A STUDY OF THE TIDE TABLES PUBLISHED BY THE DIFFERENT NATIONS

by

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A study of the Tide Tables published and sold by the different nations, gives an interesting insight into the progress made during the past century in the tidal predictions and the successive improvements in the methods which permit the navigator to-day to determine the height of the tide with the rapidity and precision demanded by modern navigation.

It is held that the necessity for a knowledge of the tides has been well recognized since the earliest historical times; and, in fact, various books concerning tides contain chapters relating to their origin, the evolution and development of the theory of tides, and many interesting details for which the reader is referred to the books in question. For example, we might cite the *Historical Sketch* by Sir George DARWIN in chapter IV of his work entitled *The Tides and Kindred Phenomena of the Solar System* also the *Historical Account* in the *Manual of Tides* by ROLLIN A. HARRIS ; paragraphs 5 and 6 in the introduction of the work of E. FICHOT on *Les Marées et leur utilisation industrielle,* the 2nd chapter *Development of Tidal Knowledge* by H. A. MARNER in his work entitled *The Tide* and finally chapter 1, — *Historical* of the Admiralty Tide Tables (standard edition) part 1, 1929, compiled by H. D. WARBURG.

From this historical research it appears that within the knowledge of European peoples, at least. — the first tide table of which we have definite information is the Table published about the year 1220 by John WALLINGFORD, ABBOT of ST ALBANS, giving the hours of flood at London Bridge for the lunar month as functions of the moon's age.

It appears from the publication of FLAMSTEAD that about 1683, annual tables were published regularly giving the time of high water at London Bridge. Since 1770, the Rev. George HOLDEN, making use of observations made day and night, over a period of 20 years, by the harbour master HUTCHINSON, started the publication of the Table of Tides for Liverpool. The publication has continued uninterruptedly since that time.

At the beginning of the last century, although, from a mathematical standpoint, the theory of tides, since the publication of Newton's *Principles,* (1687) had been greatly developed, above all, byLAPLACE (1711-1774), it is a curious fact that the actual preparation of tables (for Liverpool, London and several other ports) remained entirely in the hands of calculators using "undivulged methods" which methods in some instances at least, were handed down from father to son for several generations, as a family possession, and the publication of new tables accompanied by a statement as to the mode of calculation, was resented as an infringement of the rights of property (*).

It was about this time that the English mathematician, Sir John LUBBOCK and later Dr WHEWELL, using the empirical method outlined by BERNOUILLI in 1740, which he employed in reducing the tidal observations made at Brest and Rochefort between 1711 and 1715, undertook the arduous labour of reducing the systematic observations on tides covering a period of 19 years at the London Docks in order to start the compilation of reliable tide tables. In this very considerable work, which necessitated the classification and the reduction of 13,391 observations made at Liverpool (1774) and 24,592 observations made at the London Docks (1809-1828), they were assisted by Mr. DESSION, calculator of the Nautical Almanach Office.

As a basis they chose the period of the cycle of the lunar orbit in order to take into account all of the changes due to variation of the time of transit of the declination and of the parallax of the moon. They started by classifying all the times and heights of high water with respect to the time of the moon's transit of the meridian immediately preceding the high water. Then they established the average lag and the average height of the tide. For each hour of passage the lags were classified according to the declination, and the average taken for every 2° of declination. Subtracting these from the average lag, the table of correction due to declination is obtained ; in the same manner tables for correction due to parallax were obtained.

In this manner Tables of Correction were obtained as early as 1831 and were perfected further for taking into account the age of the tide. These were reduced to formulae by WHEWELL. These tables permit a fairly accurate prediction of the time of high water, based on the determination of the "lunitidal intervals" and the "Establishment of the Port" (H. W. F. and C.)

The first Tide Tables published by the Hydrographic Department appeared in 1833. The above principles, known by the name of the "Lubbock Method"(**) or the method of averages, were improved to take into consideration the various inequalities and have been in common use for a long period. They have been in partial use until very recently in the computation of the British Tide Tables — principally for the ports of the British Isles. Under their modified and abridged form they are known under the name of the "Equation Method" (***) and are briefly described in the Preface of the "Admiralty Tide Tables". This method derives its name from the fact that the corrections are determined by means of a series of equations.

Also, about 1830, the French Hydrographic Engineer CHAZALLON, going back to the method of LAPLACE and the tidal observations made at Brest from 1800 to 1806, deduced formulae for the prediction of tides including an accurate value of the ratio of the average influences exerted by the moon and the sun. These formulae, which introduced a monthly tide and an annual tide,

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(*) WHEWELL — Philosophy of Inductive Science.

(**) LUBBOCK — Philosophical Transactions 1836.

(***) See "*Geographical Journal*" May 1919.

as well as the concept of the so-called "tidal coefficients" and the "unit range" for correcting the average level, are still in use to-day in calculating the tides of Brest.

In 1839, CHAZALLON published the first annual tide tables for the coasts of France.

Since that time, tidal observations everywhere have greatly increased. The first recording tide gauge was working in England in 1930 and since then these have been provided in the principal ports. The calculation of the Tide Tables necessitated long and arduous labour and it was found more advantageous to resort to grouping the ports according to tidal regions and to prepare a "Table of Tidal Differences" which permits the deduction of the tide for any port from the data given for another standard port, using the time or height differences, — varying or not with the phase of the moon (Method of variable differences).

In India, although the first observations made by the Hydrographic Department at Kidderpore Dock date from 1806, systematic observations were not undertaken until after the work of WHEWELL in 1833. The first recording tide gauge was installed at Kurachee in 1855. In 1866, the attention of the Great Trigonometrical Survey of India was drawn to the appreciable fluctuations in the level of the water in the Gulf of Cutch which necessitated a very accurate study of the tidal movements in that region. It was decided to apply the new method of tidal analysis based on the method of LAPLACE, which had been described by Sir William THOMSON in 1863 and was known as the Harmonic Analysis. For this purpose, Lieut. A. W. BAIRD was sent on a special mission to Europe to study the details of this novel method of recording and analysing tides. From 1877 to 1886, he established all of the permanent recording stations for India and the Bureau of Calculations at Poona (*)

The tide tables for the Indian ports appeared subsequent to 1880 and were calculated by the new machine (1879) called The Tide Predictor, conceived by THOMSON, and built and perfected by Mr. Edward ROBERTS at the India Stores Department, London. The latter also carried out all the tidal calculations during this period for the British Association in the Nautical Almanach Office.

Prof. G. H. DARWIN assisted materially in facilitating the more complete evaluation of the various harmonic constants by this theoretical development of the tide-generating potential in periodic terms (1883). This method was especially applicable to the ports on the Indian coast and, as a result, the tidal predictions could be made regularly since that time with the aid of the machine. However, in certain riverain ports the number of components given by the machine was insufficient to include all the constituents of the compound tides, and it was found necessary to apply corrections to the results given by the machine in accordance with the method of corrections for inequalities developed by LUBBOCK and employed by the Admiralty for British ports (Corrected Harmonic Method).

(*) Major A. W. BAIRD — "*Manual of Tidal Observations*" — 1886.

The machine employed by ROBERTS furnished the predictions for 1880 for Bombay and Kurachee, and, in 1881 was employed for 8 other Indian ports. In 1891 it was modified in construction to include 24 component tides. Although belonging to the Indian Government, it was possible, by writing to London and paying the charges, to obtain other predictions from the machine which remained under the charge of Mr. ROBERTS until 1903. At that time the predictions covered 37 ports in India and in the British posessions in the Orient. The annual tables cost 4 rupees only.

In 1908, when Messrs. Edward ROBERTS and Son had the new machine constructed for 33 components, known as the Roberts Universal Tide Predictor (which was located in the firm's house at Broadstairs), the Indian Tide Predictor was shipped to Dehra Dun in India.

In the United States, the Coast and Geodetic Survey has published tide tables since 1853, In 1882, Prof. FERRAL had built a special machine for maxima and minima which was in use from 1885 to 1911, in the computation of the annual tables issued by the Coast and Geodetic Survey. The harmonic method only was employed for these predictions. In 1897, it was described by Dr. ROLLIN A. HARRIS in his Manual of the Tides. Since 1912, the Harris-Fischer Tide Predicting Machine N° 2 has been used for all predictions ; it is capable of totalizing 37 components.

In France, the Ingénieur Hydrographe HATT in 1893 invited attention to the growing interest in the employment of the harmonic method for the predictions for colonial ports and, in the *Annales Hydrographiques*, he published several extracts from the works of DARWIN. Later, in 1905 the Ingénieur Hydrographe ROLLET DE L'ISLE published his Manual on the Observation and Prediction of Tides to further the same purpose. The harmonic method of predicting tides has been employed since 1898 for making hourly predictions for the French ports and since 1901, after the acquisition of an English Tidal Predictor totalizing 16 tides, the method was extended to the Atlantic ports and those of Indo-China.

In the Dutch Indies, the tidal observations, their analysis and prediction from harmonic constants, have been in systematic use since 1896, following the method of J. P. VAN DER STOK ; — although for certain ports on the coast of the Netherlands the method employed to-day is a recent empirical method developed by H. E. BRUIJN — a modification of the Lubbock method.

In Japan, since 1883, the hydrographic missions have observed the tides for 15 day periods at 500 stations and, applying the method of DARWIN, they have deduced from this data the 6 fundamental harmonic components. Since 1909, 17 recording tide gauges have been installed, and it has been possible to compute 28 harmonic components for 40 stations.

After 1900, the Hydrographic Department of Tokio published Tide Tables in their *"Nautical Ephemeris"*. Subsequent to 1921, the Tide Tables have been published as a separate volume.

Recently, the prediction of the tides and the preparation of the annuals by means of machines have become wide-spread. In 1910 Brazil acquired a Kelvin machine constructed in England. Japan purchased a Kelvin machine in 1914 and two others in 1924. In 1915 Germany constructed a machine which has been in use by the Naval Observatory in Hamburg since 1919; Argentine has employed a Kelvin machine which has served in the preparation of their Annual since 1918. Portugal purchased a machine in 1924. Finally, the Tidal Institute of Liverpool, founded in 1919, with Dr DOODSON improved the analytical treatment of the over and compound tides, the influence of which become especially marked when the tidal wave is propagated over shallow or estuary water. In this connection, the Institute contributed much towards improving the British machines with which it carries out comparative tests and has modified the mechanical details of construction of these machines. For the rest, the detailed description and the use of these machines are given in Special Publication N° 13 of the International Hydrographic Bureau, entitled *Tide Predicting Machines* (1926).

Having examined the means available at the present day which are employed in making tidal predictions, let us turn to a consideration of the publications of the different countries issued for the purpose of imforming the navigator of the vertical movement of the tide.

