

## THE SURVEY OF MOUNT RAINIER\*

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U. S. GEOLOGICAL SURVEY



NOW that the new topographic map of the Mount Rainier National Park, recently published by the U. S. Geological Survey, has had its first testing at the hands of The Mountaineers, who last summer encircled the peak, it may be apropos to describe in a few words how that map was made and, incidentally, how the height of Mount Rainier itself was measured. The more desirable does it seem to do so, as to the layman modern topographic methods are still largely enshrouded in mystery, so that he has little whereby to judge of the merits of a map or of the reliability of an altitude determination. Several figures have been announced within the last two decades for the elevation of Mount Rainier, no two of them in accord. It may be well, therefore, to show why this new figure, for which finality has been claimed, is more trustworthy than the others.

Like all other topographic maps now being made in the United States, that of Mount Rainier was constructed wholly "on the ground." Time was—not very long ago either—when "accurate" maps were based upon transit-and-chain surveys, the notes of which were laboriously reduced and plotted—in an office, perhaps 2,000 or 3,000 miles away. The real drawing of such maps often was not begun until after the field work had been completed; and, as errors and omissions cropped up occasionally in the notes and sketches (for even the most conscientious mind will err), it happened now and then that the draftsmen were obliged to eke out facts with ingenious fiction. It is possible that the layman's inborn distrust of the veracity of maps dates from those good old days. The modern topographer lays no claim to sheer perfection, but he at least enjoys the inestimable advantage of working with a method that leaves no very good excuse for mistakes or slips, and really no excuse whatever for straight omissions. The philosophy of this system is that the map shall be drafted in the field, as fast as the measurements are available, and that the features of the landscape shall be sketched in then and there. When the field work is finished, accordingly, the map is finished too—in pencil—and needs only to be inked and engraved.

The instrument which makes this field mapping practicable is known as the plane table, by which cryptical appellation is meant a simple drawing board mounted on a tripod and so fitted that it can

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be leveled, turned at any angle and clamped rigidly in any position. On this table, securely fastened by thumb-screws, is a stiff sheet of double-mounted paper, upon which the manuscript map grows inch by inch, as slowly as an intricate piece of embroidery. The same sheet may be in use an entire field season, or perhaps several seasons (one of the Rainier sheets saw service three different years). It is worked on almost every day, yet, incredible though it may sound, that sheet will reach the office bright enough to be called white. Some people experience difficulty in keeping a drawing reasonably clean for a single week indoors. Of course, the plane table sheet is carefully protected by



SUMMIT OF  
PINNACLE PEAK

A plane table party taking vertical angles with the alidade to points on the flanks of Mount Rainier, four to six miles distant.

stout manilla paper, only a tiny patch being exposed for the work in hand, and it is transported in a water-proof leather case.

On the plane table, resting directly on the map, is the alidade, the map maker's instrument par excellence, which takes the place of the surveyor's traditional transit. It has a telescope, level and vertical arc, besides various attachments devised to expedite its use. At its base is a flat ruler, about 18 inches long, which permits lines being drawn upon the map parallel to the line of sight. The laborious reading and subsequent plotting of deflection angles is done away with. The topographer simply sets the alidade with its ruler on the point occupied by him (marked by a fine needle hole in the paper), sights the object to be located, and draws a sharp line with a hard, chisel-pointed pencil (7H to 9H, according to the humidity of the air and the paper). The

method is both shorter, and more accurate in its results, than the old-fashioned process.

Chain and tape are also dispensed with. In the telescope are fitted, besides the customary cross hairs, two horizontal stadia hairs, which are so spaced that on a rod held at a distance of 100 feet they subtend one foot, at 200 feet, two feet, and so on. To measure the distance to a given point the topographer need but send his rodman there, and count the number of feet and fractions of a foot included between the stadia hairs, and multiply his reading by 100. Whether the point to be located lie on the other side of a canyon or of a lake, makes no difference—so long as his rodman can reach it, a single peep through the instrument will give him the desired distance. At the same time he can determine the elevation of that point. The vertical arc shows him the angle which the telescope makes with the horizontal, and with this angle and the distance determined, he computes the difference in elevation between the point sought and his instrument. Special attachments reduce the arithmetical work involved to a few simple figures. Thus the topographer is able to work swiftly, locating points to right and left, as far as a thousand feet or more, plotting them forthwith and drawing the contours in accordance with the elevations.

