Determination of True Meridian

By

A. DeGROOT, M. Am. Soc. C.E.
Former Director, Civil Engineering School
International Correspondence Schools

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International Correspondence Schools
Scranton, Pennsylvania

ICS

International Correspondence Schools Canadian, Ltd.
Montreal, Canada

What This Text Covers . . .

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The Celestial Sphere

Properties of a Sphere

Methods of Locating True Meridian

1. At any point on the earth's surface, we can establish a line that would point toward the north pole or the south pole. Such a line lies in the true meridian at that point. If the point is located in the Northern Hemisphere, or north of the earth's equator, the line is directed toward the north pole. If the point is in the Southern Hemisphere, or south of the equator, the line is directed toward the south pole. In any important survey, the direction of the straight line joining any two points should be established by the angle that the selected line makes with the true meridian at some specific point on the line.

Neither the north pole nor the south pole is marked on the earth's surface in any distinguishable way. Even if a pole could be easily found, a mark on the earth's surface would not be visible at another point on the earth more than a few miles away. Furthermore, there is no fixed mark in the sky that would show the direction of the meridian at a point at all times. It is possible, nevertheless, to determine the direction of the meridian at any point on the earth's surface by observing a visible heavenly body, such as the sun or a star, in a prescribed manner.

In this text, two methods of determining the direction of the meridian will be described. One is by observation of the pole star, called *Polaris*. The other is by observation of the sun. In order that the field procedures and the calculatio involved in these methods may be understood, it is necessa to have a knowledge of the principles of solid geometry a astronomy on which they depend. These principles will ther fore be explained first.

Conception of Celestial Sphere

2. In geometry, a sphere is defined as a solid bounded by surface every point of which is at the same distance from point within called the center. A ball is a typical sphe The surface of such a solid should be called a spherical su face, but it is commonly called a sphere.

The distance from the earth to the sun is about 92,000,0 miles, while the diameter of the earth is only about 8,000 mile The distances to the various stars are so enormous that they a usually measured in light-years. A light-year is the distan traveled by a ray of light in a year. Light has a speed of abo 186,000 miles per second, and even the nearest star is abo 4 light-years from the earth, while the more remote stars a thousands of light-years away. Therefore, in comparison wi the distances to the sun and stars, the entire earth may considered a point.

We all have noticed that the sun, the stars, and the mo appear to move across the sky. It is known that the vario stars are at different distances from the earth and are movi independently of one another. Nevertheless, the changes their relative positions, as seen from the earth, are extreme small. In ordinary astronomical work for determining t direction of the true meridian at a point on the earth's surfac the observer imagines that the heavenly bodies are attache to a gigantic sphere with the earth at its center. This sphe is called the celestial sphere. It may be assumed that t celestial sphere rotates around the earth.

The sun and the moon appear to move among the stars the celestial sphere. The motion of the sun with respect

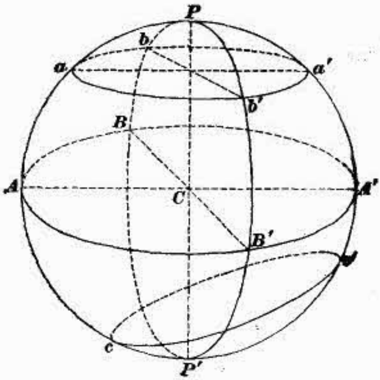

FIG. 1. CIRCLES ON A SPHERE

the stars will be discussed later. The motion of the moon, however, is of no interest in locating a true meridian.

Great and Small Circles of a Sphere

3. The position of a body on the celestial sphere may be described in several different ways. Before you try to understand the systems used for this purpose, you should be familiar with certain properties of a sphere.

A radius of a sphere is a straight line extending from the center of the sphere to any point on its surface. A straight line passing through the center of a sphere and extending between two opposite points on the surface is called a diameter of the sphere.

If we imagine that a sphere is cut into two parts by a plane, the surface of either part exposed by the cutting plane will be a circle. Such a surface is called a section of the sphere; and we may say that every plane section of a sphere is a circle. Any section passing through the center of a sphere is known as a great circle. In Fig. 1, for example, the sections *ABA'B'* and *BPB'P'* are great circles because they pass through the center *C* of the sphere. A great circle divides the sphere into two equal parts, called hemispheres. If a plane section does not pass through the center of a sphere, it is a small circle. The sections *aba'b'* and *cc'* are small circles because these sections do not pass through *C*. Two or more circles of a sphere that lie in parallel planes are known as parallel circles. Thus *ABA'B'* and *aba'b'* are parallel circles.

Axis and Poles

4. The earth is continually turning or rotating on an imaginary line called its axis. For the purposes of this text the earth can be considered to be a sphere; and its axis is a certain straight line passing through its center. In general, the axis of a circle of a sphere is the straight line that passes through the center of the circle and is perpendicular to the plane of the circle. The axis of any circle of a sphere passes through the center of the sphere; and all parallel circles have the same axis. In Fig. 1 the line *PP'* is the axis of the great circle *ABA'B'* and also the axis of the small circle *aba'b'*.

