INTERNATIONAL HYDROGRAPHY 1835

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The discussions at last year's Hydrographic Conference regarding the construction of cotidal charts, recall the co-operation of the Maritime States, on both sides of the Atlantic, in a similar cause, more than a century ago. In June 1835 the times and heights of high and low water were continuously observed for a period of 20 days at more than 600 stations. In the words of the Reverend Dr. Whewell, who inspired the investigation, they « extended from the mouth of the Mississippi, round the Keys of Florida, along the coast of North America, as far as Nova Scotia; and from the Straits of Gibraltar, along the shores of Europe to the North Cape of Norway ».

Prior to these observations seamen were by no means ignorant of the progress of tides along the shores of Europe, but the published statements were full of contradictions, and the available data were quite unsuitable for a scientific investigation.

The tidal charts which were in use in those days have been described by Professor E.G.R. Taylor in « The Sailor in the Middle Ages » (1). On those charts, the times of high water at the various ports were indicated by lines radiating from a compass. At those where high water occurs at about the times of the Moon's transits the lines originated at the north or south points of the compass. Each of the other points of the compass indicated a difference of about 45 minutes in the time of high water; thus a line originating at W. by N. indicated that high water occurs about 45 minutes after moonrise and moonset, while one originating at N.W. by N. indicated that high water occurs about 2 h. 15 m. before the transits of the Moon. A tidal chart of this type, by G. Bronscon (c. 1500-25) formerly in the library of Samuel Pepys, is now in the National Maritime Museum at Greenwich. On this chart high water in Liverpool Bay and on the Lancashire coast, and also on the south coast between Portsmouth and Dover, is indicated by lines radiating from N.N.E., i.e. high water occurs 1 1/2 hour before Moon's transit. That the Astronomer Dr Edmund Halley came into possession of such a chart is probable, judging by the following extract from the journal Book of the Royal Society, which reads: « Halley showed the propagation of the tides about the island of Great Britain, that in six hours the western flood was carried through the Channel, but the northern flood from Buchanness to the Foreland required twelve hours; that the whole north part of Irish Sea was full at a time, the like in the eastern part of the Channel, wherein it is high water for all the length of Kent and Sussex, more that 100 miles. »

(1) Journal of the Institute of Navigation, Vol. 1.

Centuries before that, the progress of the tide southwards along the eastern shores of England was known, according to a description attributed to the Venerable Bede (c. 673-735). In an account of the tides of the Solent, it is said : « In this narrow sea, the two tides of the sea, which flow round Britain from the immense Northern Ocean, daily meet and oppose one another. After this meeting and struggling together of the two seas, they return into the ocean from whence they came. »

The erroneous opinion that the tidal wave travels also southwards along the western shores of Britain evidently prevailed in some circles for centuries. It was refuted by one of the early Maritime Surveyors employed by the Admiralty, Graeme Spence, in a memoir dated 1792 : « From the knowledge I have acquired of the tides about the Scilly Isles, and from the very accurate observations of others on the west coasts of Britain and Ireland; I shall next endeavour, for the good of Science, to set some Speculative Writers aright in their account of the Tide which fills the western part of the British Seas, namely that the flood sets to the south along the west coast of Ireland, as well as along the east coast of England, and continues to set to the southward from Ireland to the British Channel and coast of France. » He goes on to describe how the flood tide sets eastward from the Atlantic, dividing off the southwest point of Ireland and then sets northwards along both the west and east coasts of Ireland; that further south the tidal wave travels in an easterly direction between Cape Finisterre and Cape Clear, filling the Bay of Biscay, the English Channel and the Irish Sea as far northward as the Isle of Man.

In a paper read to the Royal Society in 1819, Captain James Anderson, R.N., points out that high water in the English Channel occurs at the same time at Beachy Head and Dieppe, at Fairlight and the Somme, at Dungeness and Boulogne and at Deal and Calais. He goes on to say that when the tide is rising on the shores of Norfolk and Suffolk, it is falling on the shores on Holland, and vice versa. He gives his opinion that the tide which enters the North Sea from the north, and that which enters through the English Channel, meet on a line extending from the Kentish Knock to the Skagerrak.