GREAT BRITAIN.

The first tide tables published by the Hydrographic Department of the British Admiralty date from the year 1833. In a small pamphlet restricted to a few pages, predictions were given for the time of high water in 4 ports of the British Isles.

In 1836 the heights of high water were given as well as the times, the predictions covering 9 English ports and Brest.

In 1870 the tables contained predictions for high water for 23 ports in the British Isles and for Brest.

In computing the time of low water from the data given in the tables use was made of the "approximate rise and fall tables" — the height of the low water being deduced from the above using the "half mean spring range". In 1897, predictions were added for the time and the height of low water in the most important ports.

The tide tables also furnished a table of differences to be applied to the times and heights given for certain ports in the first part, from which it was possible to deduce the times and heights of the high water in a number of other ports on the coast of England and Europe.

At the end of the volume, tables gave the vulgar establishment for ports of the whole world (H. W .F. and C.) and the height of mean high water springs and mean high water neaps above the datum of chart soundings.

In 1910, the tide tables also furnished predictions for the German ports. In all, predictions were published for 36 ports, of which 26 were in the British Isles.

The predictions of tidal currents, which up to that time had been included in the tide tables, were revised, augmented and published as a separate volume.

In 1911 there were added the predictions for 8 colonial ports giving a total of 40 detailed predictions.

1915 — The arrangement of the tables was changed so as to enable the rise and fall of the tide to be more easily followed, 58 ports predicted at 18 of which high waters only were predicted.

1918 — An "Abridged edition" of the tables, containing the tidal information for ports in Europe was published in addition to the Standard edition.

1920 — Low waters were predicted in addition to high waters, at all Standard ports; 62 ports predicted of which 28 in the British Isles.

Times were given on the 24 hour system from 00 (midnight) to 23 (11 p. m.) and heights in feet and tenths.

The tidal differences, formerly in Part I, were transferred to Part II.

Part II was revised and tidal differences, low water lunitidal intervals and heights of mean level, where known, added to the information formerly given.

In 1924, the edition of the tide tables gave predictions for 82 ports.

In 1927, Part II was revised — publication contemplated every 5 years — containing the list of harmonic constants for 1250 ports, together with tables to permit their direct employment in making tidal predictions. This method is particularly recommended to navigators in preference to the employment of "differences". The tables give the differences for more than 6250 ports.

In 1929 the Tide Tables gave complete predictions for 29 ports in the British Isles and for 90 ports overseas; in all, 119 ports.

The edition comprises 380 pages for Part I; price 4s. net.

The edition comprises 510 pages for Part II; price 3s. net,

The Tide Tables also give the astronomical data on the phase, the declination and the transit of the moon at the Greenwich meridian; instructions for calculating the tide from the establishment and differences; supplementary tables for computing the height of tide at times between high and low water, a table of conversion from metres to feet, the list of tide levels and datums, special tables for Portsmouth and Rosyth, and table showing the meteorological influences on the tides at Wilhelmshaven and Rio de la Plata.

The tide tables of the British Admiralty give, in the form of tables, the sources, the method of prediction and the reference authorities for the 119 ports for which detailed predictions are published.

In 1922, of 73 predictions, 27 were made by the Hydrographic Department (15 by the method of Equations, 6 by the Lubbock method and 6 by variable differences); 28 by Messrs. ROBERTS and Son; 10 by the National Physical Laboratory at Teddington. 5 were borrowed from the Coast and Geodetic Survey of the United States of America; 2 from the Department van Waterstaat of the Netherlands and 1 from the French Hydrographic Service.

In 1925, of the 96 predictions, 26 were made by the Hydrographic Department (20 by the Equation method, 2 by the Lubbock method and 4 by the method of variable differences); 26 by Messrs ROBERTS and Son; 4 by the National Physical Laboratory of Teddington; 1 by the Tidal Institute of Liverpool. 14 were taken from the Office of Tidal Operations of the Survey of India; 1 from the Tidal and Current Survey of the Dominion of Canada; 9 from the U. S. Coast and Geodetic Survey; 5 from the Hydrographic Service at Paris; 3 from the Gezeitentafeln (Germany); 3 from the

Hydrographic Department of Tokyo and 2 from the Department van Waterstaat.

In 1929 of the 119 predictions, 26 were made by the Hydrographic Department (of which 6 were made by the method of Variable Differences); 39 by the Tidal Institute; 8 by Messrs Edward ROBERTS and Son; 14 by the Survey of India; 1 by the Tidal Survey of Canada; 17 were taken from the U. S. Coast and Geodetic Survey; 5 from the Hydrographic Service of Paris; 3 from the Gezeitentafeln of Germany; 3 from the Japanese Hydrographic Service and 2 from the Department van Waterstaat of the Netherlands.

UNITED STATES OF AMERICA.

The first tide tables, published in 1853 by the Coast and Geodetic Survey, were in the form of a supplement to the Annual Report of the Director of the Service and consisted simply of more or less elaborated means for enabling the mariner to make his own prediction of tides as occasion arose.

The first tables to give the predicted tides for each day were those for the year 1867. They gave the times and heights of high waters only and were published in two separate parts; one for the Atlantic and one for the Pacific coast of the United States. Together they contained daily predictions for 19 stations and tidal differences for 124 stations. Up to and including the Tide Tables for the year 1884, all the predicted tides were computed by means of auxiliary tables and curves constructed from the results of tidal observations at the different ports.

From 1885 to 1911 inclusive, the predictions were generally made by means of the Ferrel tide-predicting machine. From 1912 to the present time, they have been made by the Harris-Fisher machine.

A few years later, predictions for the low waters were also included.

In 1896 the tables were extended to include the entire maritime world, with full predictions for all tides at 70 ports and various constants including tidal differences for about 3000 stations. By the application of the tidal differences and ratios to the predictions for the 70 reference stations the mariner is enabled to obtain the approximate times and heights of the tide for other places, other constants were given enabling to compute directly with some approximation times and height for other ports. The difference between two consecutive high waters being function of the declination of the moon, reaches a maximum when the moon is in the tropics. The American tables gave this diurnal tropical inequality, which may be interpolated between *o* and the maximum. The sign of the declination of the moon determines the sign of the diurnal correction for the heights and the times of high water relative to the lower transit of the moon and to the upper transit, which are indicated by the indices *a* and *b*:

a) for upper transit for N dec. and lower transit for S dec.

b) for lower transit for N dec. and upper transit for S dec.

Since 1912 the predictions have been made by means of machine N° 2 of the Coast and Geodetic Survey.

In 1917 the arrangement of the tables was modified.

In 1922, the high waters and the low waters were grouped together instead of giving them in the consecutive order in which they are produced as before.

In 1929, the American tables contained complete predictions for 88 ports, of which 37 were in the United States and dependencies, and tidal differences for more than 3600 other ports.

In accordance with a cooperative arrangement for the exchange of tidal predictions, the British Admiralty furnished predictions for 17 ports. Predictions were furnished by the Canadian Hydrographic Service for 4 ports and by the Deutsche Seewarte for 2 ports.

The complete edition of the Tide Tables, United States and Foreign Ports, contains 470 pages. Price 75 cents.

These comprise a table for computing the height of the tide for any hour desired; a table for the time of sunrise and sunset in different latitudes; a table for moonrise and moonset at 13 places and the astronomical data on the phases of the moon, the equinoxes and the solstices.

The Coast Survey also publishes special pamphlets, (separate reprints) aside from the tables covering the ports of the Atlantic and the Pacific and for New-York.

Aside from the tables, the Coast and Geodetic Survey also publishes separate annual tables giving the tides and currents for the Atlantic Coast, the Pacific Coast and the Philippine Islands.

Finally, it should be mentioned that in 1924, the U. S. Coast and Geodetic Survey issued Special Publication N° 98 which is sold for the price of one dollar. This publication, entitled a *Manuel of the Harmonic Analysis and Prediction of Tides* includes a table of the principal tidal harmonic constants for 840 stations throughout the world; together with complete and detailed explanations as to the method of using same. The publication is edited by Paul SCHUREMAN.

FRANCE.

The *Annuaire des Marées des Côtes de France* (*Annual for the tides for the coast of France*) appeared for the first time in 1839. Interrupted in 1841, it was issued again in 1842 and has been issued regularly since that time by the Service Hydrographique.

The times and the heights of the high and low water for Brest for every day in the year are calculated by the formulae of LAPLACE, the constants of which were determined by CHAZALLON. The data for the other ports are determined by means of the tables of tidal differences, established by the large number of observations obtained for the most part by means of recording tide gauges. The principle is as follows:

When high water is produced in one of the ports at a certain time, high water will occur at another port on the same coast at a time which is always the same when the first time remains the same; the same agreement is observed in the case of the times of low water; as well as for the heights of the high and low water.

However, this agreement holds only when the fundamental elements of the tide are practically the same in the two ports. This condition therefore limits the regions in which this method is applicable in making predictions based on this phenomenon.

It is applicable in particular to the entire western and northern coasts of France. For example, knowing the time of high water at Brest we may obtain the times of high water in all the ports along the coast by simple addition or subtraction.

However, the difference between the corresponding times of high water at Brest and the port in question, may vary considerably depending on whether the tides are spring tides or neap tides; and consequently, in order to obtain accurate results it would be necessary to give these values for every hour at Brest. But the table may be reduced to two figures by grouping the ports into regions in which these differences have approximately the same value for the same time as Brest. The ports in each region are then referred to one of the ports for which complete predictions are given in the table, either located in that region or adjacent to it. The differences between the times for this last port, which is called the standard port (port of reference) and for the ports in the region referred to it are then practically constant, and it suffices simply to give the values for the spring and the neap tides.

Formerly the Annual simply gave the complete predictions for the times and the heights of low water at Brest and Havre. The data of the low waters of the other ports were referred to the times of these two ports (old tables *B* and *C*). But the above-mentioned considerations naturally also hold for the predictions of the time of low water and for the heights of the high and low water. On this principle therefore, there has been developed table *A* published since 1912, containing the list of ports on the north and west coasts of France, grouped into regions having the same port of reference. Complete predictions for this standard port are given in the tables. Therefore tables *B* and *C* have been omitted from the Annual.

Having been gradually extended, the French Tide Tables now give complete predictions — times of high and low water for 17 French ports, and complete differences for 111 ports on the northern and western coasts of France.

The tables also give a lunar and solar calendar, the tidal coefficients in hundredths, the list of bench marks and datums for the tide table and for charts and the levels of the sills of the dry docks of the French ports.

Since 1898, the *Annual* gives the hourly heights of the tide at Brest and at Saint-Malo, obtained by means of the machine.

