ration, and the expansion and contraction of water by heat and cold, may be conceived to operate independently of the others, and although the influence of all the rest were annihilated. But there is another cause, the rotation of the earth on its axis, which can only come into play when the waters have already been set in motion by some one or all of the forces above described, and when the direction of the current so raised happens to be from south to north, or from north to south.

The principle on which this cause operates is probably familiar to the reader, as it has long been recognized in the case of the trade winds. Without enlarging, therefore, on the theory, it will be sufficient to offer an example of the mode of action alluded to. When a current flows from the Cape of Good Hope towards the Gulf of Guinea, it consists of a mass of water, which, on doubling the Cape, in lat. 35°, has a rotatory velocity of about 800 miles an hour; but when it reaches the line, where it turns westward, it has arrived at a parallel where the surface of the earth is whirled round at the rate of 1000 miles an hour, or about 200 miles faster.* If this great mass of water was transferred suddenly from the higher to the lower latitude, the deficiency of its rotatory motion, relatively to the land and water with which it would come into juxtaposition, would be such as to cause an apparent motion of the most rapid kind (of no less than 200 miles an hour) from east to west.

In the case of such a sudden transfer, the eastern coast of America, being carried round in an opposite direction, might strike against a large body of water with tremendous violence, and a considerable part of the continent might be submerged. This disturbance does not occur, because the water of the stream, as it advances gradually into new zones of the sea which are moving more rapidly, acquires by friction an accelerated velocity. Yet as this motion is not imparted instantaneously, the fluid is unable to keep up with the full speed of the new surface over which it is successively brought. Hence, to borrow the language of Herschel, when he speaks of the trade winds, "it lags or hangs back, in a direction opposite to the earth's rotation, that is from east to west†," and thus a current which would have run simply towards the north but for the rotation, may acquire a relative direction towards the west.

We may next consider a case where the circumstances are the converse of the above. The Gulf Stream flowing from about lat. 20° is at first impressed with a velocity of rotation of about 940 miles an hour, and runs to the lat. 40°, where the earth revolves only at the rate of 766 miles, or 174 miles slower. In this case a relative motion of an opposite kind may result; and the current may retain an excess of rotatory velocity, tending continually to deflect it eastward. Polar currents, therefore, or those flowing from high to low latitudes, are driven towards the eastern shores of continents,

* See a table in Capt. Hall's work before cited.

† Treatise on Astronomy, chap. 3.