The points at which the axis of a sphere meets its surface are called the poles of the sphere. Also, the poles of any circle on a sphere are the points at which the axis of the circle meets the sphere. If the line *PP'* is the axis of the sphere, the points *P* and *P'* are its poles. These points are also the poles of all circles, as *ABA'B'* and *aba'b'*, of which *PP'* is the axis. It follows that parallel circles of a sphere have common poles.

Primary and Secondary Circles

5. If any great circle of a sphere is selected as a primary circle, all great circles passing through the poles of that circle are called its secondaries. For example, if the great circle *ABA'B'* in Fig. 1 is taken as a primary circle, then the great circle *PAP'A'*, which passes through the poles *P* and *P'* of the primary, is one of its secondaries; and the great circle *PBP'B'* is another.

The plane of any great circle obviously is perpendicular to the plane of each of its secondary circles. Also, if one circle is a secondary of another circle, the second circle is a secondary of the first one. The circle *ABA′B′* is a secondary of the circle *PAP′A′*, as well as a secondary of the circle *PBP′B′*.

Spherical Angles

6. The angle between the planes of any two great circles of a sphere is called a spherical angle. One method of determining a spherical angle is as follows:

1. Select a point on the straight line of intersection of the two given planes.

2. Through the point chosen, draw two lines—one in each plane—that are perpendicular to the intersection line.

3. Determine the angle between the two lines thus drawn.

In Fig. 1, for example, the spherical angle between the great circles *APA′P′* and *BPB′P′* may be measured by considering the angle *A′CB′* between the lines *CA′* and *CB′*, which are drawn from the point *C* perpendicular to the line *PP′*. But the angle *A′CB′* is measured by the arc *A′B′* on the great circle *ABA′B′*, which is secondary to both circle *APA′P′* and circle *BPB′P′*. It therefore follows that *a spherical angle between any two great circles of a sphere is measured by the arc between those two circles on their common secondary.*

The angular distance between any two points on a sphere is the angle between two radii drawn from the points to the center of the sphere. Thus, the angular distance from *A′* to *B′* is the angle *A′CB′*. You will note that an arc on a great circle can measure either a spherical angle between two great circles or an angular distance between two points.

Circles on the Earth

Equator and Meridians

7. The axis of the earth is the imaginary line about which it actually rotates; and the geographic poles of the earth are the imaginary points on its surface at which it is intersected by its

Fig. 2. Reference Lines on the Earth

axis. The northerly point of intersection is called the north geographic pole, or simply the north pole; and the southerly point is the south geographic pole, or south pole.

The plane of the earth's equator is the imaginary plane that passes through the center of the earth and is perpendicular to the earth's axis. This plane intersects the earth's surface in an imaginary circle called the terrestrial equator, or simply the equator. Any imaginary plane passing through the earth's axis is a meridian plane; and the imaginary circle in which such a plane through the axis intersects the earth's surface is known as a meridian.

In Fig. 2, which represents the earth with various imaginary lines on its surface and within it, *NS* is the earth's axis; *N* is the north pole; *S* is the south pole; the circle *EQRT* is the equator; and the circles *NRSE*, *NGS*, and *NFS* are meridians. All meridian planes are perpendicular to the plane of the equator. The meridian through any selected point on the earth's surface is called the meridian of that place.

Meridians are really circles, and all meridians converge toward the earth's poles. For the purposes of ordinary surveying, however, where only comparatively small distances are involved, meridians are treated as straight lines and the meridians at two points several thousand feet apart are assumed to be parallel.

Latitude

8. The latitude of a point on the earth's surface is the angle that the radius of the earth passing through that point makes with the plane of the equator. In Fig. 2 the latitude of *B* is the angle *BOR*. This angle is measured by the arc *RB* of the meridian passing through the point. Similarly, the latitude of *G* is measured by the arc *G'G*. The latitude of a point may, therefore, also be defined as the angular distance of the point from the equator. This distance is measured on the meridian through the point, and it is the number of degrees in the arc included between the equator and the point.

Latitude is an angular quantity, not a linear quantity. When it is stated that the latitudes of the points *B*, *G*, and *F* are, respectively, *RB*, *G'G*, and *F'F*, you must remember that these arcs are to be expressed in degrees. The latitude of a point is said to be *north* or *south*, according as the point is north or south of the equator. North latitudes are considered positive and are generally indicated by the sign +, while south latitudes are negative and are indicated by the sign −.

Any plane parallel to the equator cuts the earth's surface in a circle called a parallel of latitude, or simply a parallel. For example, the circle *eqrt* in Fig. 2 is a parallel of latitude. The plane of any parallel of latitude is perpendicular to the earth's axis. All points on the same parallel, as *r*, *G*, and *F*, have the same latitude, since the arcs *Rr*, *G'G*, and *F'F* obviously are equal.