MAP CONSTRUCTION.

BY WILLIAM H. SNYDER.

Master in Science, Worcester Academy.

Since of necessity maps must always occupy a most important part in the study of geography it seems particularly essential that the pupil should as soon as possible be taught to appreciate the methods by which maps are constructed. The writer has therefore felt that perhaps others might be interested in some laboratory work that he has been trying to do along the line of map construction. Although it is easy to understand how a plan of a flat area can be drawn, yet it is rather difficult to see how the curved surface of the earth can with any degree of accuracy be represented on a plane surface. In order that this difficulty of representing a curved surface upon a flat surface may be really appreciated by the pupil and not be a matter of simple hearsay instruction, it has been for several years the custom of the writer to give each of his pupils a cheap six-inch globe and ask him draw from it a map of North America, being careful to have it just as accurate as possible. For this purpose he has furnished the pupil with a ruler, a pair of compasses, a piece of thread to measure with, and in fact any simply contrivance which the pupil has desired. After the map has been drawn a tracing of it is made on tracing paper and the tracing held above the globe and compared with the outline of North America as seen through it upon the globe. Of course the two never exactly correspond. The pupil is then asked why they do not, and if he thinks he can hit upon some better scheme. It is always surprising how many really practical schemes of partially overcoming the difficulty will be developed by the different members of a bright class. It is rarely that three or four of the different kinds of projection are not roughly hit upon. An exercise of this kind never fails to convince the class that there must be a carefully prepared scheme if the surface of the earth is ever properly to be represented on a map and that even then it is very doubtful if it can be represented in its proper proportions. The pupils become anxious to learn what these schemes are.

Take now a piece of paper similar to that just used and near one of the shorter edges draw a line parallel to this edge. Measure on this line a length equal to the circumference of the circle of 3 in. radius (Fig. 2.) Divide the length into 36 equal parts and at the points of division erect perpendiculars, extending these perpendiculars to the opposite edge of the paper. Divide one of these perpendiculars into parts equal to the parts into which the tangent line was divided, by the lines drawn from the centre through the divisions of the quadrant. From these points erect perpendiculars across the paper. The perpendiculars will be parallel to the shorter edge of the paper if the paper is cut in the shape of a rectangle. Parallels of latitude have thus been drawn as they would be projected from the centre of a 6-in. globe onto a cylinder folded around it. There are then on the paper lines representing the projections from the centre of the globe of both parallels of latitude and meridians. Number on the line first drawn, which represents the equator, the meridians making the centre meridian 85° west. On the edge of the paper number the parallels of latitude making the equator 0° .

As will be seen the cylindrical projection causes a degree of latitude to vary from a small length at the equator to infinity at

FIG. 2

the pole, and a degree of longitude which at the pole has no length is made to everywhere have a length equal to that of a degree on the equator. Thus in passing from the equator toward the poles the areas of surfaces on the earth are increased when represented on this projection, but the increase east and west and the increase north and south are not proportionate. The Mercator's projection is simply a modification of the cylindrical projection in which the exaggeration north and south is made equal to that east and west. After doing this work the pupil is actually able to appreciate why Greenland, an island which on the globe is of small size, when seen on his ordinary map of the world is about half the size of North America, and why the Dominion of Canada appears larger than the United States. The usefulness of this projection consists largely in the fact that north and south are directly up and down the map and east and west are toward the right and left.

Probably the best of the hemispherical projections for study is the Stereographic. In this projection a piece of paper is considered as held tangent at a point on the earth and from a point directly opposite this point lines are drawn to the paper through the intersections of the parallels of latitude and longitude. Through these projected intersections the projected meridians and parallels are drawn. The instructions given by the writer to his class for this projection are as follows:

