

er, dass in den obigen Formeln anstelle der Drucke p_i und p auch die sogenannten Druckanomalien gegenüber einem homogenen Meer von 0° und $35^\circ/\infty$ genommen werden können. Als Tiefe d_i der Deckschichte wählt er 1000 dyn. m. Die konstruierte Strommengekarte entspricht im wesentlichen den sogenannten Isobaren-Karten in der Abhandlung von HELLAND-HANSEN und NANSEN; die P -Linien zeigen, wie die dynamischen Isobathen, die kräftige Ausbuchtung nach Süden, die bekanntlich als Wirkung einer morphologischen Beeinflussung des Bodenreliefs auf die Meeresstömungen angesehen wird. Insofern nur die Schichte Oberfläche bis 1000 m Tiefe berücksichtigt wird, werden hier im südlichen Teil der Karte (etwa 47° N. Br.) etwa 2 Millionen Tonnen, im nördlichen Teil (etwa 66° N. Br.) rund 1,6 Millionen Tonnen Wasser per Sekunde transportiert.

Ohne Zweifel wird bei zukünftigen dynamischen Berechnungen von ozeanographischem Beobachtungsmaterial die Ermittlung der Strommengekarte eine grosse Rolle spielen und uns so einen weiteren Einblick in die Dynamik der Konvektionsströme gewähren. A. DEFANT.

J. E. FJELSTAD. Ein Beitrag zur Theorie der winderzeugten Meeresströmungen. Gerlands Beiträge zur Geophysik. B. 23, H. 3. Leipzig, 1929.

S. F. GRACE. Internal Friction in Certain Tidal Currents. Proc. Roy. Soc., A, vol. 124. London, 1929.

In the theory of ocean currents the internal friction between the water strata moving on top of one another has proved to play an important rôle. With internal friction should then be understood not only the molecular viscosity due to the irregular free motions of the individual molecules but chiefly the enormously intenser effect of turbulence, i. e., of irregular motions of larger or smaller masses of water. As a rule it has been assumed that this latter effect can be interpreted as an "eddy viscosity" acting in a similar way to molecular viscosity; so that their combined effect may be correspondingly expressed by a "virtual coefficient of viscosity", which would everywhere be much greater than the coefficient of molecular viscosity and would vary considerably from one place to another according to conditions. For the sake of mathematical simplicity, and in the absence of any other reasonable particular assumption, most oceanographers have assumed this coefficient to be constant along any vertical line.

In later times several writers have endeavoured to do without this conventional assumption, either replacing it by the more general assumption of a variable coefficient or even rejecting altogether the idea of a virtual viscosity. According to the latter view the effect of turbulence on the mean motion may be equivalent to a tangential stress, which does not, however, necessarily act in the direction of shear or vanish in case of no shear. This view has become of more actual interest in face of the important researches of L. F. RICHARDSON, according to which the eddies of turbulence — in any case in the atmosphere — may have different dimensions up to very large ones. For it is obvious that it is not strictly possible to express the effect of turbulence in terms of viscosity, if the distances covered by individual masses of turbulently moving water (corresponding to the

mean free path in the theory of gases) are not very small as compared to all other linear dimensions appearing in the problem.

I wish in these remarks to call notice to some contributions tending towards the theoretical development here referred to.

FJELSTAD in his paper keeps to the conception of (eddy-) viscosity though with a virtual coefficient which may vary in any way along the vertical. An interesting formula is given, by means of which this coefficient may be calculated for any level whatever, if the velocity and direction of motion are known (by observation or by interpolation) everywhere from the level in question down to the bottom. The validity of the formula is restricted to the case of stationary, pure drift currents; *i.e.*, the horizontal pressure gradient is assumed to be *nil*. On the other hand it requires no derivations except one derivation of the direction of motion, and it is therefore more convenient and better suited to give accurate results than the corresponding methods developed by TH. HESSELBERG in 1919 and by H. SOLBERG in 1925.

The author applies his method to the currents observed by H. U. SVERDRUP in 1924 at a station north of Siberia, or really to the average motion there during a tidal period. Furthermore he gives an interpolation formula with two parameters for the virtual kinematic coefficient of viscosity

$$\nu = \nu_0 \left(\frac{z + \epsilon}{h + \epsilon} \right)^{0.75},$$

where z and h are the depths from the sea surface down to the water layer under consideration and to the sea bottom respectively, and where ν_0 and ϵ are parameters. The formula proved to fit the computed values of ν very well. From these values the author back-calculates the velocities of the current in the several levels. There is good agreement between the calculated and the observed velocities, which implies an additional verification of the computed values of ν . [The same series of observations has been analysed before by means of HESSELBERG's formula but not with quite as good results (H. U. SVERDRUP. The Waters on the North Siberian Shelf. Bergen, 1929)].

