Meteorological Reports &c.

—

Fr. G. Galton

f 1r

Report of Committee of Met.l Dep.t of Bd. of Trade. 1866.

REPORT OF A COMMITTEE

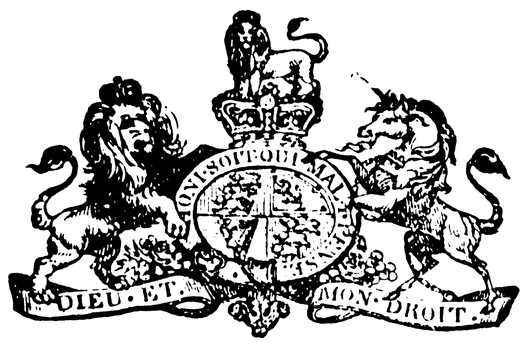
APPOINTED

TO CONSIDER CERTAIN QUESTIONS

RELATING TO

THE METEOROLOGICAL DEPARTMENT OF THE BOARD OF TRADE.

Presented to both Houses of Parliament by Command of Her Majesty.



UNIVERSITY COLLEGE LONDON
GALTON PAPERS
2/2/1/1

LONDON:
PRINTED BY GEORGE EDWARD EYRE AND WILLIAM SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.
FOR HER MAJESTY'S STATIONERY OFFICE.

14145.

1866.

REPORT OF THE

Note.

Upon the death of the late Admiral FitzRoy, a correspondence took place between the Board of Trade and the Royal Society, with respect to the Meteorological Department of the Board of Trade.* The result of that correspondence was the appointment of a Committee consisting of the following gentlemen, viz.:—

Francis Galton, Esq., F.R.S., General Secretary of the British Association for the Advancement of Science, nominated by the President and Council of the Royal Society;

Staff-Commander Evans, R.N., F.R.S., Chief Naval Assistant to the Hydrographer of the Admiralty, by the Admiralty;

T. H. Farrer, Esq., one of the Secretaries to the Board of Trade, by the Board of Trade;

To consider and report upon the following questions:—

1. What are the data, especially as regards Meteorological Observations at Sea, already collected by, and now existing in the Meteorological Department of the Board of Trade?
2. Whether any and what steps should be taken for arranging, tabulating, publishing, or otherwise making use of such data?
3. Whether it is desirable to continue Meteorological Observations at Sea, and, if so, to what extent, and in what manner?
4. Assuming that the system of Weather Telegraphy is to be continued, can the mode of carrying it on and publishing the results be improved?
5. What Staff will be necessary for the above purposes?

The following Pages contain their Report.

---

* See Appendix No. 1.

UNIVERSITY COLLEGE LONDON
GALTON PAPERS
2/2/1/1

REPORT.

In order to give a satisfactory answer to the questions put to us, we have found it necessary to enter at some length into the history of the Meteorological Department of the Board of Trade, and into its original as compared with its present functions. The subject matter with which this Department has been connected naturally falls into two great divisions, corresponding with the change which has taken place in those functions, viz.,

I. The Statistics of the Meteorology of the Ocean; and

II. The Prognostication of Weather in the British Isles, together with Observations of the changes of Weather within or near those limits, for the purpose of ascertaining the Laws upon which such Prognostications are or ought to be founded.

We have accordingly treated the first of these subjects in the First Part, and the second in the Second Part of our Report; and we have in the Third Part given a statement of the means necessary to carry our recommendations into effect.

The Conclusion contains some remarks applicable to the whole subject.

PART I.

Measures taken, or to be taken, for procuring Meteorological Statistics of the Ocean.

1. Origin of the Meteorological Department of the Board of Trade.
2. Description of Original Functions of the Department, as laid down by the Royal Society, and adopted by the Government.
3. Steps taken by the Department to obtain Meteorological Observations at Sea.
4. Method adopted by the Department in extracting Observations.
5. Criticism of this Method.
6. Suggestion of a more complete Method of extracting Observations.
7. Want of Estimate of Probable Precision.
8. Estimate of Number of Observations required to determine the Meteorology of the Ocean.
9. Description of the Publications actually issued, and of the Discussion of Observations now in progress, as compared with the desiderata of the Royal Society.
10. Remarks on the form and character of the above Publications.
11. Further use of the Meteorological Registers for purposes of Navigation.
12. Recommendations for the future on the points discussed above, viz., as regards:—
(*a.*) The Works and Discussions of Observations now in progress.
(*b.*) The Collection of further Observations.
(*c.*) The method of extracting the Observations.
(*d.*) The method of discussing and tabulating the results of the Observations when extracted.
(*e.*) Publication of Meteorological Results.
(*f.*) Publication of other Results useful to Navigation.

PART II.

Weather Telegraphy, Foretelling Weather, and Observations of Weather within or affecting the British Isles.

13. Origin of the Practice of Telegraphing and Foretelling Weather.
14. Establishment of System of Telegraphing Weather.
15. Establishment of Storm Warnings and daily Forecasts of Weather.
16. Practice of the Department in foretelling Weather.
17. The practice not carried on according to any definite Rules.
18. The Maxims on which the Department acts not founded on any sufficient induction from facts.
19. Experience of the Office not utilized in reducing this Practice to a System.

20. Distinction between daily Forecasts and occasional Storm Warnings.
21. Comparison of daily Forecasts with the facts as observed by the Department.
22. Comparison of daily Forecasts with facts, observed elsewhere.
23. Comparison of daily Forecasts with each other, and with Storm Warnings.
24. Utility or inutility of daily Forecasts.
25. Conclusion concerning daily Forecasts of Weather.
26. Conclusions concerning Telegraphic Reports and Remarks.
27. Storm Warnings—The official Description and Explanation of them.
28. Inherent ambiguity of this Description.
29. Comparison of Storm Warnings with facts, as recorded by Meteorological Department.
30. Comparison of Storm Warnings with facts, as recorded by Wreck Department of Board of Trade.
31. Results of the comparison as regards Force of Wind.
32. Results of the Comparison as regards Direction of Wind.
33. Incompleteness of Data for Comparison.
34. Popularity and utility of Storm Warnings.
35. Conclusions as to Correctness and Utility of daily Forecasts and Storm Warnings.
36. Fishery Barometers.
37. Investigation of Laws which govern changes of Weather in the British Isles.
38. Recommendation of six stations with Self-recording Instruments.
39. Further Observations from Lighthouses, Ships, &c.
40 Discussion and Charting of arrears of British Weather.
41. Results to be looked for from the above.
42. Recommendations.

PART III.

Estimate of Cost.

43. Cost of Existing Meteorological Department.
44. Recapitulation of Work to be done hereafter.
45. Means and Method of executing this Work.
a. Estimated Cost of this Work.
46. Reasons for proposed Increase of Expense.

CONCLUSION.

47. Answers to questions put to us.
48. Weather Changes in all parts of the World.
49. Periodical Revision.
50. Final Remarks.

Part I.—Steps taken or to be taken for procuring Meteorological Statistics of the Ocean.

1. *Origin of the Meteorological Department of the Board of Trade.*

In and before the year 1852,* the then Lieutenant Maury, acting under the sanction of the United States Government, had, by the help of the Navy and the Merchant ships of the United States, been for some time collecting Meteorological Observations made at sea. In 1852 Sir John Burgoyne, then Inspector General of Fortifications, contemplated the establishment of a certain number of Meteorological Observatories on land, to be managed by the Royal Engineers, and a suggestion was at his instance made to the United States Government that the observations so carried on, and any observations made under the direction of that Government should be conducted on one uniform plan. To this a counter proposition was made by the United States Government to the effect that any uniform system should include observations at sea, and that the different maritime nations of the world should be invited to make such observations on one uniform plan. This counter proposal was submitted by the British Government to the Royal Society;

---

* See Parliamentary Paper 115, Sess. 1853.

and it was finally determined,* in accordance with the report of Lieutenant Maury on his return, to postpone for the present the attempt to reduce to one uniform system the various Meteorological Observations by land, which different nations were then already making; but that it was desirable to invite the various maritime nations of the world to collect, through the medium of their National and Mercantile Navies, certain Meteorological Observations at sea, to discuss those observations, and to communicate the results to one another.

A conference consisting of representatives from different maritime countries subsequently met at Brussels, in August and September 1853.† This conference reported to the effect that it would be impracticable to obtain one great desideratum, viz., uniformity of scales and instruments, but they expressed a strong opinion that steps should be taken to secure the accuracy of the instruments that might be used. They describe those instruments as follows:—

A mercurial Barometer; Thermometers with dry and wet bulbs; also one with a black bulb; and an Hydrometer, or instrument for measuring the specific gravity of water.

Finally, the conference prepared a form of Meteorological Log or Register, with instructions for filling it up.

The Meteorological Department of the Board of Trade was subsequently constituted under the authority of Mr. Cardwell, then President of the Board, and the late Admiral FitzRoy was appointed as its head.

2. *Description of Original Functions of the Department as laid down by the Royal Society and adopted by the Government.*

In the meantime the President and Council of the Royal Society were informed, on June 15, 1854, by the Board of Trade, that it was proposed to establish a Department for the discussion of Meteorological Observations made at sea in all parts of the globe; and their opinion was asked as to the desiderata of Meteorological science to which that Department should direct its attention.

They replied in a letter‡ dated February 22, 1855. Its purport may shortly be stated as follows:—

1. That the usual monthly, quarterly, and annual Means of Barometric pressure, Aqueous Vapour, and Temperature, together with the Variability of each of them, should be ascertained and tabulated for suitable geographical spaces, comprised between specified meridians and parallels, and, in their aggregate, covering the entire ocean.

2. That the Temperature of the surface of the Sea, in different months of the year, should be carefully observed, as affording data of the utmost value to the study of Climatology as a science; also, that the Temperature, Direction, and Velocity of Ocean Currents, and their variations in different months and in different years, should be a prominent subject of inquiry.

3. That an examination should be made into the varying limits of the Trade winds and Monsoons.

4. That the fluctuations of Temperature on a large scale, such as might affect simultaneously great portions of the globe, should be investigated by a comparison of "Five-day Means," made at all *fixed* stations.

5. That charts of the Magnetic Variation should be constructed. (N.B.—This task was subsequently undertaken by the Hydrographic Department of the Admiralty, who published the required charts in 1858.)

6. That it would be desirable to make observations at the military stations of Gibraltar, Malta, Corfu, and on the coasts of Australia and New Zealand; and to make hourly observations for at least one year, at some station in the West Indies, to supply diurnal corrections for existing observations.

7. They further stated,§ in the course of subsequent correspondence, that one of the most important objects of the Meteorological Department, both in a practical and theoretical view, would be to procure statistics of the Direction and Force of the Wind, in those parts of the Atlantic Ocean which are most usually traversed by ships. They also remarked that it would be advisable to establish stations at the Azores, Madeira, Ber-

---

* See Parliamentary Paper 115, pp. 17 and 21.

† See Parliamentary Paper 4, Sess. 1854, with form of log annexed.

‡ Report of Meteorological Department, Board of Trade, 1857, p. 19; and Proceedings of Royal Society, 1855. This letter is so important that we have had it reprinted, with an extract from a subsequent letter, in the Appendix to this Report, No. 2.

§ Meteorological Department Report, 1857, p. 34, and Appendix to this Report, No. 2.

muda, Ascension, and St. Helena, for a continuous record of the Winds by means of self-recording instruments.*

The opinions expressed by the Royal Society were adopted by the Government, and may, therefore, be deemed to form the instructions under which the Meteorological Department was to pursue its labours. It will be observed that the great object steadily kept in view was the collection and subsequent discussion of facts and observations, too numerous to be collected and discussed by private persons. The publication in a form available to seamen of such results as might be immediately useful to them, would be a collateral duty, naturally arising out of the primary functions of the Office. There is no indication that it was a part of the functions of the Department as originally instituted, to publish undiscussed observations on the one hand, or to speculate on the theory of Meteorology on the other. Still less can it be considered to have been a part of those functions to attempt the prognostication of weather.

3. *Steps taken by the Department to obtain Meteorological Observations at Sea.*

When the Meteorological Department was first established, its Superintendent took active and efficient steps to give effect to the wishes of the Royal Society, by distributing information on the methods of observing, by procuring verified† instruments, by lending them with discrimination to the captains of Merchant ships and, with the co-operation of the Admiralty, by supplying the Royal Navy. All this was done on a liberal scale; more than 1,000 sets of instruments have been supplied to ships of the Royal Navy, as a part of their general equipment, and nearly the same number of sets have been lent to captains in the Merchant Service.‡ The gratifying result of these efforts was the receipt of 1,298 Registers, made during voyages that appear to average 140 days at sea, and therefore containing in the aggregate, (at the rate of three sets of observations a day, which is as many as the Department makes use of in obtaining the Meteorological means,§) about 550,000 separate sets of observations. The number of these Registers was steadily increasing, and would, no doubt, have been very much greater, if the attention of Admiral FitzRoy and of his Department had not become gradually diverted from the objects recommended by the Royal Society, to those belonging to a wholly different department of Meteorology, namely, the Prognostications of Weather. With the views thus entertained Admiral FitzRoy feared an accumulation of Ocean Statistics far beyond the divided powers of the Office to reduce; and he felt himself justified in ceasing to accumulate further contributions of Meteorological Observations taken at sea.‖

So far as we can judge from a cursory inspection, the Registers that have been received by the Department have been made with much industry, and the large majority of them appear from that internal evidence which Meteorological Registers necessarily contain, to have been executed with scrupulous care and assiduity.¶ It has become evident to us, beyond all doubt, that not only the Royal Navy, but also the Merchant Service, contains an abundance of officers willing to make, and thoroughly capable of making, excellent Meteorological Observations at sea; and further, that the Department is already in possession of a large number of really valuable records for determining the Meteorology of the Ocean in the way specified by the Royal Society.

Moreover, the Meteorological Observations contained in the logs of the Royal Navy, especially those made in recent years, with instruments much more accurate and trustworthy than they had previously been, form a large and valuable store of Meteorological materials.**

We think that it would be a subject of legitimate regret if these observations were not turned to the fullest account, and if the further contribution of such similar data as

---

* We may add that, after the death of Admiral FitzRoy, further inquiries, dated May 26, 1865, were made of the Royal Society by the Board of Trade, and that the President and Council of the Royal Society stated in their reply that the objects specified in their previous letter are still as important for the interests of science as they were thought to be in 1854. See Proceedings of Royal Society, 1865. Letter from Royal Society to Board of Trade, dated 15th June, 1865, App. No. 1.

† " . . . the instruments used previous to 1855 were not duly compared with such standards as can now be " referred to. This deficiency is unfortunately common to most of the meteorological observations one finds " recorded anywhere, except at regular observatories, before the Kew Committee of the British Association " undertook to recommend a barometer . . ."—*First Number of Meteor. Papers, Board of Trade*, p. 2.

‡ See Appendix to this Report, No. 3.

§ Unless any two observations in the *same square* have been made at least eight hours apart, only one of them is used in calculating means.

‖ Report, 1862, p. v. § 18.

¶ See also Report, 1857, p. 57.

** A small part of these has been turned to account by the Meteorological Department in its charts of the Black Sea, showing the direction of its winds at different seasons.

may yet be needed in order to fulfil the desiderata of the Royal Society, were declined or discouraged.

We also think that no more time should be lost in collecting such further observations as may be needed; inasmuch as the longer the period of time over which the observations are spread, the more difficult will it be to make the results obtained from them useful hereafter in determining questions that may arise concerning Secular Variations (if any) in the Atmosphere. We think, therefore, that the distribution of registers and the loan of instruments should be proceeded with at once, and that this should be done on as wide a scale as is consistent with a due regard to economy and to the means which may exist for making use of the observations when made. According to the calculations given below,* about 1,100,000 observations will probably yet be needed before the materials necessary to fulfil the desiderata of the Royal Society are procured. But there are many parts of the ocean through which few ships go, whilst others lie in the most usual tracks. Care will therefore be necessary so to select the voyages and the places of observation, as to procure observations for those parts of the ocean which are for the time being not completed, and not to overload the Office with needless observations for those which are. Judgment and knowledge will also be required, so as to avoid unnecessary labour on those parts of the Ocean of which the Meteorological phenomena have been adequately observed and discussed through the efforts of Foreign Governments or Institutions.

