried far beyond the standard parallels, and if these are not a great distance apart, the distortion over the entire chart is small.

A straight line on this projection so nearly approximates a great circle that the two are nearly identical. Radio beacon signals travel great circles; thus, they can be plotted on this projection without correction. This feature, gained without sacrificing conformality, has made this projection popular for aeronautical charts because aircraft make wide use of radio aids to navigation. Except in high latitudes, where a slightly modified form of this projection has been used for polar charts, it has not replaced the Mercator projection for marine navigation.



A secant cone for a conic projection with two standard parallels.

Polyconic Projection

The latitude limitations of the secant conic projection can be minimized by using a series of cones. This results in a polyconic projection. In this projection, each parallel is the base of a tangent cone . At the edges of the chart, the area between parallels is expanded to eliminate gaps. The scale is correct along any parallel and along the central meridian of the projection.

Along other meridians the scale increases with increased difference of longitude from the central meridian. Parallels appear as nonconcentric circles; meridians appear as curved lines converging toward the pole and concave to the central meridian.

Azimuthal Projections

If points on the earth are projected directly to a plane surface, a map is formed at once, without cutting and flattening, or “developing.” This can be considered a special case of a conic projection in which the cone has zero height.

The simplest case of the azimuthal projection is one in which the plane is tangent at one of the poles. The meridians are straight lines intersecting at the pole, and the parallels are concentric circles with their common center at the pole. Their spacing depends upon the method used to transfer points from the earth to the plane.

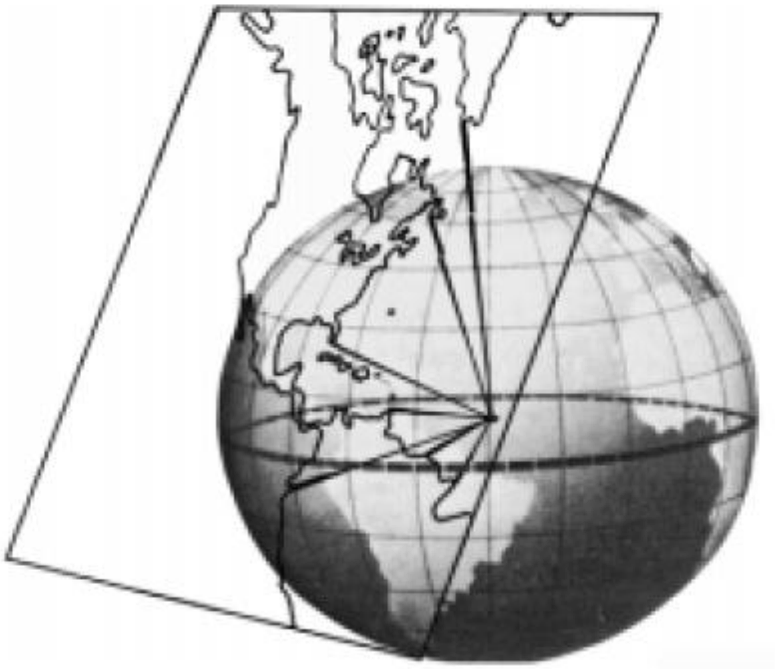
If the plane is tangent at some point other than a pole, straight lines through the point of tangency are great circles, and concentric circles with their common center at the point of tangency connect points of equal distance from that point. Distortion, which is zero at the point of tangency, increases along any great circle through this point. Along any circle whose center is the point of tangency, the distortion is constant. The bearing of any point from the point of tangency is correctly represented. It is for this reason that these projections are called azimuthal. They are also called zenithal.

Several of the common azimuthal projections are perspective.

