CHAPTER I

SHAPE, SIZE, AND MOVEMENTS OF THE EARTH

It is easy to show that the surface of the sea is round and not flat. The hull of a ship may be hidden from sight by the sea, while the masts and spars are plainly visible above it. Such an effect can be produced only by the curvature of the sea surface.

The precise size and shape of the Earth can be determined by the surveyor.

The Earth is one of the planets, and, like all the planets, it both moves round the Sun, and also spins upon itself. The first of these movements is called revolution; it takes a year for the Earth to move round the Sun. The second movement is called rotation. The Earth spins upon its axis in a day. The motion round the Sun in a year gives us the seasons; the turning in a day gives the succession of day and night.

Latitude and Longitude.

To understand what is meant by Latitude and Longitude, and the Poles and the Equator, it is well to go at once to the globe. The globe is mounted so that it spins on an axle, and the points where this axle passes through the globe's surface are the Poles. The actual Earth has not a mechanical axle to turn on; but it turns as if it had. The line on which it turns is called the Earth's axis.

On the globe we shall find a number of lines drawn direct from Pole to Pole. These are called *meridians*.

And we shall find a number of circles drawn round the globe at intervals, all parallel to one another, and all

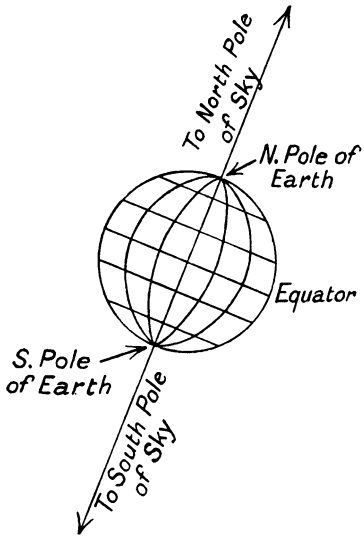

Fig. 1. The Globe—Meridians and Parallels

cutting the meridians at right angles. These circles are called the *parallels of latitude*, and the largest of them, which encircles the Earth exactly midway between the two poles, is called the *Equator*.

It must of course be understood that these lines and circles do not exist upon the real Earth; one cannot see the Equator when one crosses it. But they are useful on the globe in helping to define the positions of places by their latitude and longitude, as we shall see immediately.

It is customary to divide a circle into 360 degrees. Then if there are on the globe twenty-four meridians equally spaced, we may say that they are 15 degrees, or 15° apart. And if there were thirty-six meridians drawn they would be 10° apart. Similarly, if the

parallels divide the quarter circle of 90° between the Equator and the Pole into nine equal parts, the parallels are 10° apart.

But we must not think of the meridians and parallels as confined to those lines which are ordinarily marked upon the globe. Through any point on the globe we may draw a parallel of latitude and a meridian. The distance in angle between the parallel and the Equator is called the *latitude* of the place. The angle between the meridian of the place and the meridian of Greenwich Observatory is called the *longitude* of the place, East or West of Greenwich as the case may be. Thus when we are given these quantities, the latitude and longitude of a place, we know exactly where it is upon the Earth. And it would be difficult to describe its position exactly in any other way.

Time.

Time may be measured by clocks, but how is one to know that the clocks are going at the right speed? The regular turning of the Earth upon its axis gives us a perfectly regular clock, and the astronomer makes use of this motion to tell the time by the stars and the sun.

It is clear from the globe that the time must be different in different parts of the Earth, for while it is day on one side it is night on the other.

The time is the same for all places on the same meridian, and it changes regularly with the change of longitude from Greenwich. Thus differences of longitude may very well be expressed in time, and they very often are. Thus we may say that a place is four hours west of Greenwich. And it is clear that since the whole circuit of the Equator may thus be reckoned either as 360° or as 24 hours, we change longitude in degrees into longitude in time at the rate of 15° to one hour.