There was thus by 1835 a fair amount of data with regard to the progress of the tide around the British Isles. Navigators were also aware of the relationship between the time of high water on the shore and the time at which the tidal streams turned in the coastal waters, for the expressions « Tide and half tide », « tide and quarter tide » and « tide and half quarter tide » were commonly used to describe the interval between high water on the shore and the end of the flood stream in offshore waters. In addition some charts of the English Channel showed the results of a tidal stream survey carried out by Dr. Halley in 1701, the times, on the day of full or new Moon, of the end of the eastgoing stream, in various parts of the Channel, being indicated by Roman numerals. As Roman numerals were already invariably used in directories and charts for tabulating the times of high water, on the day of full or new Moon, some confusion was inevitable.

The expression « cotidal line » had been first introduced by Dr. Lubbock in a paper read to the Royal Society in 1831. He defined it as « the series of points at which it is high water at the same instant. » Two charts accompanied this paper, one of the waters around the British Isles and the other of the world; on these charts reputed times of high water on the day of full or new Moon, or

H. W. F & C. were shown. Unfortunately the cartographer who drew these charts seems to have been unaware of the distinction between the Roman numerals used to indicate high water times and those indicating the end of the flood stream. In some places the end of the flood stream occurs 3 hours after high water, and in consequence of the confusion between the times of high water and the end of the flood stream the progress of the tidal wave appeared in some areas to show very marked irregularities. Lubbock confined himself, therefore, to drawing only a few straight lines joining places on opposite sides of the English Channel, and places on opposite sides of St. George's Channel, at which high water occurred at the same time.

There were many criticisms of the data on Lubbock's charts, and in the following year Whewell revised the information on them, using only data from the most recent surveys and from the most reliable authorities. These charts, accompanied a paper entitled « An Essay towards a first approximation to a Map of Cotidal Lines », in which he says : « I have, by the kindness of the Hydrographer, Captain Beaufort, been allowed the free use of the charts and manuscripts belonging to his department, without which advantage, indeed, I should hardly have been able to make the present attempt, imperfect as it may be ». He quotes the following authorities :

« Reconnaissance Hydrographique des Côtes de France » under the direction of M. Beautemps-Beaupré,

« Connaissance des Temps », M. Daussy,

« Annuaire du Bureau des Longitudes »,

« Nories Sailing Directions ».

The surveys of Professor Murdock Mackenzie, Lieutenant Murdock Mackenzie, R.N., and Mr. Graeme Spence, Maritime Surveyors to the Admiralty.

The surveys of Captains Martin White, Mudge and Hewett, R.N.

The surveys of Captain Huddart, at one time in the East India Company, surveyor and engineer.

The charts, sailing directions and tide tables compiled by Mr. Dessiou, Master, R.N.

This data showed that the tidal wave has a regular progress around the British Isles, although at certain points the times of high water change very rapidly. Whewell drew cotidal lines across the English Channel and Irish Sea, joining those points on opposite shores at which H.W.F. & C. are the same. Elsewhere he drew cotidal lines extending only a short distance from the shore. He says : « I cannot conclude this memoir without again expressing my entire conviction of its imperfect nature. I should regret its publication if I supposed it likely that any intelligent person should consider it otherwise than as an attempt to combine such information as we have, and to point out the want and need of more. I shall be neither surprised nor mortified if the lines which I have drawn shall turn out to be in many instances widely erroneous ».

In his final paragraph he makes the suggestion that « Probably tide-observations at all the points of the coast of England where the officers of the Preventive

Service are stationed, carefully made and continued for a fortnight, would give us a clearer view of the progress of the tide along our coasts than we can obtain by any means at present extant ».