It will be noted, however, that some slight discrepancies exist between these figures and the high and low waters in these two ports. These are due largely to the impossibility of a harmonic analysis, and of taking into consideration the modifications of the astronomical tides, which are due to the relative shoalness of the water in the vicinity of the coast.

This is the reason why the method is not suited for the prediction of the hourly heights at Havre. However, this may by calculated in a different manner, by means of abacus, the explanation of which was given in the

Annales Hydrographiques of 1899. This has been in use since 1905 in making the hourly predictions for this port which are published in the tide tables.

This is followed by a table giving the constants for a large number of ports in the world, which are to be applied to the times of high water at Brest to obtain the time of high water of the port in question. These constants have been calculated from the formula, taking into account the difference between the establishment of Brest and the other ports.

It is necessary to remark, however, that this formula, and therefore the results obtained by the use of same, are only approximate even when the tide in the port under consideration is solely semi-diurnal; since it is assumed that the age of the tide and the ratio of moon's and sun's average influences are the same in the port under consideration as at Brest. This, however, is far from the truth in most of these cases. This method is rendered even more inaccurate when the semi-diurnal wave is further complicated by the superposition of a diurnal tide which is not negligible, as frequently happens elsewhere in the Atlantic. A note at the head of the page indicates further when this condition holds and when it does not.

In addition the Annual gives the predictions for high water in 4 British ports and the differences which permit the times and heights of high water to be determined in a number of other British ports.

The Annual is concluded with tables of conversion; tables for the tidal signals for the height of water in use on the coast of France, and the French system of Buoyage.

Since 1928 the times are expressed from 0 to 24 hours, standard time (Greenwich mean time).

Heights are given in decimetres.

The Annual of Tides for the coasts of France comprises 444 pages; pocket size edition; price 2 francs.

The Service Hydrographique also published Annual Tide Tables for the French Colonies, in three volumes: China Sea, Indian Ocean and Atlantic.

The tide tables for the French Colonies on the China Sae were published first in 1873, under the title; "*Annuaire des Marées de la Cochinchine et du Tonkin*". These were edited by the Ingénieur Hydrographe HÉRAUD, who superintended the calculations and supervised the publication until 1897.

Until 1898, the predictions were limited to the three ports of Cangiou; Saïgon and Doson and were calculated with the aid of special formulae derived by HÉRAUD. (*Annales Hydrographiques*, 1872).

In 1899, the tides at Quinhone were included in the tables for the first time; these were obtained by the method of harmonic analysis with the aid of the Kelvin machine which mechanically traces the curves of the tides.

In 1901, this method of tidal prediction was also adopted for Nantschéou, based on observations made by Enseigne de Vaisseau FROCHOT.

In 1904, this method of prediction was extended to all the ports included in the tables; the tides at Saïgon only being deduced from the concordance with those of Cape St Jacques. Subsequent to 1929, the tides at Cape St Jacques are given in the tables in place of those at Cangiou, in the prediction of which the annual and semi-annual tides are taken into consideration.

In the tables for 1929 there are included, among other things, general information pertaining to the tides of Indo-China, by Ingénieur Hydrographe COURTIER, and detailed predictions for high and low water for eight ports in Indo-China. Differences are given for 44 stations.

Aside from the tides in the French ports of Indo-China, the tables also give the tides at Singapore, Hongkong, Shangaï and Tientsin. The tidal data for the first three ports are communicated directly by the British Admiralty in exchange for information on the tides at Cape St Jacques, Doson, Pakhoi. Those of Tientsin are determined from the harmonic constants published in the American tide tables.

The tables for the French Colonies on the Indian Ocean also give detailed predictions for high and low water for 9 ports, with the differences for about 20 ports. They are based on a short series of observations only and analyzed by the harmonic method.

The tables for the French Colonies on the Atlantic are also based on a short series of observations made to determine the harmonic constants. The predictions for Casablanca were deduced from somewhat longer observations extending over one year, obtained from the recording tide gauge in use by the Service of Public Works of Morocco. These tables give detailed predictions for 8 stations and some differences.

Each small volume, pocket size, contains from 120 to 160 pages and costs 1 franc.

The French predictions extend therefore to 42 ports for which detailed predictions are given and about 180 differences.

INDIA.

The *Tide Tables for the Indian Ports* have been published annually since 1880. These tables were calculated by Mr. Edward ROBERTS for the Government of India, according to the Corrected Harmonic Method, which is explained in detail in the "Professional Volume XVI", published in 1901 by the Great Trigonometrical Survey of India, (by Mr. J. ECCLES).

After 1910, the National Physical Laboratory of Teddington (England) also took part in the preparation of the Tables for the Ports of India (these tables give complete predictions for 37 ports) until such time as the work was taken over by the Office of the Tidal Computation of the Survey of India at Dehra Dun (1923).

In this connection it is necessary to cite the very comprehensive publication recently issued by the Survey of India (1926) which gives the complete theory as applied in practice to the machine of the Survey for making the harmonic analysis. It is entitled *The Tides* by Major C. M. THOMPSON (1926)

GERMANY.

In Germany the Deutsche Seewarte publishes the *Gezeitentafeln*, annually, which are very complete. Two editions are issued, one complete edition and one restricted to European ports.

We have no information regarding the history of this publication, but in 1928 the complete edition comprised 300 pages and sold for 15.75 M., giving complete predictions for high and low water for 10 German ports, 18 European ports and 22 ports outside of Europe, in all complete predictions for 50 ports. These tables are prefaced by a lunar and solar calendar, supplementary tables for the calculation of the heights of tide at intermediate hours and a table giving the standard time employed in the different countries.

For every European port for which complete predictions are given, the German tables show the movement of the tide in the form of a graph for the different phases of the moon, an invaluable aid in interpolating to compute the exact level.

Following the predictions for each principal port, the tables give the differences for the other stations in the same region. Complete differences are given for about 1800 ports.

A series of charts gives the set and drift of the tidal currents at 360 stations on the North Sea (indicated on the chart); the hourly changes are shown.

The table is concluded by a list of establishments of ports and differences which are given for about 2100 stations.

The complete predictions for 3 Dutch ports (Hook of Holland, Ijmuiden and Vlissingen) are furnished by the Engineer in Chief, Director of the Ryks Waterstaat of 's Gravenhage; those for 3 English ports by the British Admiralty; those for 2 Japanese ports by the Hydrographic Department of the Japanese Navy (Nagasaki and Yokohama) and for 6 ports of North America by the U. S. Coast and Geodetic Survey at Washington.

The other predictions are calculated by Herr H. MEIER under the direction of Dr. RAUSCHELBACH, according to the principles explained in the *Annalen der Hydrographie* 1921 entitled "Uber die Vorausberechnung der Gezeiten mittels der deutschen Gezeitenrechnungmaschine".

The predictions for Wilhelmshaven are made by empirical methods. The predictions for the other German ports are obtained from the differences.

The predictions for Havre, Cherbourg and Brest are obtained from the harmonic constants; those for Calais and Cordouan from reference to Brest. The predictions for Dover, Immingham and Liverpool are calculated from the harmonic constants. The predictions for Leith and Greenock are furnished by the Hydrographic Department of London, calculated by the method of Equations (H. D. Warburg — The Admiralty Tide Tables and North Sea Tidal Predictions — see *Geographical Journal,* Vol. LIII, N° 5) This information is given in exchange for information on the tides at Heligoland, Cuxhaven and Wilhelmshaven.

The predictions for Portsmouth and Harwich are obtained by an empirical method; those of Devonport by concordance with Brest and those of North Shields by concordance with Leith. Those of Queenstown are obtained from the predictions of the Hydrographic Department based on the Equation Method.

The predictions for Capetown are calculated by the harmonic method as well as those for Aden, Bombay Dublat, Rangoon, Singapore, Hongkong and Woosung. The data for Nagasaki are obtained from concordance with Sasebo and Yokohama by comparison with Yokosaka; the data for the two reference ports being calculated by the harmonic method by the Hydrographic Department of Tokio.

The predictions for Sydney (Australia) are calculated by the harmonic method, as well as those for Balboa, Valparaiso, Buenos-Ayres, Rio de Janeiro and Galveston. The U. S. Coast and Geodetic Survey furnished the harmonic constants of San Francisco, Charleston, Old Point Comfort, Philadelphia, Sandy Hook and Boston in exchange for predictions for Cuxhaven, Hamburg, Bremerhaven, Bremen, Wilhelmshaven and Emden.

The times are given from 00 to 23 h. 59 m. zone time. The heights are given in metres.

JAPAN.

Systematic tidal observations were commenced in Japan in 1872 in the bay of Suragawa. The first tables for tides were published in the Nautical Ephemeris for 1900 (Chöseki-Hyö). In 1921 these were given in a separate volume giving predictions for 26 ports in Japan and the Far East. The edition for 1925 contains complete predictions for Yokosuka, Shimonosaki, Sasebo and Zinsen, obtained from a Kelvin Tide Predictor with 15 constants. Those for Shanghaï, Hongkong and Singapore are furnished by the British Admiralty. The predictions for the 19 other ports were obtained by a more expeditious method.

In 1928 complete predictions were given for 32 principal ports. The predictions for Hongkong and Singapore were obtained from the British Admiralty, and those for the 30 other ports were made by the Kelvin machine with 15 constants.

For 1929, the tables are published in two parts. The first part gives the complete predictions for 26 ports in Japan and the Far East ; Part II gives the predictions for the ports in the Pacific and the Indian Ocean.

The tables also comprise the following information for each region covered by the table :— *M. H. W. I.* Spring Rise, Neap Rise, Mean Sea level above the datum ; Standard port of reference, Tidal differences.

In those regions where the diurnal inequalities are of such importance that they give rise to one single high water or one single low water during the day, the following constants are given in parenthesis relative to the tropic tides.

M. H. W. I. (*M. H. H. W. I.*) }
M. L. W. I. (*M. L. L. W. I.*) } (additive to the upper (or lower) transit of the moon when the declination is *N* (or S).

Mean height of *H. W.* (*H. H. W.*)
Mean height of *L. W.* (*L. L. W.*)

These factors are given for about 1450 ports.

These tables also give the times of turn of the tidal currents and their maximum set at four stations on the Inland Sea.

Tables are also given for the conversion of feet into metres ; a table for the calculation of the height of water at any time between high and low water, small cotidal charts for the vicinity of Japan, a diagram for the currents in the Inland Sea and in the estuaries of Yantsekiang, and general information regarding tidal phenomena in the Japanese waters.

The times are expressed in hours from 0 to 12.

The heights are given in metres.

The edition of 1928 comprises 331 pages, and is sold for 1 yen 60.

The two volumes for 1929 comprise 465 pages.