Near one of the shorter edges of a sheet of paper about 18x24 inches describe a circle of 3 in. radius (Fig. 3.) Draw a diameter A B parallel to the longer edge of the paper. At the point B farthest from the shorter edge of the paper erect a perpendicular B C (7 inches long.) Draw another diameter K K at right angles to the first diameter. The two diameters will divide the circle into quadrants. Divide the quadrant nearest B C into 9 equal parts. From A draw lines through each of the points of division and continue these lines till they cut the line B C. The line B C will then be divided into 9 parts. The point of division nearest C, letter D. Extend the diameter A B and at a point H on the extended diameter which is at a greater distance from B than is the point D describe a circle of radius B D. Draw a

diameter at right angles to the line B H. Letter the points where the diameter cuts the circle N and S. Extend the line B H till it cuts the large circle at a point E. The extremity of the diameter nearest B, letter W. The large circle has now been divided into quadrants. Divide each of these quadrants into 9 equal parts. Divide the radii W H, N H, E H and S H each into parts similar to those into which the line B D was divided. In each case the division nearest B should lie next to the centre H. Beginning at the points N and S number the divisions of the circle on either side of these points in even tens from 90 to 0. The line W E in each case will be 0. Number the divisions of the lines W H and E H in the same way.

Placing one leg of a pair of compasses on the extended line N S, draw arcs of circles through the three points on each side of the line W E, which are numbered 80, 70, etc. These arcs will be the projections of the parallels of latitude. Placing a leg of the compass on the line W E or its extension, draw arcs of circles through the points N, S, and each of the divisions into which W H and E H have been divided. These arcs are the projections of the meridians. Taking one of these meridians as the prime meridian, number the meridian from 0 to 180.

It will be seen that in this projection places near the point of tangency have their outlines correctly reproduced, but that the

farther away a place is from this the greater the distortion. This distortion, however, is never as great as that at the north and south on the cylindrical or Mercator's projections. Here, however, the directions north and south and east and west must be traced on a curved line, thus making it much more difficult to tell at a glance the direction of one place from another. Also it is not possible on this projection to show more than one-half of the surface of the earth on a single map. This projection or a slight modification of it is the one most often used for hemispherical maps, and from its study the pupil is able to understand why it is that countries near the centre of these maps are almost exactly of the same shape as when seen on the globe, while those at the extremities of the map are somewhat distorted.

The simple projection that best shows the method of representing a small section of the earth's surface is the conic. In this projection a conical shell is considered as having its inner surface tangent to a parallel of latitude passing through the centre of the surface which it is desired to map. The intersections of the parallels of latitude and meridians are projected upon this. In this way the surface for projection is brought near to the surface onto which it is to be projected and distortion is thus decreased. It is possible to make a hemispherical projection in this way, but of no larger area. The instructions given by the writer to his class for this projection are as follows:

Draw a circle of 4 in. radius and from the centre C of a diameter erect a perpendicular (Fig. 4.) Mark by N and N' the points where the perpendicular cuts the circle. The circle has been divided into quadrants. Bisect the two quadrants that lie on the N side of the diameter and letter the points of bisection P and P'. At the points P and P' erect perpendicular to radii drawn through each of these points. Extend these perpendiculars till they intersect each other at a point on the extended line C N. Letter this point H. Extend the line H P to a point I, making the distance P I nearly equal to the distance H P. In a similar way draw the line H P' I'. The lines H I and H I' are tangent to the circle at a point 45° from the diameter. Divide the quadrant that passes through the point P into 9 equal parts.

On either side of the point *P* mark off on line *H I* distances *equal* to the distances along the arc from *P* to each of the divisions into which the quadrant was divided. Use a pair of compasses and consider the cord of a small arc equal in length to the arc. The division farthest from *H* letter *M*. On the line *H I'* mark off the distance *H M'* equal to *H M*. *M M'* is the diameter of the base of the infolding cone. The divisions of the line *H I* are

FIG. 4

the equidistant projections on the tangent line (which is a side of a cross section of the conical shell) of each of the even ten degrees of latitude.

On a large piece of paper describe a circle with a radius equal to the distance *H M* of Fig. 4. This circle is a curve similar to that formed by the perimeter of the conical shell when unrolled and flattened out. Letter the centre of this circle *D* (Fig. 5.)