This suggestion was put into effect during the following summer, in consequence of representations made to Captain Bowles, Chief Commissioner of the Preventive Service, and to Captain Beaufort, Hydrographer to the Admiralty. The analyses of the observations obtained at the Coastguard Stations were, with the permission of the Hydrographer, commenced by Dessiou who had undertaken the analyses of the tides at London and Liverpool on the lines laid down by Lubbock. Unfortunately towards the end of the year Dessiou fell ill, when only the analyses for the south coast of England were complete. However, those were sufficient to demonstrate the success of the operation and to provide grounds for inaugurating a more ambitious investigation; namely to repeat the observations at the Coastguard Stations in the following summer, and to invite foreign maritime states to make contemporaneous observations on their coasts.

In February 1835, the Hydrographer made the following proposal to the Board of Admiralty : « The great experiment made last summer, of registering for a fortnight the times and heights of high and low water at every Coastguard Station round Great Britain & Ireland, has produced so many interesting facts, that it would be highly expedient to repeat a similar course of observations this year.

The value to Nautical Science of the result, would, however, be prodigiously increased, if simultaneous observations were made along the opposite coasts of the Channel and of the Atlantic, and I have reason to believe that most of the Foreign Governments would cheerfully lend themselves to the enterprise.

The best period for the purpose will be from 9th to the 28th June ; and if their Lordships should approve of the proposition, and will move H.M. Government to invite the co-operation of Denmark, Hamburgh, Holland, Belgium, France, Spain, Portugal and the United States of North America in this useful work, I will lose no time in preparing detailed instructions and printed forms for the uniform entry of the observations ».

In the words of Whewell : « The proposal for the foreign observations was entertained and promoted with great zeal by the Board of Admiralty ; and the Duke of Wellington, at that time Foreign Secretary of State, being applied to, to forward the scheme, His Grace fully acceded to the application, and made requests to foreign governments to join in the undertaking, in a manner which procured from them the most cordial and effective co-operation. Through the ambassadors of the maritime powers of Europe, and through A. Vail, Esq., the Chargé d'affaires of the United States, who entered into this design with great interest, arrangements were made, and directions circulated, for simultaneous observations from the 9th to the 28th of June ».

From these international observations Whewell completely revised his cotidal chart of the waters round the British Isles, and entitled it « a second approximation to a Map of Cotidal Lines ». He also published a cotidal chart of the shores of western Europe, a reproduction of which accompanies this paper.

In referring to the manner in which the observations were made, Whewell says : « The directions were for the most part faithfully and effectively carried out. The observations at different places, made under very different circumstances and by persons of different classes, have, as might be expected, very various

degrees of merit ; but the general relation, both of accordance and discrepance, among the observations, convince me that in almost every instance they were conducted with care and fidelity. In many of the foreign observations the labour employed in order to obtain accurate results has been immense ; and the persons under whose care they have been carried on are men of eminent scientific attainments ».

In Holland, for example, the observations were made under the immediate superintendence of Dr. G. Moll, Professor of Natural Philosophy in the University of Utrecht, and one of the Commissioners for the examination of Naval Officers. In the shallow and exposed waters off the shores of Holland, the labour involved was indeed immense. Gunboats were specially despatched to Sluicedeep, Brouwershaven, Gœdereede, Terschelling and Rottum, to take the observations at those places, and a vessel was hired for that purpose at Ameland. The following extract from Dr. Moll's report refers to the observations at Kykduin : « As the coast is very much exposed to the action of the wind, and nothing affords any shelter, it was only by dint of great exertion and perseverance that a site could be prepared for making the observations at this dreary place. It was found necessary to construct a species of jetty, in order to protect the poles from the surf. A gang of about 40 or 50 seamen from the men of war in Texel, were employed upon this service ».

