various topographical surveys carried on by the Militia and other Government Departments, the International Boundary Survey and the triangulation branch of the Geodetic Survey. J. B. Johnson, in his manual of surveying, has the following to say on this latter phase of the subject: "In order that triangulation distances may be reduced to sea-level, the elevations of the bases at least must be found. It is impossible to carry elevations accurately from one triangulation station to another by means of the vertical angles, on account of the great variations in the refraction. Barometric determinations of heights are also subject to great uncertainties unless observations be made for long periods. The only accurate method of finding the elevations of points in the interior above sea-level is by first finding what mean sea-level is at a given point, by means of automatic tide-gauge records, for several years, and then running a line of precise spirit

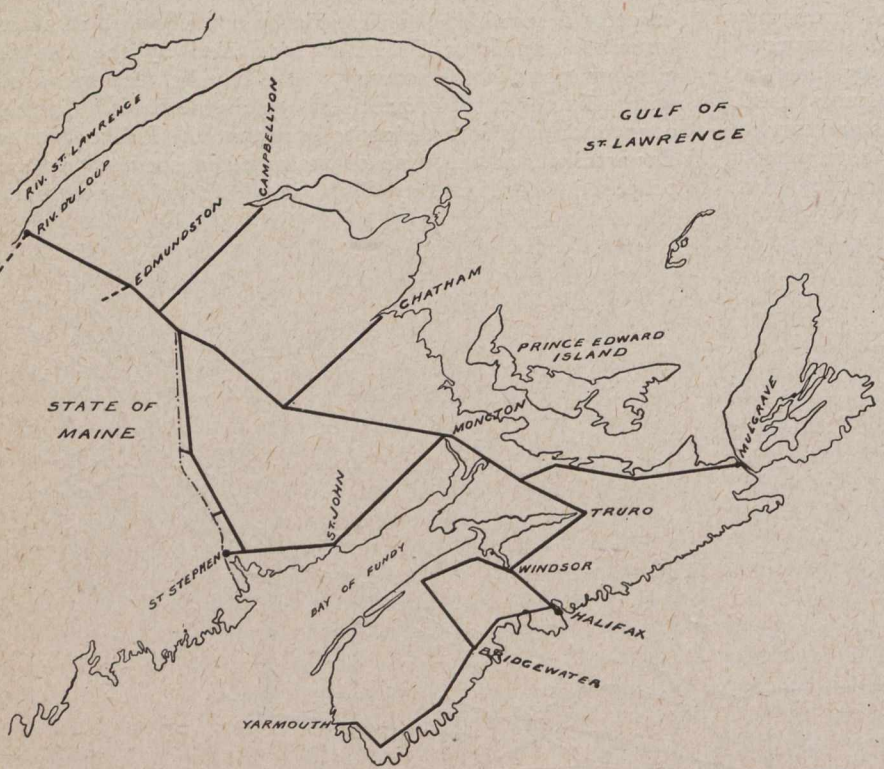

Fig. 2.—District Covered by Levels Run from B.M. at St. Stephen, N.B., Established in 1873 by the U.S. Corps of Engineers, and from Mean Sea-Level as Established by the Tidal Survey at Halifax, N.S.

levels from this gauge inland and connecting with the points whose elevations are required. Most European countries have inaugurated such systems of geodetic levelling, this work being considered an integral part of the trigonometrical survey of those countries."

Precise levelling is, whenever possible, carried along railway tracks, rather than along highways or across country, the advantages of this practice being many. The rate of rise and fall of the track is usually fairly uniform and no steep hills are encountered, thus allowing longer average sights to be taken and allowing the backsights and foresights to be easily kept of equal length. The rails furnish excellent supports for the levelling rods and thus the time is saved which would otherwise be consumed in putting artificial turning points into the ground. The masonry structures—bridges and culverts—situated along the railways are utilized for placing permanent benchmarks; this is of advantage both to us and to the railway companies. Again, the use of a hand-car for going to and from work and for moving along from point to point during the day, effects a large saving of time and labor, and the transportation of the camping outfit from camp to camp by freight is cheaper and more convenient than the method by horse and wagon. Against these and other advantages may be set the fact that the refraction and boiling of the atmosphere caused by the sun is considerably greater on a railway track, owing to its exposed character and the materials of which it is constructed.

Datum Planes and Territory Covered.—Geodetic levelling is always based upon mean sea-level as a datum, mean sea-level being assumed to be everywhere the same except insofar as it may be affected by the irregularities of the coast line, as, for instance, in land-locked bays or the estuaries of rivers in which the free entry and exit of the tide may be obstructed. Automatic self-registering tide gauges have been established and are maintained by the Tidal and Current Survey, Department of the Naval Service, at various points on the Atlantic and Pacific coasts; regarding the determination of mean sea-level by the aid of these gauges the superintendent of the survey, Dr. Dawson, has made the following statement: "The value of mean sea-level is found in the first place for a period of one continuous year at a time. It is based upon the height of the tide at every hour (day and night) taken from the autograph record of the tide gauge. By comparison with direct observations for time and height, the record from the registering gauge is reduced to a truly uniform datum from year to year, with relation to a bench mark. The value of mean sea-level in each year is thus the average of 8,760 individual measurements at successive hours without a break. If any serious interruption occurs, a fresh beginning is made. The basis for the final determination is in all cases a series of complete years of this character; and such determinations have evidently a very high accuracy."

The levelling of the Geodetic Survey has been started from five bench marks or reference points, in widely separated parts of the country, each one being connected—more or less directly—with mean sea-level. The first levelling was started from the United States Coast and Geodetic Survey bench mark at Rouse Point, N.Y., and two lines have been extended from this point, one easterly through Megantic and Levis to Edmundston, N.B., and Riviere du Loup, Que., with several branches to the international boundary, and the other westerly to Ottawa, Toronto and Windsor, also northerly to Sudbury and Sault Ste. Marie; at the end of last season this line had been extended 200 miles north of the Soo to Franz, the junction of the Algoma Central Railway with the main line of the C.P.R.; 3,370 miles of levelling are included in this district. The second initial-point was a bench mark at St. Stephen, N.B., whose elevation had been established by the United States Corps of Engineers in 1873; from this our levels have been carried northerly to Riviere du Loup, Que., and easterly to Moncton, N.B., the total amount of levelling, including cross lines and branches, being 1,022 miles. The initial-point for the third district was the automatic tide gauge at Halifax, mean sea-level at this point having been established by the Tidal Survey from their records extending over nine complete years. Two main lines of levelling