From a point on this circle *measure* off a distance equal to the circumference of the circle of which the line $M M'$, the diameter of the base of the infolding cone, is the diameter (≈ 3.14 .) Mark the extremities of the distance A and B . The arc $A B$ is the perimeter of the unrolled and flattened-out conical shell. Divide the distance $A B$ into 36 equal parts. These divisions are the projections on the perimeter of the cone of the meridians

FIG. 5

of each ten degrees of longitude. From D draw lines to these divisions. The lines are projections of the meridians on the infolding conical shell. Using the distances from H to each of the divisions of the line $H I$ as radii, inscribe about the point D arcs of circles which shall cut all the meridian lines which have been drawn between the lines $D A$ and $D B$. These arcs will be the projections of the parallels of latitude. Beginning with the arc nearest the point D number these parallels of latitude

in even tens from 90 to 0. Taking any one of the meridians as a prime meridian, number the meridians on each side of it from 10 to 180. The meridians and the parallels of latitude have thus been projected onto the inner surface of an infolding conical shell and the conical surface laid flat. The conical surface was made tangent at 45° .

It will be seen that in this projection the exaggerations east and west are practically the same for equal distances north and south of the line of tangency, and that the north and south exaggeration is not great. Here, however, the directions east and west follow curved lines and those north and south straight lines, but these straight lines are not up and down the map. Thus it is difficult to tell without rather careful inspection the direction of one point from another. A modification of this projection is the one generally used in making maps of countries and grand divisions. In order that the characteristics of map projection may be better appreciated the writer is accustomed to give each pupil a list of the latitudes and longitudes of the prominent points around the outline of one of the grand divisions and have dots made for these on each outlined projection, and afterwards the dots connected thus giving an outline map of a grand division on each of the projections constructed. This does more than simply help to show the characteristics of the projections; for it teaches latitude and longitude which somehow is a *terra obscura* to the average boy and girl. Theoretically most of them know what these terms express, but they have no practical realization, and many of them when writing the longitude of the meridians have no idea of stopping the upward progress of their numbering at 180 degrees or of allowing the pole to stand as simply 90 degrees.

That this sort of work is both most interesting and instructive has been the writer's experience with classes during the past five or six years. It clears up the appearance of vagueness and unreliableness which maps are likely to have, since the same country may have a different shape when seen represented on different maps. It also gives a definiteness to geographical work which is liable to be lacking. It removes the idea which seems

to be inherent in the mind of the boy or girl coming from the lower schools that north and south must be up and down and east and west to the right and left. Maps become something more than devices for showing directions and for measuring out distances which are often found to be wrong, with a wrongness which is generally assigned to carelessness of construction, whereas it may be due to an inherent characteristic of the map. Maps thus cease to be considered as haphazard representations and become definite and skilfully devised efforts to represent as nearly as possible that which it is impossible to represent exactly. They have a real scientific interest and geography itself appears more as an exact science.

A GRAPHICAL REPRESENTATION OF THE PERIODICITY OF THE CHEMICAL ELEMENTS.

BY WILHELM SEGERBLOM, INSTRUCTOR IN CHEMISTRY, PHILLIPS
EXETER ACADEMY.

An article in a recent number of *SCHOOL SCIENCE* on a lecture table device for illustrating the periodic system of the chemical elements puts me in mind of a little graphical device I have used in the class in second year chemistry when trying to show the periodic recurrence of certain properties of the elements.

In a detailed study of Mendeleeff's Table with the class the following facts are brought out:

- (1) From Group I. to Group VII. the metallic character decreases.
- (2) From Group I. to Group VII. the acid character increases.
- (3) The valence increases from Group I. to Group IV. and then decreases to Group VII., except in a few cases in Groups V. to VII. where there is a continuation of the increase found in the first four groups.
- (4) The capacity for oxygen increases from Group I. to Group VII.
- (5) The capacity for hydrogen is nil in the first three groups,