Dr. Moll also refers to two interesting phenomena on the coast of Holland, which had not previously come to the notice of scientists. The first extract refers to the « agger », or double low water at Gœdereede : « A very curious observation was made at this station. It is a phenomenon well known to pilots and fishermen frequenting this port, that exclusive of the ordinary tides an extraordinary and periodical rise of the water takes place which is called « agger » by the seafaring people of this district ». The second extract refers to the « naspui » or double high water at Kykduin : « Another phenomenon relating to the tides, is well known on this coast under the name of « naspui ». It consists in this, that about an hour before the time given by the common reckoning for high water, it begins to fall a little and soon afterwards rises as high and sometimes higher than before ».

The following is the report of the Commission, appointed to supervise the tidal observations in Portugal, addressed to Baron de Sa' da Bandeira, Secretary of State for Marine.

« Most Illustrious and Excellent Sir,

The Members of the Commission charged to direct a series of observations on the movement of the Tides, in accordance with the Instructions published in England by the Lords of the Admiralty on a similar subject, foreseeing that the greatest practical difficulty in such observations would be, even in the calmest weather, the continual disturbance of the water, directed their first attention to every possible means for the removal of this serious inconvenience; bearing this in view, they caused the gauges destined to mark the continual height of the Tides to be enclosed in a quadrangular case, with a small orifice at the base so that the surface of the water in the interior of the case would follow the slow movement of the tide without, however, being subject to the rapid action of the waves.

These Gauges being constructed, the Commission charged very able officers to visit all the points of the Coast and to choose situations that under every pos-

sible shelter, were yet placed out of the reach of the causes, which in Rivers, as also in Bays, retard, or accelerate, the movement of the Tides. These officers fulfilling completely the first part of their instructions, placed conveniently those gauges, and being furnished previously with good Chronometers, and other instruments necessary to observe most scrupulously their rate, commenced on the ninth day of June a series of simultaneous observations.

The Maps with the results of these observations, which the Commission now addresses to Your Excellency show all the Phenomena of the movement of the Tides. The maximum and minimum of the heights, and velocity at the different periods of the rise and fall, and every essential circumstance which might influence its variations, such as the force and direction of the wind, are therein minutely explained.

The Commission confide entirely in the zeal, knowledge and scrupulous attention of all the Officers who presided at these observations, and therefore placing before Your Excellency the result of their labours, have no difficulty in assuring Your Excellency that the series of observations have a degree of practical certainty, that joined to others which might be made in other parts of the globe, may serve as a basis for any reasoning or system, tending to the progress of Physical Knowledge.

God preserve Your Excellency. »

The extracts from these reports typify the fine spirit in which this investigation was carried out by all the countries concerned. The following is a list of the stations in Europe and America, at which the observations were obtained.

PORTUGAL

Oporto
Vianna
Peniche
Cascaes
Sines
Pera
Bay of Lagos.

SPAIN AND MOROCCO

Bilbao
Santander
Ferrol
Camarinas
Cadiz
Algeciras
Ceuta.

BELGIUM

Ostend
Blankenberg
Rade Ste-Marie
Anvers
Nieuport.

FRANCE

Dunkerque
Calais
Boulogne
Cayeux
Dieppe
Havre
Lambrille
Barfleur
Cherbourg
Granville
Chausey
St-Servan
Bréhat
Abrevrack
Ile d'Ouessant
Brest.

NETHERLANDS

Spaardam
Zwanenbury
Amsterdam
Rottum
Ameland
Ter Schelling
Nieudiep
Kykduin
Petten
Katwyk
Delfland
Brielle
Hellevœtsluis
Goedereede
Brouwershaven
Westkapelle
Flushing
Sluice deep.

DENMARK

Altona
Pin Aue
Gluckstadt
Brunsbuttel
Meldorf
Tonningen
Stein Schleuse
Vollerwick
Ording
Pelvorm
Seesand
Amrum
Wuck
Sonderhoe
List
Blaavands Huk
Nyeminde Gab
Torskminde
Agger
Hals
Frederikshavn
Skagen
Hirtshals.