In order to facilitate this selection, and also with the view of enabling the Department the more readily to deal with and refer to the observations, we suggest that each register should contain a small printed chart of the ocean divided into squares as explained under the following head, and that on this chart the voyage of the ship should be traced. This chart might be so constructed as to call the attention of the navigator intrusted with it to those squares in which observations are most needed. And from it a concise index might be made in the Department, containing a list of the squares, and a reference to each register containing observations for that square. From the absence of any such charts or indices, we are unable at the present moment to give any general statement showing for which of the squares (if any) sufficient observations have been obtained, for which of them the observations are deficient, and what is the extent of the deficiency.

index chart

4. *Method adopted by the Department in extracting Observations.*

We proceed to explain the method employed by the Department in extracting and handling the crude observations contained in the ships' Registers.

In the first place, the surface of the globe is divided into spaces as suggested by the Royal Society, ranging betweeen 80° N. lat., and 70° S. lat., and bounded by each tenth meridian and tenth parallel. These spaces, in themselves of unequal areas, and of different shapes, were named "Ten-degree Squares;" because of their uniformly rectangular appearance in the charts drawn upon Mercator's projection, which are those employed by navigators. Each of the "Ten-degree Squares" has received a special number. For instance, the Square 303 embraces the space included between the equator and 10° S. latitude, and between 30° and 40° W. longitude. Again, every one of the "Ten-degree Squares" admits of a quarterly subdivision into smaller squares of Five degrees. These are distinguished by the letters *a*, *b*, *c*, *d*. Thus, 303 *a*, is the north-easterly quarter of the above-mentioned Square. Lastly, in some rare cases, a further subdivision has been provided for by an extension of the same principle of lettering.

Fixing our attention, for the present, on the "Ten-degree Squares," it appears, from a chart we annex,† that when those are omitted which are occupied by land or by ice, there do not remain more than 330 with which the Meteorological Department would have to deal. This number must be accepted as approximate, because many squares are partly occupied by land and partly by sea, and a somewhat arbitrary division has in those cases to be made between them.

In the second place, every observation has to be copied out of the Registers‡ and sorted on some determinate plan, into those of the 330 Ten-degree Squares to which they severally belong. We may here observe, that when this is done, and not before then, the labour of their discussion admits of comparison with that of the same number of observations, received from a similar number of land stations.

The method adopted by the Department § in extracting the several classes of observations from the Registers and appropriating them to their several Squares is, speaking generally, as follows.‖ Each class of observation is taken out separately, and every

---

* See p. 11.

† *See* Appendix, No. 4.

‡ For the form of Register, *see* Report, 1857, p. 74.

§ Report, 1857, pp. 41–55.

‖ We say "generally," because the methods employed for different classes of observations differ considerably among themselves, and the practice of the Office has also varied a little from time to time. But it would be impossible to enter into fuller particulars without much and unnecessary tediousness.

Register that is likely to include any part of the particular Sea under discussion is searched for the particular class of observation under consideration; and for every observation that is taken out of it, the Ship's Name or Number, the Date, and, in some cases, the Latitude and Longitude, have to be appended to the observation. All this is copied into a page headed by the number of a Five-degree Square, and contained in a book assigned to the subject under discussion. Thus Admiral FitzRoy writes in 1857,* "At "present there are in use about 60 collecting books of tabular Forms, called Data "Books, appropriated to the following subjects:—namely, Barometer, Thermometer, "Hydrometer, Winds, Weather, Currents, Variation, Soundings, Crossings, Passages, "Storms, Ice, Shooting Stars and Meteors, Aurora, and Electricity." The process just described, is distinguished in the Department by the term "collecting." The next step consists in re-copying the observations thus collected into separate sheets, each of which is devoted to a particular month; no other facts being entered, except the Ship's Name or Number, and the date of observation. This is called "grouping" the observations.

5. *Criticism of this Method.*

With the experience now gained of this mode of analysis, we think that the present method of dealing with the Registers is capable of considerable improvement.

That it is the cause of Loss of Time, Inconvenience, and even of Error, appears clearly from the following considerations:—

1st, as regards Loss of Time.

Though a great deal of time has been given to "collecting" the Observations, yet no Register has ever yet been more than partially examined. Each search has been directed towards some limited object, and a great deal of labour has been spent in going over and over again the same voluminous records, in order to extract from them different classes of observations.

Again, the Ship's Number, the Date, and, in some cases, the Latitude and Longitude, have to be copied afresh for every observation in each set, instead of having to be copied, once for all, for the entire set. Referring to the forms given in the Report for 1857, pp. 43–47, it will be seen that about as many figures and letters are employed, on the average, upon the mere Accessories to the Observations, as upon the Observations themselves. If these Accessories were annexed (as in the way we are about to propose) once for all, to the entire set, much of that labour would be saved.

2dly, as regards Inconvenience.

When the observations have been "collected" for a particular inquiry, it is almost impossible to make use of them should any variation or extension of the inquiry prove to be requisite. Thus, there are now sufficient data in the Collection Book for Winds, to determine with approximate accuracy the usual winds that blow in each Five-degree Square; but as no latitudes or longitudes are recorded in the pages of that Collection Book, the observations that refer to these matters are undetermined as to locality, and may have been made at numerous points very distant from each other. They may have been made anywhere in a Square of Five degrees of latitude, or 300 nautical miles in length. If it were desired to make inquiry into the limits of the Trade Winds or Monsoons in any one of those Squares, it would be necessary, according to the system adopted by the Department, to search all the registers afresh, and to establish a Collection Book for that particular purpose.

Again, when it was thought advisable to inquire into the Variation of the Barometer in the high latitudes of the Southern hemisphere, a very large number of barometric observations was "collected" for Zones of five degrees in width. The labour devoted to this collection is valueless towards sorting the barometric observations into the several Squares that compose these Zones. Therefore that additional inquiry, a very small but important matter in itself, must be undertaken wholly afresh, and on its own basis. It would be easy to add many similar instances to show the inconveniences of the present system.

3rdly, as regards the Errors introduced.

That errors really exist, is manifest by an inspection of the "Wind roses" of the published charts, whose singularly irregular shape, in many cases, almost compels us to admit either that no law governs the caprices of the wind, or that the Wind Observations have been discussed on an erroneous principle.

There appear to be two defects in principle, which are sufficient to produce numerous Errors in the results.

First, as we have just mentioned, no record usually appears of the Latitude and Longitude in the Collected Observations; consequently all observations contained within the same Square are discussed on equal terms, though they may have been taken at

---

* Report, 1857, p. 12.

opposite extremes of a large area, and may belong to entirely different meteorological systems. These cannot be disentangled and sorted into groups, under the present method. As an example, we may state that it is impossible to sort to one side the observations that refer to the influence of a Monsoon, or to that of a Land and Sea Breeze, or to the Temperature of the air as modified by an Ocean Current, or to the several Ocean Currents that run side by side in the same Square. It is also impossible to separate the direction of the Wind during one part of a month, whilst a Monsoon prevailed, from the direction of the Wind during the other part of the month, when the Monsoon was absent.

Secondly, neither in the collected observations, nor consequently in the grouped ones, does any record appear of the degree of Merit of the Register from which each separate observation is taken, whether it is "excellent," "very good," "good," or "ordinary."* It is important that these distinctions should be borne in mind, especially when discussing observations that show some disagreement between themselves. It is all important when inquiring into Ocean Currents, where observations are valueless unless both the Latitude and Longitude, as determined by astronomical observations, and by the Dead Reckoning, are laid down with frequency and precision. Even observations of the Thermometer, Wet and Dry, are of little value, unless made with intelligent care. But under the system adopted by the Department, the records of the best observers are treated with no more consideration than those of the least qualified; and a group of good observations is liable to be swamped by the introduction, on equal terms, of a larger group of inferior observations. In short, it does not appear to have been the practice to "weight" the observations, or to keep any record by which they can be weighted. In a Square we examined for the purpose, 487 *c*, we found this omission to have a prejudicial effect even on the averages of the Winds. In the Five-degree Square to which we have referred, there were 127 Board of Trade observations of the wind, and 427 others extracted from Maury's charts.† The results of the Board of Trade observations gave a "Wind Rose" bounded by points that, after the averages of adjacent observations had been taken, fell naturally into a continuous curve, and therefore had a primâ facie appearance of truth. This was increased almost to a certainty, by finding that the observations when divided at haphazard, still gave rise to the same appearance, though with inferior regularity. On the other hand, Maury's 427 observations resulted in a much less regular figure, and therefore, though nearly four times as numerous as those of the Board of Trade, had not in their aggregate so high a value as the latter. If this is the case with Winds, which all Sailors observe with moderate exactness, much more would it have been the case with Ocean Currents upon which only the most experienced navigators are capable of forming a thoroughly trustworthy opinion. There can be no doubt that in combining observations of unequal merit, the different observations should be very differently weighted.

To resume. The objections we entertain against the present system of extracting Observations from the Registers, may be shortly stated as follows:—

No Register is ever exhausted.

Labour is lost in repeatedly searching the same pages for different items.

The entries of Ship's Name or Number; of the Latitude and Longitude; and of other mere Accessories to the Observations, are unnecessarily repeated.

The Collection Books do not give sufficient data, even as regards their own particular subject, when accurate inquiries are needed.

No data are afforded for "weighting" the Observations.

6. *Suggestion of a more complete Method of Extracting Observations.*

Looking to the experience gained, we think that the following plan will be free from the above objections, and will facilitate the object in view; viz.:—

First, to examine each Register, and to assign to it some letter or other sign, to indicate its general Meteorological character and value; to mark out the Observations referring to those Squares for which Observations are still wanted; to underline the remarks that require copying; and to calculate and insert the corrected height of the Barometer in red ink.

Secondly, to copy out each set of Observations, with all its Accessories, into a schedule printed on a thin Card or piece of tough paper, as shown below. Every log will thus be gone through in regular order, and will be exhausted of those parts of its contents which are necessary to determine the Meteorological Means. It may then be kept and dealt with in such manner as may be expedient for the other purposes mentioned below.‡

* See Report, 1857, pp. 13 and 57, for the use of these terms.

† See p. 13 for explanation of this process.

‡ See page 15.

Thirdly, to sort the Cards into boxes or pigeon holes, each devoted to a particular sub-division of a particular Square, so that on going to any one of them, everything which is known about that sub-division of the Square will be found in it. The cards should be further arranged in the pigeon holes, according to Months.

Fourthly, to select a Sub-division of a Square, to examine each of its Months seriatim, and to discuss separately in each month the Barometer, Thermometer, and other elements. The Cards of the month should be sorted into groups according to the "Weights" to be attached to the observations written on them, and into sub-groups according to the Hour on which they were made. Then the observations in each sub-group should be added together, the Sums should be multiplied by the Weights, and the diurnal Corrections applied; and, lastly, the Mean of the whole should be taken.

It will be observed that the mobility of the contents of the boxes or pigeon holes would lend a most important aid in disentangling the observations; and all the more so in those instances where further, and perhaps tentative sub-divisions of the groups would become essential.

Let us consider some of the cases we have already noticed. Suppose we wish to ascertain the Limits of the Trade winds in a particular Square: we should sort the Cards into two groups, one in which the Trade winds were present, the other in which they were absent. We should further sub-divide the groups, just as we pleased, according to months or years, to obtain the required deductions as to the variability of their limits, at different epochs. Disputed Currents running in narrow belts, could be inquired into with perfect ease, by sorting out all the Observations that related to the belt in question, from the rest that referred to other parts of the Square, and in case they should be found to disagree, by neglecting those among them that did not bear a mark of meritorious character, and by carefully weighting the rest.

So, again, if a Monsoon or Trade wind blew during part of a month, or over one part of a square, it would be perfectly easy to separate the Observations that referred to the Monsoon, from those that did not. In short, the Observations could be handled, grouped, and discussed with perfect ease under any form that each new requirement might make necessary.

It is probable that 200 Observations* for each month of the year, in each Five-degree Square, would be as many as would in any case be required to give a moderately accurate result, and 200 separate Cards form a pack of no unmanageable size.

We append a specimen of a complete copy of a set of observations on the principle we recommend. If it were cut out, it would be ready in its present form to be sorted into the box or pigeon hole belonging to its Square.†

Date, **1865**		Month. *June*	Day. *15*	Hour. *Noon.*	
Ship -	Name	*Princess Royal.*		Register value.	
	No.	*1753.*		*Good.*	
Latitude -	D.R.	*6°*	*17′*	*N.*	No. of Square. *3*
	Obs.	*6°*	*17′*	*N.*	
Longitude	D.R.	*25°*	*56′*	*W.*	Sub-division of Square. *d.*
	Obs.	*26°*	*05′*	*W.*	
CURRENTS -	Direction	*N. 73° W.*		Sea Temp.	*80½*
	Daily Rate	*22*			
MAGNETIC VARIATION by Standard Compass		*1° 41′ W.*		Ship's Head	*S. by E.*
WINDS—Direction		*S.S.E.*		Force	*5*
BAROMETER -	Corrected Height	inches. *30.07*		Weather	*b. c. p.*
THERMOMETER—Dry	*81°*	Wet *77°*		Tension of Vapour	*08.7*
CLOUDS—Form	*Cum Str.*	Amount *5*		Upper Direction	*N. W.*

REMARKS.

Passed through strong tide rips at 11 *a.m.*
Waterspout on horizon at 11½ *a.m.*

---

* See page 11.

† The Schedule should be printed, not as it is necessarily printed here in black ink, but in coloured ink (say blue) in order to give greater prominency to the entries.

The complete entry consists of about 70 letters and figures, of which the Name or the Number of the Ship and the character of its Register might be printed. A few words would be occasionally required in the Remarks.

7. *Want of Estimate of Probable Precision.*

There is another point in the method of discussing observations adopted by the Department, to which we desire to call attention; viz., that the probable degree of Precision of the results that have been arrived at is nowhere shown, and that no provision has been made to determine it. It is hardly necessary to remark that the calculation of the "Probable Precision" is a well-known application of the law of probabilities, widely employed in all branches of physical science. Its determination in an approximate form is as important to the ordinary Navigator as it is to the Meteorologist, and it is even essential to the sound practical working of the Department. For when the Precision of the results obtained for any particular Square appears to be great, the Navigator can accept what is published as being thoroughly worthy of reliance, and further inquiry concerning the Meteorological Means of that Square becomes needless. When the so-called "Probable Precision" is moderate, the results are proportionately approximate, and whether those results appear in tables or on charts, they ought undoubtedly to bear on their face a clear indication of the fact. And the collection of materials referring to that Square should be continued. Lastly, when the Probable Precision is very small, the results would not be worthy of publication.

We may here remark that the importance of a clear understanding of the degree of Precision to be aimed at, lies at the root of all estimates of past and future work. If no attempt is made to calculate the degree of Probable Precision, it is impossible to tell what value to place on the results of past work. If minute and fanciful accuracy be sought in the future work, the labour of obtaining it on a large scale would be altogether overpowering, for the Precision of the result is increased, not in proportion to the Number of observations employed, but to the Square Root of their number. If it requires 200 observations to make it probable that the thermometric mean lies within 1° from the truth, it would require, not 4 times, but 4 × 4 times, that number, or no less than 3,200 observations to increase the Probable Precision to one-fourth of a degree. As a provisional estimate of the highest useful degree of precision, we would suggest that the Probable Precision of the Monthly Means of the Wind's Direction in each Five-degree Square need not be raised to more than two Points; nor that of the height of the Thermometer to more than 1°, nor that of the Barometer to more than $\frac{1}{20}$th of an inch.

8. *Estimate of Number of Observations required to determine the Meteorology of the Ocean.*

We are unable to estimate accurately the number of observations that would, on an average, be required to give results of the degree of precision we have just described, for each Five-degree Square. The requirements of the most variable climate would not probably exceed 200 observations for each quarterly division of each Ten-degree Square in each of the 12 months. That is to say, in a variable climate (4 × 200 × 12, or) about 10,000 observations in each of the 330 Ten-degree Squares, would be required to supply the necessary material for determining its Meteorological Means. A far smaller number would be needed in Squares situated between the tropics, where the climate is usually exceedingly regular in its changes. A hundred or even fewer observations in those latitudes would give, on an average, a result of greater precision than 200 under the former circumstances. No doubt there are many Ten-degree Squares whose Meteorological systems are so uniform that it would be unnecessary to subdivide them. In these cases, 100 observations in each month, or 12,000 observations altogether for the whole Ten-degree Square, would be sufficient.

Under these circumstances, and considering also that much work has already been effected by foreign Governments and by private individuals, we think we may be justified in provisionally assuming that 100 observations in each month in every Five-degree Square, or 5,000 observations altogether in every one of the 330 Ten-degree Squares would represent the average number with which the Department would have to deal, before its work is complete. This calculation results in a grand total of 1,650,000 observations to be collected and discussed. Perhaps one-third of them are to be found in the registers now in possession of the Board of Trade, but for the reasons mentioned above,* we are unable to speak of this proportion with certainty.

