

EXPOSÉ CRITIQUE DE LA THÉORIE DES MARÉES (CRITICAL EXPOSITION OF THE THEORY OF TIDES)

by

INGÉNIEUR HYDROGRAPHE GÉNÉRAL E. FICHOT
MEMBRE DE L'INSTITUT ET DU BUREAU DES LONGITUDES.

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Tome XI of the *Annales* of the Bureau of Longitudes terminates by an important contribution from Ingénieur hydrographe général E. FICHOT, Member of the *Institut* of Paris and of the Bureau of Longitudes, the title of which is: *Exposé critique de la théorie des marées* (Critical exposition of the Theory of Tides). Very comprehensive information is given on the present state of the theory of tides considered as a problem of hydrodynamics; the author points out the mathematical difficulties to be met with and emphasizes the questions which are still subject to controversy. M. FICHOT has based his commentary on the lectures formerly delivered by Henri POINCARÉ on the theory of tides, which he completes on several points, and, as he himself states, the principal aim of his work is to serve at the same time as introduction and supplement to those memorable lectures.

In the present work, the tides in the earth's crust being very small and, on the other hand, the influence of the atmospheric tides on the ocean being so extremely slight, the author has confined his attention to an ocean resting upon a solid crust which is not deformable, and subject to the action of a constant atmospheric pressure. Thereafter, he proceeds to show to what extent the results obtained are modified by the deformations of the earth's crust.

Even when these deformations are neglected, however, the aspect of the phenomenon is profoundly modified in many cases, depending upon whether the effect of friction between the liquid particles has been neglected or not.

However much the initial hypothesis may be simplified, the problem of the tides still remains very complicated, and in order to solve it in all of its theoretical generality, one must proceed step by step with the successive study up to the most difficult cases. Further, each of these cases may be applied with more or less approximation, to certain regions of the ocean which possess a sort of individuality of their own, and which thus furnish a key to the various peculiarities revealed by observation.

But no matter how the solution is presented, it is important to fully emphasize the dependence of the tide produced on its relation to the mechanical constitution of the liquid mass under consideration. From the point of view with which we are concerned, this constitution may be defined by the nature of the oscillations to which the mass is susceptible when it is thrown out of its position of equilibrium and, under the assumption that it is free from all external influences. The tides thus engendered will necessarily participate in some measure in the character of the various oscillations, and a case may occur where one of these imposes its own aspect to the exclusion of all of the others. It is precisely this predominance which marks, so far as tides are concerned, the influence of the very general phenomenon of *resonance*, the role of which is of capital importance in all physical theories dealing with undulatory movements.

Thus, a previous knowledge of the conditions under which it is produced, in any mechanical system allows us, by ready comparison between them, to comprehend even the difficult points in the theory of tides.

The first chapter, which is very short, is a brief historical account of the ways, so widely diversified, through which from earliest times a solution of the tidal problem has been sought.

The second chapter is devoted to the study of the small oscillations of a mechanical system the constitutive points of which possess a finite number of degrees of freedom in the assumed hypotheses, such that the results are directly applicable to the seas of the globe.

In chapter III, which forms the most important part of the work, the author has grouped all that concerns the theory of oceanic tides. He particularly stresses the

physical significance of the hypotheses on which the general equations of the problem are based; he then investigates special cases for which the explicit solution has been obtained, in the first place by LAPLACE, for an ocean the depth of which depends wholly on latitude, and afterwards by HOUGH assuming an ocean of constant depth; finally he states the general solution given by Henri POINCARÉ in his treatise on tides (*Leçons de Mécanique Céleste*, 3, *Théorie des Marées*), edited by E. FICHTER, Paris, 1910), based on FREDHOLM'S integration method for resolving the entire problem whatever the law of depth variations may be.

This chapter terminates Part I now published. The following is an outline of the continuation of this work:—

Chapter IV deals with the production and propagation of the tides in a system of narrow channels. Here the theory which readily reveals the influence of depth variations, allows, by extension, the concept of the reinforcement of amplitude which characterises the coastal tides, without resorting to the intervention of resonance.

In Chapter V the author has concentrated his personal contribution to the comprehensive study of the propagation of tides in the more special cases where the width of the channel no longer allows the investigator to confine his analysis to one dimension only; in a system similar to an inland sea, the external tide is propagated according to a very special amphidromic order.

Chapter VI contains a study of river tides and, generally speaking, those tides where all the circumstances combine to complicate the equations when the influence of friction is no longer negligible and where the amplitude of the oscillations is no longer very small compared to depth.

Chapter VII studies the tides of the Earth's crust and their influence on observed oceanic tides.

The aim of the author has been, not so much to write a didactic treatise as to throw light upon the essential difficulties of the problem and to make apparent, by comparative analysis, what ought to be retained of the various solutions so far offered. He specially emphasises the points still subject to controversy, and insists on certain original ideas the explanation of which it would be rather difficult to find elsewhere — often also on personal concepts which more than 20 years of observation and research have suggested to him.

