water-waves. If we were to imagine dune-waves which, while still retaining precisely the same properties that they actually do possess, were to be impelled by the wind at a velocity equal to that of the waves of the ocean, and supposing that the drifting sand did not hide the prospect of this imaginary sandy ocean, then the resemblance between their movement and the movement of the on-rolling oceanic waves would be at once manifest. In the case of the dune-wave all we in reality see is the position it has last assumed. There is one important difference between these two categories of wave to which we shall return again lower down, namely the fact that the velocity of oceanic waves increases as the waves increase in magnitude, whereas the opposite is true of sand-waves.

If we study the paths followed by the sand-particles in the wave-movement of a progressive dune, we shall find both resemblances and differences between them and the paths followed by the water-particles in oceanic waves. The water-particles in an oceanic wave travel along a cycloidal path in a vertical plane in the direction in which the wave is advancing. »Es sind also zwei Bewegungen zu unterscheiden: einmal die oszillierende oder Orbitalbewegung der Wasserteilchen und zweitens die fortschreitende der Wellenform.»* This path of motion is called a trochoid. The water-particles do not participate in the trochoidal, only in the orbital, motion. In the course of a dune's advance, the different sand-particles describe different paths according to the positions in which they last came to rest on the leeward slope of the dune. A sand-particle which falls all the way to the base of the leeward side of a dune, and repeats its completed movement during several periods, does indeed describe a path in a vertical plane in the direction in which the dune is advancing, but it is a path that is not cycloidal, because there occurs an interval between every two successive periods, so that what we have is rather a species of continuous trigonal movement (*vide* vol. I, pp. 273—274). Sometimes the particle lies on the crest of the dune, sometimes at its base, but with the entire dune-mass resting upon it. A water-particle, however, that happens to be on the surface, remains constantly on the surface, whilst at the same time it describes its orbital movement every time a fresh wave reaches it — assuming of course that the conditions remain constant. This is also apparent from the following simple definition by Forel — in which incidentally several resemblances between sand-waves and oceanic waves are pointed out: »Wellen sind langgestreckte unter einander parallele Wasserrücken, die Wellenkämme oder Wellenberge, zwischen denen die Wellenthäler liegen. Wellenkämme und -thäler bewegen sich gleichzeitig und mit gleicher Geschwindigkeit vom Entstehungsort der Welle fort und zwar so, dass während einer ganzen Periode der Welle derselbe Oberflächenpunkt des Wassers der Reihe nach einem Wellenkamm, dann einem Wellenthal und schliesslich wieder einem Wellenkamm angehört.»** Suppose we have an absolute fluid; it is conceivable that it might have a motion which in this respect resembles the motion of sand, i. e. rolling. If, for instance, we let drops of water fall upon a dusty, inclined table, they roll in precisely the same way as dunes do: a given point on the circumference of any drop which may at one moment be upper-

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* Krümmel, *Handbuch der Ozeanographie*, II, p. 3.
** *Handbuch der Seenkunde*, p. 64.