Wind Drift.

A STRONG wind at sea has long been known to cause a drift of the upper layers of water superimposed upon the regular and periodic tidal currents. Sailing coastwise in clear weather, the navigator can determine the position of his vessel by bearings on landmarks, but in thick weather he can no longer do this, and it then becomes a matter of importance to know the velocity and direction of the currents, both tidal and wind-blown, to which his vessel may be subject. In sailing and slow-moving ships, seamen have need to make a rough allowance for this wind drift, in addition to the leeway made by the vessel, when calculating their position by dead reckoning in bad weather. The necessary allowance has never been more than a guess, usually on the assumption that the wind-blown current runs in the direction of the wind, simply augmenting or decreasing the normal speed of the tidal currents.

The early theory due to Zöppritz was based on a consideration of the internal friction of sea-water in regular motion, and took no account of either eddy motion in the water or the effect of the rotation of the earth upon the wind-driven current; it fitted in with the general experience of seamen, but did not accord with later observations of the drift of the *Fram* in the polar ice, during 1893-95, when the ice drifted some 28° to the right of the wind's direction and proceeded on the average at 2 per cent. of the wind's velocity. A mathematical consideration of the forces due to the tangential pressure of the wind on the surface and the rotation of the earth acting upon particles of water in motion led Ekman to conclude that, unless constrained by land or shallow depths, the surface water would move 45° to the right of the wind's direction throughout the northern hemisphere and at greater angles with decreasing velocity at greater depths. Observations of the upper 10 cm. to 60 cm. of water at a number of Finnish and Swedish light vessels in the Baltic showed a movement some 19° to the right of the direction of the wind. The speed was nearly twice as great when the wind blew in the same direction as the coast line, than when blowing directly on shore or off shore. The average speed of the current varied, not directly with the wind's velocity as occurred with the polar ice, but with its square root.

A number of other estimates of the relation between the velocity of this surface drift and of the wind have been made, but they show no general agreement; a few observations suggest that this deviation from the direction of the wind increases with depth, as would be expected from Ekman's conclusions, but the depth to which these currents extend in varying circumstances is unknown. This facet of the subject is one of some practical interest in fishery research; for example, the young of herring born in the English Channel are carried by such a current into the North Sea.

The need for accurate knowledge of the wind drift as well as the tidal currents along the Pacific coast of the United States, where harbours are many miles apart, sailing courses long and periods of thick weather not infrequent, has led the U.S. Coast and Geodetic Survey¹ to collect and analyse numerous current data from five light vessels. After allowing for the calculated tidal current the residual drift, almost entirely due to wind, was obtained for several thousand observations. These were made by means of a pole 15 ft. long, weighted at one end and floating

1 ft. out of the water; no allowance is made for the pressure of wind on the exposed part of the pole.

The velocity of the wind drift set up by winds varying between 10 miles and 60 miles an hour was approximately 2 per cent. of the velocity of the wind, being slightly under this value for high winds. This is a similar relation to that found by Nansen for the polar ice, but an entirely different relation from that found by Whitting for the surface 10 cm. to 60 cm. in the Baltic. The latter also holds for the surface 15 cm. in the English Channel and North Sea, as deduced from the drift of bottles so weighted that only about 3 c.c. of the cork end floats above water.

The direction of the wind drift along the Pacific coast averaged 23° to the right of the wind's direction, except for winds from the south-west sector, in which case the coast line trending north and south constrained the current to move north, 24° to the left of the wind's direction.

The observations recorded by the U.S. Coast and Geodetic Survey are a definite addition to the data available, and have in consequence a wider interest than that of the purpose for which they were primarily made.

H. W. H.

The Japanese Earthquake of Mar. 7, 1927.

FOR the second time since the great earthquake of Sept. 1, 1923, Japan has been visited by a destructive earthquake. The Tajima earthquake of May 23, 1925, was followed on Mar. 7 at 6.28 P.M. (or 9.28 A.M. G.M.T.) by another in nearly the same district, but probably some miles to the east. According to the official report issued from Tokyo, the central zone covers the counties of Naka and Yosa in the province of Tango. It is also stated that the roads to the north of Maizuru are impassable owing to the deep fissures caused by the earthquake. Thus, the centre must be close to the west coast of Wakasa Bay on the Japan Sea side of the islands.

In the small towns of Mineyama, Iwataki, Kaetu, Amino, Kayamachi, Ishida, and Yamada, containing from two to four or five thousand inhabitants, most of the houses are demolished or destroyed by the fires that broke out afterwards. As these, however, are not industrial centres, the purely economic effects of the earthquake will not be serious. The great towns of Osaka, Kyoto, and Kobe, to the south of the earthquake-zone, though strongly shaken, have suffered but little damage. The total number of lives lost is reported to be 2459.

The name of the province of Tango appears but seldom in Sekiya's catalogue of Japanese earthquakes. About fifty miles to the south, however, lies the important seismic district of Kyoto, and about the same distance to the east and south-east are the provinces of Mino and Owari, in which occurred one of Japan's greatest earthquakes, that of Oct. 28, 1891, with its remarkable fault-displacements.

Though their results in the loss of life and the destruction of property have been serious, both the earthquake of 1925 and that of Mar. 7 last are typical examples of the earthquakes that occur on the Japan Sea side of the islands. The late Prof. Omori divided the destructive earthquakes of Japan into two classes, local and non-local, according as they affected one province or several provinces. From the fifth century to near the close of the nineteenth century there were 221 destructive earthquakes in Japan. On the Japan Sea side of the islands there have been scarcely any but local shocks, while the Pacific side has often been shaken by great non-local earthquakes.

C. DAVISON.

¹ U.S. Coast and Geodetic Survey Special Publication, No. 121, pp. 80. Coastal Currents along the Pacific Coast of the United States. By H. A. Marmor. (Washington, 1926.)