* See page 7.

9. *Description of the Publications actually issued and of the Discussion of Observations now in progress, as compared with the desiderata of the Royal Society.*

We now proceed to give a statement of the work that the Department has actually accomplished in discussing observations, and in publishing the results.

As regards the desiderata of the Royal Society, mentioned above,* and numbered 1, 2, 3, and 7, relating to Barometric Pressure, Aqueous Vapour, and Temperature of the Atmosphere, to the Temperature of the Surface of the Sea, and the Temperature, Direction, and Velocity of Ocean Currents, and to the limits of the Trade Winds and Monsoons, a very small portion has been completed; about one-half of the discussions of the observations relating to these subjects have been commenced, and are in various stages of progress. We think it may be assumed, subject to the general remarks made above concerning this work, that less than one-fourth of it has been done. The following Tables and Lists will perhaps more clearly set forth the several details than a generalized statement.

The discussion of observations necessary to satisfy the desideratum numbered 4, "the "*five-day means* of Temperature at *fixed* stations," has not been commenced. We observe that this was considered by the Royal Society a matter of special importance, and we have referred to it specially below.†

The desideratum numbered 5, concerning Magnetic Variation, has, as above stated, been fulfilled by the Hydrographer of the Admiralty.

The desideratum numbered 6, relating to observations at certain stations in the colonies, has not been commenced.

TABLE SHOWING THE PROGRESS MADE IN COMPILING AND PUBLISHING THE METEOROLOGICAL ANNUAL, QUARTERLY, AND MONTHLY MEANS OF THE 330 TEN-DEGREE SQUARES WHICH COVER THE ACCESSIBLE PARTS OF THE OCEAN.

Subject.		Published.	Ready for Publication.	"Collected" and "Grouped,"‡ or in process of "Grouping."		"Collected,"‡ or in process of Collection.	
		No. of Squares.	No. of Squares.	No. of Squares.	Estimated Progress.	No. of Squares.	Estimated Progress.
Winds	Annual	—	—	—	—	290	$\frac{1}{10}$
	Quarterly	*a* 200	—	48	$\frac{3}{4}$		
	Monthly	*b* 23	*b* 17	*b* 210	$\frac{3}{4}$		
Barometer	Annual	*c* 72	—	—	—	270	$\frac{1}{10}$
	Quarterly	—	—	—	—		
	Monthly	*c* 96	—	137	$\frac{3}{4}$		
Thermometer [Dry and Wet.]	Annual	—	—	—	—	268	$\frac{1}{8}$
	Quarterly	—	—	—	—		
	Monthly	—	—	143	$\frac{3}{4}$		
Temperature of Sea	Annual	330	—	—	—	286	$\frac{1}{10}$
	Quarterly	23	—	—	—		
	Monthly	—	—	71	$\frac{1}{3}$		
Ocean Currents	Annual	—	—	—	—	260	$\frac{1}{3}$
	Quarterly	24	—	—	—		
	Monthly	—	—	56	$\frac{3}{4}$		
Specific Gravity	Annual	325	—	—	—	—	—
	Quarterly	—	—	—	—		
	Monthly	—	—	—	—		

a { Direction of wind only. Converted from Maury.

b { Direction and force. Maury and Board of Trade combined.

c In zones of 5 degrees.

* See p. 5. † See p. 42.

‡ For the meaning of the words Collected and Grouped, see above, pp. 7, 8.

f. 76

List of Wind Charts Published.

North Atlantic Ocean	- -	10° squares.	Quarterly
South Atlantic Ocean	- -	„	„
Brazil (coast of)	- In Squares of { 4° Lat. 2° Long. }		„
Cape Horn (East)	In Squares of { 2° Lat. 4° Long. }		„
„ (West)			„
North Pacific Ocean (East)	-	10° squares.	„
„ Western part		„	„
„ Central part	-	„	„
Central America	- - -	„	„
Indian Ocean (North)	- -	„	„
„ (South)	- -	„	„
Africa, S. and E. coasts	- -	„	„

Converted from Maury's Wind Charts.* Direction alone given.

Trade-Wind Charts, for North and South Atlantic Oceans, published in 2° squares, monthly, with per-centage of Calms and Rains.

Charts embracing the following Ocean Statistics, viz. :—Currents, Sea Temperature, Prevalence of Rain, Magnetic Variation and Dip, Wind (direction and force).†

16 in No. { North Atlantic Ocean (from Equator to 40° N. Lat.) } 5° squares for months. { February. May. August. November.

Charts of Miscellaneous Character published.

1 Chart of Black Sea. Winds (direction and force), Currents. Quarterly.
„ Balaclava Storm of 1854. Winds (direction and force). Barometer.
Published in No. I. of Meteorological Papers.

Synoptic Charts of Royal Charter gale, 1859, contained in an Atlas accompanying No. X. of Meteorological Papers. The gales also of January 19, December 1, 2, 3, 4, 1863, published in Report of 1864.

Specific Gravity of Ocean and Sea Temperatures.

Mean *Annual* values in 10° squares. These have been "*collected*" independently of month of observation. Extremes and remarks for each ocean are given and diagrams appended. The sea temperatures were collected with specific gravity, for the purpose alone of applying temperature and corrections.

Published in No. XII. Meteorological Papers.

Intertropical Diurnal Range Tables of the Barometer.

English and Dutch observations combined, with a view of obtaining an *approximate* value or correction for Barometrical Observations made on board any ship crossing the Equator in the Atlantic and Indian Oceans.

Published in No. VII. of Meteorological Papers.

Barometric Means, for high North and South Latitudes.

"*Collected*" for zones of 5° parallels, and for the special purpose of ascertaining without delay, whether Barometric pressure diminishes in high latitudes rapidly and uniformly.

Published in No. XIV. Meteorological Papers.

---

* We refer to the charts published by the American Bureau of Hydrography, when under the supervision of Commander Maury. That zealous and indefatigable officer, eager to give with the smallest possible delay some usefully approximate knowledge of the meteorology of the ocean, especially of its winds and currents, collected an enormous number of observations from the best sources then accessible to him, and combined them on his charts. His material is more than four times as extensive as that contained in the Registers of our own Meteorological Department, but it is compiled in a form so puzzling and intricate as to be scarcely intelligible to an ordinary navigator. According to one part of Maury's system, the course of every ship was laid down upon the published chart, and the direction of the wind marked upon that course at each observation. The charts are printed in colours, different colours being ascribed to the different quarters of the year, and the months of each quarter are distinguished by other devices. The result is unhappily very perplexing. The face of the charts is overlaid with meshes of interlacing lines in extraordinary number, so as to resemble entangled skeins of many-coloured threads. Admiral FitzRoy treated these charts as a vast repertory of original observations. He was anxious to publish charts without delay that should be of use to the practical seaman, by showing the prevailing winds at sea during different seasons of the year, and Maury's observations were ready at hand for the purpose. He therefore devoted a large part of the earlier efforts of the Department to the "conversion" of Maury's charts into another form; but in doing so, some part of their value was lost. The latitude and longitude of each of Maury's observations are shown in his maps by the place in which the observation is protracted. These are omitted in the "conversions" of the Department. He simply extracted the observations out of each Five Degree Square, and combined them quite irrespectively of their position in it, or of any other consideration whatever. The charts that are founded upon Maury are, therefore, liable to the objections we have already urged against the system of collecting and grouping employed by the Department, in respect to its own Registers. The comparatively scanty, though far more carefully selected observations of the British Marine, were simply combined with Maury's materials; and, therefore, an imperfect rendering of Maury's charts must be considered as the basis of the great majority of the Wind Charts published by the Meteorological Department of the Board of Trade.

† In this series of Charts, Maury's Wind observations are combined with those from Board of Trade Registers. As to Maury's Charts, see note above.

Icebergs in Southern Hemisphere.

Compiled from the papers of Mr. J. T. Towson, of Liverpool, 1855–9, various other authorities, and from about one-half of the Board of Trade Registers. Charts appended.
Published in No. XII. Meteorological Papers.

Land Observations (under Heads 6 and 7, of Royal Society's Requirements).

These are contained in Nos. I., IV., and V. of the Meteorological Papers. They refer to the following stations, and were made for the annexed periods :—

No. of the Meteorological Paper in which published.		Period embraced by the Register. Years.	Months.
V.	Orkney { All Elements - - - - -	22	—
	Wind and Thermometer - - - -	33	—
	The necessary observations for correcting the barometer have been generally omitted. The winds are referred to only 8 points of the compass.		
I.	Cape of Good Hope. Results from Meteorological observations made between Jan. 1842 and Jan. 1856 - - -	14	—
V.	Decima, in Japan - - - - - -	7	—
	Thermometer observations only.		
V.	Papiete, in Tahiti - - - - - -	5	—
	A summary for each of the five years.		
I.	New Zealand. The meteorology of, based on observations made by Capt. Drury, R.N. - - - -	4	—
I.	Valparaiso - - - - - - -	3	—
	No summary of the three years.		
I.	Bermuda - - - - - - -	2	—
I.	Halifax - - - - - - -	2	—
I.	Ascension - - - - - - -	2	—
IV.	Arctic Seas, Register of the "Fox" - - - -	2	—
	Reprint of the *Noon* observations only, with preface, monthly summary of Temperature, Barometric pressure ; Ice ; Auroræ, &c.		
V.	Ekukanyeni, in Natal - - - - -	1	3
	Summary for each month, and for the year 1858 given.		
I.	Ceylon. Point de Galle - - - - -	1	—
	Winds and rain observed.		
I.	„ Trincomalee - - - - - -	1	—
I.	„ Columbo - - - - - -	—	—
	Winds and rain observed.		
V.	Oratava, in Teneriffe - - - - - -	1	—
	A reprint of the Register. The observations were taken at irregular hours. No summary or discussion.		
V.	Maritzburg, in Natal - - - - - -	0	9
	(In continuation of those made at Ekukanyeni.)		
I.	Caledonia Bay, Isthmus of Darien - - - -	0	2
	Reprint of a Register. A brief summary annexed.		
I.	Cartagena, New Grenada - - - - -	0	2
	Reprint of a Register. A brief summary annexed.		

Anemometry.

XIII.	Halifax - - - - - - -	2	0
VIII.	Bermuda - - - - - - -	1	6
	These have been discussed with minuteness and in a complete manner.		

10. *Remarks on the form and character of the above Publications.*

Upon the papers above described we have to observe that, whilst they evince much industry, they appear to have been selected and published without any plan ; that original observations and fragmentary and miscellaneous papers on detached subjects form a large part of these publications ; and that where the observations have been discussed no uniform method of tabulating the results has been adopted. Indeed it is stated in the Preface to the first Number of the Meteorological Papers, that the observations printed in the volume are "mere fragments ; sufficient, perhaps, to encourage observers, and "induce them to send ampler records (in confidence of appreciation), and enough to "show what is required." Similar views appear to have prevailed in many of the subsequent publications.

We do not think it desirable that such a mode of publication should be continued. Special facts, of immediate interest to mariners, such as the discovery of a new shoal, may properly be the subject of a special notice or advertisement, such as are now issued of facts of a like nature by the Hydrographer of the Admiralty. And these facts,

as well as others of immediate practical value, may properly be incorporated with and published in charts. These, however, are matters for the Hydrographical Office. The publications of any Meteorological Department ought, we think, to be made upon some well considered and uniform plan. They should not, except in the most special cases, include original observations, or Meteorological Registers in extenso, and if it is necessary to do so, a summary of the results should be appended. They should generally, if not exclusively, be confined to results so carefully digested as to be easily understood and readily handled. These results, consisting in the main of the Means of Barometric Pressure, Vapour Tension, Temperature, and Wind, together with the Variability of each of them, should be tabulated on one uniform and well considered system.

It is, in our opinion, impossible to exaggerate the importance of this object.

11. *Further use of the Meteorological Registers for purposes of Navigation.*

In the foregoing observations and suggestions we have borne in view that which was the principal object of the Royal Society in the letter above referred to, viz., the collection and discussion of meteorological statistics of the ocean, on principles well known to and universally practised by meteorologists.

It is to facts thus observed and discussed that we must look for the advancement of scientific knowledge, and, through the medium of such knowledge, for results useful to the navigator. But we have not overlooked the fact that in addition to the ultimate results to be thus obtained, the Royal Society and the Government, at the time the Meteorological Department was established, contemplated the possibility of results more immediately useful to navigation, and that such results were in effect one of the chief objects which Maury, to whom so much praise is due for originating the project, had constantly in view. We agree that these objects should not be lost sight of.

The Meteorological Registers frequently contain information which may be turned to the immediate account of navigation, *e. g.*, notices of rocks, shoals, icebergs, &c., in the column headed Remarks; minute information concerning local currents or other incidents of special interest to navigation in particular localities; and, if regarded as a whole, evidence concerning the best and shortest routes for various voyages. As, however, the results to be thus obtained vary with the wants of navigation, and with the state of hydrographical knowledge for the time being, we forbear attempting to define them, or to prescribe any definite course in extracting and publishing them. It is, however, clear that nautical experience and hydrographical skill will be necessary in directing such labours.

Whether a special officer shall be appointed for this purpose, whether, if so, he should be connected with the Board of Trade, or, as is more likely to be desirable, with the Hydrographic Office, will be a matter for consideration in organizing the system. Whatever plan be adopted we think it desirable that the Registers should be in the first instance discussed for the purpose of estimating the Meteorological Means, and that they should afterwards be made use of for the more immediately practical purposes mentioned above. If in the former discussion it should appear that there is on any special Register a fact of immediate interest to the Hydrographer that fact or that Register may be at once sent to him. But we think it of great importance that the regular work of extracting the Meteorological Means should henceforth go on regularly and without interruption. This need in no way interfere with our further conclusion, that knowledge which is obtained through the medium of the observations of sailors, and which is capable of being utilized for their benefit, should be so utilized as soon as possible, and that they should feel a confidence that it is so utilized.

12. *Recommendations for the Future on the Points discussed above.*

We have now to offer our recommendations seriatim concerning the various points referred to above, taking them in the order into which they seem naturally to fall rather than in that in which we have above discussed them.

(*a.*) *As regards the Works and Discussions of Observations now in progress.*

We recommend that the following use should be made of the results already obtained by the Meteorological Department, and now remaining in MSS.

Winds.—The nearly completed work referring to the South Pacific, to be finished, and a series of charts printed from it, corresponding in every respect to those already published of the North Pacific.

[The Department will then have issued wind charts for the whole Ocean, and for each quarter of the year.]

The Trade Winds and Monsoons for the Indian and Pacific Oceans to be extracted and charted, and to be published under the same form as those already published for the Atlantic Ocean.

All the Collection papers that refer to Winds, their Direction or Force, to be bound up into volumes, referring to separate Oceans. The arrangement to be methodical; a preface to contain a full description of the principle on which they have been made and of the order of their contents, and generally speaking, the volume to be prepared in such a way as to be self-contained, and perfectly convenient for future reference.

The same to be done with the Grouping papers.

Further work under this head, on the present system, to be discontinued.

Ocean Currents.—The Collections so far as they are at this moment completed, to be bound into volumes, on exactly the same principle as recommended for the winds.

The same to be done for the Grouping papers.

Further work under this head, on the present system, to be discontinued.

Sea Temperature.—The Collection to be completed in North and South Atlantic, but not to be grouped.

Then all the collections to be bound into volumes as above.

The same to be done for the existing Grouping papers.

Further work under this head, on the present system, to be discontinued.

Temperature of the Air.—The results already obtained to be submitted to revision, and such of them as appear worthy of publication to be printed and published in the form of Tables,* containing the Mean readings of the Thermometer and the Number of observations, for every Month and for every Five-degree square.

Both Collections and Groupings to be bound as above.

Further work under this head, on the present system, to be discontinued.

Vapour Tension.—The results of the Wet bulb thermometer as already obtained, to be treated in the same way, and incorporated in the same Table with the Temperature of the Air. Also the Vapour Tension, as obtained from a comparison of the monthly means of the Wet and Dry bulbs to be added to them.

Both Collections and Groupings to be bound as above.

Further work under this head, on the present system, to be discontinued.

Barometric Pressure.—The results already obtained to be treated on exactly the same method as the Temperature of the Air and the Vapour Tension. The results to be incorporated in the same Tables.

Both Collections and Groupings to be bound as above.

Further work under this head, on the present system, to be discontinued.

The result of our recommendations will be to complete and publish whatever results of value are near their completion, as well as to publish those series which are complete. We then propose to discontinue the present system of discussing observations; but to put the remainder of the work of Collecting and Grouping which has been already done into a convenient form for the immediate wants of the Hydrographical Department of the Admiralty in making and correcting charts; and also for ulterior use in calculating the Meteorological Means.

