A PROFILE RELIEF MAP.

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While having a class in physical geography make profiles from a contour map, the idea of making a relief map by means of a series of profiles occurred to me. As preliminary practice for the class, I drew several ideal contour maps, about eight inches square, with contour lines rather far apart but representing a rise of one hundred feet. I chose an arbitrary vertical scale of $\frac{1}{4}"=100'$, which makes the work very easy for beginners. These ideal maps represented the most common forms of the earth, and I tried to incorporate the various combinations of contour lines. The profiles were run $\frac{1}{4}"$ apart, and when cut out were separated by strips of wood about $\frac{1}{4}"$ thick (allowing for the thickness of the cardboard). I used the unglazed four-ply Bristol board, which is one mm. thick. The spaces between the profiles were then filled with moulding wax, and the relief map was complete.

The pupils evinced so great an interest in the work that I then attempted the enlargement of the United States Geological Survey topographic sheet of our vicinity, by means of enlarged profiles. The result was so gratifying that I have been urged to give the benefit of my experience to others who may desire to do the same kind of work.

The class was divided into pairs and it was the duty of one of each pair to read the map and of the other to plot the reading. The pairs exchanged their duties as they desired. Profiles were run every millimeter. No one pair ran successive profiles, but skipped as many profiles as there were pairs. Thus, if there were fifteen pairs the profiles for any one pair would be fifteen millimeters apart. The advantage of this method is that each pair is a check upon the two adjacent pairs, the mistakes in the successive profiles being self-evident. Since it was desired to increase the size of the map twenty-five times, the distances, as read between successive contour lines, were multiplied by five, before plotting, and the adjacent profiles were separated five millimeters between centers.

The method of procedure is rather hard to describe without drawings, but is as follows: My class comprised seven pairs.

Each pair marked its copy of the map every seven mm. on both sides, one pair taking divisions 0-7-14-21-28, etc., the second pair taking numbers 1-8-15-22-29, etc., the third pair marking divisions 2-9-16-23-30, etc., and so on, the numbers given being the number of millimeters above the bottom of the map. To work upward was found easier than to work downward. Then the reader of each pair placed a millimeter rule on the map, where it was marked, and read the elevation on the left side of the map, at the very edge. This reading was plotted by his partner in a manner which will be shown later. Then the reader, using a magnifying glass (2" diameter is large enough), read the number of millimeters on his scale at which the next hundred contour line came; readings were made to half millimeters. He multiplied this number of millimeters by five (we made tables to prevent careless errors), and gave the result, together with the altitude, to his partner, who plotted it. The horizontal distance in millimeters was given first, followed by the altitude in hundreds of feet. This process continued across the map and then the exact altitude of the edge was given and plotted.

Each pupil who plotted was provided with a plotting board, which was designed for this purpose. It consisted of a piece of $\frac{7}{8}$ " planed redwood, 8" wide and one meter long, with a meter stick fastened near the edge but on the flat side of the board. This edge was countersunk so that the thickness of the meter stick, which projected above the surface of the board, was equal to the thickness of the Bristol board plus the thickness of a celluloid 60° drawing triangle. Thus the top surface of the triangle and the top surface of the meter stick were flush. The one plotting would take a piece of Bristol board as long as the width of the finished map, and wide enough for the particular profile, plus 4" for a purpose to be shown later, and fasten it, by means of thumb tacks, flush with the right hand end of the board, at which end the numbering on the meter stick begins. Then he was ready to receive the first reading.

Since the map had to have some thickness, even at sea level, two inches were chosen. This accounts for two inches of the extra four inches. Therefore, if the reading was at sea level, a dot would be placed two inches above the bottom of the cardboard. No vertical measurements were necessary, however, since a scale was placed on the under side of the transparent triangle.

Having the scale placed on the under side of the triangle avoided parallax. This scale began, that is had its zero, two inches above the base of the triangle and it was divided into arbitrary divisions, numbered with successive hundreds. Since the contour interval was twenty-five feet, these divisions were subdivided into quarters.

When the plotter received the reading, he would slide the triangle along to the proper horizontal distance and place a dot at the desired hundred mark, close to the vertical edge of the triangle. Therefore, there was no measuring and the dots were placed exactly over the proper position on account of the squareness of the triangle. All horizontal readings were given as total distances from the edge of the map so that there could be no additive errors. When all the readings were plotted a smooth curve was run through all the dots and the profile was cut out.

The duties of the reader were not confined merely to the reading of horizontal distances and elevations. He had to note every road, brook, shore line, and marsh which his profile was crossing, and this was plotted, not on the profile but on the other two inches of cardboard, above the profile. When this part was cut from the profile it became a template, containing all the information concerning the country which it crossed. Both profiles and templates were numbered and signed by each pair.

As fast as the profiles were finished they were assembled, being separated five millimeters between centers by means of strips of wood. Since the thickness of the wood varied, paper strips were added from time to time, always keeping the profiles in their proper places. All errors were apparent, and when these had been corrected the map was nailed together, profile after profile. In order to obtain squareness and rigidity, a table was provided with a false top, on which were firmly fastened two pieces of wood, 2"x2", longer than the two dimensions of the map, and at right angles to each other. After a few profiles had been nailed together, screws were run through one of these pieces into them. All profiles were slid up against the other piece and then nailed to the growing map. As the map was nailed together there was a tendency to buckling, which was prevented by running long screws from the under side of the false top up into the assembled map.

When all the profiles were assembled, the spaces between them were filled with a soft modeling wax and the surface of the map moulded, using the profiles as guides. The map was finished with a smooth surface, obtained by careful rubbing with the fingers. Then it was placed in a wooden flask, made of two-inch planks tightly fitted around it, and the flask was filled with plaster of Paris of a creamy consistency. This produced a matrix which was easily removed from the modeled map, since the modeling wax was oily. After the matrix was dry, little irregularities were smoothed out, the surface well smeared with vaseline, and a cast made. The same flask was used, the cast taking the position formerly occupied by the original map, but, of course, bottom side up.

After becoming thoroughly dried the cast was smoothed with fine sandpaper and painted with the conventional colors. In this work the templates were used to obtain the location of all points. The template number, multiplied by five, gave the distance in centimeters of the template's position above the starting point, or bottom of the map. The locating of points and the painting of the map were the hardest part of the whole work and were the most tedious.

If relief maps are to be made the same size as the topographic sheets from which the information is obtained, the system of piling up cut-out contours is the best method. If the relief map is to be larger than the topographic sheet, the method of enlarged profiles is much better than the use of the pantograph to enlarge contour lines. Mistakes are not magnified and there is a sure check upon the work.

The scale of the finished map is $1''=1,000'$, horizontally, and $1''=500'$, vertically. The map has been framed with $\frac{7}{8}''$ Oregon pine, $7''$ wide, which is fastened into strips of wood which had been cast into the plaster of Paris, of course below the surface of the map. This map will be on exhibition at the Alaska-Yukon Exposition, at Seattle.

Nearly 2,000,000 h. p. in the form of gas is allowed to escape from the blast furnaces of the country. This condition is rapidly being changed by the installation of gas engines to develop the power. There is also a great fuel waste in the manufacture of coke, beside the loss of many valuable by-products. It is estimated that these losses amount to \$50,000,000 annually.