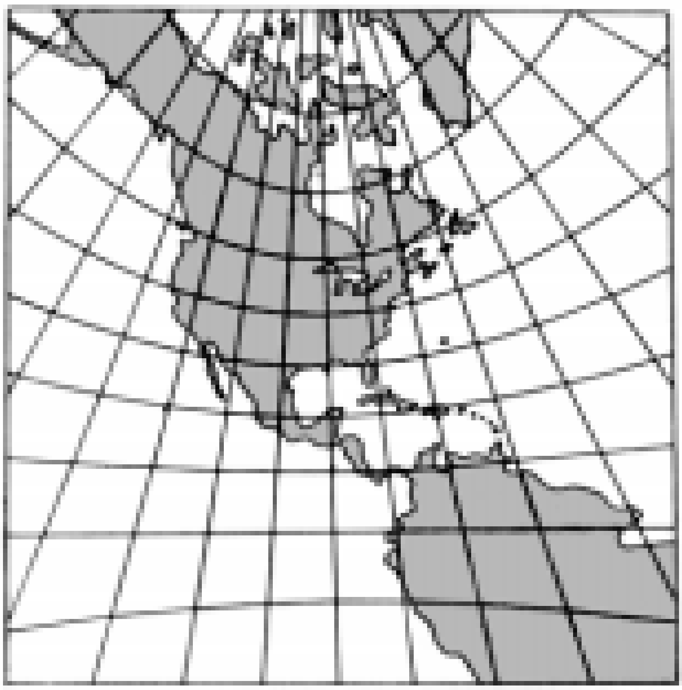
Gnomonic Projection

If a plane is tangent to the earth, and points are projected geometrically from the center of the earth, the result is a gnomonic projection. See Figure 316a. Since the projection is perspective, it can be demonstrated by placing a light at the center of a transparent terrestrial globe and holding a flat surface tangent to the sphere. In an oblique gnomonic projection the meridians appear as straight lines converging toward the nearer pole.

The parallels, except the equator, appear as curves. As in all azimuthal projections, bearings from the point of tangency are correctly represented. The distance scale, however, changes rapidly. The projection is neither conformal nor equal area. Distortion is so great that shapes, as well as distances and areas, are very poorly represented, except near the point of tangency.



An oblique gnomonic projection.



An oblique gnomonic map with point of tangency at latitude 30°N, longitude 90°W.

The usefulness of this projection rests upon the fact that any great circle appears on the map as a straight line, giving charts made on this projection the common name great-circle charts.

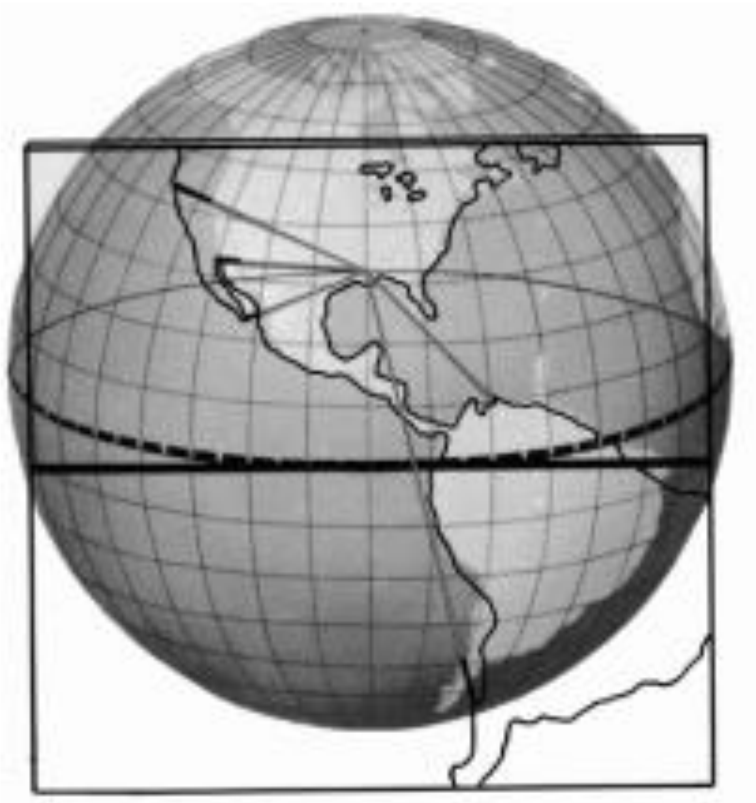
Gnomonic charts are most often used for planning the great-circle track between points. Points along the determined track are then transferred to a Mercator projection.

