THE ASSOCIATION OF THE ROYAL SOCIETY WITH PROGRESS IN KNOWLEDGE OF OCEANIC TIDES

It is now well known that the tides of the ocean constitute a gravitational phenomenon in which the moon plays a large part, and that it was Newton's *Principia*, published in 1687, which laid the foundations of all sound theoretical work upon the subject. But before the appearance of the *Principia* and in the very early years of the Society, Wallis, Flamsteed and Halley, as well as Sir R. Moray, S. Colepresse, H. Philips, S. Sturmy and J. Childrey, published papers on tides in the *Philosophical Transactions*.

Wallis, in 1666, based his theoretical considerations on Galileo's ideas, and came very near to discovering some of the features of gravitation. A number of his points were taken up by Childrey, in 1670, and compared with the results of the observations of seamen. Halley's paper of 1684 was also concerned with general principles, and quoted observations on the diurnal tides of Tonkin taken by F. Davenport. Philips studied the tides observed at London, and in the years 1682-84 Flamsteed, the first Astronomer-Royal, gave tide-tables for London Bridge, together with differences between the times of high water at London Bridge and those of high water at other places. Moray, in 1666, discussed methods of observing tides, while in 1668 Colepresse and Sturmy dealt with observations at Plymouth and Bristol respectively.

In the *Principia* Newton gave an analysis of the tide-producing forces on the principles of gravitation, and then proceeded to account for many of the general features of the observed tides. These included the semidiurnal nature of the principal tides, the diurnal inequality, and the phenomena of spring tides and neap tides. In the *Philosophical Transactions* for 1697 Halley directed attention to the excellence of this part of Newton's work.

During the eighteenth century, little of the outstanding work on
tides was immediately associated with the Royal Society, a more prominent part being taken by the Académie des Sciences of Paris. However, one of the four winners of the prize awarded in 1740 by that Academy was a distinguished Fellow of the Society, viz. MacLaurin. The prize was offered for work on tides, and MacLaurin’s essay contained his theory of rotating spheroids of liquid.

But throughout the nineteenth century, Fellows of the Society maintained a fairly continuous stream of important contributions to the subject, and many of these were published in the *Philosophical Transactions* and *Proceedings* of the Society.

Thomas Young’s work, 1813-24, dealt with dynamical principles. Though not carrying out mathematical developments of the type of those made by Laplace, he brought forward a number of considerations which were then new and which foreshadowed the lines of much later progress. In the *Philosophical Transactions* for 1831 H. R. Palmer described a self-registering gauge which he had designed and used in the Thames, and J. A. Lloyd also described observations on the tides of the Thames. Sir J. W. Lubbock’s contributions (*Philosophical Transactions*, 1831-37) were of an eminently practical nature, and formed the basis of subsequent Admiralty practice. He analysed extensive series of observations from a number of ports, correlating tidal features with astronomical elements, and providing a basis for the making of tide-tables. The work of Whewell (*Philosophical Transactions*, 1833-50) partly followed the same lines as that of Lubbock and partly dealt with the distribution of tides over the oceans and seas. He organized series of simultaneous observations in different countries. In the *Philosophical Transactions* for 1838 T. G. Bunt described a tide-gauge which he had erected on the Avon, and in those for 1866 he discussed the observations taken with this gauge. In the *Philosophical Transactions* for 1843 Sir E. Belcher published observations from Tahiti.

In 1845 Sir G. B. Airy published his *Tides and Waves*, one of the great treatises on all aspects of the subject, and in four papers in the *Philosophical Transactions* (1842-78) he dealt with observations from particular stations. Airy’s methods were followed by the Rev. S. Haughton who in the *Philosophical Transactions* (1863-78) dealt principally with tides round the coast of Ireland and in the Arctic. In the
Philosophical Transactions for 1848 and 1851 Captain F. W. Beechey gave the results of his observations on the tidal currents in British waters, and for many years this work remained the best and most complete of its kind. In the Philosophical Transactions for 1868 W. Parkes gave the results of his analysis of tidal observations from Bombay and Karachi.

A new departure of the first importance was made in 1868 by Sir W. Thomson (Lord Kelvin) when he inaugurated the harmonic methods of tidal analysis and prediction. Thomson's work in this connexion was continued by Sir G. H. Darwin who wrote many papers on methods of analysis. At first this work was closely associated with the British Association, but the later papers of Darwin were published by the Royal Society. In 1885 and 1889 the first two collections of harmonic tidal constants were published in the Proceedings by Darwin and A. W. Baird.

Thomson and Darwin also continued Laplace's work on the dynamical theory of the tides in geometrically simple basins. The solution of the general equations first formulated by Laplace constitutes a great problem in mathematics, of which all the really difficult cases were still unsolved at the end of the nineteenth century. Since the time of Laplace this branch of the subject has remained peculiarly British, and practically all the notable progress has been made by Fellows of the Society. After deriving his differential equations, Laplace had considered an ocean covering the whole earth, but the validity of his solution had been attacked by Airy in England and by Ferrel in America. Thomson began, in 1875, by giving a complete vindication of Laplace's solution, and then considered certain cases of small bodies of water. H. Lamb in his Hydrodynamics (1895) gave an excellent account of tidal dynamics, and made a number of original contributions, one of which concerned the limiting forms of long period tides. Still considering an ocean covering the whole earth, S. S. Hough in the Philosophical Transactions for 1897 gave a solution which was more general than Laplace's, and included a determination of the free tidal oscillations of such an ocean.

At the beginning of the twentieth century Lord Rayleigh attacked those mathematical problems which at that time could be considered
'classical.' His contributions consisted in approximate solutions for oscillations which were either slow or quick compared with the effective rotation of the earth. Since 1919 there have been many contributions to both the practical and the theoretical aspects of tidal research, by Fellows of the Society who are still living. The most notable achievements concern the analysis of observations, the distribution of tides over seas, the estimation of the magnitude of the dissipation of tidal energy, and the tidal dynamics of geometrically simple basins. The most important of these simple basins is that of an ocean bounded by meridians, and complete determinations of the tides over such an ocean have now been made.

It should be mentioned that quite recently, both in France and in Norway, it has been maintained that the approximations on which Laplace's differential equations are founded, are not valid. This question has not yet been settled to the satisfaction of all workers on the subject.

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