The work entitled "Tide and Currents in Japan and adjacent waters 1914" (Nippon-Kinkai-no-Chöseki) by the Hydrographic Engineer S. OGURA, gives a list of the harmonic tidal constants for 450 stations on the coast of Japan.

The Japanese tide tables are the only tables which show in small sketches the location of the reference ports and show the tidal regime of the localities referred to standard ports.

U. S. S. R.

The Administration of the Hydrographic Office of Leningrad publishes annual tide tables restricted to the coast of Russia (EΞEGOΔHNK ΠPNΠNBOB).

Since 1909 for the Murman coast.

Since 1914 for the White Sea.

Since 1915 for the White Sea and the Arctic Ocean.

Since 1915 for the Pacific Ocean. This latter was not issued for three years — 1920 to 1922.

The edition of 1928 appears in 2 volumes of 101 + 96 pages, price 2 roubles each.

The dates are given in accordance with the new style calendar (gregorian calendar) the times are given from 0 to 24 hours, zone time, heights are given in feet and tenths above the datum of the charts.

The tables give complete predictions for high and low water as well as the hourly heights for 5 ports, Ekaterinskaya and Kem on one hand, and for the Gul of Castries, the island of Langr and the bay of Nagaeva on the other hand ; differences are given for about 200 other stations, as well as the harmonic constants for 65 stations and the current predictions for 32 stations.

NETHERLANDS.

The Department of Waterstaat publishes annually the *Getijtafels voor Nederland* giving complete predictions for high and low water for 15 ports in the Netherlands.

Times are expressed from 0 to 12 hours, local mean time at Amsterdam, and the heights are given in centimetres in accordance with the N. A. P. (Naunheurigheids Amsterdamsch Peil).

The tables comprise 200 pages and may be purchased at GEBROEDERS VAN CLEEF at 'sGravenhage.

The tides at Delfzijl, Ijmuiden and Brouwershaven and the times of low water at Hansweert are calculated by the empirical method of DE BRUIJN ; the others being calculated from the differences.

A table gives the differences for 38 stations in Holland.

The Magnetic and Meteorological Observatory at Batavia publishes annually separate "*Getijtafels*" for the various stations in the Dutch Indies. These tables are calculated by the Burgelike Openbare Werken by the harmonic method of VAN DER STOK (*) The height of the tide for every day in the year is given.

Times are local mean time and heights in decimetres.

In 1929 the tables of predictions have been published for 9 stations.

CANADA.

The Canadian Tidal Service was established in 1894.

Since 1896, the Tidal and Current Survey of the Department of Marine and Fisheries of the Dominion of Canada, at Ottawa, has published the Tide Tables.

The predictions for the Atlantic ports were begun in 1897 and for those of the Pacific in 1901.

The edition of 1924 consists of two volumes of 75 pages each; one for the ports on the Canadian east coast and the other for the Canadian Pacific ports. There is also a pocket size edition for the region of the St Lawrence and one for the Bay of Fundy.

Complete predictions are given for 16 ports.

The predictions for Quebec, Father Point, St John, N. B., St Paul Island and Halifax are based on the harmonic analysis of observations obtained from recording tide gauges extending over a period of from 19 to 22 years. Those for Charlottetown were obtained from observations extending over 11 years.

The predictions for Cape a la Roche are obtained from the differences with respect to Quebec. Those of Pictou from the differences with reference to Charlottetown; those of Yarmouth with St John and those of Miramichi (Portage Island and Horseshoe Bar) from St Paul Island and from Sands Heads. (R. Fraser).

The predictions for the 5 Pacific ports are based on harmonic analysis of observations extending over periods of 10 to 15 years, while those of Sands Heads were based on observations from 1895 to 1904.

The times are given as the hours of standard time from 0 to 24 hours and the heights are given in feet and tenths. The Tables for the Pacific give the times of high and low water in the sequence in which they occur.

For the rest, the tables give the differences and the ratio of amplitudes which permit the tides to be computed at 315 Canadian stations.

The tables also contain general information relative to the periods of the tidal currents in Canadian waters, by Dr. W. BELL DAWSON, and the tables giving the results of a study of the currents in 4 stations in British Columbia.

After 1908, the prediction for the ports in Canada were made with the machine of Messrs. ROBERTS and Son. Since 1925, the Tidal Institute of

(*) J. P. VAN DER STOK — Winds, Weather, Currents, Tides and Tidal Streams in the East Indian Archipelago — Batavia 1897.

Liverpool has started to make the analysis and then the predictions for the account of Canada. In 1927, it furnished the predictions for Portage Island; and in 1929 for Portage Island, Victoria and Vancouver.

ARGENTINE.

Since 1920, the Hydrographic Service of the Argentine Republic has published the *Tablas de Mareas* for the ports of the Republic of Argentine and Uruguay calculated by the Kelvin machine totalizing 16 constants, in the possession of that Office.

These tables, particularly those issued since 1924, are in a very convenient form. They have been developed in the course of the last few years. The edition of 1922 comprises 150 pages and that for 1929 contains 350 pages.

The tables give the periods for each tidal station on which the calculation of the table is based and the list of the reference datum.

The tables are divided into three parts. The first gives the complete predictions for high and low water in the reference ports.

The second part gives the differences for obtaining the predictions for 60 secondary ports and the third part the lunar and solar calendar and the various tables for the calculation of the times of high and low water by different methods. Finally there is a table for calculating the height of the water at any time between high and low water.

In 1922	complete	predictions	were	given	for	7	reference	ports.
In 1924	»	»	»	»	»	10	»	»
In 1925	»	»	»	»	»	12	»	»
In 1927	»	»	»	»	»	14	»	»
In 1929	»	»	»	»	»	17	»	»

Since 1928 the tables also give harmonic constants for the principal ports of reference.

The times are given in zone time and expressed in hours from 0 to 24. The heights are given in feet and tenths above the datum of the largest scale Argentine charts of the locality.

The Third part gives complete examples of the calculations.

The price of the tables is 2 dollars.

PORTUGAL.

Since 1902 the Divisio Hidraulica do Tejo has published the *Tabela des marès em Lisboa* calculated from the observations made with the tide gauge at the arsenal of Lisbon.

Until 1911 the times were given in mean time of the Astronomical Observatory of Lisbon (Tapada). Since 1912 the times have been given in standard time of Western Europe, *i. e.* Greenwich mean time, expressed in hours from O to 24. The heights, in metres and centimetres, are in a separate column with a green wash, to distinguish the figures from the column for hours.

Aside from generalities on the tides and a special table for the reduction of soundings at spring and neap tides, the Annual gives various tables of conversion and information concerning navigation and the services of the port of Lisbon.

SIAM.

Permanent tables giving the hourly height of water over the bar of Bangkok as functions of the age of the moon, were published in 1908 by Captain R. TORRESEN.

In 1910, a recording tide gauge was installed at Khohttlak Island by the Royal Survey Department of the Army In 1914, the service made an analysis of the observations taken at Bangkok extending over four years and sent the harmonic constants to the National Physical Laboratory at Teddington where the tables for 1916 were calculated; giving the times and heights of high and low water for Koh Hlak (Tidal Observatory Lat. 11° - 48' N. — Lon. 99° - 49' E.) Times are given in hours, local mean time, and the heights expressed in metres above the chart datum.

In 1917, the Direction of the Port published a small annual table entitled "Revised Tide Tables of the Meman Chao Phraya Bar", based on observations from 1912 to 1916; giving the times and heights of high water in feet and inches.

Since 1918 this Annual also gives the times of low water and certain information concerning navigation in Siamese waters.

Since 1920 the times have been given for the time zone of Siam.

Subsequently the Tide Tables have been published by the Hydrographic Department of Bangkok.

CHINA.

Since 1922, the Coast Inspector's Office of the Chinese Maritime Customs, Shanghaï, has published a small Annual for the times of high and low water at Side Saddle, from data furnished by the recording tide gauge of the Chinese Customs.

The times are given in hours from 0 to 12 hours, local mean time, and the heights in feet and fractions. An appendix gives the differences for "Tungsha" and Woosung.

In 1926-1927, the Tidal Institute of Liverpool made an analysis of the tidal observations at New Chouang and Side Saddle and furnished the predictions for 1927 for Side Saddle.

In 1928 the Chinese Hydrographic Office published the first edition of the *Tide Tables for Side Saddle and Woosung* calculated and prepared by that Service. The tables give complete predictions for the times and heights of high and low water for Side Saddle and Woosung. The times are given in hours from 0 to 12, zone time, and the heights are given in feet and tenths.

AUSTRALIA.

The Astronomical Observatory of Perth has published annual Tide Tables giving the times and heights of high and low water for Port Hedland (Western Australia) based on the data obtained from the recording tide gauge installed in that port in 1912. The analysis was made by the U. S. Coast and Geodetic Survey and the predictions were made on the machine belonging to the Coast Survey.

The tables also give the constant difference for the ports of Cossack, Broome and Derby.

The South Australian Harbours Board of Adelaide also publishes a small volume from data furnished by the British Admiralty, giving the annual predictions for high and low water for Port Adelaide together with about a dozen differences referred to that port.

Similarly, the Marine Board of Launceston (Tasmania) and the Harbour and Rivers Department of Brisbane (Queensland) publish small brochures giving the predictions for the port of Launceston and for the port of Brisbane (Pile Lighthouse). The information is based on the harmonic analysis of the observations obtained from the recording tide gauge and the predictions have been calculated by the National Physical Laboratory of Teddington. Together with about forty differences, the tables give various information relative to three northern ports; such as, "mean sea level", the "maximum recorded rise" and the "lowest recorded fall".

Since 1926, the Tidal Institute of Liverpool has made the predictions for Brisbane.

The Coast and Geodetic Survey has also made predictions for the account of New South Wales.

At present the Commonwealth of Australia is arranging for the predictions of the tides for the Australian ports to be made through the intermediary of the British Admiralty, which will insert these predictions in the Tide Tables published by it.

In 1929 the predictions made by the Tidal Institute covered 6 Australian ports published in the Tide Tables but it is now a question of increasing this number.

NEW ZEALAND.

The Ministry of Marine of New Zealand, at Auckland, publishes the *New Zealand Nautical Almanach and Tide Tables* giving complete predictions for the time and height of high and low water for 6 ports of New Zealand, and the differences based on Auckland and Wellington for 108 stations throughout the Dominion. The predictions were made on the machine of the National Physical Laboratory of Teddington from data furnished by the Land Department of the New Zealand Government.

Since 1926, the predictions have been made through the work of the Tidal Institute of Liverpool; which, in addition, has made predictions for a seventh port, — New Plymouth.

VARIOUS.