(*b.*) *As regards the Collection of further Observations.*

We recommend that the issue of Meteorological Registers and the loan of Instruments should be re-commenced and carried on as rapidly and widely as is consistent with considerations of expense and convenience. The work will not be complete until there are the necessary number of observations, say 5,000 on the average, for each of the 330 Squares into which the Ocean is divided.† But since, as we have said, there are some of these Squares into which few ships go, and some parts of the Ocean for which foreign observers may have done all that is necessary, discretion will have to be exercised in issuing the Registers, so as to obtain materials for the Squares which are not complete, and so as not to overload the Office with unnecessary material in respect of those which are. We further recommend that a Chart be annexed to each Register, showing the track of the Ship through the Squares; and that an Index be kept in the Office referring, under the head of each Square, to each Register containing observations relating to that Square.

(*c.*) *As regards the method of extracting the Observations.*

We recommend that this should be done in the manner we have suggested above.‡ And we recommend that this shall be done for all the Registers in the Office, whether

---

* See Appendix, No. 5, for a suggested form of such Tables.

† *i. e.*, about 1,650,000 in all, including the 550,000 already obtained.

‡ See pp. 9, 10.

they have been already partially extracted or not. We believe that what we recommend would not exceed the labour of completing what remains to be done according to the present system. We do not think that the extracts already made can be so employed as to produce satisfactory results, or that they can be combined, in a manner that would do justice to the intrinsic merit of the observations, with extracts made on a more complete and satisfactory system.

(*d.*) *As regards the method of discussing and tabulating the results of the Observations when extracted.*

We recommend that the results of the Observations when extracted should be tabulated on one uniform plan, and we give in the Appendix* a form of the Table, which we think might be adopted for the purpose. It would occupy one page of a book, and letter-press descriptive of the square, explaining whatever the table might not be able to include, might occupy the page opposite, or be printed separately. The details are described in the form above referred to. It is not desirable that the Squares should be described and tabulated in the strict order of their numbers, or that their issue should be long delayed for the sake of making the issue complete, but rather that separate parts should be published at the discretion of the Office, capable of being bound together into well-indexed volumes, each referring to some particular Ocean.

(*e.*) *As regards Publication of Meteorological Results.*

We recommend that the Meteorological publications be, as a general rule, confined to the results obtained as above, and that no original observations, no fragmentary papers, and no speculations on Meteorology be henceforth issued.

(*f.*) *As regards Publication of other Results useful to Navigation.*

We recommend that any special matters of immediate importance to navigation which are discovered in extracting the Register be at once brought to the notice of the Hydrographer for publication, if he thinks fit. We also recommend that the Registers, when the Meteorological extracts have been made, shall, either under the direction of the Hydrographer or otherwise, be so kept and dealt with as that they may be utilized for the current and varying wants of navigation.

In respect of Charts we do not feel it necessary to give any special recommendation. The Admiralty Hydrographic Department are now devoting considerable pains to the preparation of physical charts, such as Ice, General Ocean Current, and Wind Charts. In these it is proposed to embody the results collected by the Meteorological Department in a form available to seamen.

PART II.

Weather Telegraphy: Foretelling Weather; and Observation and Statistics of Weather within or affecting the British Isles.

13. *Origin of the Practice of Telegraphing and Foretelling Weather.*

We next proceed to consider the subject of Weather Telegraphy, of Foretelling, or, as Admiral FitzRoy termed it, "*Forecasting*,"† weather, and of observing the changes of weather within the British Isles, with the view of discovering the laws which govern those changes. This last part of the subject is intimately connected with the foretelling of weather, since it is upon a knowledge of such laws, and upon such a knowledge only, that any sound system of foretelling weather can be based.

As early as the year 1857‡ the late Admiral FitzRoy's attention had been directed to the daily observation of the changes of weather over the British Isles, with a view to the prediction of such changes. He states in his report of 1862§ :—

"By continued and consecutive series of charts, several hundred in number, con-
"structed on the simultaneous or synchronous principle, an insight into the laws of
"our atmosphere, into meteorological dynamics (distinct from statistical results, pre-

---

* Appendix No. 6.

† This word "*Forecast*" seems to have been used for the reason that it expressed a less degree of precision and certainty than the more usual words "Predict" or "Foretell." Whether the reason is a sound one may be doubted. The use of vague phraseology has a tendency to make those who use it satisfied with uncertain conclusions.

‡ Report of Meteorological Department, page iii, 1862; also Eleventh Number of Meteorological Papers, 1862, page 276.

§ Paragraph 8, p. iv.

" viously obtained at observatories and elsewhere), has been gained, *which has enabled* " *us to know what weather will prevail during the next two or three days, and, as a* " *corollary, when a storm may occur.** These seem satisfactory and rewarding results. " Their bases shall be popularly explained in the following chapters of this report."

In September 1859 the following resolution was adopted by the Council of the British Association at Aberdeen :—

" The Committee of the section of Mathematical and Physical Science having repre- " sented the probable importance of occasional telegraphic communication between a few " widely-separated parts of Great Britain and Ireland, by which warning may be given " of storms, the General Committee recommends application to the Board of Trade for " such an arrangement as may further this object authoritatively."

This resolution was communicated to the Board of Trade in December of the same year, and Admiral FitzRoy was directed to prepare a plan, to be tried experimentally, to convey to and from a certain set of telegraph stations intelligence of approaching storms. Admiral FitzRoy was subsequently put into communication with the Committee of the British Association, consisting of General Sabine, Professor Walker, and Mr. Gassiot, and the following resolutions were in consequence, on the 25th February 1860, adopted by the Council of the Association :—

" 1. Great Britain and Ireland to be divided into three 'weather districts,' North, " East, and South-west. The first including all Scotland; the second, thence by the " coast to Dover Straits; and the third, all the south and west coasts of Ireland.

" 2. In each of these districts, officers now on duty there, to be selected, instructed and " provided with instruments (now available).

" 3. These officers (only three or four in each district) will send such telegraphic " messages to London *occasionally*, as their instruments specify.

" 4. These messages will be posted at Lloyd's, and transmitted to the other selected " stations, where they will likewise be conspicuously posted.

" 5. If found useful, *results* of such limited communications may be followed by more " extended systems."

It will be observed that upon the face of these resolutions there is nothing to show that the Council of the British Association intended anything more than that storms already known to exist at one place should be announced by telegraph to other places; and that at any rate there is nothing in them upon which to found such an elaborate system of foretelling probable weather as was subsequently adopted.

In the meantime M. Le Verrier, Senator and Director of the Imperial Observatory at Paris, had established a system of telegraphing the state of the weather daily, not only from various ports in France, but also from other ports in Europe, to Paris, and also from port to port in France, and he invited the British Government to join in the system.

In doing this, M. Le Verrier expressly confined himself to the communication of the actual state of the weather, and apparently deprecated any premature attempt to foretell anything except the approach of storms known by telegraph to exist elsewhere. Indeed he wished, in the first instance, even to avoid this, and to confine the system to regular daily communication of actual Weather by periodical Telegrams. In a letter to Professor Airy, the Astronomer Royal, dated 4th April 1860, which contained his first proposal, after stating at length the measures he had adopted and was proposing for the purpose of such communication, he says: " Signaler un ouragan des qu'il apparaîtra en un point de " l'Europe, le suivre dans sa marche au moyen du télégraphe et informer en temps " utile les côtes qu'il pourra visiter, tel devra êtra en effet *le dernier résultat*† de " l'organization que nous poursuivons. Pour atteindre ce but, il sera nécessaire d'em- " ployer toutes les ressources du réseau Européen et de fair converger les informations " vers un centre principal, d'où l'on puisse avertir les points menacés par la progression " de la tempête." And he adds: " Cette portion de l'entreprise est aussi de beaucoup " la plus délicate. Il faut éviter d'en compromettre le succès en voulant la produire " avant le temps où son utilité, universellement sentie, en fera partout réclamer l'or- " ganization." In a subsequent letter to Admiral FitzRoy, dated 18th April 1860, written in reply to one in which Admiral FitzRoy had apparently suggested an endeavour to predict storms by a special service, he says: " Le service régulier que nous avons " établi n'est pas tout ce qu'on pourra faire. J'indique, à la fin de ma lettre (*i.e.*, in " the passage quoted above from the letter to Professor Airy) qu'il faudra ultérieurement " en établir un service extraordinaire pour prevenir de la marche des tempêtes, au " moment même où elles apparaitront." And after pointing out that such an extra-

---

* The Italics in this passage are our own.

† The Italics are our own.

ordinary service, if commenced prematurely, might lead to great errors, which would compromise everything, he says: " Si donc vous me la permettre, M. l'Amiral, " j'oserais vous recommander de ne pas repousser ce que nous proposons en s'appuyant " sur ce qu'on pourrait faire davantage."

Admiral FitzRoy, however, relying on his belief that information had been collected and sufficiently digested in his office during five years with the special object of Foretelling Weather, and thinking that this country should take an independent course, and thinking also that too much time and labour had been given by meteorologists to registering and publishing facts, and that too little attention had been directed to practical results, persevered in his intention of foretelling, or, to use his own expression, *forecasting*, not only storms announced by telegraph as already existing, but Weather generally.

14. *Establishment of System of Telegraphing Weather.*

Arrangements were accordingly made during the summer of 1860 for the regular daily communication by telegraph to London of the state of the weather at 15 stations in the United Kingdom, for receiving daily telegrams of Weather from various places in Europe through Paris; and for the daily communication by telegram to Paris of the state of the weather at certain points in the United Kingdom.

The facts thus communicated to the Meteorological Department were thenceforth published in the daily papers.

15. *Establishment of Storm Warnings and daily Forecasts of Weather.*

At the same time Admiral FitzRoy made arrangements for hoisting Storm Signals and Weather Warnings at certain ports, and they were hoisted for the first time in February 1861.* In June of the same year an attempt was made in another department of the Board of Trade to institute a careful check upon the accuracy of the storm warnings by obtaining exact returns from various public officers at the places where they were hoisted. To this subject further reference is made below.† In August 1861 a great extension of the Weather Predictions took place, first in extending the Storm Signals to many places not previously warned, viz., to 130, as it would seem, instead of to 50 places as at first; and in making Daily Forecasts of the Weather in the newspapers.

The system of Telegraphy, of Storm Warnings, and of Daily Forecasts has since been continued, and is now carried on with great zeal and intelligence by Mr. Babington, who, during the latter months of Admiral FitzRoy's life, had the principal management of it. The public have taken great interest in it, and there can be no doubt that the Storm Warnings are very popular at the ports. Foreign Governments have shown much interest in the system. The predictions of the English office have been sent daily to Paris. M. Le Verrier has organized a system of Storm Warnings similar to our own, and also publishes daily a very full Bulletin of the actual weather, illustrated with maps of Barometric Pressure and of Wind. The Bulletin and map are published by a private person, but under the control of the Imperial Observatory, and may be subscribed for like any other newspaper. For some time his Bulletin contained predictions of the probable weather for different parts of France, but we observe that these daily predictions have been recently discontinued. Professor Dove, at Berlin, has recently organized a system of occasional Storm Warnings, similar, we believe, to our own. Italy has lately been establishing a system of Storm Warnings on an independent plan.‡ Holland has also established a system of occasional Storm Warnings, and Russia is doing the same. Occasional Storm Warnings are sent from the English Meteorological Office to Denmark, Sweden, Hanover, Hamburgh, and Oldenburgh, at the request of the authorities in those countries.

Under these circumstances we have felt it our duty to inquire very carefully upon what basis the practice of making predictions, both Daily and Occasional, rests; and what evidence there is, first, of its accuracy, and, secondly, of its practical utility.

16. *Practice of the Department in foretelling Weather.*

The following is, so far as we can learn, the practice pursued by the Department in foretelling probable Weather §:—

In making Daily Forecasts the area of the British Isles is divided into districts; and the average state of the weather in each district is deduced from the weather reports received from the stations contained within it.

---

* Report, 1862, page xi. † See page 28.

‡ See correspondence between M. Matteucci and Admiral FitzRoy in Report of Meteorological Department for 1864, pp. 33 to 36.

§ See Admiral FitzRoy's Weather Book, p. 127.

A Daily Forecast for each district is then made provisionally.

The separate Forecasts are next collated and revised, regard being paid to the following particulars :—

(*a.*) The mutual actions of the estimated weather in each of the districts of the British Isles.

(*b.*) Scattered information in respect to such distant areas of high and low barometer, as the continental stations can afford.

(*c.*) Geographical conditions of mountain, plain, or sea, by which the free movements of the air may be affected.

It is the custom of the Department to perform the whole of the foregoing operations, and to determine the forecast, after a simple inspection of the list of weather returns. No notes or calculations upon paper are made. The operation occupies about half an hour, and is conducted mentally.

This operation is performed every morning, and the result is sent to the papers.

If from the returns thus received, or from subsequent Telegrams, the Department, still reasoning in the same way, concludes that a gale is to be expected, notice is sent by telegraph to the ports to hoist the Storm Signals.

17. *This practice not carried on according to any definite rules.*

We have already mentioned that Admiral FitzRoy collected for several years a number of observations and prepared a number of charts, with a view to this special object. We have made inquiries on the subject of these observations and charts. But we do not find that they were ever carried on or completed so as to bring out clear and definite conclusions, or that their results were ever reduced into the shape of definite rules or principles. At any rate no such conclusions and no such rules now exist in the Department. Mr. Babington tells us that he does not think that the grounds on which the Department acts in foretelling weather are capable of being stated in the form of Rules or Laws, and he is unable to give us any precise information as to those grounds otherwise that by referring to Admiral FitzRoy's publications, and giving us particular examples. Admiral FitzRoy himself has, in his Report of 1862, and in his Weather Book, indicated certain general conditions implied by the state of the atmosphere as observed simultaneously at scattered stations, and certain probabilities of future weather arising therefrom, and similar conditions and probabilities may be inferred from Mr. Babington's examples. That many of these conditions and probabilities are capable of being stated in the form of Laws, and that some of them are Laws that would be accepted by Meteorologists generally we do not doubt; nor do we doubt that the probabilities are in many cases considerable, and especially in the important cases of sudden and violent changes of weather. But we do not find that these conditions and probabilities have been reduced into any definite or intelligible form of expression, or are, as they now exist in the Office, capable of being communicated in the shape of instructions. Were the gentlemen now in the Department to leave it, no rules would be found in the Office for continuing the duties on their present basis. We have endeavoured to give a notion of such of the maxims or probabilities on which the Department acts as we are able to extract from the sources above referred to.* But we are conscious that in attempting this we may be doing injustice to the practice.

18. *The Maxims on which the Department acts not founded on any sufficient induction from facts.*

Under these circumstances it is scarcely necessary to say that the maxims on which the Department acts in foretelling weather, whatever they may be, and whatever may be their intrinsic value, are not shown to have been obtained and established in the Department itself by means of accurate induction from observed facts. Neither is there any evidence that in framing such maxims, the various attempts of other Meteorologists to give precision to the science have been utilized. No exact value seems to have been assigned to such maxims. Still less has it been attempted to estimate, by any accurate method of calculation, the value of the compound probabilities that necessarily arise from the application of each separate combination of these maxims to the ever varying and complicated phenomena of the weather.

19. *Experience of the Office not utilized in reducing this practice to a system.*

Nor do we find that the experience of the Department in issuing these predictions, which is now of five years' standing, has been turned to account in reducing the practice

---

* See Appendix No. 7.

to a system. If on the occasion of each prediction steps had been taken to elicit distinctly and to record the reasons or maxims on which it was based, and if, upon comparing the actual result with the prediction, steps had been taken to ascertain in what respects the assumed maxim or maxims had been properly applied to the observed facts and had been found consistent with the subsequent results, and in what respects it had been misapplied to or inconsistent with them, the Department would probably by this time either have been in possession of certain determined and trustworthy rules, or would have been in a position to say that no such rules can be framed. But this has not been done. The particulars of weather, pressure, wind, &c., as telegraphed each day, and as published in the newspapers, with the forecasts, are kept in a book; and in this book are also entered such accounts of the weather, of the effects of gales, &c., as it is found possible to extract from the newspapers.* But, in the first place, the data thus obtained are not sufficient for an accurate test. The daily telegrams are only from a few places, and only for a given moment in the 24 hours; whilst the extracts from newspapers are vague and miscellaneous. And in the second place, no attempt has been made to utilize the facts obtained from these several sources, or to draw any conclusions from the comparison of the facts with the predictions. They have been published at length for 1862, but they have not been analyzed. The experience of the gentlemen employed in the work may no doubt have given them some additional insight; but so far as concerns any exact conclusions, capable of being stated in definite terms, the five years' experience of the system of foretelling weather have produced no results.