The great circle is then followed by following the rhumb lines from one point to the next. Computer programs which automatically calculate great circle routes between points and provide latitude and longitude of corresponding rhumb line endpoints are quickly making this use of the gnomonic chart obsolete.

Stereographic Projection

A stereographic projection results from projecting points on the surface of the earth onto a tangent plane, from a point on the surface of the earth opposite the point of tangency. This projection is also called an azimuthal orthomorphic projection.

The scale of the stereographic projection increases with distance from the point of tangency, but it increases more slowly than in the gnomonic projection. The stereographic projection can show an entire hemisphere without excessive distortion. As in other azimuthal projections.



An equatorial stereographic projection.

A stereographic map of the Western Hemisphere.

great circles through the point of tangency appear as straight lines. Other circles such as meridians and parallels appear as either circles or arcs of circles.

The principal navigational use of the stereographic projection is for charts of the polar regions and devices for mechanical or graphical solution of the navigational triangle.

A Universal Polar Stereographic (UPS) grid, mathematically adjusted to the graticule, is used as a reference system.

Orthographic Projection

If terrestrial points are projected geometrically from infinity to a tangent plane, an orthographic projection results (Figure 318a). This projection is not conformal; nor does it result in an equal area representation. Its principal use is in navigational astronomy because it is useful for illustrating and solving the navigational triangle. It is also useful for illustrating celestial coordinates. If the plane is tangent at a point on the equator, the parallels (including the equator) appear as straight lines. The meridians would appear as ellipses, except that the meridian through the point of tangency would appear as a straight line and the one 90° away would appear as a circle.

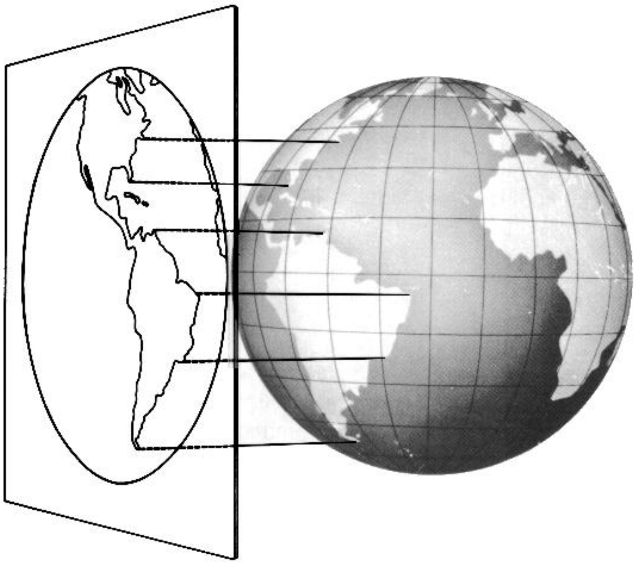
Azimuthal Equidistant Projection

An azimuthal equidistant projection is an azimuthal projection in which the distance scale along any great circle through the point of tangency is constant. If a pole is the point of tangency, the meridians appear as straight radial lines and the parallels as equally spaced concentric circles.

If the plane is tangent at some point other than a pole, the concentric circles represent distances from the point of tangency. In this case, meridians and parallels appear as curves.