Tide Tables are published by various Colonial Governments and also by local authorities in a number of ports throughout the world. However, it is not always easy for mariners to procure these various local tide tables and it is the aim of the Hydrographic Services to furnish the navigators with sufficient information on the tides to permit them to enter any port in the world, independent of the local tide tables.

TIDAL INSTITUTE OF LIVERPOOL.

This Institute was founded in 1919 by the University of Liverpool, with the financial aid of the Association of Shipowners Companies of Liverpool for the purpose of furthering scientific research on tides, to constitute a centre of information on tides and to undertake special work on tides for commercial concerns and others.

Thus, since 1923, the Institute has been engaged in making analyses for British expeditions, for the International Hydrographic Bureau, for the National Council for the Exploration of the Sea, for the Canadian Government and various port authorities.

Since 1924, it has furnished complete predictions made with the aid of its new machines to various port authorities and Governments, both colonial and foreign: Predictions for high and low water for Liverpool in 1924 for the Tables of Holden. In 1925, the predictions of the Liverpool Institute were incorporated in the Tables of the British Admiralty, which previously gave predictions for this port made by Messrs. ROBERTS and Son.

The Tidal Institute made the predictions for 1926 for Liverpool and for Portland with the aid of the harmonic machine which, however, were corrected for the influence of shoal water by the new method initiated by Dr. DOODSON. In addition, it furnished the predictions for Brisbane and the 6 ports of New Zealand, which had formerly been made by the National Physical Laboratory of Teddington. Since that time the National Physical Laboratory has ceased to furnish the predictions for the Tide Tables of the British Admiralty, which formerly included such ports as Suez, Aden, Bushire, Bombay, Dublat, Rangoon and Mergui; — these predictions now being made by the Office of Tidal Operations of the Survey of India.

Since then the British Admiralty has confided more and more work of this nature to the Tidal Institute. In 1917, the Institute furnished the predictions for 14 ports as well as the complete predictions for every hour for the heights of water at Liverpool.

The predictions for high and low water made by the Institute were extended to 21 ports in 1928, of which 12 were incorporated in the British Tide tables. For 1929, the Tidal Institute furnished predictions for 51 ports, of which 38 were included in the Tide Tables of the British Admiralty.

The following list shows the stations throughout the world for which complete predictions are given for the times and height of high and low water, which are published in the various tide tables for 1929, in so far as the International Hydrographic Bureau has been able to procure such tables.

A special column has been reserved for the British Tables, the American Tables and the German Tables : — in the first column are shown the predictions made by local authorities, while the last column indicates the publications in which the predictions are given, exclusive of the three Governments mentioned above.

The sign ⊕ indicates the original predictions for which there have been given, as far as possible, the dates and duration of the observations on which the predictions are based, authorities making the predictions and the methods employed. The sign + indicates that the predictions have been made by another country. When the country in question has but repeated the predictions, the name of the original country has been given in parenthesis.

The designation "H" indicates that the predictions are given from hour to hour throughout the day, while the sign (*) indicates that the predictions are confined to high water only. The method of prediction is indicated by the abbreviations thus : — *Eq :* Equation method, — *harm :* harmonic method, etc.

It is realized that the above tabulation is necessarily incomplete and inaccurate as it has been impossible to consult all of the original sources, but it is hoped that the Offices interested and the readers of the Hydrographic Review will aid the Bureau to correct such omissions and errors by calling them to the attention of the International Hydrographic Bureau in order that the Bureau may take cognizance of these modifications and be enabled to publish the corrections in a subsequent issue of the Hydrographic Review.

It is hoped also that the Offices which publish annual Tide Tables will add to the predictions given, information similar to that contained on pages 370, 373 and 374 of the Admiralty Tide Tables (Standard Edition) Part. 1 — 1929 and that, if possible, they also publish tidal diagrams for certain ports of the type given in the German *Gezeitentafeln,* 1929, pages 27-57-71-90-115, etc.

The International Hydrographic Bureau notes the interest which has been taken in the sketches given on pages 2-3 of the Japanese Tide Tables, Part 1, 1929, of the localities referred to Standard Ports, It also invites attention to the particularly convenient form in which the *Tablas de Marea* of the Argentine Republic are issued (1929), and the practical means taken in the *Tabela das Marès em Lisbon* for distinguishing the column of figures giving the heights from the column of times, by means of a colored wash.

Finally, it is recommended that the Tide Tables give, where possible, the harmonic constants for the ports and the authority from which they are taken.

A study of the above tabulation reveals the fact that complete hourly predictions for each day of the year are given for 19 ports and that complete predictions for high and low water are given to-day for 262 ports.

It may be stated that it is on the information given for these 262 ports that the navigators base their calculations on the height of the tide at any instant, and it is interesting to study the accuracy of the means at their disposal for making such calculations.

1) The predictions of the times and heights of high and low water, given by the annual tables, have an accuracy which depends on the duration of the observations, the method, and the extent more or less to which the analysis is carried, the corrections which are taken into consideration, the number of constants totalized by the machine, the accuracy of the machine and of the results which the machine furnishes.

A comparison of the data furnished by the tide tables with the actual records of the recording tide gauges taken subsequently, gives some idea from a practical standpoint upon this question if care has been taken to suppress observations influenced by meteorological conditions whose influence cannot be foreseen and corrected. A curve of error may be obtained, provided the comparison is continued over a sufficiently long period (for example, for one year) and percentages of errors calculated. Such a curve of errors is shown below in fig. 1.

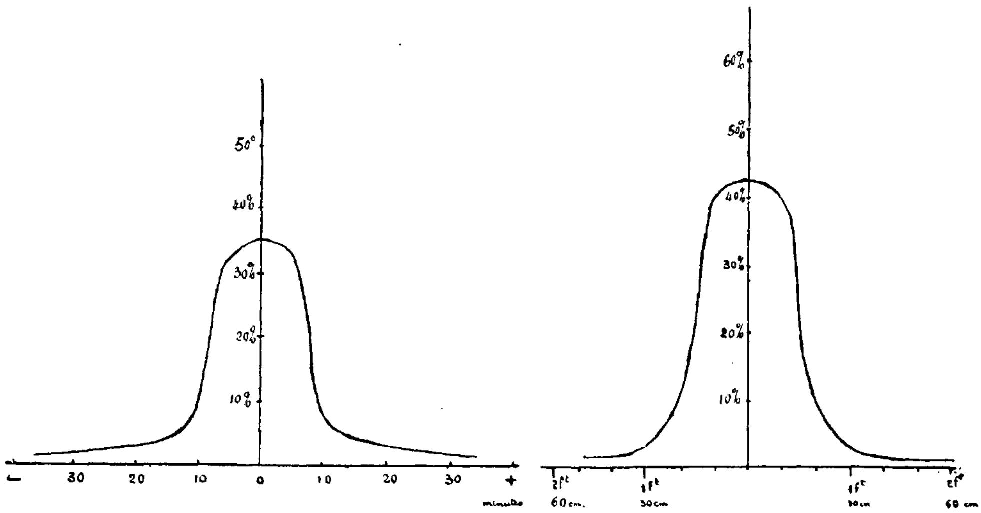

fig 1

We may cite, for instance, the curves obtained for Brest from 1895 to 1898 by the French Hydrographic Service, those obtained by Professor Darwin for Portsmouth in 1897 and for Aden in 1884 and those obtained for Portland (Maine) and Seattle (Washington) in 1919 by the U. S. Coast and Geodetic Survey.

These curves, symmetrical when there is no systematic error in the predictions, will naturally vary from port to port and for the same port from year to year.

It has also been remarked that the predictions for a given port may vary according to the method or where different machines are used and that at times these discrepancies may become quite appreciable (differences of 12 centimetres in the height and of 10 minutes in the times are not rare and even greater discrepancies are sometimes encountered). The various national offices have undertaken the study of the discrepancies for the purpose of reducing the sources of error, in particular the Tidal Institute of Liverpool (*see* special Publication Nº 13 of the International Hydrographic Bureau, page 71).

2) Efforts have been made for a long time to solve the problem of obtaining the height of water at any instant by interpolation from the data given in the tables, that is between four factors — two and two — (the two times and the two heights).

In his *Mécanique Céleste,* (book IV - 1810) LAPLACE expressed himself on this subject as follows:-

"Let us consider a vertical circle, of which the circumference represents a half day and the diameter equals the total tide, — that is, the difference in height between high and low water, and suppose that the arcs of this circumference, starting with the lowest point, represent the times elapsed since low water, the verse-sines of these arcs will equal the heights of the water corresponding to the times.

"This law will be exactly followed in the centre of an ocean where the tides are uninfluenced by the coasts, but in our ports, local conditions affect the tides, and the sea takes more time to fall that it does to rise."

This concept of LAPLACE is expressed somewhat differently by the statement that the movement of the ocean level follows a *senusoidal law.*

Towards 1840, WHEWELL and CHAZALLON issued tables based on this law although their own observations had shown that it was not quite accurate.

In 1842, AIRY made a special study of the rise and fall of the level of the sea at Deptford. He conceived the idea of combining all the intervals between two successive high waters into a single period which he divided into 360 parts, and all of the amplitudes into a single amplitude divided into 2000 parts, from which he compiled 2 tables giving the fractions of the amplitudes in fractions of the phase 360, one for spring tides and the other for neap tides.

In 1848, BEECHY developed rectangular diagrams giving the height of the sea at any instant based on the hypothesis that the sinusoidal law was valid.

In 1868, the Ingénieur Hydrographe BOUQUET DE LA GRYE furnished diagrams for a certain number of ports on the coast of France, the curves of which were based on observations. In making the determinations for any particular day it was necessary to interpolate between the curves depending on the age of the moon.

For a long time the British Admiralty Tide Tables gave 5 diagrams which permitted the approximate height of the tide to be determined for the intermediate hours. The diagrams were given for periods of rising and falling respectively 5 h., 5 h ½, 6 h., 6 h. ½, 7 hours. For some time past these diagrams have been replaced by numerical tables with double entry which serve the same purpose.

The use of these tables, supported by numerous practical examples has been described in detail in the work of Commander H. D. WARBURG, *Tides and Tidal Streams* (Chapter V).

For the greater part, the tide tables published by the various countries give analogous numerical tables, based on the duration of the rise varying from 3 to 13 hours and the various amplitudes ranging from 15 centimetres to 12 metres.

For example the tables VIII in the Annual for 1929 of the Argentine Republic appear to be most practical. These diagrams or numerical tables are simply a translation of the sinusoidal law.

The mnemonic rules known to pilots under the name the "rule of twelve" or the "rule of hundredths" (which are also used in another form for the reduction of soundings, with different values for the fractions depending on whether the tides are spring or neap) are simply others forms of expression of the same sinusoidal law.

