implies *back*. Take the word apart: *re* = "back" and *fer* = "bearing." To bear back to something, from a frame of *refer*ence (or from anything else that pertains) is a way of understanding any whereabouts. It's one of those things that are so obvious that we forget we ever knew them, and so we must be reminded. The concept of *reference*—bearing back—is a useful one to keep in the front of our minds throughout our acquaintanceship with mapping.

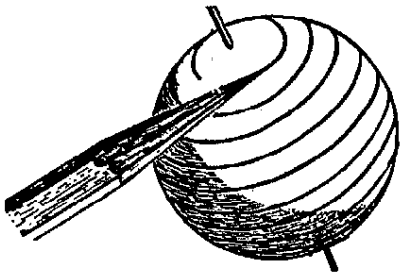
Cartographers use another synonym: *index*. Like the index of a book, index lines indicate specific details inside a map. In making maps, experts try to get all the indexes they can, and in reading maps the rest of us had better look for as many as we can. The more important the map, the more accurately must its reference lines and index lines and index points coordinate. They themselves must be particularly accurate. When they are so accurate that we can have complete faith in them, they merit the name of *FIDUCIAL*. Fiducial points or marks are what mappers must first establish in order to be sure of proceeding wisely a bit further.

BUT THE WORLD IS ROUND: SPHERICAL COORDINATES

If the whole world were flat, like our back yard, this scheme of rectangular coordinates would serve all map purposes. But with a globular world we have to develop a set of coordinates which fit it just as snugly and precisely as a grid fits a flat, rectangular surface.

A rectangle has four sides to act as a reference frame to mark off from. But what has a globe? It begins nowhere and ends nowhere.

But it moves. The earth turns on its axis. It has poles. They are definite points. Just as the center of a circle is a definite point from which

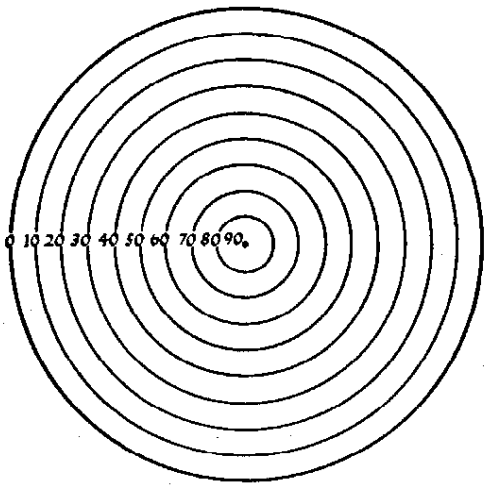


you can measure, lay out, divide, and locate places within a circle, so the poles are definite points for measuring and locating everything and anything on the surface of the earth.

Midway between the poles we imagine a line like a belt around the middle of a fat man. Equator is just the right name for it: it *equates* the globe in north and south halves.

Poles and Equator. That is all we need for a frame of reference to build up as neat a system of coordinates as anybody could ask for.

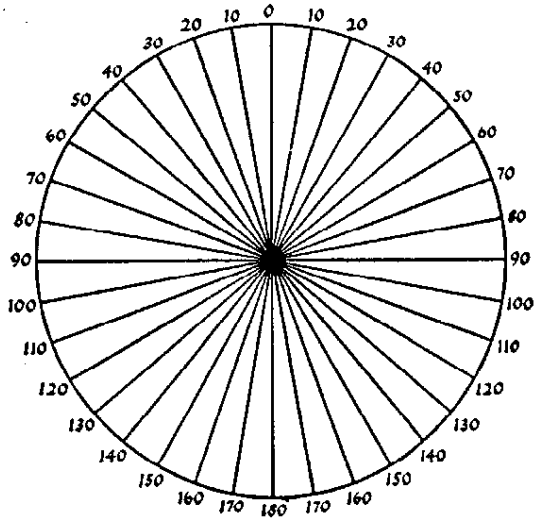
The Equator is the largest of a series of circles like the circles on a target. And the Pole (North or South) is the bull's-eye. The biggest circle is numbered 0 and the bull's-eye 90.



These circles are parallel to each other; so they are called *PARALLELS*.

What they do is show how far anything is from the earth's base line, the Equator. North or south. If, for instance, you find an island

on the third line south and that parallel is numbered 30, then the position of that island is 30 S. That, strictly speaking, is its *LATITUDE*. That's all latitude means: how far north or south of the Equator.



