

THE ORIGIN OF OCEAN TIDAL SECONDARY UNDULATIONS. BY F. NAPIER
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Last year the writer had the honor of reading before the members of this Institute a short paper, entitled "A Probable Solution of the Secondary Undulations Found Upon Ocean Tidal Records." As the information then obtainable was extremely limited, the important points were set forth as suggestions for criticism. Since the publication and widespread distribution of your valuable "Proceedings" containing this paper, the writer has received numerous encouraging letters bearing upon this subject from various quarters of the globe.

In order to still further pursue this most engrossing and what is to be hoped valuable investigation, arrangements were made by Mr. Stupart, Director of our Service with the Marine Department at Ottawa, whereby the writer was granted free access to all the Canadian Tidal records now under Mr. M. W. Bell Dawson, Engineer in charge of the Tidal Survey, who also assisted me in every way possible. Tracings were made from over 1,000 daily tidal records, showing different types of undulations, from the following stations:—Halifax, Anticosti, St. Paul Island, Forteau Bay, St. John, N.B., Father Point, and Point Levis; also the original records were obtained from the temporary tidal stations at Carleton, P.Q., Pictou, N.S., Souris, P.E.I., St. Peter's Bay, P.E.I., and the Grindstone Island Barograph records from 1893-1894 to study with the corresponding Anticosti tidal traces, also tracings from several St. John, N.B., barograms. Upon returning to Toronto these records were carefully studied in conjunction with the corresponding synoptic weather charts at the Observatory. The result of this investigation clearly demonstrated that these undulations are due to the direct action of atmospheric waves or billows, as they pass over the harbours or bays, which tend to form minute undulations upon the surface of the water, and as these small water undulations advance farther into semi-enclosed basins become magnified as they reach narrower and shallower portions where the tide gauges are situated. Permit me briefly to summarize what has already been observed by others bearing upon this interesting subject.

In 1838 this phenomenon was observed at Swansea, England, where a regular time interval of from fifteen to twenty minutes was noted. Some of these records were sent to Sir George Airy, who was then unable to account for them. Admiral Smythe referred to this phenomenon at Malta, where it had long been termed "Mirobia," and supposed to be due to distant storms. In 1878 Sir George Airy read a paper before the Royal Society upon the tides of Malta, in which he speaks of these undulations as simple harmonic curves, whose heads are sometimes notched as by the intermixture of small waves. That they had a marked time interval of twenty-one minutes and a range of twelve inches amplitude, much exceeding that of the lunar tides. He believed they were "seiches" similar to those discovered by Forel upon the Swiss lakes, and supposed them due to a reflexive action from the shores of Sicily and the African coast. Major Baird, of the Indian Tidal Survey, referred to this phenomenon in 1868 as being most pronounced at the ends of bays, but offered no explanation. In 1896 Professor Duff, of Purdue University, studied these undulations at St. John, N.B., and Indiantown, and later presented a paper before the Royal Society of Canada, in which he also classes them as "seiches," due to some form of oscillation between the two sides of the Bay of Fundy. He does not attempt any explanation for the abnormal movements often observed during fine settled weather. Mr. H. C. Russell, of New South Wales,