surrounding rock or masonry. After the exposed end has been planed to a smooth surface by means of a file, it is stamped with a steel die containing the above-mentioned letters. Then, by means of a cold chisel, a horizontal cross mark is made, upon which the elevation is taken; finally the number is stamped with other steel dies. Elevations are not marked on because the elevation of a bench mark is a precise levelling net may not be finally decided upon for a long time. The closing of circuits and introduction of new cross lines will call for adjustments which will make changes of greater or less magnitude in the elevations. Also, the computation of the elevations from the field notes is a work of some magnitude and would delay the operations of the parties were it performed in the field. It is, therefore, left to be done in the office after the notes have been carefully checked. I might say, also, that an engineer would not usually attempt to look for the bench marks haphazard, but would set out armed with descriptions of their locations.

Levellers are instructed to aim at getting bench marks at intervals of about three miles when suitable locations which may be encountered en route. Engineers are thus enabled, if they wish, to reduce their elevations to our precise datum without any additional field work on their part.

A precise levelling party consists of seven men, the chief or leveller, recorder, two rodmen, umbrellaman, cook and a railway employee, usually a section man, to pilot the hand-car. Camps are made at the stations along the line, the distance apart varying from 10 to 20 miles. The levelling is carried continuously forward, day by day, through the camp and to a point about half-way to where the next camp ahead will be.

General instructions issued to levellers are: "All lines are to be levelled twice, in opposite directions, called forward and backward levelling. Backward shall in every respect be independent of forward levelling and the same turning points shall not be used. If the forward levelling is made in the forenoon, the backward—over the same section—should be made in the afternoon, it being desirable to secure as much difference in atmospheric conditions between the forward and backward measurements



Fig. 4.—District Covered by Levels Run from B.M. of the United States Coast and Geodetic Survey at Stephen, Minn.

can be found, and in no case to run more than eight miles without establishing one. To comply with the latter requirement it has been found necessary to erect, at certain points, concrete piers, specially for bench marks. These piers are 6 feet 3 inches high, 9 inches square at the top and 15 inches square at the bottom, resting on a concrete footing. The whole pier is buried to within about 9 inches of the top, and the copper bolt built in, near the ground surface, having been previously stamped and numbered. The piers are usually built on the railway right-of-way, within 3 or 4 feet of one of the fences and on fairly level ground, where they will not be exposed to danger from future alterations in the railway grade.

Temporary bench marks are placed at intervals of 1 mile or thereabouts. They consist usually of spikes, driven horizontally into telegraph poles, and, as their designation implies, they are used only for convenience while the work is progressing. They are not embodied in the final records.

Besides establishing our own bench marks as above described, it is our practice to connect with any permanent or semi-permanent bench marks of other organizations as is possible without materially delaying the work for this purpose.

"Other things being equal, it is considered better practice to complete all forward levelling to be done at one camp before making any backward measurements, rather than to run a few sections forward and then backward and repeat this process two or three times before moving camp.

(Read before the Royal Astronomical Society of Canada, at Ottawa, March 31, 1916.)

(To be continued.)

Satisfactory accounts have been received of the performance of the ice-cutting car-ferry Leonard which was built by Messrs. Cammell, Laird and Company to convey the National Transcontinental Railway Company's trains across the St. Lawrence from Quebec to Point Levis. Since her first trip in May last the vessel has transferred as many as 90 cars in a single day. The trains are carried on a tidal or upper deck, which has three lengths of track, 272 ft. long and each able to hold three passenger coaches. The vessel has three sets of triple expansion engines, two being for propulsion, while the third drives the ice-cutting propeller, which is fitted at the bow.