20. *Distinction between Daily Forecasts and occasional Storm Warnings.*

In thus criticising the basis on which the system of foretelling weather at present rests, we have not distinguished between the occasional Storm Warnings and the Daily Forecasts, because it was urged by Admiral FitzRoy,† and is still stated in the Department that both rest on the same footing, and must stand or fall together as part of one system. But we are not satisfied that this view is correct, and we think that it probably does injustice to the Storm Warnings. That the laws which govern the weather are uniform in their operation, and that the lesser as well as the greater changes in the atmosphere are subject to fixed conditions, we are ready to assume; and we do not doubt that in order to give occasional warnings of violent storms, it is necessary to obtain as constant and as frequent observations as for Daily Forecasts. But imperfect as our knowledge of these laws and conditions still is, it is only natural to suppose that the more sudden and violent changes of wind and weather which are the subject of the occasional Storm Warnings, are preceded by more decided indications than is the case with the more common and less violent changes of our variable climate; and that the observations made in the former case (*e.g.*, of a sudden fall of the barometer), may afford a comparatively trustworthy intimation of the approaching phenomena, whilst the smaller daily changes of barometer, thermometer, &c., during ordinary weather, may to our imperfect appreciation have no meaning which we are able accurately to interpret. We believe that this view of the case is borne out by the facts as mentioned below.

21. *Comparison of Daily Forecasts with the facts as observed by the Department.*

We proceed to consider what evidence there is of the accuracy of the predictions already made, and in doing this we think it desirable to distinguish between the Daily Forecasts and the Occasional Storm Warnings, and to treat the former first.

We find that from the commencement of the practice of Foretelling Weather, a book has been kept in the Department, in which the daily reports of weather from the stations, as published, are entered, with the appended Forecast for the subsequent day or days, so that by comparing the report made on the one day with the Forecast for that day made on the previous day or days, some kind of comparison of Forecast with fact may be made. In addition, extracts have been made with much diligence from the newspapers and other sources of statements concerning the daily weather at the Ports, as well as concerning any remarkable storms or other phenomena, as indicated by wrecks, vessels putting into port in distress, &c. And from the materials thus given an attempt was at one time made to compare the Daily Forecasts with the facts. The whole of the book for the period from the 31st July 1861 to the 27th February 1862 has been printed and published‡ by the Department. But these books are far from giving us the means of forming a conclusive opinion. In the first place, the Forecasts themselves are, as might be expected, expressed in such general terms that there is difficulty in com-

* See Eleventh number of papers published by the Department, pp. 22 to 266, where the Reports and Forecasts from 31 July 1861 to 27 February 1862 are published at length.

† Report 1863, p. v.

‡ 11th No. of Meteorological Papers.

paring them with facts. In the second place, at the outset of the practice, the times for which the Forecasts were made were changed several times. Sometimes they were for the next succeeding day, sometimes until next report, sometimes for the next two days together, sometimes for each of the next two days separately. And the districts to which they were applicable have also been altered. It is, therefore, difficult to compare the Forecasts of one period with those of another. In the third place, the facts given by the Daily Weather reports (which have also been altered from time to time), are not sufficient to give any accurate information of the actual weather. With the exception of the items "Extreme force of wind since last report," and "Direction of extreme force," (particulars which were not inserted in the reports originally), the daily observations are made only once in the 24 hours, viz. at 8 a.m. They are made at a few places only; and are so arranged in the published report as to make it difficult to attach a general meaning to the report, without re-arranging it in each case. Nor do the extracts from the newspapers and miscellaneous sources give much additional help. Miscellaneous facts, gathered by the Department itself from miscellaneous sources, without knowledge of the observers, and without order or method in the observations, can be of little value. We think, therefore, that a comparison of facts with Daily Forecasts, made under these circumstances, and from these data, is wanting in all the elements necessary to inspire confidence. And we are confirmed in this view by the examination of a page taken at random from the book in question.*

22. *Comparison of Daily Forecasts with facts, as observed elsewhere.*

But there exist other methods of testing the accuracy of the Daily Forecasts of weather.

In 1864 steps were taken in the Wreck department of the Board of Trade for instituting a comparison of the actual weather with the Daily Forecasts and the Storm warnings. As regards the Daily Forecasts, the only materials available were those contained in the daily published Weather Reports, and for the reasons above mentioned those data were found very insufficient for the purpose. Such as they were, however, they were compared with the Forecasts. Each place named in the weather reports was taken separately, and for each day in the four months, March, April, September, and October, at each place. Two separate diagrams were prepared, showing, the one, the two forecasts of direction of wind for the district in which the place was situate, made on the two preceding days, and, so far as practicable, the actual direction of the wind; the other showing the two Forecasts of strength of wind for the same district, with the actual extreme strength of the wind. For instance, suppose the day to be a Thursday, for which forecasts had been made on the preceding Tuesday and Wednesday. The first diagram represented the Forecast of direction of wind for the Thursday made on the Tuesday, the Forecast of direction of wind for the Thursday made on the Wednesday, and the actual direction on the Thursday. The second diagram showed the Forecast of Force of wind for the Thursday made on the Tuesday, the Forecast of Force of wind for the Thursday made on the Wednesday and the actual force of the wind on the Thursday. It was not thought worth while to print the whole of these diagrams in the Parliamentary Return † moved for in 1864. But Scarborough was selected as a typical place, and the diagrams in question for that place are printed in the Return. The comparisons of the Forecasts with the facts, so far as direction of wind is concerned, are of no great value, because the weather reports only give the direction of wind at 8 a.m.; but as regards force, they are more important, since the weather reports give the extreme force of wind during the 24 hours, and not only at 8 a.m. A glance at the diagrams in this Parliamentary Paper will show the little correspondence there is between the black line which marks the actual extreme force, and the shaded lines which mark the Forecasts.

23. *Comparison of Daily Forecasts with each other and with Storm Warnings.*

These diagrams afford a more important test. Though it is under the circumstances impossible to make an exact comparison of Forecasts with facts, it is possible to make an exact comparison of the Forecasts with each other; *i.e.*, to compare the Forecast for Thursday made on the Tuesday with the Forecast for Thursday made on the Wednesday; and it is possible to do this exactly as regards both direction and force. A glance at the diagrams in the Parliamentary Return above referred to will show that there is not only no correspondence, but no determinate relation of any kind between them. The Forecasts made on two succeeding days for the third day differ from one another in every possible way.

---

* This page, 164, with a criticism upon it, is given in the Appendix No. 8.

† See Parliamentary Paper No. 200, Session 1864.

But this is not all. In the same Parliamentary paper are contained diagrams showing in a much more accurate manner the comparison of the Occasional Storm Warnings for 1863 with the facts. In these diagrams are entered on shaded lines the Daily Forecasts for the days on which the Storm Warnings were subsequently sent out. There were on the whole 47 days, in 1863, on which Storm Warnings were issued; and out of these there were only 10 days in respect of which the Daily Forecasts gave for any district whatever in the United Kingdom any notice of a storm or violent gale. For instance, looking to page 67 of the above-mentioned Return, we find that the Forecast made on the 15th December 1863, predicted calm or moderate weather in the southern district on the 16th December, whilst on the morning of the 16th December a Storm Warning was issued to the Southern coast, and was followed in some places by a heavy gale. If the districts or places, as well as the days, were taken separately, the difference between the Forecasts and Storm Warnings would be still more striking. We have reason, as we shall point out hereafter, to think that the Storm Warnings have been more accurate than the Daily Forecasts; and the fact above noticed shows at any rate that if they have proved to be correct, the Daily Forecasts must have been very much the reverse.

It has not been thought worth while to attempt any similar comparison of the Daily Forecasts with each other, or with the Storm Warnings for the whole of the period subsequent to 1863, more especially as it does not appear that the Department has since that time made any change in the method or principles upon which it has acted. But the Daily Forecasts for the month of December 1865 have been compared with each other, and with the Storm Warnings issued in that month. From this comparison it appears that, taking the Daily Forecasts for each district of the United Kingdom, North, West, South, and East, separately, as published in the newspapers, there were in that month 84 sets of reiterated Forecasts, or in other words there were 21 days, for which in respect of each of the four districts two Forecasts were issued, one on the previous day, and the other on the day before that. But of the 84 sets of double Forecasts there are only 11 in which the two Forecasts agree with each other verbatim. There are 27 which agree substantially with each other, and 46 which do not. The per-centages, omitting fractions, are as follow:—

Verbatim agreement	13	per cent.
Substantial do.	32	„
Total disagreement	55	„

Further it appears that four distinct Storm Warnings were issued in the month of December to each of the four districts. Taking the warnings for each of the four districts of the United Kingdom separately, the number is 16. For the districts in respect of which these Storm Warnings were issued, there were in all 32 Daily Forecasts, and of these Forecasts there were 10 only in which a gale was predicted. There were, therefore, only 10 Daily Forecasts, out of 32, which agreed with the Storm Warning, and 22 in which no gale was predicted, and which consequently were at variance with the Storm Warnings. The per-centages are:—

Agreement 31.
Disagreement 69.

It seems therefore clear that, as a rule, the Daily Forecasts agree neither with each other nor with the Storm Warnings, though all are issued by the same Department, according to the same system, and within a short time of one another.

We have had the Daily Forecasts, the Storm Warnings, and Daily Reports of the actual and extreme Force of Wind for the year 1865 at seven selected ports thrown into the form of a calendar, so as to show opposite each day in the year the Storm Warning, if any, the Forecasts made on the two previous days, and the actual extreme strength of wind; and we find that the Tables thus obtained entirely bear out the above conclusion. Two of these tables, viz., those for Shields and Plymouth, are printed in the Appendix.*

Under these circumstances we cannot say that there is evidence that the Daily Forecasts have been correct in point of fact, or that "we are enabled," to use the words quoted above,† "*to know what weather will prevail during the next two or three days*, "*and, as a corollary, when a storm will occur.*" On the contrary the evidence points strongly the other way.

24. *Utility or Inutility of Daily Forecasts.*

As regards the utility of the daily Forecasts, we have to observe, in the first place, that if there is no sound basis on which they are founded, and no evidence that they

* See Appendix No. 9.

† See p. 18.

have been correct in point of fact, they are wanting in everything which can render them practically useful. But even independently of this, we doubt whether intimations of ordinary coming weather, so vague as these Forecasts must necessarily be, can be of any real value. If it were possible to tell the sailor in a particular port that the wind, for say 24 or 48 hours, would be westerly; or to tell the farmer in a given district that he would have rain within that time; or to tell the gardener that his crops would need protection from frost or hail; or to tell the traveller that the weather would be propitious for his journey,—these predictions, if correct, would be useful. But nothing of the kind is attempted. The Forecasts indicate, as the Department has repeatedly stated, merely the opinion of the Department concerning a probability. They extend to large districts, without attempting to describe the varied particulars of weather in different parts of those districts. And they thus fail to give that information which alone could make such predictions of practical value.

25. *Conclusion against continuing Daily Forecasts of Weather.*

Considering, therefore, that there is as yet no scientific basis for these daily Forecasts, that they are not shown to be generally correct in point of fact, and that there is no evidence of their utility, we see no good reason why a Government Department should continue to undertake the responsibility of issuing them.

In this conclusion we believe we are borne out by the best practical meteorologists. M. Le Verrier, who for some time attempted a practice of the same kind, has, as we have said before, given it up. Maury, as is obvious from Admiral FitzRoy's remarks,* is opposed to it. M. Dove, of Berlin, is confining himself to a system of Storm Warnings, and appears to find some difficulty even in this.† M. Matteucci, of Turin, was obviously in difficulty, even as regards the Storm Warnings.‡ And we may add that we can find no evidence that any competent meteorologist believes the science to be at present in such a state as to enable an observer to indicate day by day the weather to be experienced for the next 48 hours throughout a wide region of the earth's surface.

It may be said that the Daily Forecasts cause no additional expense, and that they are popular and interesting, and should therefore be continued.§ But we do not think this argument satisfactory. The practice of issuing daily official notices of the weather, the truth of which is warranted neither by science nor by experience, is inconsistent with the position and functions of a Government department, and must be prejudicial to the advancement of true science. It must lead the public to confuse real knowledge with ill founded pretences, and, in the end, to despise the former because the latter prove to be unfounded. It must divert the attention of those who are engaged on the predictions from what is really practicable and useful, and, by compelling them to issue formal opinions every morning, whether they have any substantial grounds for those opinions or not, has a tendency to produce fatal results of carelessness and inaccuracy.

26. *But not against publishing Telegraphic Reports and Remarks.*

For these reasons we deprecate the continuance of those Daily Forecasts which attempt to predict with more or less accuracy the direction and force of wind, and other particulars, for each of the two succeeding days and for each of the four districts into which the country is divided. But in doing this we do not wish to put an end to the system of telegraphic communication of weather, or to the publication of those telegrams in the newspapers, or to the publication of the general remarks on the results and bearing of the information, which, following the example of M. Le Verrier, Mr. Babington has been recently in the habit of publishing with the telegrams. Such remarks, if made with knowledge and judgment, have the following advantages: they may be made or not, as the circumstances require; they need not extend to any particulars except those which the reported facts press upon the attention of the observer; and they translate the figures and facts given by the telegraphic reports into a form intelligible by, and probably interesting to, the public.

We insert in the Appendix a specimen of one of the published Reports, with the "Daily Predictions," and also with the "remarks" to which we have adverted. We also insert a specimen of M. Le Verrier's daily weather Bulletins.‖ As regards these Reports some further recommendations will be found below.¶

---

* Report of 1864, Appendix, p. 18.
‡ Report of 1864, Appendix, pp. 33–36.
‖ See Appendix, Nos. 10 and 11.

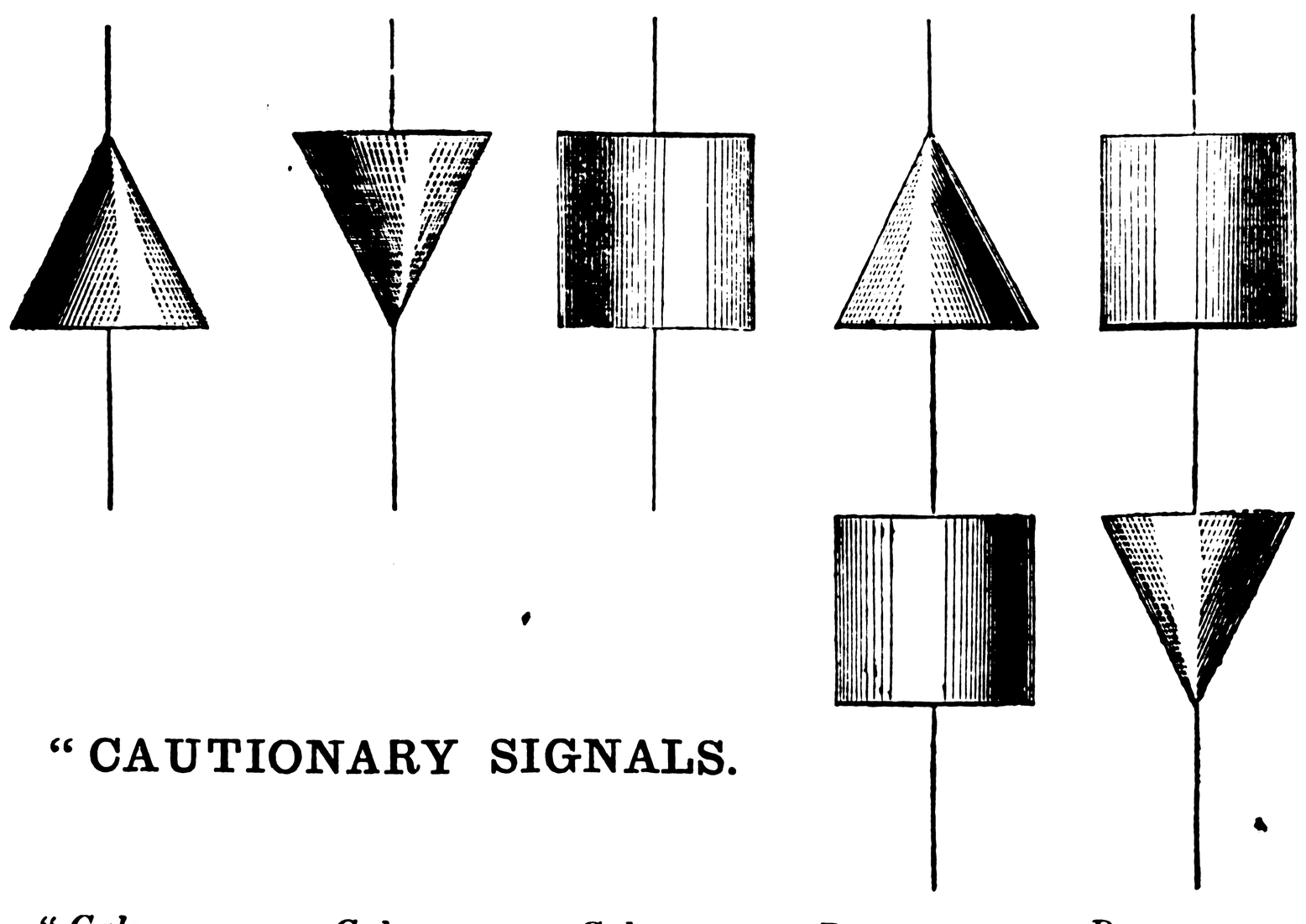
† Report of 1864, Appendix, pp. 30, 31.
§ See Admiral FitzRoy's Report of 1863, p. vii.
¶ See pp. 37, 38.

f. 13r

27. *Storm Warnings.—The official Description and Explanation of them.*

We pass now to the subject of the Occasional Storm Warnings and to such tests of their accuracy as we have been able to procure. The following is the description and explanation of these signals, verbatim, as published and circulated amongst mariners by Admiral FitzRoy.

