

tion, and from this secondary base, the distance from *T* to *W* was had. The fact that *W* was not accessible from *X* will perhaps explain the discrepancy of .079 feet between the actual and triangulated distance between *T* and *W*, as a very slight error in the alignment of *T* which was accessible, would account for the difference.

Actual measurements were relied upon for the laying out of the work, and the triangulation was simply used as a means of detecting any large and appreciable errors that might possibly have come into the actual measurements, so small a measuring standard being used. Actual distance measured with the rod was 5516.908 feet, which compared favorably with the triangulated distance, which was 5516.860 feet, the difference being .048 foot, or about $\frac{1}{2}$ an inch. The measuring of the centre line was considered the most difficult part of the work, and the actual measuring of the length of the bridge, slightly over a mile in length, took about six weeks of very trying time, especially on account of high winds.

7	Station	Slope	Total slope	Vertical	Slope ²	Vert. ²	S ² - V ²	Hor.	Station	Remarks
	22		14.8						1666+66-892	Oct 5-16
		15.2								Temperature +44°
										No wind - Conditions
Change 8			30.0	11.685	900.1200	136.5392	763.5808	+27.633	1666+39-259	favourable.
Change 8		15.0								
	24									
		14.9								
Change 9			29.9	13.367	894.0609	195.0771	698.9827	26.436	1666+12-821	
Change 9		14.9								
	26									
		15.2								
Change 10			30.1	12.019	906.1304	144.4561	761.6743	27.598	1665+85-223	
Change 10		14.7								
	28									
		15.3								
Change 11			30.0	19.081	900.1200	364.0846	536.0354	23.152	1665+62-071	
Change 11		14.9								
	30									
		15.3								
Change 12			30.2	15.909	912.1608	253.0963	659.0645	25.672	1665+36-999	
Change 12		14.7								
	32									
		15.0								
Change 13			29.7	8.607	882.2088	74.0804	808.1284	28.417	1665+07-972	
Change 13										

Fig. 13.—Sample Page from Field Book.

As it was necessary to proceed at once with the excavations, a great many of these were laid out immediately. The "bent" hubs were established by laying off the proper distances from the "change" stakes, the chainages of which had already been established as per notes in Fig. 13. Owing to the number of haulage roads that were to have been opened, and the number of sight-seers constantly walking about, it was decided to have all bent hubs protected by a railing on four good posts set firmly into the ground, and enclosing a space sufficiently large to allow the setting up of a transit inside, and all intermediate stakes pulled out so as to avoid confusion, and to give the workmen, teams, etc., an opportunity of working without disturbing stakes. The preservation of permanent stakes and hubs was an important question on this work, and a great deal of pains was taken to protect them. The "bent" hubs were also referenced by means of other hubs set out at considerable distances, and approximately at right angles to the centre line. It will not be necessary to describe fully the actual laying out of the foundations, but it might be said that

it was only necessary to turn off an angle of 90° 00" from the centre line, and to measure out the given distance to the centre of the particular foundation. This was done by the tape on fairly level ground, but the measuring rod, and plumbing arrangement was used on irregular ground. This was generally done before the ground had been disturbed, and by setting up the transit over the centre of the foundations and turning off other angles of 90° 00", four hubs were set that were sufficient for the contractors to carry out the work. When the ice was out of the river, the river piers were located by triangulation, which scarcely need be described. When it was possible to lay out piers from the ice, this was done in a similar way to that in which the land piers were laid out.

The initial bench mark was established from preliminary location bench marks, and inside the enclosure at hub *X* a hole similar to one which would have been dug for a telephone post, was made. Into this, a $\frac{5}{8}$ inch steel rod was driven so that the top of it would be slightly below the original ground. Then concrete was dumped into the hole around the steel rod. The hole was then filled in with earth, and the bar carefully referenced, so that no unnecessary digging would have to be done in finding the rod. After the concrete had firmly set, the rod was examined to see that it had a well-defined top, on which a bench mark was established. Other bench marks were established at convenient points, from which, with one "turn," elevations could be given for the finishing of a pedestal near same. It was so arranged that it was never necessary to make more than one turn from any bench mark in setting elevations for the finishing of the tops of any of the pedestals.

In levelling to establish a system of benches, difficulty was had in the getting of fine calm days, and it was rarely possible to get two good days in succession. A Gurley level and sliding target rod were used. The levelman, after reading the rod, directed the rodman to set the target. This was then read again by the leveller, and if correct, both rodmen were instructed to read the target as a check on the leveller himself. As

another precaution, after taking the final reading on the rod, the leveller was instructed to see that the bubble of the level was in the centre, and that in focusing, no jarring was done to the level. The level was always tested for adjustment every time before using, twice a day.

The levels were checked from one side of the gorge to the other several times, and although the writer is not in possession of the original notes at the present time, as far as he can remember, a check was had as close as .025 of one foot, which, considering the nature of the ground and the weather that was contended with, seems rather to have justified the care taken. The writer considers, for similar work, that a one-piece target rod is superior to the two-piece one that was used. With one of these there would be no danger of the slipping that has to be guarded against with the two-piece rod. Constant use also has a tendency to wear the mechanism of the two-piece rod, thereby making it less accurate for careful work. The sun being fairly dull at this time of the season, no sun shade was used. One precaution that was taken was that the leveling rod was, as far as possible,