And further, it is clear that the time at a place will be different from the time at another place whose longitude is not the same. And if clocks kept this local time everywhere, each town would have its own

time, which would be very inconvenient in railway travelling and in all business affairs. Therefore it

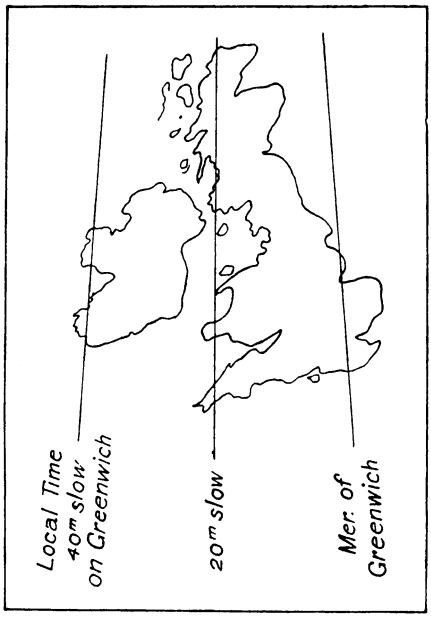

Fig. 2. Solar Time in the British Isles

is arranged by law that Great Britain keeps the time of the meridian of Greenwich. And gradually other countries have fallen in with this scheme, so that France and Belgium also keep Greenwich time; the countries of central Europe keep their clocks an hour fast on ours; the eastern United States keep five hours slow; and so on. This system is called *Standard Time.*

The Seasons.

We cannot fail to notice that the Sun at midday is very much higher in summer than in winter. His rays then fall more directly on the ground, and a square yard of ground receives a much larger share

of the summer rays than of the very sloping rays of winter. Thus it is much warmer in summer than in winter, in our country.

Further, in our country, the Sun remains above the horizon much longer in summer than in winter. We have a long day and a short night; and of course the greater duration of sunshine has also the effect of making the summer hotter than the winter.

The height of the Sun at noon, and the length of the day, vary very much in different parts of the Earth, and at different times of year, so that it is rather difficult to explain in a few words exactly what happens. But we may say briefly that:

On the Equator the day and the night are always equal; the Sun goes directly overhead at noon at the times we call spring and autumn; and at other times he passes at some distance, but never a great distance from the point directly overhead, called the *Zenith*. Thus on the Equator there are no marked seasons, as with us. There may be a wet season and a dry season, but there is no warm season and cold season.

On the other hand, within the Arctic regions, the Sun disappears altogether for some months, and there is perpetual night, very cold. But to make up for this, in the Arctic summer the Sun remains above the horizon for some months, and there is perpetual day. The Sun is never very high, and so it is never very hot; but it is much warmer than might be expected, and mosquitoes make the summer almost unendurable in many places.

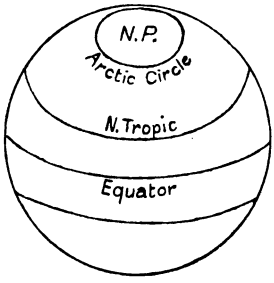

Fig. 3. Earth as seen from Sun, June 21

Twilight.

If there were no air the Sun's rays would fall in straight lines upon the Earth, and everything would be

in full sunlight or else in shadow; the sky would be black, and the stars would be seen round about the Sun. But, as it is, the dust in the air scatters the light, and the Sun's rays which enter the air obliquely are bent round, or refracted. The result of this is that we have the pleasant diffused light of the sky, and that when the Sun has set it does not become dark at once, but there is twilight.

Maps.

A map is an attempt to show on a sheet of paper as much of the shape and features of a country as can be done within the limits of the scale of the map. Naturally, the larger the scale, the more can be shown.

The ordinary Atlas map is on a very small scale: perhaps one twenty-millionth of the actual size of the Earth. Thus it is impossible to show more than the principal features of the country—the rivers, the large towns, the chief railways. The difficulty on all maps is to show the mountains and hills, or what is called the 'relief' of the ground. Shading or colour to denote height above sea-level will become confused with colour intended to show the divisions of the land for purposes of government—the states or the counties. Therefore it is common to have two maps, one showing the latter, which is called the 'political' map; and one showing the relief of the ground, called the 'physical' map.

The physical maps in atlases are now very generally coloured on what is called the 'layer' system, in varying shades of green, yellow, and brown, to indicate the height of the ground above the level of the sea.

Maps on a larger scale, such as the maps of the Ordnance Survey, are called topographical maps, the word topographical meaning the description of the place. They aim at showing all the natural features of the country—the hills, rivers, forests, lakes, and so forth; and also the towns and villages, the roads, canals, railways, and other means of communication which have been made by man. Topographical maps

allow one to find the best way about the country for business or pleasure.

The chief difficulty again is to represent the relief of the ground, and many devices are used for that purpose. The slopes may be marked by *hillshading*; or lines of equal height above sea-level (*contours*) may be drawn; and in addition the ground between the contours may be tinted on the *layer system*. All these ways, separately or in combination, are found on different maps, and what is suitable for one kind of country is often very unsuitable for another.