"BAROMETER CARD AND STORM WARNING SIGNALS.

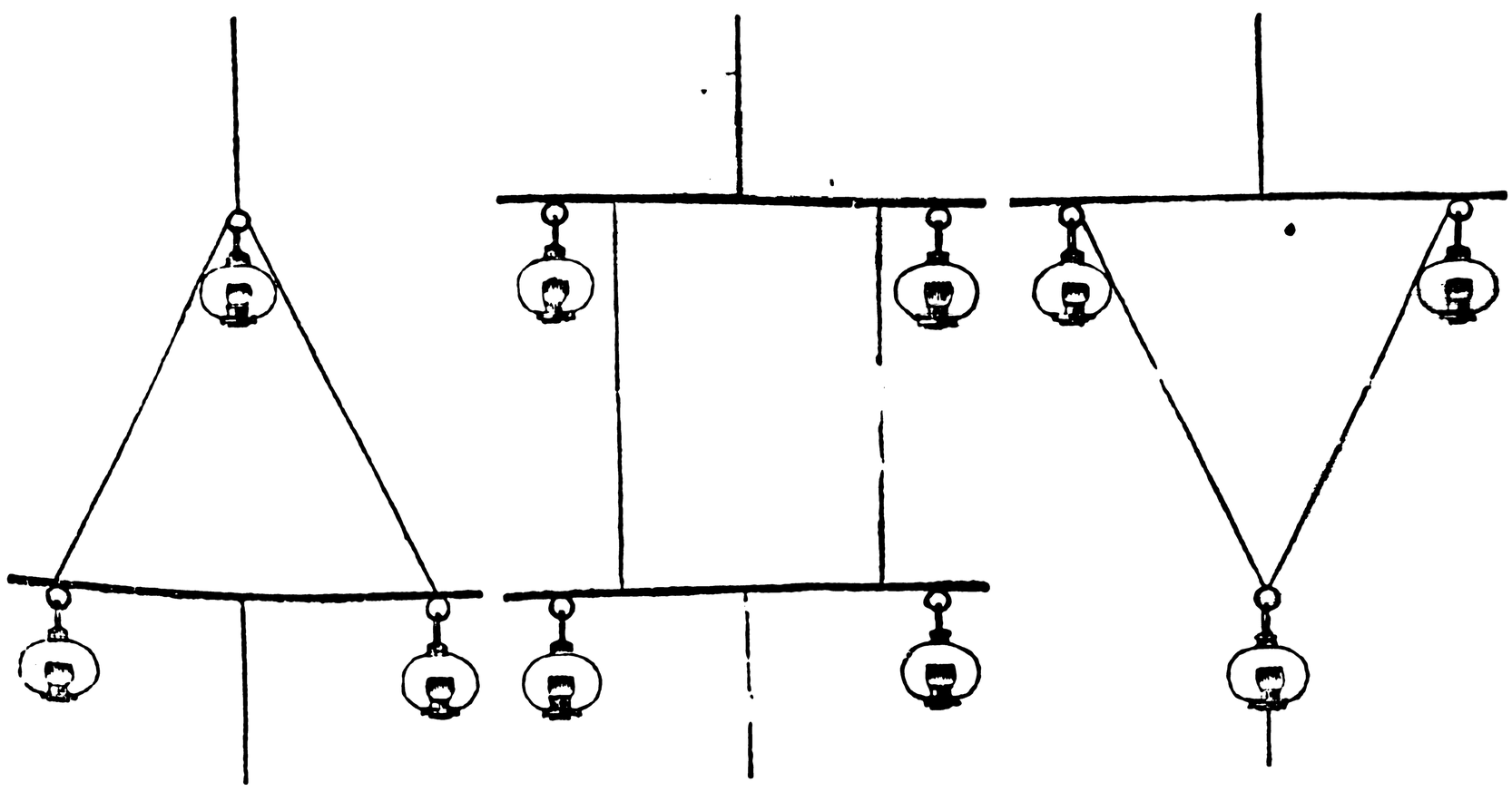


"CAUTIONARY SIGNALS.

"NIGHT SIGNALS.

"(instead of the above)

"Lights in triangle, or square.



"Four lanterns and two yards, each four feet long, will be sufficient—as only one signal will be "used at night.

"These signals may be made with any lanterns, showing either white, or any colour, but *alike*.

"*Red is most eligible*. Lamps are preferable to candles. The halyards should be good rope, and "protected from chafing. The lanterns should hang *at least* three feet apart."

Official Explanation of Storm Warning Signals.

"A staff and two canvas shapes being provided, the following use will be made of them
" occasionally; perhaps once or twice in a month, on a yearly average.

"One shape, that of a drum (or cylinder) has the appearance of a black square of (not less than)
" three feet (seen from any point of view) when suspended.

"The other shape, a cone (not less than) three feet high, appears triangular (from any point of
" view) when suspended.

"A cone, with the point upwards, shows that a gale is *probable;* at first from the *northward.*
" North Cone.

"A cone, with the point downwards, shows that a gale is *probable;* at first from the *southward.*
" South Cone.

"A drum, alone, shows that stormy winds may be expected *from nearly opposite quarters** "
successively.

"A cone and drum give warning of dangerous winds, the probable *first* direction being shown by
" the position of the cone, point up, above the drum, for northerly (or polar) wind, point down, and
" below the drum, for southerly.

"Whenever such a signal is shown (in consequence of a telegram from London) it will be kept
" up distinctly, till dusk of *that day only,* unless otherwise specially directed.

"These cautionary signals advert to winds during some part of the next nights and two or three
" days; therefore due *vigilance* should prevail (until the weather is again settled), without deferring
" *departures* or any operations *unnecessarily.*"

28. *Inherent Ambiguity of this Description.*

Upon this explanation we have to observe that the signals and the meanings attached to them by the Department are not free from ambiguity.

(1.) It is not clear whether the drum and cone differ from the cone singly or the drum singly as regards direction only, or as regards intensity as well as direction.

(2.) In the words printed on the diagram the cone with point upwards is stated to mean "a gale probably from the northward;" but in the further explanation it is stated to indicate "a gale *at first* from the northward." It is therefore difficult to know precisely not only what is intended by the cone with the point upwards, but in what way the cone with the point upwards differs from the cone with the point upwards and the drum.

(3.) The same thing is true, *mutatis mutandis,* of the cone with the point downwards.

(4.) In the above description and explanation the cone with the point upwards is made to signify the North, and the cone with the point downwards the South. But in the Report of the Meteorological Department for 1862,† it is stated that the cone with point up indicates a gale from the "north polar direction," or "polar quarter," that is, as Admiral FitzRoy further states, "from W.N.W., true, by North to E.S.E.," and that the cone with point down indicates a gale from the "tropical or equatorial "quarter," *i.e.,* from "E.S.E., true, by South to W.N.W."

(5.) The signal is to cover "some part of the next nights and two or three days." The scope given by this, and the consequent ambiguity, need no observation.

It is obvious that these ambiguities in the signals themselves and in the explanations given by Admiral FitzRoy make it difficult to compare the Storm Warnings with the subsequent facts. There is comparatively little difficulty in ascertaining whether a Storm Warning has been followed by a gale; but in many cases there is almost insuperable difficulty in ascertaining whether the different characteristics indicated by either of the two cones or by the drum, or by the combination of these signals have actually taken place. Suppose, for instance, that the signal has been a south cone, and that the wind has changed from S. by W. to N.W., is the signal to be considered as having been correct, or would a south cone under a drum have been the appropriate signal? Or, suppose a gale to range from E. to S., what would be the appropriate signal? Again, suppose a south cone to have been hoisted on Monday for a given district, is the warning to be deemed to have been fulfilled if a southerly gale has taken place on the Wednesday night or Thursday following? Or, suppose the south cone on Monday to have been followed (as is frequently the case) by a drum or north cone on Tuesday, what must the weather be to correspond with the warning?

How seriously these ambiguities must affect the practical value of the warnings, and how desirable it is to remove them, if possible, is obvious. On this part of the subject certain specific recommendations will be found below. We now mention them for the purpose of showing how difficult it must be to apply precise tests to warnings which are themselves wanting in precision.

---

* In the Barometer Manual for 1863 the words in italics are altered into the following, viz.: "*from more than one quarter.*"

† Page 63.

And this difficulty is greatly aggravated by the facts noticed above, *viz.*, that there have not been kept in the Meteorological Department itself any precise records of storms or of the weather following upon the Storm Warnings. The only records kept in this Department are those mentioned above,* and it is needless to repeat how vague, incomplete, and unsatisfactory they must necessarily be. In one respect, however, they are more satisfactory in the case of violent gales than in the case of more ordinary weather. The former attract much more attention and are much more fully and more accurately reported in the newspapers than the latter, and the materials, therefore, of which the Department has made use are so far more copious and trustworthy. Still they are far from having that completeness and exactness which science requires.

29. *Comparison of Storm Warnings with facts as recorded by Meteorological Department.*

From these materials Mr. Babington, who is the senior clerk in the Meteorological Department, and who has had the charge of the Department since Admiral FitzRoy's last illness, has with much industry made a Digest, extending in the whole from the 1st March 1862 to the 31st March 1865, of all the Storm Warnings issued by the Office during that time, with the character of the wind and weather following.†

We have carefully examined these several papers. Having regard to the want of precision in the forecasts themselves, and to the want of completeness, as well as of precision, in the Observations to which we have adverted above, we need scarcely say, that we can regard any results to be derived from them as approximate only. It is probable that in estimating these results in figures and summing them up, no two persons, and even no one person making the calculation twice over, would adopt the same figures, or arrive at precisely the same results. But we have, nevertheless, attempted to obtain a result in the following manner, and we believe that it is not without its value.

The warnings are generally issued for different districts. We have, therefore, treated each warning sent to each district as a separate warning, and have endeavoured from the facts given in the Digests prepared in the Meteorological Department, to ascertain whether this warning was followed by a gale, and whether the actual direction of the gale agreed with the direction indicated by the warnings. The approximate figures which we have thus obtained are as follows:

Number of Warnings.		Force alone.		Direction, as well as Force.	
		Right.	Wrong.	Right.	Wrong.
April 1, 1862 to March 31, 1863	say 160 -	130 or 81 per cent.	30 or 19 per cent.	55 or 34 per cent.	105 or 66 per cent.
April 1, 1863 to March 31, 1864	say 125 -	85 or 68 per cent.	40 or 32 per cent.	60 or 48 per cent.	65 or 52 per cent.
April 1, 1864 to March 31, 1865	say 120 -	90 or 75 per cent.	30 or 25 per cent.	40 or 33 per cent.	80 or 67 per cent.
Total	- 405 -	305 or 75 per cent.	100 or 25 per cent.	155 or 38 per cent.	250 or 62 per cent.

In estimating Force in this table those Warnings have been treated as "right," in which a gale was blowing when the signal was hoisted, as well as those, from whatever direction, in which a gale followed the Warning.

In estimating Direction those Warnings have been treated as "wrong," in which no gale has followed the Warning, as well as those in which there has been a gale, but not from the direction indicated by the signal. It is obvious that this is the proper way of treating them. The warning of the Direction of a coming gale cannot be right if there is no gale.

It will be observed that according to these returns about six out of every eight of the Warnings were right as regards Force. If from these were deducted the cases in which

* See page 21.

† This Digest, for the period from 1st March 1862 to 31st March 1863, is published in the Meteorological Report for 1863, Appendix 2 to 9. For the period from 1st January 1863 to 31st March 1864, it is published in the Meteorological Report 1864, pp. viii. to xxi. And for the period from the 1st April 1864 to the 31st March 1865, it is contained in papers which were submitted to the Royal Society, and which are referred to in their letter to the Board of Trade of the 15th June 1865.

a gale was blowing when the signal was hoisted, the proportion of those to be deemed successful, would be less.

In respect of Direction only three out of every eight were right, and in this respect the result would probably be more unfavourable if the ambiguities noticed above had not rendered it necessary to give a great latitude to the meaning of the Storm Warnings.

The results of these returns do not show that there has been any marked improvement in the three years.

It may be added that it also appears from these Returns that there were the following gales, for which no Storm Warnings were issued, viz.:

April 1, 1862 to March 31, 1863	12th June.	Warning sent to part of coast;	gale extended to other parts.
	18th December.	Ditto	Ditto.
	17th January.	Ditto	Ditto.
April 1, 1863 to March 31, 1864	12th May.	Warning to part of coast;	gale extended to the whole.
	21st July.	Ditto	Ditto.
	30th September.	Ditto	Ditto.
	1st October.	Ditto	Ditto.
April 1, 1864 to March 31, 1865	21st July and 23d August. Gales between these dates for which no warnings were sent. The gale on 31st July was sudden and severe.		
	16th September and 17th October. Ditto, ditto. One commencing 2d October lasted several days.		

30. *Comparison of Storm Warnings with facts as recorded by Wreck Department of Board of Trade.*

We have, however, in respect of some of the Storm Warnings, a better test. From the 1st of July 1861 a more exact and complete Return of the weather following each Storm Warning has been provided by another department of the Board of Trade, viz., the Wreck Department, in the following manner. Upon a Storm Signal being issued, notice is sent by the Meteorological Department to the Wreck Department of the nature of the signal, the time of issuing it, and the places to which it is issued. At each of these places there is an Officer, either of the Coastguard or of the Customs, who is in constant communication with the Board of Trade. He is provided with a Form of Return, of which a specimen is given in the Appendix,* in which he enters the force and direction of the wind at the time of hoisting the signal, and at each interval of four hours† until the expiration of 72 hours from that time. This Return is then sent to the Wreck Department of the Board of Trade. There is, therefore, in that Department a complete history of every gale which has followed a Storm Warning since July 1861, at those places at which a Warning Signal has been hoisted. These Returns were submitted to Admiral FitzRoy, but no use has been made of them by his Department. He objected to them on the following grounds:‡—

1. "That the observations were made by landsmen or others, many of them incapable "of recording the weather correctly, or unlikely to do so."

We do not think the objection valid. The greater number of the observers are in the service of the Coastguard, seafaring men, constantly on the watch, and accustomed to observe and estimate the force of the wind. The remainder are officers of Customs, very intelligent men, with a numerous out-door staff, also constantly on the watch and accustomed to shipping and to observe weather. Observations of this kind have not of course the value of observations made by self-recording instruments; but they are the best that can be had, and are at least as trustworthy as the observations made by telegraph clerks, or extracted from the newspapers, on which the Meteorological Department have solely relied.

2. Admiral FitzRoy's second objection was:—"That observations made at six-hourly "periods could not have given a correct report of wind and weather during even one "day. The common chances were 18 hours to 6, or 3 to 1 against any given blast of "wind not lasting more than 5 hours being noted at all."

We are unable either to assent to this objection, or to understand the principle upon which he has calculated the chances. In the first place, there are very few gales which do not last more than 5 or 6 hours. In the second place, the chances against any blast of wind of less than 6 hours' duration escaping notice are not what the objection states them to be.