NORWAY		U.S.A.	
Tromsoe	Tananger	Eastport (Maine)	Gosport
Andenaes	Lindesnaes	Mount Desert Isle	Cape Hatteras
Varoe	Christiansund	Portland	Cape Fear River
Froyen	Oxoe	Portsmouth	Charleston
Munkholm	Arendal	Gloucester	Savannah
Christiansund	Ostre Rusoer	Boston	St. Augustine
Runde	Jomfruland	Cape Cod	Key West
Kumlesund	Langesund	Provincetown	Tampa Bay
Bergen	Frederikswaern	Nantucket	Pensacola
Skudesnaes	Valoerne	Newport	Mobile Point
Stavanger	Frederikstad	Warren	Fort Wood
	Horten	Gardiners Bay	Fort Pike.
	Svelvigen.	New York	
		Sandy Hook	SOUTH AFRICA
		Delaware	Simons Bay
		Old Point Comfort	Table Bay.

The observations were obtained under the direction of Count Toreno in Spain, M. Beautemps-Beaupré in France, Captain Tegner in Denmark and the Honourable Mahlon Dickerson, Secretary of the Navy in the United States. The Danish observations were forwarded in a bound volume, accompanied by a similar volume containing Captain Tegner's analyses of the observations. In every case the names of the officers who supervised the observations were given on the forms.

Previously the tidal charts of the Middle Ages and Whewell's earlier cotidal chart gave the high water time on the day of full and new Moon, H.W.F. & C. ; which, on the assumption that the Moon's transit occurs on those days at O.H., is also the interval from the Moon's transit. This lunitidal interval on the day of full and new Moon was known as the « Vulgar Establishment of the Port ».

From the International Observations, the lunitidal intervals of every high water were calculated for each port. The intervals for each port were then plotted and a smooth curve drawn through them, and the mean lunitidal interval obtained by averaging the greatest and least intervals from that curve.

The Moon's parallax and declination affect the greatest and least intervals occurring in any semilunation, and thus the mean lunitidal interval in that semilunation. From the prediction tables computed by Dessiou for London and Liverpool, it was found that at those two ports, the average of the greatest and least intervals during the period of the International Observations was 7 minutes greater than the true mean, or « Corrected Establishment ». In order to find the « Corrected Establishment » at the ports where the international observations were obtained, Whewell subtracted 7 minutes from the average of the greatest and least interval at each port.

These « Corrected Establishments » were converted from solar to lunar time and reduced from local to Greenwich time to become « Cotidal Hours ». The following table shows for some of the principal ports, the greatest and least lunitidal intervals occurring during the observations, the « Corrected Establishments » and the « Cotidal Hours ».

Place	Least Interval	Greatest Interval	1/2 Diff. — 7 min.	Corrected Establis.	Long	G.M.T. Corrected Establis.	Cotidal Hour
Europe	H.M.	H.M.	M.	H.M.	M.	H.M.	H.M.
Cadiz	1 02	2 32	38	1 40	+ 25	2 05	2 02
Cascaes	0 50	2 22	39	1 29	+ 35	2 04	2 01
Ferrol	1 45	3 28	44	2 29	+ 32	3 01	2 58
Brest	2 48	4 17	37	3 25	+ 18	3 43	3 36
Cork	3 57	5 32	40	4 37	+ 33	5 10	5 01
Plymouth	4 24	5 56	39	5 03	+ 17	5 20	5 10
Cherbourg	6 55	8 25	38	7 33	+ 6	7 39	7 24
Havre	8 50	10 37	46	9 36	0	9 36	9 17
Dover	10 22	11 53	38	11 00	— 5	10 55	10 33
Ostend	11 35	13 22	46	12 21	— 12	12 09	11 44
Flushing	00 40	2 20	43	1 23	— 14	1 09	1 06
Katwyk	1 20	3 05	45	2 05	— 17	1 48	1 44
Ter-Schelling	7 48	9 20	39	8 27	— 21	8 06	7 49
Rottum	10 00	11 25	35	10 35	— 26	10 09	9 48
Norderpiep	11 48	13 25	41	12 29	— 36	11 53	11 30
Amrum	12 13	14 07	50	13 03	— 33	12 30	0 04
Hirtshals	Calculated by			16 27	— 40	15 47	3 14
Skagen	Capt. Tegner			17 55	— 42	17 13	4 37
Christiania	4 44	6 34	50	5 34	— 44	4 50	4 39
Arendal	3 09	5 09	53	4 02	— 37	3 25	3 17
Stavanger	—	—	—	9 54	—	—	9 12
Andaenes	12 08	13 36	37	12 45	— 60	11 45	11 22
Tromsoe	0 32	2 10	42	1 14	— 75	2 29	2 27
U.S.A.					H.M.		
Key West	9 15	10 45	38	9 53	+ 5 57	3 50	3 30
Charleston	6 57	7 57	24	7 21	+ 5 20	0 41	0 26
Sandy Hook	7 05	8 18	30	7 35	+ 5 00	0 35	0 20
Cape Cod	10 50	12 15	35	11 25	+ 4 38	4 03	3 40
Portsmouth	11 00	12 13	30	11 30	+ 4 44	4 14	3 51