The paper by S. F. GRACE deals with tidal currents and more particularly with the semi-diurnal lunar harmonic constituent of these currents and of the friction in certain places, chiefly in the North Sea. It owes its interest mainly to the fact that the author has in a way made himself independent of the conception of viscosity.

Two alternative assumptions are made. One is so far in accordance with the notion of viscosity that the tangential stress is assumed to vanish in each level where the velocity is stationary with depth. The other, suggested by G. I. TAYLOR, is that the tangential stress vanishes at the sea surface but not necessarily at such levels where the velocity is stationary. The latter assumption is strongly at variance with common conceptions, but it is in reality the more plausible one (for, since an harmonic constituent of tidal currents only is concerned, the tangential stress of the wind must be supposed to be effectively eliminated), and it would have been extremely interesting to have had it put to a conclusive test. Unfortunately

— as the author has himself emphasised — the series of observations at disposal is rather scanty, and is not likely to be sufficient for that purpose.

The author attempts to calculate, by means of an interesting method, the components of frictional force acting in different levels: It should be remarked that, since his method is essentially based upon the commonly accepted non-linear relationship between skin-friction and velocity at the bottom, the semi-diurnal harmonic constituent of the friction cannot be expected to be entirely predominant, even if that would be the case with the corresponding constituent of the velocity as compared to its other harmonic and irregular constituents. This circumstance — as well as the possibility of not inconsiderable errors connected with certain inevitable extrapolations — reduce the importance of the present results. The paper is presented by the author as a preliminary survey only, and a closer study of the subject will certainly be looked for with great interest.

V. WALFRID EKMAN.

GEORGE F. McEWEN. A Mathematical Theory of the vertical Distribution of Temperature and Salinity in Water under the Action af Radiation, Conduction, Evaporation, and Mixing due to the Resulting Convection. Bull. Scripps Institution of Oceanography, La Jolla, Cal., Techn. Ser. Vol. 2, Nr. 6, pp. 197—306, 11 figures in text, University of California Press, Berkeley, Cal.

Die Arbeit ist eine Erweiterung und Vertiefung früherer Arbeiten des Verfassers, besonders einer zur 50-Jahrsfeier der Universität von Californien 1918 erschienenen Schrift, die sich mit dem kalten Auftriebwasser an der Californischen Küste beschäftigte. Seltener wird eine mathematische Theorie fähig sein, den physikalischen Vorgängen ausgedehnter Gewässer im Einzelnen zu folgen; vielmehr wird sie stets vereinfachende Annahmen machen müssen, um der Probleme Herr zu werden, und deshalb hängt die Anwendbarkeit einer solchen Theorie nicht nur von ihrer mathematischen Eleganz ab, sondern davon, in welchem Grade die zu Grunde gelegten Annahmen sich den wirklichen Verhältnissen anpassen. Gerade in diesen Grundannahmen geht daher der Verfasser über seine früheren Arbeiten hinaus. Die Sonnenstrahlung dringt nur wenige Meter tief ein; die Weiterleitung der Wärme übernehmen vertikale Strömungen und turbulente Vorgänge, während die Oberfläche sich durch Leitung, Strahlung und Verdunstung, am stärksten durch letztere, abkühlt, jedoch nicht überall gleichmäßig, sondern fleckenweise verschieden stark. Dadurch werden einzelne Wasserteilchen spezifisch schwerer und sinken ab; aber auch hierzu ist allerdings nach dem Verfasser notwendig, dass der Unterschied des spezifischen Gewichtes erst einen gewissen Schwellenwert überschreiten muss, ehe ein Teilchen sich in Bewegung setzt. Nun denke man sich die Unterschiede zwischen der Dichte der sinkenden Wasserteilchen und der ihrer Umgebung nach ihrer Grösse geordnet; dann werden am seltensten solche Teilchen vorkommen, die relativ am schwersten sind, und umgekehrt; anderseits dagegen werden sie sich am schnellsten abwärts bewegen. McEWEN's Grundvorstellung besteht also darin, dass bald hier Gruppen von relativ schweren Teilchen in grossen Abständen und schnell, bald dort Gruppen von relativ nur wenig