However, to meet this criticism, the intervals of observation were, in 1863, reduced to 4 hours, and the observers were called on, by special instructions in each case, to note the greatest violence of the gale if happening during a 4 hours' interval.

---

* See Appendix No. 12.

† At first the entries were made at 6 hours' intervals, but in consequence of Admiral FitzRoy's criticisms they have since 1st January 1863 been made at 4 hours' intervals.

‡ See his Report as originally printed, but not published, for 1862, page lxiv.

3. Admiral FitzRoy urged that it was not fair, when a Storm Signal had been hoisted throughout a district, to take the weather at each place separately as a test of its correctness or utility. A signal might, he would say, be hoisted at Liverpool and a gale might blow at Holyhead.

There is something in this objection, but not much. It is seldom that a galè is so entirely local in its character as to reach one place in a district and leave neighbouring places untouched. If a whole district is warned, the gale must, unless the warning is wholly untrustworthy, reach most of the places in the district. And if a Storm Warning hoisted at a given place is to mean, not that the wind is to blow at that place, but that it is to blow at some unknown place to which a ship may go from that place, it becomes too vague to be tested or relied on.

4. Admiral FitzRoy, with respect to Reports on the Direction of the Wind, observed that the reporters did not seem aware that only two directions were indicated by the Storm Warnings, viz., wind from the polar quarter, including the whole semicircle from W.N.W., true, to E.S.E, and wind from the tropical quarter, including the semicircle from E.N.E., true, to W.S.W.

We have before observed on the ambiguity of the signals, as regards direction, and we shall observe further on this subject below.

On the whole we think, notwithstanding these criticisms, that the Reports in question, and the analyses of them made by the Wreck Department, though far from perfect, as we shall point out below, afford the most valuable data which now exist for checking the correctness of the Storm Warnings, and for tracing the course and progress of violent gales in the British Isles, and we regret that they have not been duly made use of for this purpose, since, if they had, the Meteorological Department would probably by this time have been in possession of much precise and valuable information on the subject, which might possibly have placed the practice of predicting gales on a sound inductive basis.

31. *Results of the Comparison as regards Force of Wind.*

We proceed to give such results as we have been able to obtain from the digests already prepared in the Wreck Department from the returns made by Officers of Coast-guard and Customs; first, as regards force of wind, and secondly, as regards direction.

The returns from 1st July 1861 to 31st December 1861 were digested in a tabular form, which (as it has not been published) is printed in the Appendix.* The general result may be given as follows:—

FORCE OF THE WIND.

All Places warned from July to December 1861.						
No. of Warnings.	No. of Cases in which the Wind rose to Force 7,† or upwards.		Total Success.	No. in which it was at or above 7† at Time of Warning.	No. in which it did not reach 7.†	Total Failure.
	Within 36‡ Hours.	Above 36‡ and within 72 Hours.				
413	168 or 41 p. c.§	46 or 11 p. c.	214 or 52 p. c.	Not stated.	199 or 48 p. c.	199 or 48 p. c.

This result is, however, subject to correction. It is not stated in the analysis in how many cases the wind was blowing a gale when the signal was hoisted. If we suppose the number to have borne the same proportion to the whole as in the next tables, it would

* See Appendix, No. 13.

† In this first Table the "Warnings" were treated as successful in respect of Force if the wind actually reached the force 7; *i.e.*, a moderate gale, in which a ship can carry double reefs, jibs, &c., &c. In the subsequent Tables it was thought right to treat them as successful only if the wind reached the force 8, *i.e.* "a fresh gale," or upwards. Force 8, according to the Beaufort notation, means "a fresh gale," in which a ship, if well found, manned, and navigated, will carry "triple reefs, &c." and will be well able to keep the sea. In compiling the tables for the Wreck Register the Wreck Department do not include under the head of "casualties arising from stress of weather" any cases in which a casualty happens when the wind is under force 9.

‡ We have given the gales within 36 hours as well as those within 72 hours, because we think that a warning to be practically useful ought not to extend over three days and three nights. Fifty warnings, each covering 72 hours, would extend over the whole winter.

§ In calculating the per-centages in this and the following Tables, fractions are omitted.

be about 20 per cent. If this be deducted from the 52 per cent. of success mentioned in the above Table, it will leave only 32 per cent. of success.

The same returns were analysed for the year 1863 by the Wreck Department, and the result has been printed in the shape of a Parliamentary Paper.* From this paper it appears that the results, given as nearly as possible in the same form as above, are as follows :—

FORCE OF THE WIND.

All Places warned in the Year 1863.						
No. of Warnings.	No. of Cases in which the Wind after the Warnings rose to Force 8 (*i.e.* a fresh Gale) or upward.		Total Success.	No. at which it was at or above 8 at Time of Warning.	No. at which it did not reach 8.	Total Failure.
	Within 36 Hours.	Above 36 and within 72 Hours.				
2,288	655 or 29 p. c.	167 or 7 p. c.	822 or 36 p. c.	462 or 20 p. c.	1,004 or 44 p. c.	1,466 or 64 p. c.

The analysis of the whole of these returns by the Wreck Department, which is a work of great labour, has not been carried on regularly since 1863.

But we have had two other analyses made in that Department in the same form ; the one for the whole of the ports, for the months of December in the three years, 1863, 1864, and 1865, and the other for 7 selected ports, viz., Aberdeen, Galway, Harwich, Holyhead, Plymouth, Shields, and Yarmouth, for the whole of the years 1863, 1864, and 1865. The detailed summaries thus obtained will be found in the Appendix.† The general result, given in the same form as above, is as follows :—

FORCE OF THE WIND.

All Places warned in December 1863, 1864, 1865.							
Periods.	No. of Warnings.	No. of Cases in which the Wind after the Warning rose to Force 8 (*i.e.*, a fresh Gale) or upwards.		Total Success.	No. at which it was at or above 8 at Time of Warning.	No. at which it did not reach 8	Total Failure.
		Within 36 hours.	Above 36 and within 72 hours.				
Dec. 1863 -	366	121 or 33 p. c.	77 or 21 p. c.	198 or 54 p. c.	25 or 7 per cent.	143 or 39 p. c.	168 or 46 p. c.
Dec. 1864 -	85	6 or 7 p. c.	6 or 7 p. c.	12 or 14 p. c.	6 or 7 per cent.	67 or 79 per cent.	73 or 86 p. c.
Dec. 1865 -	335	180 or 54 p. c.	33 or 10 p. c.	213 or 64 p. c.	40 or 12 per cent.	82 or 24 per cent.	122 or 36 p. c.

FORCE OF THE WIND.

Seven selected Ports. Years 1863, 1864, and 1865.						
Periods and No. of Reports received from the Seven Ports.	No. of Cases in which the Wind after the Warning rose to Force 8 (*i.e.* a fresh Gale) or upwards.		Total Success.	No. at which it was at or above 8 at Time of Warning.	No. at which it did not reach 8.	Total Failure.
	Within 36 Hours.	Above 36 and within 72 Hours.				
Year 1863, 254	73 or 29 per cent.	28 or 11 per cent.	101 or 40 p. c.	31 or 12 p. c.	122 or 48 p. c.	153 or 60 p. c.
Year 1864, 171	52 or 30 per cent.	18 or 11 per cent.	70 or 41 p. c.	8 or 4 per cent.	93 or 54 p. c.	101 or 59 p. c.
Year 1865, 236	65 or 28 per cent.	42 or 18 per cent.	107 or 46 p. c.	8 or 3 per cent.	121 or 51 p. c.	129 or 54 p. c.

* No. 200, Session 1864.

† See Appendix, Nos. 14 and 15.

Putting the general results of the above tables together in the form of per-centages, and omitting fractions, we have the following Tables, viz.:

PART 1.—ALL PLACES WARNED.

Periods of Warnings.	Gale within 36 Hours.	Gale between 36 and 72 Hours.	Total Success.	Gale blowing when Signal hoisted.	No Gale.	Total Failure.
Six Months ending 31st December 1861 - -	Per cent. 21	Per cent. 11	Per cent. 32	Per cent. 20*	Per cent. 48	Per cent. 68
Year 1863 - - -	29	7	36	20	44	64
Month of December 1863 -	33	21	54	7	39	46
Ditto 1864 -	7	7	14	7	79	86
Ditto 1865 -	54	10	64	12	24	36

PART 2.—SEVEN SELECTED PORTS.

Periods of Warnings.	Gale within 36 Hours.	Gale between 36 and 72 Hours.	Total Success.	Gale blowing when Signal hoisted.	No Gale.	Total Failure.
Year 1863 - - -	Per cent. 29	Per cent. 11	Per cent. 40	Per cent. 12	Per cent. 48	Per cent. 60
Do. 1864 - -	30	11	41	4	54	59
Do. 1865 - - -	28	18	46	3	51	54

These tables show that, putting the most favourable construction on the Warnings, viz., that they are to be deemed successful if a gale follows within "two or three days";† there are two of the periods we have selected for comparison, viz., December 1863 and December 1865, in which as much as one half of the Warnings have, so far as regards Force of Wind, proved successful; and that in other periods the proportions of successes to failures has been less than one half. The same Tables also show that if we were to deem these Warnings successful only when a gale has followed within 36 hours, the proportion of successes to failures would be considerably less. On the other hand there is a marked improvement in the Warnings for the month of December 1865, over those of the month of December in previous years; and on the whole there is an improvement in the later over the earlier warnings.

32. *Results of the Comparison as regards Direction as well as Force of Wind.*

As regards Direction, the tests are far less precise and less satisfactory.

We have before observed on the difficulty of interpreting the Warnings as regards Direction. Whether a cone with the point downwards means what laymen and seamen would usually know as a southerly gale, viz., from some quarter between S.E. and S.W., or a gale from some quarter in the semicircle from E.S.E. by S. to W.N.W., or a gale commencing at some point in this semicircle, and afterwards shifting into the other or Northern semicircle; and how, if this latter interpretation is correct, the cone differs from a drum, it is impossible to understand from the published notices; and it is therefore impossible to make a perfectly satisfactory selection of the facts with which such indeterminate predictions should be compared.

In the analyses‡ above referred to an attempt was made to give Direction as well as force, and a column was inserted accordingly for that purpose. But in making these analyses no notice at all was taken of the Drum as indicating Direction; and in the column in question warnings made by that signal were omitted altogether.

The figures given in this column in the analysis are therefore for this reason very incomplete. In addition to this the only datum given in the Diagrams from which these analyses are made as to Direction of Wind, is its Direction at the moment of its highest force, and consequently, as regards the North and South cone signals, the method adopted in framing those analyses was to take the direction of the wind at its highest point, the wind being at that time of not less than the force 8, or a gale, and to see whether at that time it was blowing from some point within the semicircle which the cone was supposed to indicate. This again gives a very imperfect result. To know the true

* This is assumed, see above, page 29.
† This is Admiral FitzRoy's own expression.
‡ See App. Nos. 13, 14, and 15, and Parl. Paper, No. 200, Session 1864.

Direction of a gale it must be watched throughout its duration, and not only at its highest point. For these reasons we have not relied on the figures in question, and think it useless to tabulate the results here.

We have, however, had the returns made to the Wreck Department for the two ports of Shields and Plymouth, for the three years 1863, 1864, and 1865, analysed and put into the form of diagrams by that Department in such a manner as to show not only the force but the Direction of the Wind at each 4-hourly period of observation for 72 hours after the hoisting of the Signal. We have also had a similar analysis made of the returns from five selected ports, viz., Aberdeen, Galway, Harwich, Holyhead, and Yarmouth, for the month of December in each of the years 1863, 1864, and 1865.* Comparing the results thus obtained with the warnings, and putting the best interpretation we can upon the official explanations of the Signals, we have the following result:

DIRECTION AS WELL AS FORCE OF WIND.

Places and Periods.	No. of Warnings and their Results.			Character of Warnings.		No. and Range of actual Gales.		
	Total Number of Warnings.	Right.†	Wrong.	Drum alone or with Cone.	Cone alone.	Total Number of actual Gales.	Gale within ¼ of Circle.	Gales over more than ¼ of Circle.
Five selected Ports. December 1863, 1864, and 1865.	61	16	45	29	32	31	22	9
Plymouth.								
Year 1863 -	35	2	33	21	14	9	7	2
Do. 1864 -	25	6	19	10	14	9	7	2
Do. 1865 -	33	6	27	26	8	19	17	2
Shields.								
Year 1863 -	38	7	31	32	6	33	28	4
Do. 1864 -	21	7	14	12	9	13	8	5
Do. 1865 -	31	11	20	27	4	27	20	7
Total - -	244	55 or 23 per cent.	189 or 77 per cent.	157 or 64 per cent.	87 or 36 per cent.	140	109 or 78 per cent.	31 or 22 per cent.

It thus appears that out of the whole of these Warnings, combining Direction with Force, 244 in number, not more than 22 per cent. or less than one quarter, have been right, whilst the remainder, or more than three-quarters, have been wrong. If these instances are fair examples, and there seems to be no reason to doubt it, we cannot hesitate in coming to the conclusion that the attempt to issue Predictions combining the Direction of coming Gales with their Force has been unsuccessful.

This Table affords a good illustration of what we have said above ‡ concerning the advantages which the Department has forfeited by not keeping up a strict comparison of Predictions with facts. It will be remembered that, according to the meaning put by Admiral FitzRoy on his published explanation of the Storm Warnings,§ the cone with the point upwards signifies a gale from the Northern or Polar quarter; the cone with the point downwards, a gale from the Southern or Tropical quarter; and the Drum a gale from various directions, or from both quarters. And it also appears from the above Table that out of 244 signals no less than 157, or 64 per cent., were Drums. On the other hand it appears from the same Table, that out of 140 cases of gales reported to have followed these 244 Warnings there were only 31 or 22 per cent. which ranged through more than one quarter of the circle, or eight points of the compass, whilst the remaining 109 or 77 per cent. were confined within that limit. Had such a result been observed by the Department, and duly confirmed by further observations, it must have led them to the conclusions,—First, that their present Warnings for direction are in themselves far too wide and vague, and that if they are to correspond with the facts, they must

---

* An example of one of these diagrams is given in the Appendix No. 16.

† In the column headed "Right" in this Table are included all those cases in which the wind reached 8 or a gale, and whilst at that force agreed with the Signal. In the column headed "Wrong" are included those cases in which the Wind did not reach 8, as well as those in which it reached 8 but did not agree with the Signal. It is hardly necessary to repeat what we have stated above at page 27, that the Warning of the Direction of a coming gale cannot be right if there is no gale at all.

‡ See p. 29.

§ See p. 26.

be made much more limited and precise; and secondly, that there must be something essentially wrong in maxims or methods which led them to use the Drum in so large a proportion of cases.*

It may, indeed, be said† that although the wind may have ranged within narrow limits at the particular station, yet that, if we had examined and compared the winds over a more extended area, we should have found that their direction had a wider range. We reply, in the first place, that strong winds are exceedingly uniform in their direction, excepting in the comparatively rare case of real cyclones; and, in the second place, we reply that the predictions do not give us the data for such an examination. If, in claiming to predict the weather at any station, the Department had given us materials for defining the limits within which such prediction was to be applicable we could have made the comparison throughout those limits; but no such materials are given, and unless the comparison is to be confined to the place at which the prediction is made it is impossible to know what comparison to make, or to make any that shall be free from objection.

33. *Incompleteness of Data for Comparison.*

In concluding this comparison of the Warnings with the facts, we must observe that we are under great disadvantages, not only in consequence of the ambiguities in the Warnings themselves, but from the want of a clear and continuous statement of the weather that has actually prevailed during the whole of the time since the Storm Warnings were first established.

If we had possessed such a statement, our task would have been comparatively easy. We should have been able to say when the Storm Warnings *ought* to have been sent, and when they *were* sent. A comparison between the two would have formed a strict criterion of the system.

But there exists no such statement adequate to our wants. We possess full and trustworthy data only of the weather that *succeeded* the Warnings, not of the weather that preceded them. We cannot therefore tell when the Warnings ought to have been sent. We can only learn whether or no the Warnings were justified by the weather that followed them. This is obviously an incomplete inquiry. It leaves out of consideration the chances of success due to mere haphazard, and it appears that these are considerable in the six winter months of the year; for at that time it is probable that gales are blowing to a sufficient extent to justify a Storm Warning in every ten days on an average, and on the other hand, four days in every ten on the average, are placed under warning by the Storm Signals.

