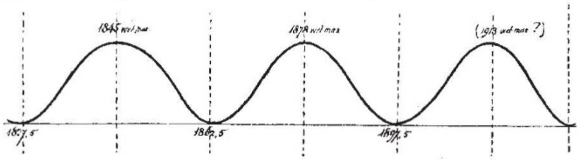
"At the same time the rain fell after sixty-six days' drought, no such instance of dry weather in the West Indies was remembered). The next minima (of wet) would correspond to 1862·5 (great earthquake in Greece, 26 Dec./61, and eruptions of Vesuvius accompanied by earthquakes), and the last, to 1897·5, which fairly corresponds to the great earthquake of Assam, so fully noticed in your journal, as one of the most intense of modern times. Moreover, these figures may be presented otherwise. Taking the great earthquake of Lisbon as of date 1755, roughly we have the annexed succession of years showing at the two extremes the dates (approx.) of two of the greatest earthquakes of modern times, and to some extent showing that thirty-five years represents a period of maximum earthquake action, and agreeing roughly with the intervals of extreme drought and with periods of great volcanic activity.



1755
+ 35
1790
+ 35
1825
+ 35
1860
+ 35
1895

As regards the year 1825, it is interesting to note that Mallet's Catalogue gives for July 26 and 27 of that year, "One of the most tremendous hurricanes on record occurred in the West Indies."

Of course a great deal has to be said as to the locality of the earthquakes, and as to the volcanoes to be considered. I certainly look on those of the Andes Cordillera as of prime importance by their influence on the upper currents.

Royal College of Science, Dublin, J. P. O'REILLY.
May 21.

Ebbing and Flowing Wells.

A CASE somewhat resembling those previously described (NATURE, May 12, p. 45, and May 19, p. 52), occurs on the dormant volcano of Barren Island in the Andaman Sea. The only (comparatively) fresh water to be found on the island reaches the surface in the form of hot springs, which gush out close to the shore at the breach through the ancient cone. The springs are due to the percolation of the drainage water beneath the most recent lava streams, which have not yet fully cooled down. The level of the springs rises and falls with the tide, and the lower part of a well, which I caused to be dug in the ash about twenty yards from the shore, filled with hot water at the flow of the tide, and ran dry at the ebb. The bottom of the well was between tide levels. The water is brackish, but rather less so at high than at low tide, the reason of which appears to be as follows. The porous volcanic materials of the island below sea level are saturated by the water of the sea, the surface of this inland subterranean water rising and falling in connection with the rise and fall of the sea tide. The drainage of the amphitheatre, then, soaks downwards until it reaches the inland salt water, over which, on account of the difference in specific gravity, it flows onward to the sea. At high tide, therefore, the drainage reaches the sea through materials which have been comparatively little wetted by salt water, while at low tide it percolates through, and washes, ejecta from which the salt water has just retired. The phenomenon is, of course, complicated by the difference in time between the inland tide and that at sea.

The springs are described in some detail in *Memoirs Geol. Surv. Ind.*, vol. xxi. p. 274 (also *Records G.S.I.*, vol. xxviii. pp. 31, 34). F. R. MALLET.
May 25.

NAVIGATION.

NAVIGATION, in its widest sense, is generally defined as the art of conducting a ship from port to port, and may conveniently be divided into coasting and guiding the path of a vessel across the trackless ocean.

Coasting is principally pilotage, assisted by a few rules based on geometry and plane trigonometry, combined with a knowledge of that oldest and most valuable of seamen's friends, the mariner's compass. A knowledge of the compass in Europe is much older than is generally supposed. It was certainly used as far back as the beginning of the thirteenth century.

The compass plays a still more important part in deep sea navigation (with which this paper is more particularly concerned), which is so closely allied to nautical astronomy that in one sense of the word it includes it, whilst in another it distinguishes the terrestrial methods of finding the position of a ship at sea, from the more accurate methods of locating her whereabouts, that the researches and labours of the astronomer have placed at the disposal of the navigator.

The earliest efforts of the seaman, when he ventured out of sight of land, were directed by the compass, which of late years has been immeasurably improved, and by a log for measuring the rate of sailing, which has become almost as obsolete as the plane sailing and the plane chart by which he estimated his position. This method, proceeding on the assumption that the earth's surface is a plane, was fairly accurate for moderate distances near the equator, or even in higher latitudes if the vessel sailed on, or near a meridian, but was quite incapable of measuring differences of longitude, and if used, for instance, on a westerly course from Cape Clear, would produce an enormous error, if the departure or westing was taken as the difference of longitude. Owing to the uncertainty and variability of the wind, sailing vessels altered their course so often that, to save the labour of working out the difference of latitude and departure for each course and distance by trigonometry, the traverse table was introduced. It is simply the tabulated values of the sides of a number of right-angled triangles, where the hypothenuse is the distance, the perpendicular the departure, the base the difference of latitude, and the course the given angle. By means of this table it was easy to get the difference of latitude made good, by taking the difference between the sum of the northings and southings, and the departure made good, by subtracting the eastings from the westings, or *vice versâ*. This was called resolving a traverse. The inability of plane sailing to afford the difference of longitude led to the introduction of parallel sailing, middle latitude sailing, and Mercator's sailing, and the inestimable chart that bears the name of the latter. It is easily demonstrated by solid geometry, that the arc of a parallel of latitude between any two meridians is equal to the corresponding arc of the equator multiplied by the cosine of the latitude; so that if a ship sails on a parallel, it is a simple operation to convert her meridian distance or departure into difference of longitude. But a ship does not always keep to a parallel; in sailing, however, from point to point, she must leave one parallel and arrive at another. Now let the portion of the rhumb line between these two parallels be conceived to be divided into infinitely small parts, which will be sensibly straight lines on each of which is a triangle representing the corresponding difference of latitude and meridian distance. Then the departure will be the sum of all these meridian distances, and must be equal to the arc of a parallel somewhere between the two extreme ones. In middle latitude sailing it is assumed to be equal to the arc of the parallel that lies midway between the one left and that arrived at, and the difference of longitude is obtained as in parallel sailing, substituting the middle latitude for the parallel.

Though the above assumption is not strictly accurate (the real parallel always lying on the polar side of the middle latitude), the results deduced from it in favourable cases are such very close approximations as to be preferable to those obtained by Mercator's sailing, which is theoretically irreproachable.

About the middle of the sixteenth century, Gerard Mercator introduced the chart which has since borne his name, in which the meridians are all parallel and the degrees of latitude increased towards the poles, and on