

where  $h$  is the mean longitude of the sun. The above two constituents have been called  $MA_2$  and  $Ma_2$  respectively; they perturb  $M_2$ , the principal lunar constituent, once in the year. These constituents, which are conjugates with respect to  $M_2$ , have been chosen so that  $MA_2$  loses and  $Ma_2$  gains on  $M_2$  very approximately 1 degree per day.

Five years' observations of the Liverpool tides, 1918, 1920, 1922, 1924 and 1930, have been analysed for these new constituents and the results indicate that the perturbation shows a definite consistency of phase from year to year. Over the five years examined the average perturbation was 1.25 % of that of  $M_2$ .

The Tidal Institute has had occasion to determine the values of the constituents  $MA_2$  and  $Ma_2$  for various places in the British Waters, and to notice that this perturbation exists generally around the British Isles.

Analyses have revealed the existence of this perturbation in many other places also, such as Saint John, N.B., Punta Delgada, Port Hedland, Johore Baru.

The real causes of these perturbations are not yet very well known; they might, perhaps, be attributed to periodical modifications in the conditions of the various seas or rivers, such as ice conditions at the boundary of the polar regions, or predominating winds in the direction of the channels — at any rate the annual perturbation is undoubtedly produced, to a certain degree, by local meteorological conditions.

Generally speaking, at a number of places the importance of the annual perturbation in the range of the tide has been noted as of sufficient importance for inclusion in future tidal predictions, for instance, when a limit amplitude of 1 % of  $M_2$  is reached; besides, it has been noted that the phase of the perturbation  $MA_2$  or  $Ma_2$  has a consistency which can generally be relied upon; on the other hand, the value of the amplitude may vary from year to year. Thus it is necessary to proceed with caution where the amplitude is concerned and it would appear advisable for this reason to have two or three years' analyses available previous to considering the inclusion of these perturbations in the predictions.

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## THE GREATEST DAILY TIDE

by

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The daily type of tide is not of wide occurrence. A glance at a map of types of tide (see H. A. BAUER'S *Types of Tide* map, *Geogr. Rev.* Vol. 23, 1933, facing p. 266) shows such tides to occur in certain regions on the Gulf of Mexico, in Alaska, in the Philippine Islands, on the coast of China, and in a few other scattered localities. And as a rule the range of the tide at such places is small, a matter of only a few feet at most.

Observations made by Russian and Japanese investigators, which have come to light recently, show that the Okhotsk Sea is to be added to the regions in which daily tides occur. And what gives these tides special interest is that they have large ranges. The largest range occurs in Penzhinskaya Bay, which forms the north-eastern head of the Okhotsk Sea. In the upper part of this bay, at Cape Astronomicheski, the Russian Hydrographic Department secured a month of observations. During this month there were only a few days in which two high and two low waters occurred; the greater part of the time there were but one high and one low water each day. The average range of the tide was 22 feet, the average range of the daily tide was 28 feet, and on one day the range was 37 feet. At this point therefore is found the greatest daily tide in the world, as far as known.

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