Numerous graphs have also been published from time to time by the various Hydrographic Offices or by the authors themselves to aid in solving this problem rapidly. These are based on the sinusoidal law of change of level and some of them, such as the abacus N° 4 of the French Hydrographic Service, issued in 1899, include correctors for the various ports and for the various phases of spring and neap tides.

However, to be strictly practicable, these curves must permit a visual solution of the problem without the necessity for numerous additions or subtractions or passing from one curve to another, and it has been suggested therefore that the four numbers given in the Annual Tables, between which it is necessary to interpolate, T_1, T_2, H_1 and H_2, be used directly.

For example, we might trace on cross section paper to any scale, one branch of the sinusoidal curvė betwen two rectangular axes, *LW*, *HW* such as shown in the figure below (Fig. 2). On transparent paper trace one scale for the hours, *T*, (any scale desired) and another scale H for the heights.

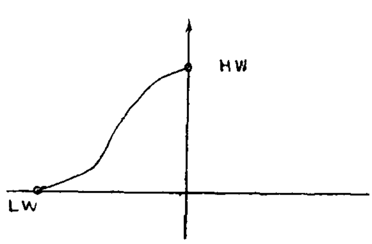

Fig 2

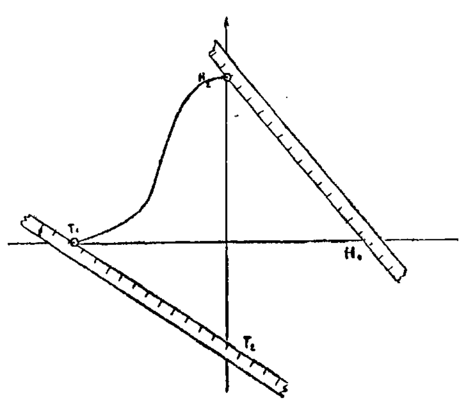

Fig 3

Then pivoting the scale T about the point LW and the scale H about the point HW, bring the graduations T_1, T_2, H_1, and H_2, to coincide with the axes as indicated in fig. 3, after this to solve the problem it suffices to move from T to obtain H (track N° 1) or starting with H to obtain T (track N° 2) fig. 4.

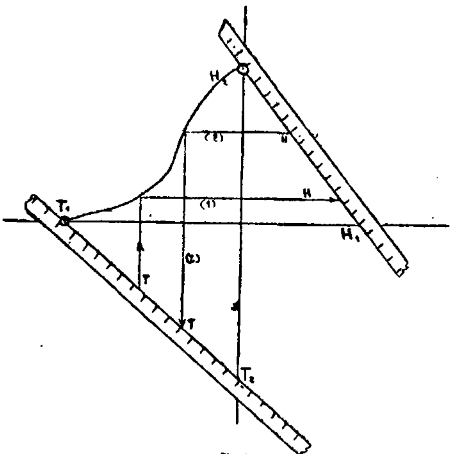

fig. 4

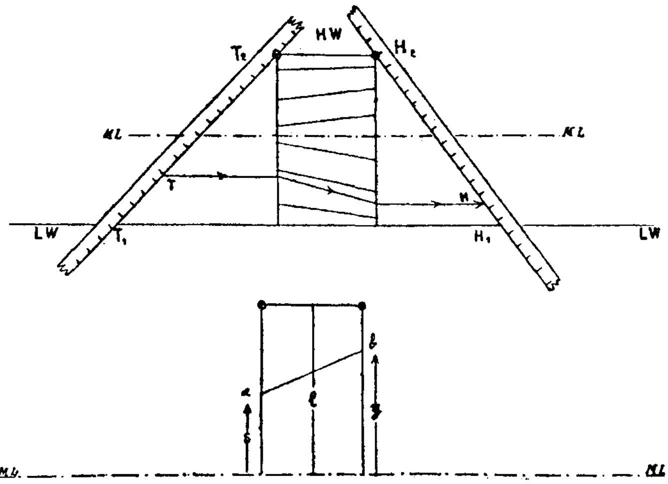

fig. 5

In order to obtain greater symmetry in reading the scales, the abacus (Fig. 5) may be traced in which the conjugate points a and b are obtained from the equation $y = \sin \frac{1}{l} s$. y, s and l are measured from the line representing the mean level. It is not necessary to move the scales during the whole period of the rise or fall.

It should be remarked that the system given for fig. 2 may be employed regardless of the law (whether sinusoidal or not) and that the procedure may also be employed with the curves of the type given in the German *Gezeitentafeln* for certain ports. Although this procedure is susceptible of application when the same port is visited frequently or when a long sojourn is made in the same waters, it would appear that the great diversity in the family of curves which it necessitates, renders it impossible of generalization.

For the rest, in this connection, it would seem that the harmonic method, giving the predictions for any instant with all the accuracy desirable in practice, should soon supplant all other methods of calculations.

To-day, the harmonic constants are calculated for about 1400 ports, which are distributed unequally throughout the world.

Since 1927, the British Hydrographic Office has issued all the publications needed to make the use of the harmonic method particularly simple and easy for mariners including the publication of the *Instructions for the analysis of tidal observations.* Certain navigators already employ the harmonic method while many are cognizant of the method, and the initiative of the Hydrographic Services in placing in their hands the list of harmonic constants will contribute to encourage greater familiarity with their practical use.

(1) Places. Lieux.	(2) Local	(3) British Admiralty Tide Tables 1928.	(4) U. S. A. Tide Tables.	(5) German Gezeiten Tafeln. 1929.	(6) Others - Autres.	(7) Référence pour / for (2) or / ou (6).
CANADA.						
Cap a la Roche	⊕ Canada - Diff. Québec 1901-1919, 6 ans.					
Québec	⊕ Canada - 1894-1920 (20 years).	+ (Canada).	+ (Canada).			Tide Tables for the Eastern Coasts of Canada. Issued by the Tidal and Current Survey, Department of Marine & Fisheries, Ottawa.
Father Point	⊕ Canada - 1897-1921 (19 years)-Roberts	+ (Roberts).				
Portage Is. (Miramichi Bay).	⊕ Canada-Tidal Institute.					
Pictou	⊕ Canada - Diff. Charlottetown 1901-1915 (28 months).					
St. Paul Is.	⊕ Canada - 1895-1919 (20 years) Roberts.	+ (Roberts).				
Charlottetown	⊕ Canada - 1907-1920 (11 years).					
Halifax	⊕ Canada - 1851-1921 - Roberts.	+ (Roberts).	+ (Canada).			
Yarmouth	⊕ Canada - Diff. St. John 1888-1900 (2 years).					
St. John (N. B.)	⊕ Canada - 1894-1917 (22 years) - Roberts	+ (Roberts).	+ (Canada).			
UNITED STATES.						
Eastport			⊕ 1862-1863 (1 year).			
Portland			⊕ 1864-1916 (2 years).			
Boston		+ (U. S.).	⊕ 1922-1924 (2 years).	+ (U. S.).		
Newport			⊕ 1892-1893 (1 year).			
New London			⊕ (1 year).			
Willets Point			⊕ 1891-1894 (2 years).			
New York			⊕ 1876-1878 (3 years).			
Albany			⊕ 1914-1915 (1 year).			
Sandy Hook		+ (U. S.).	⊕ 1876-1888 (8 years).	+ (U. S.).		
Philadelphia			⊕	+ (U. S.).		
Breakwater Harbor			⊕ 1919-1920 (1 year).			
Baltimore			⊕			
Washington			⊕			
Old Point Comfort			⊕ 1865-1877 (2 years).	+ (U. S.).		
Wilmington			⊕ 1908-1909 (1 year).			
Charleston		+ (U. S.).	⊕ 1859-1903 (2 years).	+ (U. S.).		
Savannah			⊕ 1914-1915 (1 year).			
Tybee			⊕ 1889-1890 (1 year).			
Fernandina			⊕ (1 year).			

(1) Places / Lieux.	(2) Local	(3) British Admiralty Tide Tables 1929.	(4) U. S. A. Tide Tables.	(5) German Gezeiten Tafeln 1929.	(6) Others - Autres.	(7) Référence pour / for (2) or / ou (6).
ALASKA.						
Saint Michael			⊕ 1891-1899 (145 days).			
Apokak			⊕ 1914 (87 days).			
Kodiak			⊕ 1885-1886 (1 year).			
Cook Inlet Anchorage			⊕ 1914-1918 (163 days).			
Seldovia			⊕ 1908-1913 (267 days).			
Juneau		+ (U. S.)	⊕ 1911-1912 (1 year).			
Sitka			⊕ 1893-1894 (1 year).			
BRITISH COLUMBIA.						
Port Simpson	⊕ Canada (12 years) - Roberts.					
Prince Rupert	⊕ Canada (10 years) - Roberts.	+ (Roberts).				
Clayoquot	⊕ Canada (14 years) - Roberts.	+ (Roberts).				
Victoria (B. C.)	⊕ Canada-Tidal Institute.	+ Roberts (16 years).	+ (Canada).		+ Japan (harm.).	Tide Tables for the Pacific Coast of Canada. Issued by the Tidal and Current Survey, Department of Marine and Fisheries. Ottawa.
Vancouver	⊕ Canada-Tidal Institute.					
Sands Head (R. Fraser)	⊕ Canada 1895-1904 (13 years) - Roberts.	+ (Roberts).				
UNITED STATES.						
Seattle			⊕ 1899-1900 (2 years).		+ Japan (harm.).	
Port Townsend			⊕ 1874-1876 (3 years).			
Astoria			⊕ 1874-1875 (2 years).		+ Japan (harm.).	
Humboldt Bay			⊕ 1911-1912 (1 year).			
San Francisco		+ (U. S.).	⊕ 1863-1870 (4 years).	+ (U. S.).	+ Japan (harm.).	
San Diego		+ (U. S.).	⊕ 1869-1917 (4 years).		+ Japan (harm.).	Tide Tables (Part II). Hydrographic Department, Tokyo.
PANAMA.						
Balboa		+ (U. S.).	⊕ 1912-1917 (2 years).	+ harm.	+ Japan (harm.).	
CHILE.						
Valparaiso		+ (U. S.).	+ 1892 (1 year).	+ harm.	+ Japan (harm.).	
Orange Bay (Cape Horn)		+ (U. S.).	+ 1892 (1 year).			
NEWFOUNDLAND.						
St. Johns			+ 1880 (236a dys).			