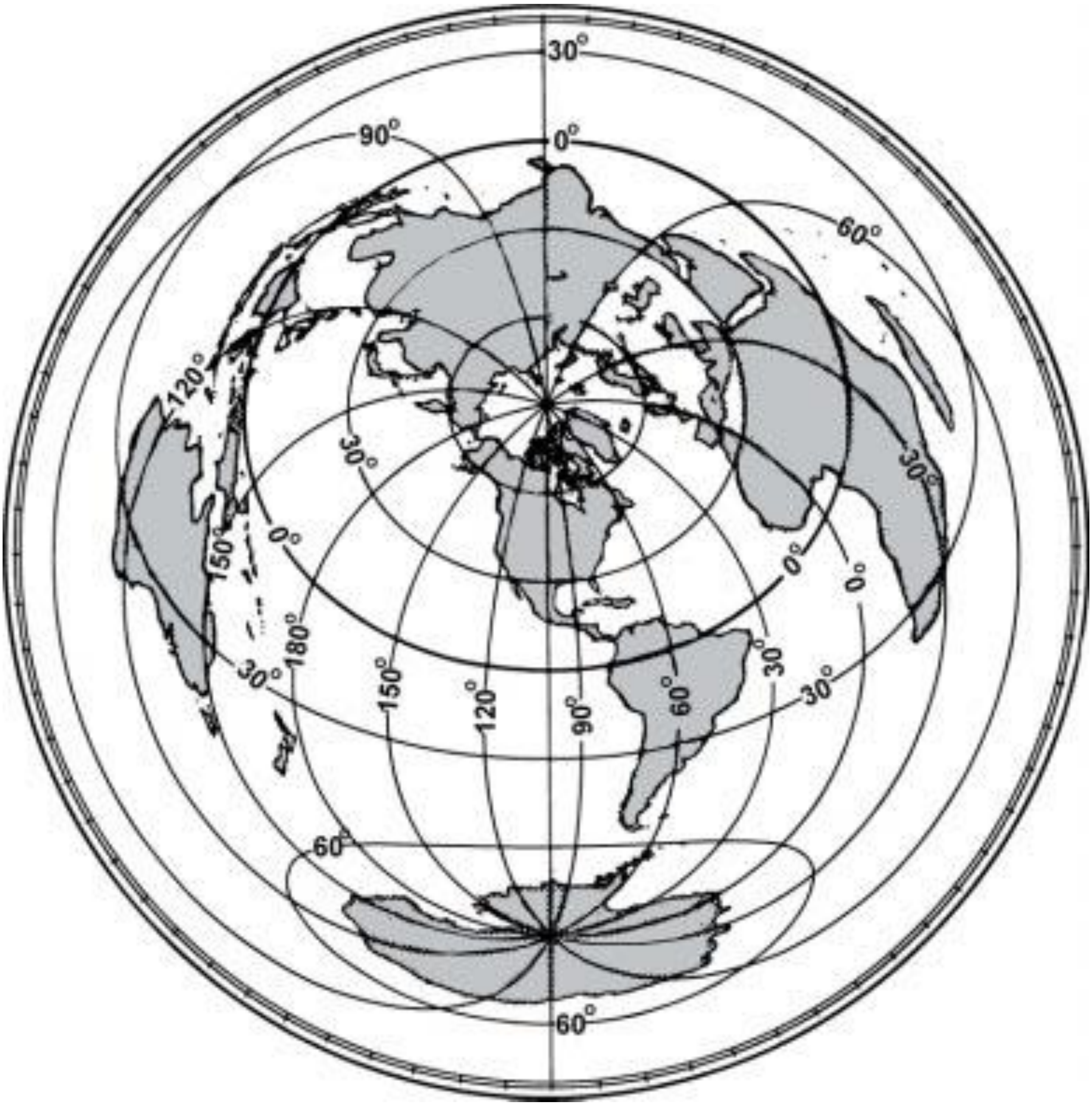
The projection can be used to portray the entire earth, the point 180° from the point of tangency appearing as the largest of the concentric circles. The projection is not conformal, equal area, or perspective. Near the point of tangency distortion is small, increasing with distance until shapes near the opposite side of the earth are unrecognizable.

The projection is useful because it combines the three features of being azimuthal, having a constant distance scale from the point of tangency, and permitting the entire earth to be shown on one map. Thus, if an important harbor or airport is selected as the point of tangency, the great-circle course, distance, and track from that point to any other point on the earth are quickly and accurately determined. For communication work with the station at the point of tangency, the path of an incoming signal is at once apparent if the direction of arrival has been determined and the direction to train a directional antenna can be determined easily. The projection is also used for polar charts and for the star finder, No. 2102D.



An equatorial orthographic projection.

An orthographic map of the Western Hemisphere.



An azimuthal equidistant map of the world with the point of tangency latitude 40°N, longitude 100°W.