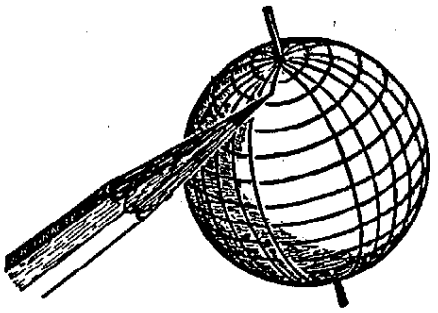
Look now at the other set of lines. They are semi-circles which swing from pole to pole. They mark off the globe much as the section-lines do on a melon or on a peeled orange. These lines are *MERIDIANS*. If you call one of them the zero meridian, you can count left or right, west or east, from it to see how far around the melon or the world a spot is. That's its *LONGITUDE*. That's all longitude means: how far east or west of the zero meridian.

The latitude and longitude lines are a terrestrial system much like our own town system of avenues and streets.

If you are flying northward or southward, you count the *parallels* which cross your path. Latitude.

If you are flying eastward or westward, you count the *meridians* which cross your path. Longitude.

Just as a football player on his grid knows his distance from a goal by the yard-lines which *cross* his run, so the traveler and map-user



know the distance before or behind them by the lines that *cross* their path on the map-grid.

If you are flying along a certain parallel, it would be your *path* but not your distance marker. The meridians which cross your path would mark how far you've gone *longitudinally*. East or west.

If you are flying along a certain meridian, it would be your *path* but not your distance marker. The parallels which cross your path would mark how far you've gone *latitudinally*. North or south.

If you are at the North or the South Pole, the meridians radiate outward from your position, the same as if you were standing at the center of a circle. In the Arctic or the Antarctic Circle, the radiuses are meridians. They are *polar coordinates*, for you can measure a distance outward on any of them to locate any point around you, inches or thousands of miles away.

In the same way as the rectangular grid coordinates have the symbols x and y for the east-west and the north-south lines, respectively, the coordinates of the spherical graticule* have the Greek letters ϕ (phi) for latitude and λ (lambda) for longitude. If you have any difficulty remembering which of these symbols stands for one or the other, perhaps the nonsense word "phlatitude" will be of some help.

* This is the term adopted by the A.M.S. for "any organized framework of latitude and longitude used for maps." *Map Intelligence*. (2d ed.; A.M.S. Training Aid 6, 1954), p. 57.

BUT WHY DEGREES?

Take this conversation:
"How much string do you want?"
"Oh, I can use about five feet."
And this:
"How much pie do you want?"
"I can eat about a quarter of it."

Here are two different ideas of measurement. The first is so many units: feet. The other is so much of a whole: a fraction. That's what a degree is, a fraction of a circle.

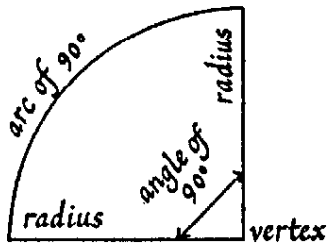
If we know the fraction of a circle of pie or of the world, we can readily know how much there is to the rest of the circle. Also, that fraction, say, ¼th, would be the same fraction for every circle, no matter what its size. So with a degree: it is 1/360th of every circle in creation, from the tiniest wheel in the tiniest wristwatch to the largest orbit in the heavens.

On our round world, regardless of how good a mile-count we might keep, we must know *what fraction of* the earth circle we are distant from the zero lines in order to have a definite idea of our location.

But why *360* degrees?

One of the favorite amusements of the ancients was watching the many-ringed circus in the heavens. They noticed things went round and round. The moon came around and disappeared about every 30 days. They called that moon-round a month ("moonth"). If they began counting those "moonths," as they naturally might, in spring, they found it took 12 "moonths" of waiting from the first bird-peep or star place of one spring to the first such of the next spring. They called that a year—a round of 12 times 30, or 360. And as naturally as they divided the circle of the year into 360 *days* they divided every possible other circle under the sun (and above it, too) into *degrees.*

By counting these divisions we can tell the size of an arc. Or of an angle. For what is an angle but a couple of radiuses of the same circle? (Don't balk at this bit of geometry. *Geo* means "earth," and *metry* means "measuring.")



Let's see how these degrees work.

Opposite is a picture * of the earth with a chunk cut out of it from the North Pole to the Equator. The spot we are locating is Sydney, Canada. Notice the (local) parallel passing through it. A line drawn from that parallel to the center of the globe makes an angle of 46° with a line drawn from the center of the earth to the Equator. That is the *angular distance* of Sydney from the Equator, 46° North. That is its latitude. As simple as that. Whenever you think latitude, think of an angle like this, and you'll have the right idea.

The latitude angle gapes north and south.

Look again at the illustration. Note the meridian passing through Greenwich. Note also the meridian passing through Sydney. These two meridians mark the sides of the cut-out portion. These two sides form at the axis of the earth an angle of 60°.