(1) Places Lieux.	(2) Local	(3) British Admiralty Tide Tables 1929.	(4) U. S. A. Tide Tables.	(5) German Gezeiten Tafeln 1929.	(6) Others - Autres.	(7) Référence pour for (2) or ou (6).
UNITED STATES (cont.).						
Key West			⊕ 1914-1915 (1 year).			
Pensacola			⊕ 1859-1860 (1 year).			
Galveston		+ (U. S.).	⊕ 1908, 1923 (2 years).	+ Harm.		
GUYANA.						
Georgetown		⊕ 1915-1916 (1 year) Tidal Institute.				
Iles du Salut	⊕ France.					Tables des Marées des Colonies Françaises de l'Atlantique. Service Hydrographique, Paris.
BRAZIL.						
Rio de Janeiro		+ (U. S.).	+ 1906-1913 (3 years).	+ harm.		
URUGUAY.						
La Colonia	+ Argentine 1907-08 (1 year).					
ARGENTINE.						
Punta Indio el Codillo	⊕ Argentine (*) Diff. la Colonia.					
Buenos Ayres		+ (U. S.).	+ 1893 (1 year).	+ harm.		
Mar del Plata	⊕ Argentine - 1915 (1 year).					
Porto Belgrano / Bahia Blanca	⊕ Argentine - 1905-1908 (3 years).	+ 1905-1908 (3 years) Tidal Institute.	+ 1905-1908 (3 years).			
Canal la Manuelita	⊕ Argentine - Diff. Porto-Belgrano.					
San Blas	⊕ Argentine - 1914-1918 (7 months).					
Porto San Antonio	⊕ Argentine - 1904-1912 (13 months).					Tablas de Marea, Republica Argentina Servicio Hidrografico, Buenos Ayres.
San Roman (San Jose)	⊕ Argentine - 1918 (15 days).					
Porto Madryn	⊕ Argentine - 1916-17 (6 months).					
Santa Elena	⊕ Argentine - 1916-17 (3 months).					
Com. Rivadavia	⊕ Argentine - 1913 (1 year).					
Deseado	⊕ Argentine - 1905-13 (14 months).					
San Julian	⊕ Argentine - 1916 (2 months).					
Santa Cruz	⊕ Argentine - 1916 (1 month).					
Gallegos	⊕ Argentine - 1915-16 (3 months).					
Rio Grande	⊕ Argentine 1921-28 (45 days).					
Bahia Aguirre	⊕ Argentine - 1920 (15 days).					

(1) PLACES LIEUX.	(2) LOCAL	(3) BRITISH ADMIRALTY TIDE TABLES 1929.	(4) U. S. A. TIDE TABLES.	(5) GERMAN GEZEITEN TAFELN. 1929.	(6) OTHERS - AUTRES.	(7) RÉFÉRENCE FOR POUR (2) OR OU (6).
BRITISH ISLES.						
DOVER		⊕ 1915-16 Hydrog. Dept. (Eq.).	+ (G. B.).	+ harm.	+ France (*)	Annuaire des Marées des côtes de France. Service Hydrographique, Paris.
SHEERNESS		⊕ 1913 Hydrog. Dept. (Eq.).	+ (G. B.).			
CHATHAM		⊕ 1913 Hydrog. Dept. (Diff.).				
LONDON BRIDGE		⊕ 1925 Tidal Institute (harm.-correct.)	+ (G. B.).			
SOUTHEND	⊕ 1925 (1 year) Tidal Institute harm. corr.					The Port of London Authority.
TILBURY	⊕ 1925 (1 year) Tidal Institute har. corr.).					
ROYAL ALBERT DOCK	⊕ 1925 (1 year) Tidal Inst. har. correct.).					
HARWICH		⊕ 1902 Hydrog. Dept. (Eq.).		+ empirique.		
IMMINGHAM		⊕ 1919 Tidal Institute (harm.).		+ harm.		
GRIMSBY						
HULL			+			
HARTLEPOOL						
R. TEES		⊕ 1897 Hydrog. Dept. (Eq.).				
NORTH SHIELDS				+ Diff. Leith.		
R. TYNE		⊕ 1916 Hydrog. Dept. (Eq.).				
LEITH-EDINBURGH		⊕ 1909 Hydrog. Dept. (Eq.).	+ (G. B.).	+ (G. B.).		
ROSYTH		⊕ 1918-19 Hydr. Dept. (Eq.).				
INVERGORDON		⊕ 1916 Hydr. Dept. (Eq.).				
STROMNESS		⊕ 1911-12 Hydr. Dept. (Eq.).				
OBAN		⊕ 1912-13 Hydr. Dept. (Eq.).				
GREENOCK		⊕ 1912-13 Hydr. Dept. (Eq.).	+ (G. B.).	+ (G. B.).		
LIVERPOOL		⊕ 11 years Tidal Inst. (harm. correct.).	+ (G. B.).	+ harm.		
HOLYHEAD		⊕ 1908-09 Hydr. Dept. (Eq.).				
PEMBROKE		⊕ 1892 Hydrog. Dept. (Eq.).				
SWANSEA		⊕ 1858-61 Hydr. Dept. Diff.				
AVONMOUTH		⊕ 1924-25 Tidal Inst. (harm. correct.).				
KINGSTOWN		⊕ 1908-09 Hydrog. Dept. (Eq.).	+ (G. B.).			
BELFAST		⊕ 1913 Hydrog. Dept. (Eq.).				
LONDONDERRY		⊕ 1853-56 Hydrog. Dept. Diff.				
GALWAY		⊕ 1845-46 Hydrog. Dept. (Eq.).				

(1) Places Lieux.	(2) Local	(3) British Admiralty Tide Tables 1929.	(4) U. S. A. Tide Tables.	(5) German Gezeiten Tafeln 1929.	(6) Others - Autres.	(7) Référence for / pour (2) or / ou (6).
BRITISH ISLES (cont.)						
Queenstown	......	⊕ 1907 Hydrog. Dept. (Eq.).	+ (G. B.).	+ (G. B.).	+ France (*)	
Devonport	......	⊕ 1882 Hydrog. Dept. (Eq.).	......	+ Diff. Brest.	+ France (*)	Annuaire des Marées des côtes de France. Service Hydrographique, Paris.
Portland	......	⊕ 1923-24 Tidal Inst. (harm. correct.).	......	......	......	
Portsmouth	......	⊕ 1914 Hydrog. Dept. (Eq.).	......	+ empirique.	+ France (*).	
Southampton	......	⊕ 1924 Tidal Inst. (harm. correct.).	......	......	......	......
RUSSIA.						
Kem	⊕ H-Russia 1909-10 (1 year) harm.	⊕ 1910 Tidal Institute.	......	......	......	Egegodnik Prilivof Cievernovo liodovitovo okeana i bielovo moria. Gydrografitcheskoie Oupravlenie, Leningrad.
Ekaterinskaya	⊕ H-Russia 1906-07 (1 year) harm.	⊕ 1907 Tidal Institute.	......	......	......	
GERMANY.						
Heligoland	......	+ (Germany).	......	⊕ Diff. Wilhemshaven.	......	......
Cuxhaven	......	+ (Germany).	......	⊕ Diff. Wilhemshaven.	......	......
Ostebank	......	......	......	⊕ Diff. Wilhemshaven.	......	......
Brunsbuttel	......	......	......	⊕ Diff. Wilhemshaven.	......	......
Brunshausen	......	......	......	⊕ Diff. Wilhemshaven.	......	......
Hamburg	......	......	+ (Germany).	⊕ Diff. Wilhemshaven.	......	......
Bremerhafen	......	......	+ (Germany).	⊕ Diff. Wilhemshaven.	......	......
Bremen	......	......	......	⊕ Diff. Wilhemshaven.	......	......
Wilhemshafen	......	+ (Germany).	......	⊕ empirique.	......	......
Emden	......	......	......	⊕ Diff. Wilhemshaven.	......	......
NETHERLANDS.						
Delfzijl	⊕ empirique.	......	......	......	......	
Harlingen	⊕ Diff.	......	......	......	......	
Vlieland	⊕ Diff.	......	......	......	......	
Helder	⊕ Diff.	......	......	......	......	Getijtafels voor Nederland. uitgegeven door het Department van Waterstaat, s'Gravenhage.
IJmuiden	⊕ empirique.	......	......	+ (Nederland).	......	
Hoek van Holland	⊕ Diff.	+ (Nederland).	......	+ (Nederland).	......	
Rotterdam	⊕ Diff.	......	......	......	......	
Hellevoetsluis	⊕ Diff.	......	......	......	......	
Vlissingen	⊕ Diff.	+ (Nederland).	......	+ (Nederland).	......	

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NETHERLANDS (cont.).						
Neuzen	⊕ Diff.					
Zierikzee	⊕ Diff.					
Brouwershaven	⊕ empirique.					
Willemstadt	⊕ Diff.					Getijtafels voor Nederland. uitgegeven door het Departement van Waterstaat, s'Gravenhage.
Wemeldingue	⊕ Diff.					
Hansweert	⊕ Diff.					
FRANCE.						
Dunkerque	⊕ Diff. Brest (1894).	+ Hydrog. Dept. Diff.				
Calais	⊕ Diff. Brest.			+ Diff. Brest.		
Boulogne	⊕ Diff. Brest 1876.					
Dieppe	⊕ Diff. Brest.					
Fécamp	⊕ Diff. Brest.					
Le Havre	⊕ H. Diff. Brest & Har. cor.1895 (1 year).	+ Hydrog. Dept. Diff.	+	+ Harm.		
Cherbourg	⊕ Diff. Brest 1884.			+ Harm.		
St. Hélier		⊕ 1903 Hydr. Dept. (Eq.).				
St. Malo	⊕ H. Diff. Brest & Har. 1875-76 (2 years).					
Héaux de Bréhat	⊕ Diff. Brest.					Annuaire des Marées des Côtes de France. Service Hydrographique, Paris.
Brest	⊕ H. Laplace et Har. 1873-75 (3 years).	+ (France).	+	+ Harm.		
Port Louis (Lorient)	⊕ Diff. Brest 1895.					
St. Nazaire	⊕ Diff. Brest 1876.					
La Rochelle	⊕ Diff. Brest 1873.		+			
Ile d'Aix	⊕ Diff. Brest 1895.					
Cordouan	⊕ Diff. Brest 1892.	+ Hydrog. Dept. Diff.		+ Diff. Brest.		
Le Boucau (Adour)	⊕ Diff. Brest.					
Le Socoa (St. Jean-de-Luz)	⊕ Diff. Brest 1897.					
PORTUGAL.						
Lisbonne (Cascaès)	⊕ Portugal.	+ 1914 Tidal Institute. Harm.	+ (G. B.).			Tabela das Marès em Lisboa - Divisâo Hidràulica do Tejo, Lisboa.
Gibraltar		⊕ (1 year) Tidal Institute. Harm.	+ (G. B.).			
AÇORES.						
Ponta Delgada		+ 1924 Tidal Institute. Harm.				

