soon suggested itself, both for reasons of economy as well as accuracy, and was accomplished by the construction of various tide-predicting machines.

The first was the British Association tide-predicting machine, or tide-predictor No. 1, the designing of which was due to Lord Kelvin in 1873. It is described in Thomson and Tait's "Natural Philosophy," second edition, Part I, pages 479, 481. This machine combines the following ten component tides: (1) The mean lunar semi-diurnal; (2) the mean solar semi-diurnal; (3) the larger elliptic semi-diurnal; (4) the luni-solar diurnal declinational; (5) the lunar diurnal declinational; (6) the luni-solar semi-diurnal declinational; (7) the smaller elliptic semi-diurnal; (8) the solar diurnal declinational; (9) the lunar quarter-diurnal, or first shallow-water tide of mean lunar semi-diurnal; (10) the luni-solar quarter-diurnal shallow-water tide. Having been little used, it was deposited in the South Kensington Museum.

A second tide-predictor was designed in 1897 by Mr. E. Roberts, of the "Nautical Almanac" office, which was at first used for the prediction of the tides for India, under Mr. Roberts's supervision. In 1903 it was removed to the National Physical Laboratory, and is now available to predict the tides for all parts of the Empire. This tide-predictor has twenty-four components.

Two other tide-predictors were constructed, from designs of Lord Kelvin, by Kelvin and White, of Glasgow. One of them, containing sixteen components, is now used by the Hydrographic Service of the French Government, and the other, upon the same model, differing only in the number of components, of which twelve are provided, was constructed for the Brazilian Government.

In 1906 Mr. E. Roberts designed for his private use a tide-predictor in which provision was made for forty components, thirty-three of which are actually geared up, and vacant places for the gearing of the remaining seven have been left for the insertion of compound tides if required. It is known as "Roberts's Universal Tide-predictor," and was exhibited in 1908 at the Franco-British Exhibition in London, where it was awarded the Grand Prix.

In the United States, where tidal work has been an important function of the U.S. Coast and Geodetic Survey, two machines have been constructed. The first, called by Professor W. Ferrel, its designer, "The Maxima and Minima Tide-predicting Machine," is described in the Coast and Geodetic Survey Report, 1883. It is provided with nineteen cranks, and consequently combines nineteen component tides. In addition to the set of cranks summing the cosine series of equation (1), there is another set of cranks, pulleys, and chain for summing simultaneously the first derivative of equation (1), namely—

$$A_1 n_1 \sin(n_1 t + \alpha_1) + A_2 n_2 \sin(n_2 t + \alpha_2) + A_3 n_3 \sin(n_3 t + \alpha_3) +$$

which, by an ingenious device, points out upon a dial the time when the value of the derived series is zero, and consequently that of the cosine series, a maximum or a minimum; and thus it gives the heights and times of high and low water without any measurement of the curves, as is required in the other machines described above.

The second tide-predictor of the Coast and Geodetic Survey has been in use for predicting the tides since 1910. Provision is made for combining thirty-seven component tides. It traces a curve of the predicted tides as well as shows the time and height of the tide upon dials, and therefore combines both features of the British tide machines and the Ferrel machine. It is described in Special Publication No. 32 of the U.S. Coast and Geodetic Survey, 1915. This publication contains illustrations and a description of each of the tide-predictors referred to above.

The ports of the Dominion for which tide-tables are prepared and published in advance—viz., Auckland, Bluff, Dunedin, Lyttelton, Wellington, and Westport—were chosen by the Nautical Adviser. Auckland is suitable as a standard port of reference of the ports lying between the East Cape and the North Cape. Bluff, Dunedin, and Lyttelton can be used as standard ports on which to base the times and heights of high and low water for the intermediate ports in the vicinity of each. To what extent the Port of Wellington can be used as a standard of reference is at present doubtful. The tides in the Marlborough Sounds and along the coast of Cook Strait would be better based on New Plymouth than on either Auckland or Wellington; while either Napier or Gisborne would make a good standard port of reference for the intermediate ports and bays on the east coast of the North Island as far north as East Cape. Westport, situated about a mile up the Buller River, is a suitable standard port for Greymouth, Hokitika, and other similarly situated ports on the west coast of the South Island. The diurnal inequality of the tides at the Westport tidal station is masked by the diurnal variation of the height of the Buller River, caused in summer by the rapid melting of the snow on the mountains, and in winter by the great rainfall.

For a more complete knowledge of the tides and their peculiarities or characteristic features within the boundaries of the Dominion it is desirable that observations should be made on the outlying islands whenever there is an opportunity of obtaining records.

In 1840 Sir J. C. Ross, in his "Voyage of Discovery," Vol. i, page 153, reports that remarkable oscillations were observed in the tides at Rendezvous Harbour, in the Auckland Islands, and also at South Harbour, in Campbell Island. When near high water, after rising to nearly its highest, the tide would fall 2 in. or 3 in. and then rise again 3 in. or 4 in. This irregular movement occupied rather more than an hour. A similar tendency to a double high and low water is generally exhibited on the Lyttelton tidal records.