stations; as also constant observation of the course which the ship may be steering.

December 16, 1847.

Sir ROBERT HARRY INGLIS, Bart., V.P., in the Chair.

"Thirteenth Series of Tide Researches." By the Rev. William Whewell, B.D., F.R.S.

The first part of this paper, "*On the Tides of the Pacific*," forms a sequel to former papers by the same author, especially to his first memoir on this subject, printed by the Royal Society in 1833 ('Essay towards a first approximation to a map of Cotidal Lines'), and to the *Sixth Series* published in 1836 ('Results of an extended series of Tide Observations made on the coasts of England and America in June 1835'). Among the results obtained in the latter paper, it appeared that all the "cotidal lines" which have been most exactly traced, meet the coast at a very acute angle; and for that and for other reasons stated in other memoirs, the drawing of cotidal lines across wide oceans is a very precarious process. In addition to this consideration, the scantiness of our materials has hitherto made it impossible to trace the tides of the Pacific in a connected form; and the absence of lunar tides in the central parts of that ocean (as at Tahiti) makes it difficult to represent the course of the tides by means of cotidal lines at all. We are thus led to consider in what other way the course of the tides over wide spaces may be represented: and it is stated by the author, that either a *stationary undulation*, or a *rotatory undulation*, of the central parts of an ocean, with a border of cotidal lines proceeding outwards from the central undulation into bays and arms of the sea, would represent, in a great measure, the tidal phenomena of the Atlantic and Pacific, as far as they are known. The *rotatory undulation* here spoken of need not be understood to be a *rotatory motion* of the water, but a geometrical rotation of the cotidal line, such as takes place in the German Ocean; the tide in the central part (that is, the rise and fall of the surface) vanishing, as was shown by the observations of Capt. Hewett, though the tidal currents at that point alternate regularly. Such a movement of the cotidal line may perhaps represent the phenomena of the North Pacific.

The author has collected materials for a Tide Map of the Pacific from various navigators;—Cook, Flinders, King, Captains FitzRoy, Sir E. Belcher, Sir James Ross, Stokes, Killet, and others of our own countrymen; Malaspina, Freycinet, Du Petit-Thouars, Wrangel and Admiral Lütke, and other Spanish, French and Russian navigators. The result of these appears to be, that on the eastern coast of the Pacific, the tide comes from the west; arrives first at the coast near Acapulco and Nicoya, and is later and later both to the north and to the south of this point; passing to the eastward round Cape Horn, as observed by King, and to the northward along the coast of North America, and then to the westward along the Aleutian Isles, and so to Kamtschatka, as stated by Admiral Lütke.

The tides in the centre of the Pacific are too small and anomalous to allow us to trace the connection among them. At Tahiti, according to the observations of Sir Edward Belcher, the solar and lunar tides appear to be equal.

The tides have been traced along the coasts of New Zealand and Australia by Cook, Flinders, and other succeeding navigators. They come from the east; and the cotidal lines which mark their progress appear to have a north and south range, except when deflected by passing round promontories and the like. When we pass westward from the eastern coast of Australia, the cotidal lines are too much broken and complicated by the intervention of islands, to be traced with our present materials of knowledge.

The second part of the memoir, "*On the Diurnal Inequality*," treats of the difference of the two tides of the same day, which has also been discussed in former memoirs by the author, and its laws so fully made out, that this inequality has been introduced into the tide tables for Liverpool and for Plymouth. This inequality depends mainly on the moon's declination. In England it is small: it is very marked on the coasts of Spain, Portugal and North America, as was shown by the observations of 1836: but in the North Pacific and in the Indian seas, it reaches an enormous amount, and shows itself with curious differences. In many places in those seas, the diurnal inequality is much larger than the differences of spring and neap tides, and is so large as utterly to confound the usual modes of estimating the "establishment" of a place.

This inequality affects the tides of various parts on the coast of Australia to a very great amount, and with very remarkable differences. It is seen at Adelaide on the south, and Port Essington on the north coast; and at each place it produces a difference of several feet between every two successive tides, when it is at its maximum: but this difference affects mainly the *high waters* at Adelaide and the *low waters* at Port Essington*. Also on the west coast of Australia, near Swan River, the diurnal inequality appears with another peculiarity, affecting the times of high water rather than the heights. These differences, the author remarks, show that the diurnal wave travels separately from the semidiurnal wave; but our materials do not at present enable us to analyse the compound tide into these two waves, and to trace the course of each.

The author observes, in conclusion, that our knowledge of the tides is not likely to be completed, nor even much advanced, by tide observations made by navigators and surveyors voyaging with other main objects. The later observations of the Pacific, though made with great industry, have added little to the knowledge derived from Cook, Flinders and King, because they were not geographically connected with each other: and the great discrepancies of the obser-

* These results follow from a series of tide observations made at Adelaide by Mr. Bealten, and at Port Essington by Sir Gordon Bremer.

vations at the same place show how little correctness the mean of them, or the result, however obtained, can pretend to.

The results of the recent observations, with which the author has been furnished by various navigators and by the Hydrographer's Office, have been obtained by throwing the observations into curves, according to methods formerly used and described by the author. This labour has been carefully performed by Mr. D. Ross of the Hydrographer's Office.

January 6, 1848.

GEORGE RENNIE, Esq., Treasurer, in the Chair.

"On Terrestrial Magnetism." By William A. Norton, A.M., M.A.P.S., Professor of Mathematics and Natural Philosophy in Delaware College, United States of America. Communicated by Lieut.-Colonel Edward Sabine, R.A., For. Sec. R.S.

The object of the author in the present memoir is to show that, by adopting certain fundamental conceptions with respect to the terrestrial magnetic forces, the magnetic may be deduced from the thermal elements of the earth. The following are the propositions which he considers he has established by his inquiries.

1. All the magnetic elements of any place on the earth may be deduced from the thermal elements of that place; and all the great features of the distribution of the earth's magnetism may be theoretically derived from certain prominent features in the distribution of its heat.

2. Of the magnetic elements, the horizontal intensity is nearly proportional to the mean temperature, as measured by Fahrenheit's thermometer; the vertical intensity is nearly proportional to the difference between the mean temperatures, at two points situated at equal distances north and south of the place, in a direction perpendicular to the isothermal line; and, in general, the direction of the needle is nearly at right angles to the isothermal line, while the precise courses of the inflected line, to which it is perpendicular, may be deduced from Sir David Brewster's formula for the temperature, by differentiating and putting the differential equal to zero.

3. As a consequence, the laws of the terrestrial distribution of the physical principles of magnetism and heat must be nearly the same; and these principles themselves must have towards one another the most intimate physical relations.

4. The principle of terrestrial magnetism, in as far as the phenomena of the magnetic needle are concerned, must be confined to the earth's surface, or to a comparatively thin stratum of the mass of the earth.

5. The mathematical theory of terrestrial magnetism which has been under discussion must be true in all its essential features.

6. We may derive the magnetic elements by very simple formulæ, and with an accuracy equal to that of Gauss's formulæ, from a very