

tions of winds are from the N. on 80.1 days, from the E. on 72.3 days, from the S. on 88.7 days, and from the W. on 123.7 days. The force of wind was estimated from 0 to 6; 0 being a calm and 6 a hurricane, the mean force being 0.6; but Robinson's anemometer is not stationary more than twice a year.

During a residence of nearly ten years in the camp the author has had the good fortune to observe that, in comparison with any other station, civil or military, its "bill of health" forms a striking contrast to their published statistics.

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*On the Method adopted at Utrecht in discussing Meteorological Observations.*  
By Dr. BUYS-BALLOT.

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*On an Error in the usual method of obtaining Meteorological Statistics.*  
By FRANCIS GALTON, F.R.S., F.G.S.

The meteorological statistics of the ocean have been hitherto obtained by extracting observations from the logs of different ships, and by sorting those that were made in different geographical divisions of the ocean into corresponding groups. The usual geographical divisions are bounded by each 5th degree of latitude and longitude, and they therefore are 300 miles in length, and have an average breadth of 150 miles. Each of the groups is treated as if it were composed of observations taken at irregular periods, by a single person stationed at a fixed observatory in the centre of the group, that is to say, the barometer, thermometer, and other elements are determined by computing the simple mean of all the recorded observations. The proportion of winds that blow from the different points of the compass is computed in a similar manner. Only one limitation is exacted in respect to the admission of an observation into a group. It is that it should not have been made at an interval of less than eight hours from any other observation by the same ship, already included in the same group. Were it not for this limitation, a zealous observer might contribute hourly, or yet more frequent observations, which, by their multitude, would prevent the scantier observations of other ships from exercising a just influence on the average. In an extreme case of this description, the weather met with by a single ship on one particular voyage might mainly govern the computed results.

In a recent report on the condition of the Meteorological Department of the Board of Trade by Mr. Farrer, Captain Evans, and himself, were pointed out many objections to the existing methods of computing ocean statistics. The object of the present paper is to draw attention to yet another objection, and to show that an additional limitation is required before an observation ought to be admitted into a group. The objection was, that the observations made by a sailing ship are more numerous in respect to antagonistic winds or calms than in respect to favourable weather. Therefore, as some parts of the ocean are mainly frequented by outward-bound and others by homeward-bound ships, the means of the recorded observations in those parts must differ materially from the true average weather. When favourable winds are blowing, a ship is rapidly wafted across the area of observation, and comparatively few observations are made within it. The wind may continue blowing, but the ship is unable to record its continuance after it has left the area in question. On the other hand, if an antagonistic wind blows, or if calms or light breezes prevail, then the ship is delayed within the area, and continues making observations during the whole, or nearly the whole period of their continuance. Taking one course with another, a ship sailing with a favourable wind crosses one of the usual five-degree divisions of the ocean in twenty-four hours, or, in other words, in three eight-hourly periods of observation. Therefore the observations made by a ship resemble observations made at a fixed observatory under the instructions that only three eight-hourly observations were to be taken during the continuance of winds, say, from the northerly quadrant, but that when the wind was in the southerly quadrant the observations were to be continued during the whole of its duration. No one would be inclined to accept the means of these observations as a just statement of the weather, yet this is precisely what is given by the method of compilation adopted by the Meteorolo-

gical Department. The weather under which a ship enters a division may be of any description whatever, except that of an absolute calm in a sea without a current, and therefore has no bearing on the present question. It must further be observed that the error he had pointed out not only affects the winds, but all the meteorological elements so far as they are correlated with the winds; the temperature and dampness are especially affected by it. The method he proposed by which this error might be obviated, was to impose a limitation to the observations in respect to interval in distance, in addition to the existing eight-hourly interval in respect to time. He proposed that observations should not be included in the groups, unless the places where they were made were at least as far asunder, measuring in the direction of the ship's general course (and not along her tacks) as she could traverse with a favourable wind in eight hours. Then on an average not more than three observations would be accepted from a single log-book in any 5-degree ocean square. He did not possess data to show how far the accuracy of the existing wind charts is impaired by the neglect of this cause of error. He presumed that it would only be in certain parts of the ocean that it would exercise considerable influence on the computed proportions of the winds, but that the ratio of the calms would be everywhere exaggerated. It was sufficient that he should point out the error as one to be guarded against for the future, for he trusted that the whole of the work in the Meteorological Office would be submitted to recomputation, and that an improved method of handling and grouping the observations would be adopted, in accordance with the recommendation of that Report to which he had already alluded.

*On the Conversion of Wind-charts into Passage-charts.*

By FRANCIS GALTON, F.R.S.

The most direct line between two points of the ocean is seldom the quickest route for sailing-vessels. A compromise has always to be made between directness of route on the one hand, and the best chance of propitious winds and currents on the other. Hence it is justly argued that an inquiry into the distribution of the winds over all parts of the ocean is of high national importance to a seafaring people like ourselves. A knowledge of the distribution of the winds would clearly enable a calculation to be made which would show the most suitable passage in any given case.

But as a matter of fact, no calculations have yet been made upon this basis; much less have charts been contrived to enable a navigator to estimate by simple measurements the probable duration of a proposed passage. The wind-charts compiled by the Meteorological Department of the Board of Trade are seldom used by navigators; for they do not afford the results that seamen principally require; they only give data from which those results might be calculated by some hitherto unexplained process, which, we can easily foresee, must be an exceedingly tedious one.

To convert wind-charts, or the tables of wind-direction from which the wind-charts have been compiled, into passage-charts, we must ascertain the distances that ships of different classes would attain in an hour, if they made the best of their way under the same wind towards different points of the compass. With a moderate wind, a merchantman of the class that usually navigates the Atlantic will, by beating to windward, make  $2\frac{1}{2}$  miles an hour, right in the wind's eye. At two points off the wind it will make 3 miles; at four, 4 miles; at six, 7 miles; at eight,  $8\frac{1}{2}$  miles; at ten, 9 miles; at twelve,  $9\frac{1}{2}$  miles; at fourteen,  $8\frac{3}{4}$  miles; and at sixteen, or with the wind right astern, it will make  $7\frac{1}{2}$  miles. We must next turn to the wind-charts, or to the Tables from which they were compiled, to ascertain the proportion of the winds that blow from different points of the compass, in the region we are investigating. Thus in one particular case we find, out of one hundred observations, that six referred to N. winds, fourteen to N.N.E., seventeen to N.E., six to E.N.E., three to E., two to E.S.E., two to S.E., five to S.S.E., six to S., six to S.S.W., six to S.W., three to W.S.W., three to W., three to W.N.W., four to N.W., five to N.N.W., and nine calms. The force of the winds was not recorded in this instance; we must therefore, for want of better information, assume them to be moderate. We have now to calculate the progress that ships could make to-