Therefore, we say that the Sydney meridian is an angular distance of 60° from the Greenwich meridian. Sydney is 60° west of Greenwich. That is the longitude of Sydney: 60° W.

The longitude angle gapes east and west.

THE PRIME MERIDIAN

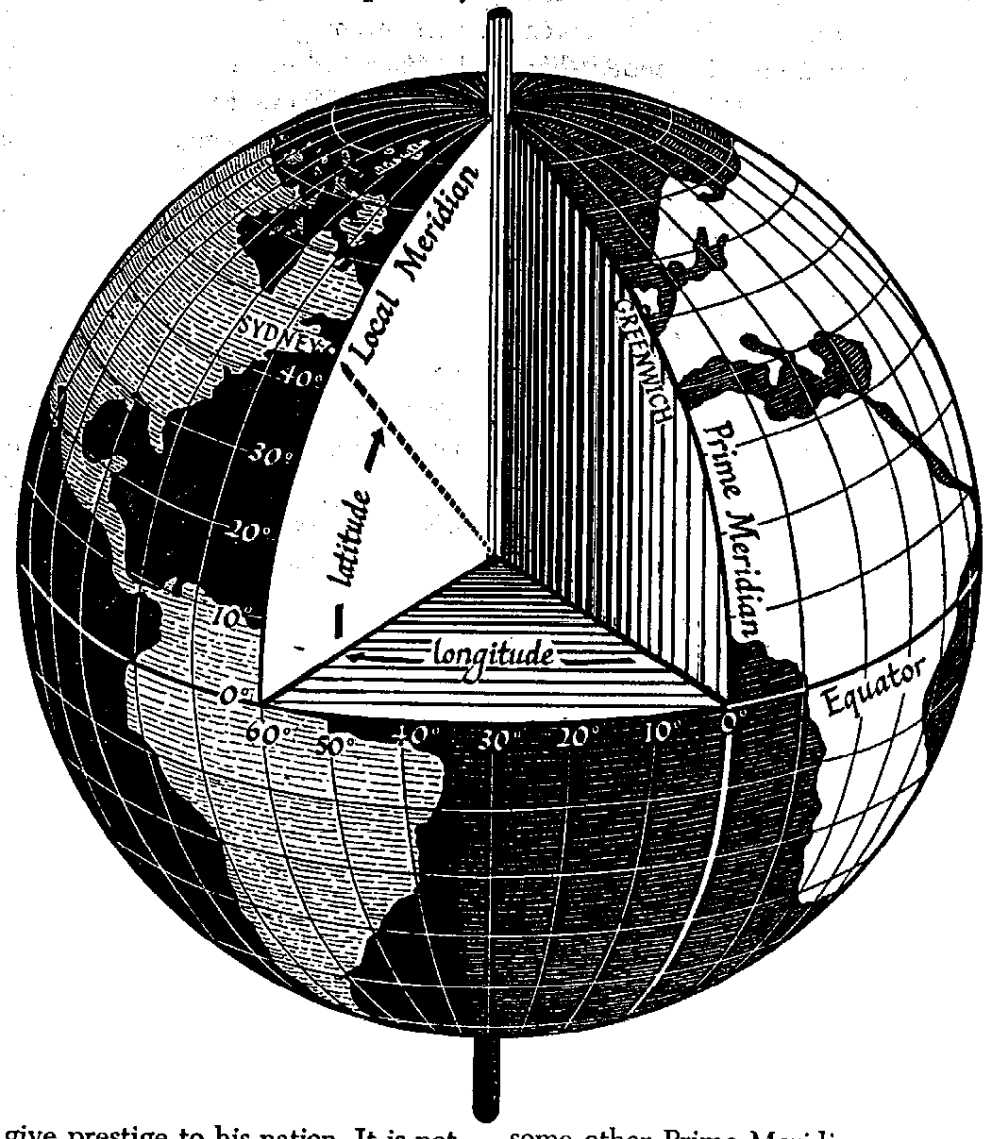
The right name for the zero meridian or longitude 0° line is the *PRIME MERIDIAN.* Unlike the Equator, there is no *earthly* reason why the Prime Meridian should be where it is rather than some other place. The Equator is where it is, because it is halfway between the

* After the Department of the Army.

poles and nobody can change the poles. Nobody can shift the Equator so that he will have the prime parallel run through his capital city and thus give prestige to his nation. It is not an arbitrary line.

But the Prime Meridian is. It can be anywhere that a world power has a mind to put it. Spain has had it pass through Madrid. And when her explorers sailed westward they reckoned longitude from the Madrid meridian. You can't blame them: they wanted to know how far they were from home, and that was their home meridian.

