have been run from Halifax, one extending to Yarmouth, the other to Moncton, the total amount of levelling included in this district being 592 miles. It is satisfactory to be able to state that the two elevations of the junction bench mark at Moncton, as derived from the St. Stephen datum and from the Halifax datum, differ by only two-tenths of a foot. The two elevations of the junction bench mark at Riviere du Loup, as derived from the St. Stephen datum and from the Rouse Point datum, differ by a little over four-tenths of a foot.

The initial-point for the fourth district was the United States Coast and Geodetic Survey bench mark at Stephen, Minn. To utilize this we were obliged to run 45 miles of levels through Minnesota to the international boundary at Emerson, directly south of Winnipeg. From Emerson one line was extended easterly to Port Arthur, the other westerly to Regina, Prince Albert, Edmonton, Calgary, etc. Last summer this line was carried west from Calgary over the summit of the Rocky and Selkirk mountains and was discontinued for the season near Revelstoke, B.C.; 3,279 miles of levelling are included in this district. The initial-point for the fifth district was the automatic tide gauge at Vancouver, mean sea-level at this point having been established by the Tidal Survey from their records extending over seven complete years. Levels from Vancouver extend southerly to the international boundary at two points and also easterly a comparatively short distance; 142 miles of levelling are included in this district.

From the above summary it will be seen that a transcontinental line has been almost completed, only two gaps in the line now remaining, one between Franz and Port Arthur and the other between Revelstoke and the end of the Vancouver line, the length of the gap, by a coincidence, being about 295 miles in each case. It is confidently expected that these will both be filled in during the coming season and we shall then have an unbroken line of precise levels connecting the tide gauge at Halifax with the tide gauge at Vancouver. This line is rapidly being paralleled by a second and in some cases by a third line where this is considered advisable.

Criticism has come from some quarters because the levels have been based partly upon intermediate points like Rouse Point, N.Y., and Stephen, Minn., instead of entirely upon the tide gauges on the sea coasts. At least two answers may be made to this: firstly, when the work was in a more or less experimental stage and the staff was inexperienced it would not have been advisable to conduct the levelling at such a great distance from headquarters; secondly (and more important), the results were required for the use of the International Boundary Surveyors and others, and with the limited organization then available it would have taken a very considerable period of time to carry levels from the Atlantic coast to the Quebec-Vermont boundary, for instance, or from the Pacific coast to the provinces of Saskatchewan and Manitoba.

Instruments.—The instrument adopted is a precise level of the United States Coast and Geodetic Survey pattern.

Great care has been expended on the construction of the rods used upon this work. They are built up of three pieces of white pine, giving a cross-section in the form of a symmetrical cross, this form having been found to offer the greatest resistance to bending and warping. They are boiled thoroughly in paraffin which tends to keep them of constant length under varying conditions of atmosphere and temperature. Silver plugs are inserted in the face of the rod approximately at the three, six and nine-foot points, and the exact positions of these points marked by a fine scratch on the face of the plug; the rod is then subdivided into feet, tenths and hundredths in alternate white and black spaces of one one-hundredth of a foot. When observing the rod the readings are made to thousandths, the hundredth spaces being subdivided by estimation. As it is impossible to subdivide a black space accurately at the distance the rod is usually observed, two sets of graduations are placed, side by side, one on each side of the centre line of the rod, the white spaces of one adjoining the black spaces of the other; thus the observer has always a white space to subdivide by reading on the right-hand or the left-hand set of graduation marks, as the case may be. The bottom of the rod is encased in a brass shoe which is fitted underneath with a hemispherical knob of steel; this is specially suitable for holding on a flat surface such as the top of the rail of a railway track.

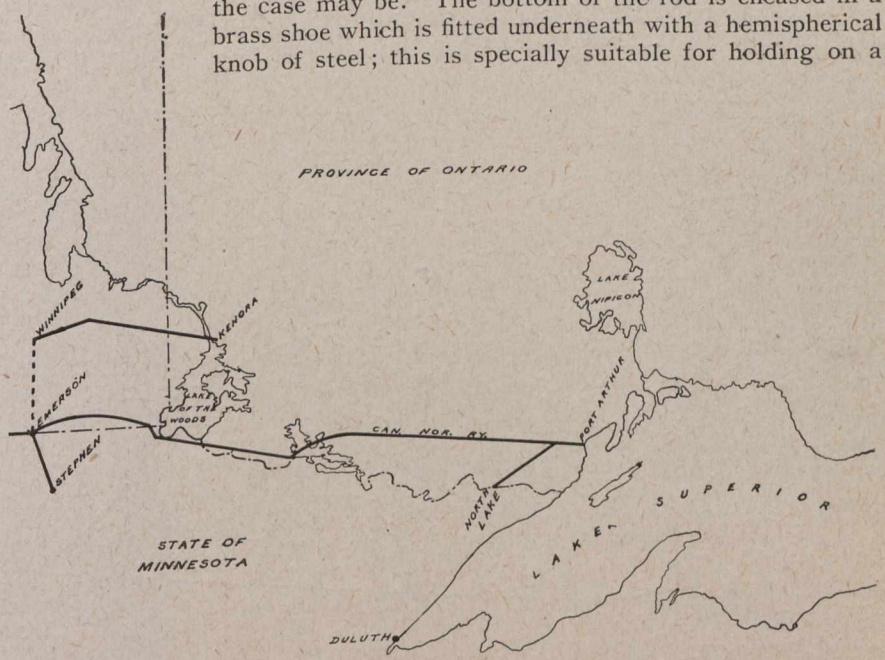

Fig. 3.—District Covered by Levels Run from the B.M. Established by the United States Coast and Geodetic Survey at Stephen, Minn.

Another piece of apparatus which is very necessary is a large carriage umbrella with a handle about 8 feet long, provided with a spike at the end to insert in the ground. The umbrella is used whenever the sun is shining while observations are in progress, to shade the instrument from its rays; without this the parts would become unequally heated and irregular and unreliable action of the bubble would follow.

While carrying the instrument between sights a cover of duck or cravenette is used for the same purpose; this also is used to protect it when working during a light rain. In a heavy rain the work has to be discontinued.

Field Methods.—The standard bench mark established by the Geodetic Survey consists of a copper bolt ¾ inch in diameter and 4 inches long, stamped on the end with the letters "G.S.C., B.M." (Geodetic Survey of Canada, Bench Mark). The bolt is sunk horizontally in rock or masonry, a hole being drilled of the exact size of the bolt or a shade larger and the latter hammered till it completely fills the hole, the end being flush with the surface of the masonry or projecting slightly. Properly put in, it is impossible for anyone to remove it without destroying the