Not all points needed, however, are accessible to a rodman. On the rugged flanks of a high peak such as Rainier, or of a range such as the Sluiskin Mountains, there are many points the location of which is essential for the support of the numerous contour lines, yet which it is manifestly impracticable to reach by stadia. Such points the topographer locates by intersection, that is, by sighting them with his alidade from at least two stations already plotted. The lines of sight drawn from the stations cross or intersect each other, and thus determine with accuracy the position of each point. Above timber line there is no lack of suitable targets—rock spires, cliff corners, spurs and reentrants, rock islands in the midst of glaciers, as well as the edges and broken cascades of the ice masses themselves (the movement of which is too slow to produce changes in the course of a few days that would be perceptible on a scale of one mile to the inch). It is wonderful, with good weather conditions, at what distances such topographic details can be intersected with the aid of a telescopic alidade. Thus, practically the entire southern side of Mount Rainier, from Little Tahoma west to Peak Success and down to the 7,000-foot level, was mapped by intersections from Pinnacle Peak and other stations on the Tatoosh Range. Considerably over 500 points lay within this area (which embraced about 12 square miles) the great majority of them, between 5 and 6 miles distant from the stations occupied. Vertical angles were read to all of them, and thus some 500 elevations were made available for the drawing of the contour lines. There were more than 70 of these lines,

the total relief amounting to considerably over 7,000 feet. Needless to say, it required more than one day to complete the task; each station was occupied several days in succession. Even then the result was attained far more expeditiously than would have been possible with the old-fashioned transit-and-notebook method.

It was from the Tatoosh Range also that angles were taken for the determination of the altitude of Mount Rainier. It is the rule of the U. S. Geological Survey to establish important altitudes by accurate lines of spirit leveling, beginning at sea-level or an already established base. Mount Whitney (14,501), the highest summit in the United States, was measured by that method, and so was Pike's Peak (14,110). But in the case of Mount Rainier, leveling was found wholly out of the question, not only because of the precipitousness of the snow chute up Gibraltar Rock, but because any attempt to carry accurate spirit levels over extensive snow slopes, such as must inevitably be traversed in the

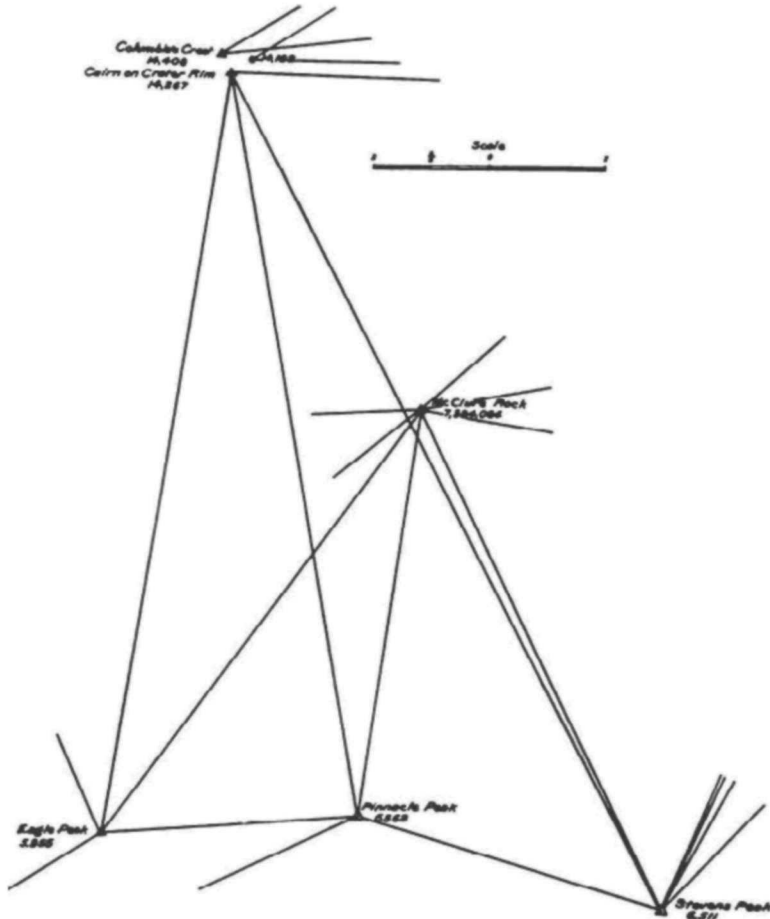


Fig. 1—Scheme of triangulation connecting McClure Rock with the Tatoosh Range, and the latter with the cairn on the summit of Mount Rainier.

