

every one of the parties, and tended to increase the total cost, but, taken as to Parties Nos. 1, 2 and 3, the statement is a fair average of what a thorough survey under like conditions will cost.

Besides the organization, as noted on page 111, which was practically the same as that engaged on these surveys, with the exception that there was only one topographer, there was the expense of an expert, at \$150 per month and his expenses, engaged in an examination of the country adjacent to the line, for the purpose of determining the quantity of sand and stone available for construction purposes. The amount of this expense is \$545.84.

In all this work it was considered absolutely necessary that all parts of it should be kept up together, and, with the large party available, it was found feasible to assign the men so that any part of the work which lagged behind could be brought up to date; the weak point is, of course, with the leveler on preliminary, if he gets behind there is little to do but to wait until he catches up. It is necessary, therefore, that an especially good man should be selected for this position. Physical ability to hustle is absolutely necessary, and the rodman must expect to trot between stations and the instrumentman between set-ups, if they cannot keep up by walking.

The leveler in a party should be, not only accurate, but quick. As an instance of what can be accomplished: On one of the lines referred to, starting from the west, more than 100 miles of preliminary were run to the eastern end of the line in 20 working days (not including Sundays and moving camp). On one day, the leveler covered 8 miles. On returning and making the final location, when every care was taken to have the levels as accurate as possible, equalization of sights being insisted on, and there being ample time for the leveler to do the work properly, no variation from any bench-mark was found greater than  $\frac{5}{10}$  ft., the final check on the bench at the western end being about  $\frac{3}{10}$  ft.

In making the preliminary location, or rather, the writer would prefer to say, in running the preliminary lines, he considers that the result to be obtained should be regarded more in the nature of making a topographical map of a strip of country through which the final location will pass, and through which runs a sufficiently accurate base line or lines, than in running a line which will be very close to the final location. There is only one place, in his opinion, to adjust the final location, and that is on a good topographical map.

This, of course, will not be misunderstood as relieving the Locating Engineer of the necessity of running these preliminary lines with judgment and a good idea of their relation to the located line. All the good judgment and "eye for country," relied on so much by some of the older locating engineers, are still as necessary as ever, but they must be supplemented by scientific methods and hard work.

The statement in regard to the final adjustment will possibly evoke some discussion from the many men who have saved thousands of dollars by slightly changing a curve in the field or otherwise after the final location is made, and the writer will admit, of course, that there is hardly a line located to-day, or likely to be, where every foot of it is exactly where it ought to be, but, in anything but the most minor changes, he believes that the fault will invariably be found in the fact that the original topographical map was not correct, or the projection not well made.

Provided the topography is generally correct, which it should be, to be of any use at all, it is possible to project a line on it, which will be the best line the country affords, and, if the work is properly done, this line can be laid out on the ground. In adjusting the line to the topography, the line can be changed and a profile obtained fifteen times on the map while it is being changed once on the ground, and all the problems affected by the change studied.

The writer is well aware, of course, that the practice as outlined in this paper will necessarily be subject to many modifications to meet different conditions.

In conducting surveys in tropical countries or in other places where it is difficult to obtain experienced engineers, and then only at largely increased salaries (in tropical countries about two to three times as much as is noted in this paper), other methods become necessary, but the writer believes that the same ends should be striven for. In these cases, there is a great temptation to the engineer in charge of such work to shrink from the responsibility of insisting that he be given *carte blanche* by his employers in the matter of engaging such assistance as he may need and in the payment to them of adequate salaries.

There is much mountain country where transportation is extremely difficult, where everything possible must be done to lighten the equipment, and where a great deal of reconnaissance can be done in more or less detail with a light party, either by a separate party ahead of a larger one, or before a larger party is organized and put in the field.