Survey.

The method of making a regular survey of a country is somewhat complicated, and we can give only a very slight account of it here. The first thing to do is to measure a 'base' on open and level ground. That

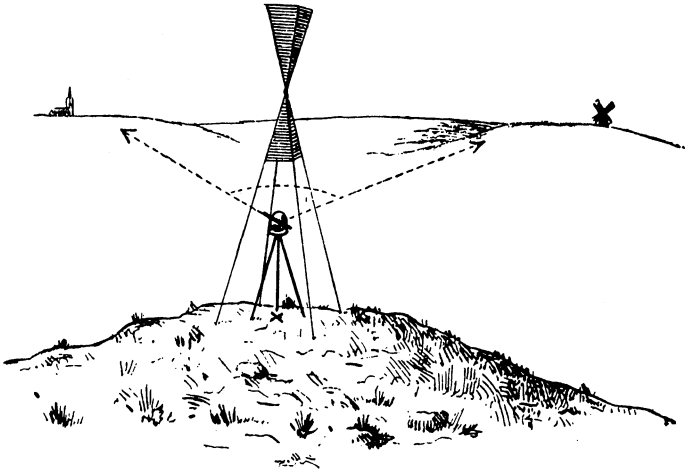

Fig. 4. Triangulation: Theodolite set up under beacon erected at one station, observing angle between two other stations on the distant church tower and windmill

gives the length of one line in feet or yards. Next, stations are chosen on the tops of hills, the towers of

cathedrals, and other prominent points, well arranged over the whole country. The two ends of the base, and all these other stations, will form a network of triangles, whose angles are all measured with an instrument called the *theodolite*. Then by a long series of calculations, by trigonometry and logarithms, the surveyor finds the lengths of all the sides of the whole 'triangulation.' Next he finds by astronomical methods the latitude and longitude of one of his stations, and the true bearing of one of the sides; and then by further calculations the positions of all his other stations. This makes a framework for the map. All the detail of roads and rivers, villages and railways, may then be filled in with the instrument called the *plane table*.

All this requires great skill and good organisation. It is no use to try to survey a country in small pieces at different times, and by different people; their results will not fit together properly. Hence the maps of a country must be made by the Government, and it is one of the most important duties of a good government to make maps of a new country as soon as possible. In Great Britain the whole country is splendidly mapped by the Ordnance Survey; but in Greater Britain there is still great need of good maps, and there are immense regions of the world which are not mapped at all, except in the very roughest way and on very small scales.

Map projections.

The network of meridians and parallels which is drawn on an atlas map is called the 'projection' for the map. If one looks at the map of Asia, for example, in different atlases, one finds different ways of arranging the meridians and the parallels; and none of them gives a really true representation, because it is not possible to represent a portion of the round world accurately upon the flat sheet of the map. Either the distances, or the shapes, or the areas, or all three, are more or

less wrong; and one has to use a different method for the construction of the projection, according as one is more anxious to get the distances, or the areas, or the shapes correct. On maps of small regions there is not much error, but the difficulty increases very much as one tries to represent more extensive regions of the world. Compare the world as shown on a globe with the world as shown in atlases, and you will see how different is the idea that the maps give of the relative positions of Northern Europe and North America, for example.

CHAPTER II

THE ATMOSPHERE

Overlying the Earth's surface there is a belt of gases known as the atmosphere. The lower part of the atmosphere is known as air, and is a mixture of nitrogen oxygen, water vapour, and carbon dioxide.

Effect of the Sun's heat.

The Sun's rays, which are our chief source of heat, pass through the atmosphere to the Earth's surface. This surface is heated in proportion to the inclination of the Sun's rays, and to the time during which these rays shine on the Earth's surface. As the Earth's surface becomes heated, the overlying layers of the atmosphere become heated by the radiation of heat from the rock or water surfaces.

The inclination of the Sun's rays, and therefore their heating power, is the same at all points along a parallel of latitude. The average inclination of the Sun's rays, and consequently their heating power, increases in either hemisphere as we go from the polar lands to the tropical lands (i.e. to lower latitudes). So air-temperatures increase in these directions. Within the Tropics, the heating power of the Sun's rays is always great, for the Sun shines overhead at noon on the Tropic of Cancer near the end of June, on the Equator near the end of March and September, and on the Tropic of Capricorn near the end of December, and at intervening places at intervening dates. So within the Tropics air-temperatures are always high. In all places not in the Tropics the summer season occurs when the Sun's rays have their