ascent of Mount Rainier, is fraught with difficulties innumerable. It was deemed more expedient, therefore, to measure the mountain's height by means of carefully checked vertical angles from neighboring peaks. The plan which suggested itself to the writer, and which was actually carried out, was first to determine the altitude of Pinnacle Peak as a "stepping stone" to the top of Rainier itself. To run levels up Pinnacle Peak, however, would have been almost as difficult as up Gibraltar Rock. It was decided, therefore, to run levels to McClure Rock, which is readily reached by trail, and from that point to take vertical angles to Pinnacle Peak, as well as to Eagle Peak and Stevens Peak, by way of check. From all three of these peaks, again, angles were to be read to the summit of Rainier. In order to insure the accuracy of the result, all the points involved in this scheme, including McClure Rock, were to be bound together by triangulation, so that the distances between them

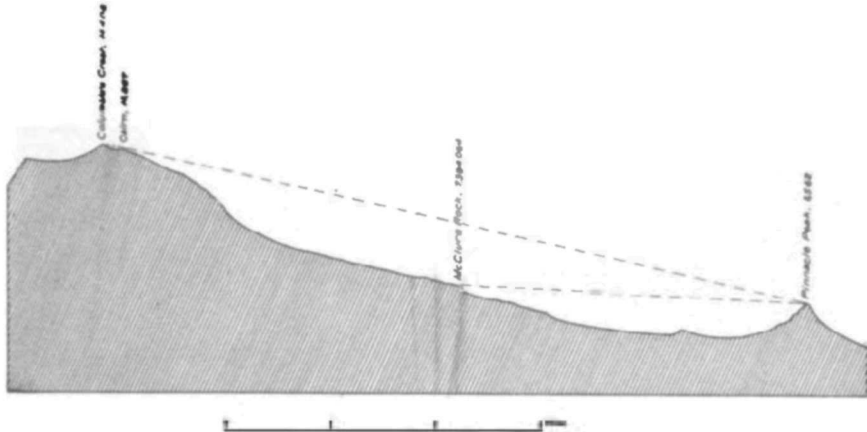


Fig. 2—Profile of Mount Rainier and the Tatoosh Range, showing the lines of sight from McClure Rock to Pinnacle Peak, and from the latter to the cairn on the summit of Mount Rainier. The vertical scale is not exaggerated.

could be computed to the nearest foot. The system of triangles is shown in Fig. 1. A curious feature of the scheme is that the initial point, McClure Rock, is considerably higher than any of the peaks of the Tatoosh Range, so that the first step was really a step downward (Fig. 2).

Unfortunately, the highest point on Mount Rainier—Columbia's Crest—is not visible from the Tatoosh Range, owing to the width of the summit crater. It was necessary, therefore, to select an auxiliary point on the crater rim that could be seen from the Tatoosh Range and from Columbia's Crest. This the writer did on his first ascent, August 18, 1910, in company with the late Charles D. Walcott, Jr., and the guide, Joe Stampfer. Sudden snow squalls compelled the party to beat a hasty retreat, but they managed, nevertheless, to erect a rock cairn 8 feet high to serve as a target for the triangulator.

On September 3 of the same year the writer made a second ascent, accompanied by Fred Owens of Tacoma, and carrying a light plane table outfit in order to determine the position and height of Columbia's Crest from the cairn, and to map the summit itself. The weather, however, turned out worse than the first time, a fierce gale arising, against which it was impossible to stand. Crawling to the shelter of the cairn, the writer managed to take two angles to Columbia's Crest, Owens throwing his weight upon the plane table to keep it from blowing away; but the exact position of the snow dome remained undetermined.

In 1911 the projected triangulation was executed, but it was not until 1913 that the position and altitude of Columbia's Crest were definitely ascertained. The honor of completing the task belongs to Topographer C. H. Birdseye, who, with his companions C. B. Harmon and Frank Krogh all but perished in a blizzard on the summit. The story of their night's vigil in a steam cave of the crater, pounding and rubbing each other to ward off a fatal sleep, has been described elsewhere. From this first unsuccessful attempt they returned with ears, fingers, and feet badly frosted; but, nothing daunted, they essayed the ascent again, four days later (August 20) when the sky had cleared. That time the weather conditions were ideal, and in the space of five hours they succeeded in taking the necessary angles to the Tatoosh Range, in locating Columbia's Crest, and in mapping the entire summit platform.

Thus was completed the survey of Mount Rainier, which has resulted in placing the peak near the top of the list of high summits in the United States. The figure announced by the U. S. Geological Survey is 14,408 feet. The manifold repetition of each angle measured, the checks afforded by back readings, and the compactness of the triangulation scheme all combine to give this figure a degree of accuracy second only to one obtainable by spirit levels—a mode of measurement impracticable on the flanks of an ice-clad peak.



MOUNTAIN GOATS

Chas. S. Gleason  
 Photograph taken August 9, 1915, in Panhandle  
 Gap on the east slope of Mount Rainier at an  
 elevation of 7,000 feet.