classic theory of the tides. He shows that in using LAPLACE'S approximation, namely, to neglect the vertical acceleration in face of the horizontal acceleration in the problem of the tides, there is a risk of its proving insufficient in certain cases, notably in those regions where, on account of interference, the current remains roughly nil while the amplitude of the vertical oscillation may be relatively considerable.

Further, the Laplacean hypothesis of a displacement *en bloc* of the molecules of an individual vertical is only legitimate when the depth is small as compared with the wave-length; it may thus be invalid in certain restricted regions where the proper periods of oscillation may be short.

A more complete theory which takes the vertical acceleration into account (*) has shown that while the hypotheses of LAPLACE are sufficient for the study of the oceans as a whole, it is quite possible for certain isolated basins, deep and not very extensive, to have superposed nodal surfaces and turn out to be sites of vertical propagation.

As a result of numerous observations made in Scandinavian waters since 1907, it has been found in the region where stratification of the sea water is very distinct that internal tidal movements are shown by the soundings at the boundaries of the layers.

These new phenomena, which are found to have a semi-diurnal period, have been discussed by Prof. PETTERSSON in the work quoted above with a view to sketching out a possible solution of these anomalies.

Assuming in the high seas an upper layer of lesser density (the troposphere), and a lower layer (the stratosphere), the equipotential boundary surface of the two layers would be capable of extreme mobility under the action of the ascending and descending movements caused by the rhythmical variation of the vertical force of the tides. This vertical component, though powerless to affect the surface tide, would have the power to cause internal tidal movements in the open sea. The presence of this equipotential surface, which might be called the tropopause of the ocean, separating layers of different homogeneity, is especially in evidence at certain places. Observations place it at a depth of about 17 metres (9.3 fms.) in the Kattegat and 100 metres (54.7 fms.) in the equatorial Atlantic. It was in the Gullmarfjord that in 1909 an effect of internal tide was first observed, having an amplitude of about 15 to 20 metres and a period of twenty-seven days.

Prof. PETTERSSON insists upon the necessity, for this kind of observation, of using current meters of more advanced design, solidy moored on tripods and capable of taking photographic records.

CURRENTS OF THE NORTH SEA.

(Extract from *Nature*, London, October 6, 1934, p. 543).

The measurement of horizontal currents in the sea presents numerous practical difficulties. In the northern North Sea these difficulties have been mainly overcome by the use of drift-bottles of suitable design. Recent analyses of elaborate drift-bottle experiments confirm the presence of extensive drift-currents in the northern North Sea. The drift-bottle and hydrographical records show that the main stream current affecting the northern North Sea is that which brings in Atlantic water around the north of Shetland through the Faroe-Shetland Channel.

In the southern North Sea, the hydrographcial conditions are governed largely by the flow of water through the Straits of Dover. By means of a current meter attached to the Varne Lightship, data concerning the strength and direction of this current have been collected continuously over the last eight years. The varying water movements observed, when balanced out over a term of years, have effected the same overall transport of water as would have been accomplished by a very slow river flowing at the rate of about 3.2 miles a day from the English Channel into the North Sea. In certain circumstances the current flows the other way. Following winds quicken it and head

(*) Marcel BRILLOUIN *and* Jean COULOMB : Oscillations d'un liquide pesant dans un bassin en rotation (*Oscillations of a heavy liquid in a basin in rotation*) : GAUTHIER-VILLARS, 1933.

winds impede it. A play of such wind conditions over the North Sea at large, as would be expected to pool up the Southern Bight (and north-westerly wind conditions are well known to do this), can most effectively hold up and reverse the current.

The results of the last three years are of especial interest, for, instead of the residual current heading boldly into the North Sea (as it most frequently had done in the previous three years) it has displayed less and less easting with the passage of time. During 1933, the current headed about half a point west of north.

Such long-enduring modifications of the current are held to be analogous in a way to the short-lived modifications produced by wind influence. The inferred cause, in their case, however, is an oceanic pulse — an accession of strength on the part of the parent supply stream which flows in from the ocean round the north of Scotland. This causes an extra strong southward urge of waters through the North Sea — with the results observed in 1933 particularly.

The Dover Straits current attains its strongest and weakest rates of flow a half year later than does the current entering the North Sea round the north of Scotland, but a quarter year later than the current in the Cromer Knoll region.

These facts are interpreted to indicate that the Dover Straits current waxes and wanes through the year in a sort of buffer relationship with the current from the north — that there exists a sort of seesaw conflict between the two. The vagaries of the Dover Straits currents are, on the strength of the findings mentioned, held to serve as pointers to major modifications of the currents in the northern and middle reaches of the North Sea half a year earlier.

ÜBER STROMUNRUHE.

(ON THE IRREGULARITIES OF CURRENTS).

From observations made in the Kattegat in August 1931.

by

H. THORADE.

An account was given in *The Hydrographic Review*, Vol. XI, No. 2, November 1934, page 179, of Messrs. A. DEFANT and O. v. SCHUBERT'S book on the current measurements carried out in August 1931 in the Kattegat by an oceanographical expedition in which four nations took part. Issue IX of 15th September 1934 of the *Annalen der Hydrographie* contains, on pages 365 to 377, an important article by H. THORADE on the same observations from a different point of view, which is of interest in the case of all current observations made on board an anchored ship.

The writer has worked out with the utmost care the observations made by the *Poseidon* with Dr. H. RAUSCHELBACH'S current-meter (1).

This apparatus, which was exhibited at Monaco in connection with the Supplementary International Hydrographic Conference 1929 and a brief description of which was given in *The Hydrographic Review*, Vol. VII, No. 1, May 1930, pages 115 to 123, by its twin-cable suspension continuously refers the direction of the current to the ship's head and records it every 10 seconds; the speed of the current is measured by recording every ten revolutions of the current-meter's screw.

From a very careful analysis of the observations H. THORADE comes to the following conclusions :—

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(1) See H. RAUSCHELBACH. — *Beschreibung eines bifilar aufgehängten, an Bord elektrisch registrierenden Strommessers* — Supplement to the *Annalen der Hydrographie*, 1929.