Very approximately the cotidal hours of places near the meridian of Greenwich are about half an hour less than the times of H.W.F. & C. shown on the old tidal charts and on Whewell's earlier cotidal chart.

On his revised cotidal chart of the waters around the British Isles, Whewell showed three sets of cotidal lines. For the purpose of comparison he showed his earlier cotidal lines drawn for the times of H.W.F. & C., and also cotidal lines drawn for the times of H.W.F. & C. as determined from the international observations and thirdly, the cotidal lines drawn for the new «Cotidal Hours».

It will be noticed in the preceding table that between Ferrol and Brest the « G.M.T. Corrected Establishment » is not very dissimilar from that at Key West in Florida. It is interesting that this similarity seems to have been known

for a very long time, for Francis Bacon (c. 1561-1626) refers to it in his essay entitled « De fluxu et refluxu maris ». The fact that high water, when referred to a common standard time, appeared to occur simultaneously on the Atlantic shores of N. America and Europe, was regarded as a proof of the theory that the tidal wave was propagated northwards into the Atlantic from the Southern Ocean.

It was the International Observations which first cast serious doubt on that theory. In this connection one of the aspects of those observations which particularly interested Whewell was the diurnal inequality in the heights of successive tides. He says : « The Diurnal Inequality of the tides is only now beginning to be attended to as it deserves; for it is a regular change, considerable in its amount and almost universal in its prevalence. It would be easy to enumerate many actual cases in which the safety or loss of a ship has been determined by this inequality ».

The International Observations showed that the diurnal inequality occurred at very different dates on the opposite shores of the Atlantic. In reference to this, Whewell says : « The different epoch of the diurnal inequality in different parts of the world is a very curious fact; and the more so, since it is inconsistent with the mode hitherto adopted of explaining the circumstances of the tides, by conceiving a tide-wave to travel to all shores in succession. In accordance with this view, the tide on the shores of America had been considered as being identical with the tide on the coasts of Spain and Portugal, which occurs about the same moment; nor does it appear easy to imagine the form of the tide-waves so that this shall not be the case. Yet we find that the tides on these two sides of the Atlantic cannot be identical in all respects; for on the 9th, 10th and 11th of June, when the diurnal inequality was great in America, it was nothing in the west of Europe and on the 18th and 19th, when this inequality had vanished in America, it was great in Europe. I may add that the notion of the progress of the tide-wave from south to north in the Atlantic is still further involved in difficulties by its appearing that at the Cape of Good Hope, the diurnal inequality showed itself most clearly on the 17th, 18th, and 19th June, as in Spain and Portugal ».

On account of these facts, Whewell decided not to draw a new cotidal chart for the world, but to defer the attempt until considerably more data were available. He never produced that cotidal chart, for his later researches led him to have little confidence in the value of cotidal lines, except near the shore and in partially enclosed waters. In a paper printed in 1854, he says : « The result is that we are led to consider whether the oceanic tides may not be produced by a great oscillation of the ocean, the littoral tides being derived from them ».