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MOROCCO.						
Mehedia	⊕ France - Harm.					
Rabat	⊕ France - Harm.					
Casablanca	⊕ France - 1919-21 (1 year) Harm.					Tables des Marées des Colonies Françaises de l'Atlantique. Service Hydrographique, Paris.
FRENCH WEST AFRICA.						
Dakar	⊕ France (1 mois) Harm.					
Conakry	⊕ France - Harm.					
SIERRA LEONE.						
Freetown		⊕ 1926-7 Tidal Institute-Harm.				
FRENCH EQUATORIAL AFRICA.						
Pte Owendo	⊕ France 1911-12 (20 days) Harm.					
Pt. Gentil (Cap Lopez)	⊕ France 1912 Harm.	+ (France).				d° d°
Pte Noire (Gabon)	⊕ France 1912 Harm.					
SOUTH AFRICA.						
Cape Town			+ 1888-1889 (1 year).	+ Harm.	+ Japan (harm.).	
Simonsbay		⊕ 1908-09 (1 year) Tidal Institute.				
Durban		⊕ 1926-27 (1 year) Tidal Institute.				
Zanzibar		⊕ 1925-27 (1 year) Tidal Institute.				
MADAGASCAR.						
Diego Suarez	⊕ France 1900 (1 month) Harm.					
Helleville (Nosi Be)	⊕ France Harm.					
Dzaoudzi (Mayotte)	⊕ France 1900 (15 days) Harm.					
Majunga	⊕ France 1891 (1 month) Harm.					Tables des Marées des Colonies Françaises de l'Océan Indien.
Nosi Maroantali	⊕ France 1903 (1 month) Harm.					Service Hydrographique, Paris.
Tulear	⊕ France 1907 (1 month) Harm.					
Tamatave	⊕ France 1901 (1 month) Harm.					
La Réunion	⊕ France 1900 (1 month) Harm.					
EGYPTE.						
Suez		+ 1879-1920 (42 years) India.			+ Japan (harm.).	

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ARABIA.						
Djibouti	⊕ France 1899 (17 days) Harm.					
Aden		⊕ 1897-1904 (7 years) India.	+	+ Harm.	+ Japan (harm.).	
Shatt-al-Arab		+ 1899-1900 (1 year) Tidal Inst.				
Bushire		+ 1892-1900 (8 years) India.				
INDIA.						
Karachi		⊕ 1868-1920 (54 years) India.	+			Tides Tables (Part II).
Bhaunagar		⊕ 1889-1894 (5 years) India.				Hydrographic Department Tokyo.
Bombay		⊕ 1878-1920 (43 years) India.	+	+ Harm.	+ Japan (harm.).	
Murmagao		⊕ 1884-1889 (5 years) India.				
Colombo		⊕ 1884-1890 (6 years) India.	+		+ Japan (harm.).	
Trincomali		⊕ 1890-1895 (6 years) India.				
Madras		⊕ 1895-1920 (26 years) India.	+			
Dublat Saugor (Hugli River)		⊕ 1881-1886 (5 years) India.		+ Harm.	+ Japan (harm.).	
Calcutta (Kidderpore)			+ 1881-1914 (29 years).			
STRAITS SETTLEMENTS.						
Chittagong		⊕ 1886-1891 (5 years) India.				
Elephant Point		⊕ 1864-1888 (5 years) India.				
Rangoon			+ 1880-1914 (30 years).	+ Harm.		
Mergui		⊕ 1889-1894 (5 years) India.				
Penang		⊕ 1906-1907 (1 year) Tidal Institute				
Port Swettenham		⊕ 1911-1912 (1 year) Tidal Institute				
Johore Bahru		⊕ 1923-1924 (1 year) Tidal Institute				
Singapore		⊕ 1882-1883 (1 year) Tidal Institute	+ (G. B.).	+ Harm.	+ Japan (G. B.) + France (G. B.).	
Sandakan		⊕ 1925-1926 (1 year) Tidal Institute				
Kuantan		⊕ 1904-1910 (2 years) Tidal Institute				
NETHERLANDS EAST INDIES.						
R. Deli (Belawan)	⊕ H. 1918 (1 month) Harm.					Getijtafels uitgegeven door het Koninklijk Magnetisch en Meteorologisch Observatorium te Batavia, Weltevreden.
R. Palembang	⊕ H. Constants interpol. Harm.					
Tg. Kalian					+ Japan 1890-1894 (4 years) Harm.	

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COREA.						
Tinnampo	⊕ Japan.					Chôseki-Hyô, Tide Tables. Hydrographic Department, Tokyo.
Zinzen (Chemulpho)	⊕ Japan 1907-1912 (6 years).	+ (Japan).				
Fusan	⊕ Japan.					
Nagaeva Bay	⊕ Russia H. 1913 (1 month) Harm.					egegodnik prilivof vostotchnovo okeana. Russian Tide Tables, Pacific Ocean, Leningrad.
Langr. Island	⊕ Russia H. 1911-1912 (4 months) Harm.				+ Japan.	
Castries Bay	⊕ Russia H. 1911 (3 months) Harm.					
Chaï Vo	+ Japan.					
JAPAN.						
Otomari	⊕					Chôseki-Hyô - Tide Tables, (Part I). Hydrographic Department, Tokyo.
Ominato	⊕ 1889 (3 months).					
Miyako	⊕					
{ Yokosuka	⊕ 1898-1900 (2 years).	+ (Japan).				
{ Yokohama			+	+ Diff. Yokosuka.		
Kobe	⊕ 1900-1906 (6 years).					
Awasima	⊕					
Kure	⊕ (2 years).					
Shimonosaki	⊕ 1910-1912 (2 years).	+ (Japan).				
Wasima	⊕ 1901-1905 (5 years).					
{ Sasebo	⊕					
{ Nagasaki			+ 1891 (3 months).	+ Diff. Sasabo.		
Naha	⊕					
Kiirun	⊕ 1905-1908 (4 years).					
Bako	⊕					
PHILIPPINE ISLANDS.						
Manilla		+ (U. S.).	⊕ 1901-1903 (2 years).		+ Japan (harm.).	
Cebu		+ (U. S.).	⊕ 1902 (6 months).			
OCEANIA.						
Honolulu		+ (U. S.).	⊕ 1891-1915 (2 years).		+ Japan (harm.).	d° (Part II).
Apia (I. Samoa)		+ (U. S.).	+ 1924-1925 (1 year).			

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NETHERLANDS EAST INDIES (cont.)						
Batavia			+ 1887-1904 (7 years).		+ Japan Harm.	
Djamoeanrif (Soerabaja W.).	⊕ H. 1894-1907 (46 months) Harm.					
Karang Kleta (Soerabaja E.)	⊕ H. (1 year) Harm.					
Pontianak (R. Kapoeas)	⊕ H. 1913-1916 Harm.					Getijtafels uitgegeven door het Koninklijk Magnetisch en Meteorologisch Observatorium te Batavia, Weltevreden.
Barito R.	⊕ H. 1918-1919 (1 year) Harm.					
Koeteï R.	⊕ H. (1 year) Harm.					
Aroe Baai (Po. Sembilan Geul)	⊕ H. 1925 (2 months) Harm.					
Tjilatjap	⊕ H. (3 years) Harm.					
SIAM.						
Koh Hlak	⊕ Siam.					Revised Tide Tables of the Menam Chow Phraya.
Bangkok Bar	H. (perpétuelles).					Hydrographic Department, Bangkok.
INDO CHINA.						
Haïtien	⊕ France 1902 Harm.					
Cangio (Cap St. Jacques)	⊕ France 1926-1927 (1 year) Harm.	+ (France).				
Saïgon	⊕ France Diff. Cangio.					Tables des Marées des Colonies Françaises des Mers de Chine.
Quinhone	⊕ France 1878 Harm.					Service Hydrographique, Paris.
Tourane	⊕ France 1902 Harm.					
Do Son (Cua Cam)	⊕ France Harm.	+ (France).	+		+ Japan Harm.	
CHINA.						
Pakhoï	+ France 1901 Harm.	+ (France).				
Nau Tcheou (K. T. W.)	⊕ France Harm.					
Hongkong		⊕ 1877-1889 (3 years) Tidal Institute	+	+ Harm.	+ Japan (G. B.) + France (G. B.).	
Side Saddle	⊕ China.	+ 1923-1924 (1 year) Tidal Institute.				Tide Tables for Side Saddle and Woosung.
Woosung Bar	⊕ China.	+ 1893 (1 year) Tidal Institute.	+	+ Harm.	+ Japan Harm. + France.	Hydrographic Department of Chinese Navy, Shanghai.
Wei aï Weï		⊕ 1915-1916 (1 year) Tidal Institute.				
Tien Tsin (Taku)		+ (U. S.).	+ 1912-1913 (1 year).		+ France Harm. (U. S.).	
Newchwang		+ 1924-1925 (1 year) Tidal Institute.				
Daïren	⊕ Japan.					

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AUSTRALIA.						
Thursday Island	⊕ 1924-1925 (1 year) Tidal Institute.	+ (Tidal Institute).				
Newcastle	⊕ 1900 (1 year) Tidal Institute.	+ (Tidal Institute).				
Port Hedland	⊕ 1913 (1 year) Tidal Institute.	+ (Tidal Institute).	+ (G. B.).			
Princess Royal Harbour	⊕ 1876-1924 (1 year) Tidal Institute.	+ (Tidal Institute).				Various Tide Tables issued by Australian Harbours Board Authorities.
Port Adelaïde	⊕ 1889-1893 (2 years) Tidal Institute.	+ (Tidal Institute).	+ (G. B.).			
Melbourne			+			
Launceston	⊕ Marine Board.					
Sydney	⊕ 1910-1911 (1 year) Tidal Institute.	+ (Tidal Institute).	+ (G. B.).	+ Harm.	+ Japan (harm.).	
Brisbane	⊕ 1908 (1 year) Tidal Institute.	+ (Tidal Institute).			+ Japan (harm.).	Tide Tables (Part. II). Hydrographic Department Tokyo.
NEW-ZEALAND.						
Auckland	⊕ Tidal Institute.	+ (N. Z.).	+ (G. B.).		+ Japan (harm.).	
Wellington	⊕ Tidal Institute.	+ (N. Z.).	+ (G. B.).			
Westport	⊕ Tidal Institute.					
New Plymouth	⊕ Tidal Institute.					New Zealand Nautical Almanach and Tide Tables, Ministry of Marine, Wellington.
Port Lyttelton	⊕ Tidal Institute.					
Dunedin	⊕ Tidal Institute.					
Bluff Harbour	⊕ Tidal Institute.	+ (N. Z.).				