The Prime Meridian used by Americans is one that passes through Greenwich, England. But the Dutch city of Amsterdam has passing through it a Prime Meridian that is 4° 35′ east of the Greenwich meridian. Here are some other Prime Meridians you may see on foreign maps:



Location	Longitude Angle (East of Greenwich)
Athens	23° 42′
Brussels	4° 22′
Copenhagen	12° 34′
Istanbul	28° 59′
Lisbon	99° 11′
Moscow	37° 34′
Oslo	10° 43′
Paris	2° 20′
Peking	116° 288′
Rome	12° 27′
Stockholm	18° 18′
Tokyo	139° 44′

The Greenwich meridian is the most generally accepted one. Look closely at this meridian where it cuts through southeast of London, in a part called Greenwich. If you were flying on that meridian and descended there you would come to a hill. On it is a famous observatory directed by the Admiralty, primarily for the advance of navigation. Here for years scientific workers have made observations of help to navigators and map-makers; and now in modern times they flash sea news, star news, and globe news around the world and across the poles for the benefit of all who have the serious responsibility of knowing their meridians. No wonder, then, that Greenwich has become a kind of home-plate for seamen and airmen, the navigation capital of the world. Globe-girdlers riding the waves and the clouds have become used to counting *from* Greenwich by counting *upon* it. They imagine a line passing through it, and the line as soon as they use it becomes real. The Prime Meridian.

From the sky the ancients got their cue for measuring the circle. They got from the same overhead source the idea of a globe.

Thus, the first spherical maps were star maps. The old-timers pointed their plows and their prows at a certain star to make sure they were going right. And so do we new-timers—with our airplane noses. To this day we use that star map. It has poles connected by meridians and, crossing them, an equator with parallels. In fact, the trick is to imagine the earth in the center of this celestial sphere in the same way as you can imagine yourself in the center of the earth globe.

Living within this imaginary sky-cage, the ancients would say when the sun reached its highest point in the daily swing across the heavens, "medius dies." Middle of the day. People kept on saying "medius dies" for so many generations that the phrase got worn and re-shaped into the word *meridian.*

A meridian, therefore, is a noon line. Our common abbrevations A.M. and P.M. refer to this line: *Ante,* meaning "before" meridian; *Post,* meaning "after" meridian.

When the sun stands high on the Greenwich meridian we can think of a great shining zero. Greenwich's longitude. The observatory flashes its time signal to timekeepers, navigators, earth-measurers, and all around the world. "Noon here!" it seems to say. "Where are you?"

At that very moment, in the Antarctic, some airmen doing exploration hear that signal. They are so far south that the sun is in the north for them. But it is also noon there. And by this they know they are on the same meridian as Greenwich. Longitude 0°.

Notice again on your globe or world map how the meridians are numbered off from the Prime Meridian. They are usually counted by 15's. This is why: the earth takes 24 hours to complete a turn of 360 degrees, through a day and a night. Divide 360 (degrees) by 24 (hours) and you get 15. That's how many degrees the sun goes across the sky in an hour. Those meridians on your map are spaced, therefore, to represent one hour's turning of the earth toward or away from the sun. Toward or away from noon.

Stand on this turning earth of ours and watch the sun for 4 minutes; in that space of time it will "move" in the sky 1 degree toward your local meridian or away from it.

All this sky-measuring is earth-measuring too. Finding your longitude is merely a matter of comparing noons with Greenwich. You are just as long a distance from Greenwich as your noon is long a time from the Greenwich noon.

If your noon comes before the Greenwich noon, you are east of Greenwich. For instance, the sun is on your meridian (12 noon) and you hear Greenwich radio 10 A.M. Then you are two hours before, or 30° east, of Greenwich. The earth must turn two more hours before

the sun will shine on the Greenwich meridian.

If your noon is after the Greenwich noon, you are west of Greenwich. Suppose the sun is at high noon on your meridian (12 noon to you) and your chronometer, set to Greenwich time, says 6 P.M. That means the earth has been turning six hours since the noon at Greenwich, and 6 times 15 is 90. That's your longitude west of Greenwich, 90° west longitude.

And if it's noon to you when it's midnight at Greenwich, you are clear on the opposite side of the world at long 180°.

Thus time and space are partners. Maps are a combination of time-lines and space-lines.

Whether you go east or go west from 0° those meridians are marked off with a higher figure until they reach the 180th. The 180th is the greatest longitude. It is the farthest you can get away from the Prime Meridian. And that is halfway round the world. Half of 360. It is just as far east of zero as it is west of it. When you get to that line you are both east and west at the same time! When mariners cross that line in the mid-Pacific, they say only 180°, and let it go at that: no need to say east or west. There is only one 180° line on the map. Incidentally, that hill in Greenwich is just 180 ft. high.