This view was first advanced by Captain FitzRoy, R.N., in an appendix to his Narrative of the Surveying Voyages of *H.M.S. Adventure* and *Beagle* (1826-1836). FitzRoy received from Whewell a copy of his « Essay towards a first approximation to a Map of Cotidal Lines », which stimulated his interest in the tides. In his journal, he says : « From 1833, I and my companions on board the *Beagle* paid more attention to the subject and made observations in the manner suggested by Mr. Whewell, as often as our other avocations allowed. It was, however, impossible to take an interest in the subject, and discover difficulties, facts irreconcilable to theory, without trying to think how to account for them ». His own observations, and those of others led him to the following conclusion : « It may appear presumption in a plain sailor attempting to offer an idea or two on the difficult subject of Tides; yet with the utmost deference to those who are competent to reason upon the subject, I will venture to ask whether the supposition of Atlantic tides being principally caused by a great tide-wave

coming from the Southern Ocean is not a little difficult to reconcile with the facts that there is very little tide upon the coasts of Brazil, Ascencion, and Guinea and that in the mouth of the great river Plata there is little or no tide ». He reasoned that the same wave did not traverse the whole ocean but that each zone of that ocean had its own libration or oscillation, depending on its particular size, shape and depth. These phrases he defines thus : « By librating I mean such a movement as that which a large jelly would have, if its upper part were pushed on one side, and then allowed to vibrate while the base remained fixed; and by oscillating I mean a movement like that of water in a basin, after the basin is gently tilted and let down again ».

In the case of the North Sea, Whewell had referred in his earlier essay to the extreme difficulty of forming the tides of the North Sea into a consistent and intelligible scheme. With the data available from the International Observations he says: « We may combine all the facts in a consistent scheme, by dividing this sea into two rotatory systems of tidal waves ». In the northern part of the North Sea he depicts the cotidal lines revolving round a point off the coast of Jutland, and in the southern part he depicts the cotidal lines revolving round a point, where there is no tide, near latitude 52° 10' N., and longitude 2° 50' E.

Captain Hewett, R.N., was at that time engaged in surveying this southern part of the North Sea, and was instructed by the Hydrographer to obtain tidal observations in the position of this amphidromic point. Hewett made two attempts in 1837, but it was not until the following year that he developed a satisfactory technique for obtaining really accurate tidal observations in the open sea. In that year, in latitude 51° 46' N., and longitude 3° 02' E., he found a range of 5 feet at spring tides. In 1840, however, he took observations for a period of 24 hours in latitude 52° 27' N., and longitude 3° 14' E., when astronomical conditions were such that the range of the tide would have about its average value, and found it not to exceed 1 foot.

In his report to Captain Beaufort he says : « Although I was then many miles both to the northward and to the eastward of the spot near which Mr. Whewell had previously expressed his wishes that the experiment should be made, yet I thought that if good observations by any means could be obtained at the above position, they would at least serve to show, in some measure, the truth or error of that gentleman's theory ». He concludes that report with the words : « I would offer my congratulations to Mr. Whewell on these results, should they prove in any degree gratifying to him ».

A great enterprise had been completed, to which perhaps a thousand observers, scattered far and wide along the shores of the Atlantic, had contributed. The most southerly observations, those at the Cape of Good Hope, were supervised by the astronomer Herschell, and some of the other observers would, perhaps, have endorsed the opinion which he expressed in his report to Whewell, that, « Observing the tides is the greatest bore upon earth, or on the waters, and the greatest exhauster of a man's patience and trial of his temper ».

The material from which this account has been compiled consists mainly of copies of Whewell's and Lubbock's papers, presented by the authors to Dessiou and Beaufort; the original tidal observations and the accompanying reports; the Hydrographer's minute book for the years 1831-1837; letters and reports of Whewell, Herschell, FitzRoy, Hewett and Graeme Spence; which are among the original documents of the Hydrographic Department.