Our examination is therefore imperfect, but nevertheless it leads to conclusions which may be regarded as true, within those limits to which it is necessary they should be narrowed in order to give a general opinion of any value. We have tested the system under numerous independent aspects, and the results corroborate one another sufficiently to justify us, whilst expressing our regret that we are unable to arrive at more precise conclusions, in giving to the question, "How far are the Storm Warnings correct?" the following approximate reply, viz., that the Warnings, so far as they indicate Force of Wind, are sufficiently correct to be of some present value, and that they hold out the prospect of becoming more valuable; but that, so far as they indicate Direction of Wind combined with Force, they are not sufficiently correct to be of any value.

34. *Popularity and Utility of Storm Warnings.*

As regards the popularity and utility of these Storm Warnings, we have no doubt that they have been favourably received by the public in general as well as by those who are most interested in them. Though the replies made to inquiries by the Board of Trade in 1862 and published in the Reports of the Meteorological Department for that year are not unanimously or universally favourable, they undoubtedly show a general desire at that time that the experiments then commenced should be continued. And, from inquiries we have made through trustworthy persons at most of the principal ports, we find that seafaring men look upon them more favourably than they did at first, that they believe them to be more correct, and rely upon them more; and that there

---

* It is needless to point out how interesting are the questions to which such observations as the above would naturally lead, *e.g.*, Can the above result concerning the limited range of ordinary gales be confirmed by further observation? If so, what are the points of the compass between which these limited gales generally range? Are there any, and what premonitory symptoms by which they can be distinguished from each other or from gales of a wider range?

† See p. 29.

would be great regret if they were discontinued. In the Appendix will be found a short abstract of the answers to our inquiries, which are, almost without exception, favourable.* The existence of this feeling is strong evidence of the utility of these Storm Warnings. But in estimating this at its true value it must not be forgotten how eagerly the world at large is disposed to base an unreasoning belief on the occasional successes of weather predictions, aud how easily it forgets the failures. We need not say that we do not wish for a moment to compare the efforts of the Department with the predictions of the ordinary weather prophets who attempt to connect the changes of weather with the stars or the changes of the moon. It is not, however, irrevelant to refer to these prophecies, and to the belief which has been so often placed in them, when we are estimating the value of popular feeling as evidence of the value of the Storm Warnings.

There is, however, no need to have direct evidence of their utility, if it can be shown that they are intelligible, definite, and, above all, correct. These points we have discussed at length above. And it is desirable in this place, when specially discussing their utility, to point out some of the practical applications of the observations which we have already made on this subject.

In the first place, the wants of different vessels with respect to these warnings are not the same. To a ship of war, a powerful steamer, or a large and well-appointed long-voyage merchant ship, the knowledge of a coming gale has a different meaning from that which it has for a laden collier or a fishing smack. To the former, to remain a day or two unnecessarily in port may be a matter of comparative indifference; to the latter it is the loss of the small margin of daily profit by which they exist. To the former again, if compelled, as in the case of regular steamers, to leave port at a particular time, it simply means, "Be cautious; have your cargo properly stowed, and your crew in "order, and be on the look out for bad weather." To the latter it may be a matter of life and death. The former will only be a day or two earlier or later on her voyage accordingly as she starts on a given day or not. The latter may, if she waits for the commencement of a gale foretold three days beforehand, lose the opportunity of completing her one, two, or three days' voyage in fair weather, and may even delay just long enough to place herself in danger. And it must be remembered that the warnings, according to the present system, cover a considerable part of the year. In the six winter months about 40 per cent. of the days are under warning. These points are well put in the following reply made in 1861 by Mr. Maclean, Collector of Customs at Yarmouth, to the question put to him, "Are they (the warnings) found to be practically useful?" He says,—

On this point also there are divers opinions. When the warning signal is hoisted the fishing vessels, in some cases, have refused to proceed to sea, although no local circumstances appeared to indicate danger or to warrant apprehension of bad weather. And as these voyages often do not exceed 24 hours' duration, much time and profit are lost. Others think that the signals have a tendency to make the mariners timid. And there appears also a wish to have the time of the expected storm more defined. For instance, a vessel whose destination might be reached in 20 hours, if in a direction contrary to that from whence the storm is anticipated, might make her voyage, whilst delay would be the cause of the storm overtaking her. This actually occurred to two vessels which were ready to sail from this during last autumn. The one that pushed on notwithstanding the storm signal being up reached her destination in safety; the vessel which delayed to sail and put to sea afterwards was caught in the storm and was lost. I must, however, especially remark one way in which these warning signals appear to be extremely useful, and that is, although the masters of vessels may put to sea, yet knowing that a storm is pending, they are careful to see that all is right or snug before retiring to rest at night, and are in a measure prepared to jump on deck on the first symptoms of bad weather. The telegraphist informs me that he has many personal applications from masters of vessels for information and advice relative to these signals, which he considered will ultimately be of great value to the seafaring community.†

It follows from these considerations that the time within which a gale may be expected after the signal is of primary importance in considering the utility of the storm signals to coasters and fishing vessels, *i.e.*, to that class of vessels which are most likely to suffer from storms; and that to be of real use to this class of vessels, the signal ought to be hoisted not more than, say, 36 or at the outside 48 hours, before the storm is expected.

Again, the utility of the signal depends in many instances on the precision and correctness with which they indicate direction. For instance, a collier from the Tyne or the Wear will care little for a westerly gale, whilst an easterly one may be fatal to her. It is of no use to tell her that a gale is expected from the Tropical quarter or from the Polar quarter; that it will range from E.S.E. by S. to W.N.W., or from W.N.W.

---

* See Appendix, No. 17.

† See Report of Meteorological Department for 1862, p. 8.

by N. to E.S.E. A N.N.W. or a S.W. wind will do her little or no harm. A N.E. or a S.E. gale may alike be fatal to her. In such a case the present attempt to foretell direction can be of little use, even if it corresponds with the subsequent facts. But that it does not so correspond is shown by the figures we have given above. We think, therefore, that the utility of these signals in point of direction is not established, and we believe that the knowledge requisite to make them precise in this respect, and therefore useful, does not at present exist. At the same time we recognize fully the importance of foretelling direction as well as force, and we trust that more accurate observation and more careful use of the materials already on hand may, at some future period, lead to a more successful result.

35. *Conclusions as to Correctness and Utility of Daily Forecasts and Storm Warnings.*

The conclusions we draw from this discussion are the following, viz. :—

That the maxims on which the Department acts in foretelling weather have not been reduced into any clear or systematic form, and are not shown to have been established by sufficient induction from observed facts.

That as a matter of fact the Daily Forecasts are not shown to be correct, and that they are not, in our opinion, useful.

That the Storm Warnings, so far as they indicate the Force of coming gales, hav been sufficiently correct to be of some use, and that their utility is widely admitted. Also that they have improved; and that they are probably capable of still greater improvement.

That the Storm Warnings, so far as they indicate the Direction as well as Force of coming gales, are not shown to have been so far precise or correct as to be of use.

36. *Fishery Barometers.*

In completing our statements of what the Meteorological Department has done with the object of warning sea-faring men against bad weather, it is right to call attention to one important step taken by it, viz., the supply to the smaller and less affluent sea-ports or fishing villages of good barometers, with directions for observing them, and drawing conclusions as to possible weather. Ninety-five of these Barometers have been thus supplied.

37. *Investigation of Laws which govern Changes of Weather in the British Isles.*

It seems to us obvious that under these circumstances the practice of issuing Storm Warnings can neither be discontinued nor allowed to continue in its present unscientific, and therefore unsatisfactory, condition. It can never be satisfactory until we have arrived at a more complete knowledge of the laws which govern the changes of Weather in the British Isles than we now possess. This subject has of late years become, chiefly through the strenuous exertions of Admiral FitzRoy, the most popular branch of Meteorology. It also affords one of the hopeful matters of inquiry to the scientific Meteorologist.

It is obvious, from what we have said above, that the Meteorological Department of the Board of Trade does not at the present time possess, and has not the means of procuring, observations sufficiently numerous and accurate for the prosecution of this inquiry.

38. *Recommendation of Six Stations, with Self-Recording Instruments.*

This has been admirably done

The Royal Society have, in their letter to the Board of Trade of the 15th June 1865,* recommended the establishment in the British Isles of six stations with Self-Recording Instruments, for the purpose of making and recording full, accurate, and *continuous* observations of Meteorological phenomena at those stations.

There is no doubt that Self-Recording Instruments are urgently needed in the present state of Meteorological science, and that they will soon in all probability be largely employed both in this country and abroad. Their advantages are manifest. By reason of the continuity of their records no wave or variation of any description in any of the Meteorological elements can escape notice, and the course of that wave or variation can be tracked with certainty from station to station, and its modification at the time of reaching each station in succession can be accurately observed. For the same reason one difficulty now seriously felt in charting the weather, viz., that which arises from observers in different places and countries adopting different hours of observation,

* See App. No. 1.

would wholly disappear; and a further difficulty, viz., that which arises from observers being unpunctual to their professed hours of observation, would disappear also. The unvarying accuracy of the record is an advantage of still greater importance than might be expected by those, who have had no experience of the frequent errors to be found in Meteorological Registers. Each error creates considerable confusion; it throws doubt on the observations accurately made at neighbouring places; and that doubt cannot be removed except by the continuity of the records at those places. This continuity is unattainable unless the weather happens to be uniform over a wide district, or unless observations are made at many more places than would be needed, if reliance could be placed upon the accuracy of the observers. Another advantage of Self-Recording Instruments is that their records are independent of particular scales. Their notation is in lines and curves, that can be measured with equal facility according to any desired scale. The Thermometer lines could be measured at pleasure according to Fahrenheit's scale, as used in England; to the Centigrade, as in France; or to Reaumur's, as in Germany. The Barometer lines could be measured with equal ease in English inches, in Millimetres, or in Paris feet. For the various reasons we have mentioned Self-Recording Instruments are of eminent local and international utility. The establishment of a series of them in England would confer a wide benefit. They would give precision and fullness to the charts of our own weather; they would set an example, that foreign Governments would probably soon follow; and they would afford material in a very acceptable form to Meteorologists at home and abroad for the discussion of the weather of Europe at large.

39. *Further Observations from Lighthouses, Ships, &c.*

But returns from the six stations recommended by the Royal Society, though full, accurate, and continuous, will not be sufficient in themselves to give a complete account of the diversified phenomena of wind, clouds, and temperature in the variable climate of the British Isles. They will operate as an invaluable framework, to be filled up by observations of a more ordinary character, and as a test of the value of such observations; but in order to complete the necessary data a considerable number of intermediate stations —say 60—will be required, and from these returns of the Wind's Direction and Force, of the Barometric Pressure, of the Temperature, and of the Difference between the Wet and Dry bulb Thermometer should be made, say four times a day, and in some few selected stations eight times a day. These observations should be uniformly made at stated hours, reckoned in Greenwich and not in local time.

There appears to be no difficulty in procuring such observations; they are already made at lighthouses, at some of which there are understood to be careful and intelligent observers. The instruments they employed could be verified by the Board of Trade, and the resulting observations would, no doubt, be placed by the Trinity House and Scotch and Irish Lighthouse Boards at the disposal of any Meteorological Office which could turn them to account. If observations were required from any place where there is no lighthouse, they might, no doubt, be procured through the Coastguard.*

It seems also advisable that observations should be sought from packet ships and other vessels continually navigating the seas adjacent to the British Isles, so as to complete the observations for a certain area of the earth's surface in the neighbourhood. This might, we hope, be done through the same instrumentality by which the Meteorological observations for the ocean are collected.

By these means the progress of all kinds of weather across the British Isles and the adjacent seas may be traced continuously and exhibited in the form of weather charts.

In ordinary weather this mass of observations need not be employed. A Weather Chart drawn once in 12 hours would be sufficient to give continuity to the records. But in weather of a marked type that undergoes rapid variations (as, for instance, in a storm whose centre moves at the rate of 20 miles in the hour,) the whole of the observations would be requisite.

But it is not sufficient for the purpose now under consideration to observe the weather of the British Isles alone.

The experience of Meteorologists, abundantly illustrated by the daily weather maps of M. Le Verrier, show beyond all doubt that the weather changes of England, and even of all Europe, are but parts of immense systems.

These systems reach southward to the trades, and with them far in the direction of the Gulf of Mexico, whilst they are of unknown extent to the North. The area of the North

---

* Experience may show that mechanical Self-Recording Instruments of far less cost than, and inferior precision to, those mentioned above, might be used with advantage for these secondary stations.

Atlantic, and especially of the Gulf Stream, appears to exercise a most important influence on the generation of the storms and weather changes that affect England.

Under a conviction of the importance of studying the weather on a sufficiently extended basis, M. Le Verrier is now engaged in producing charts of the Northern Hemisphere between the Equator and 70° N. lat., and long. 100° W. and 60° E. for each day of the year 1864.

We think it desirable that this country should take a share in inquiries of this description, proportionate to her means of obtaining information. The forms and movements of the ever-varying areas of high and low barometric pressures over the Atlantic are to be determined by comparatively few observations, and they would afford an aid of the utmost value to interpret the varieties of the storms, and of the weather generally, that first fall upon the western coasts of England and of France.*

40. *Discussion and Charting of Arrears of British Weather.*

We also think that the arrears of English weather, and especially of gales and marked weather generally, should be charted and discussed for about two years, that is as far back as M. Le Verrier's daily charts of European weather extend, using the daily telegraphic returns as a basis, and supplementing them, as far as may be found practicable, by the returns made to the Wreck Department of the Board of Trade, by the observations made at lighthouses, and by those of private observers.

In preparing and issuing the charts above referred to care should be taken to render them neat, compact, and cheap. Those published by M. Le Verrier appear to us to combine these qualities in a high degree.

41. *Results to be looked for from the above.*

As the science of weather-changes is so little understood and excites so much interest, it would probably be desirable to publish charts and discussed observations more freely at first than would afterwards be necessary. It is very much to be hoped that by these means the subject would attract the attention of men eminent in science, who are now repelled by the impossibility of obtaining information in a form they can use, without previously undergoing an excessive amount of purely clerical labour.

If these steps are taken we may hope that at no distant time the laws which govern the changes of weather in the British Isles will be so far understood as to enable Meteorologists to place the practice of foretelling weather on a sound basis. If a considerable proportion of the various states of weather can be grouped under definite categories, and if each of these categories is found to change into other definite states, with more or less regularity, it will only be necessary to determine the category under which the prevailing type of weather should be classed, in order to arrive at a knowledge of coming changes. And this may probably be done by means of a limited amount of telegraphic communication. To take the least favourable view of the subject, the knowledge obtained by means of the observations we have recommended will furnish a complete check on such predictions as may be made, and will either enable us to reduce the practice of foretelling Weather into a certain system governed by clear and intelligible rules, or will enable us to conclude that no such system or rules are possible.

42. *Recommendations.*

The following are our recommendations on the subject of Weather Telegraphy, Daily Forecasts, and Storm Warnings, and upon Observations of Weather within or affecting the British Isles, viz. :—

1. That the system of telegraphing the weather from distant stations, as proposed by M. Le Verrier, and adopted by that officer and by Admiral FitzRoy, be continued.
2. That the places from which telegrams are to be received shall be those from which they are at present received, with power to add to or diminish their number as circumstances and advancing knowledge may require.
3. That these telegrams shall be published as at present, but arranged in geographical districts.
4. That the publication of daily forecasts of weather probable on the North, East, South, and West coasts shall be discontinued.

---

* We may point out that the method of copying the observations made at sea, which we have already recommended for the purpose of obtaining meteorological means (see above, p. 9), would lend very great assistance to the branch of meteorology we are now considering. It would merely be necessary to take duplicate copies of the observations, either by means of the copying press or by a manifold writer, and to sort the duplicates according to dates. All the duplicates referring to a single day would be arranged under the same cover, following one another like pages in a book, according to the number of their Squares. They would be in a most convenient form for ready reference and to lay down upon a chart.

f. 19v

5. That the "Remarks" or summary of the general results of the telegrams, such as M. Le Verrier publishes in his Weather Bulletin, and such as Mr. Babington has recently appended to the daily Forecasts, shall be continued; but that the office intrusted with the duty shall not hold itself bound to issue such remarks daily as a matter of course, but shall only do so when it has reason to believe that there is some general view or some conclusion of interest to be derived from the reports.
6. That the practice of issuing Storm Warnings shall be continued, but with the following modifications:—
   (*a.*) That the Signals shall for the present be confined to the indication of a probable gale, without attempting to indicate from what quarter.
   (*b.*) That they shall not be hoisted unless there is reason to expect the gale within 36 or at the outside 48 hours.
   (*c.*) That when hoisted, they shall continue up until all immediate expectation of further gales has ceased.
   (*d.*) That whilst the Signals indicating Direction are discontinued for the present, care shall be taken so to arrange the Signals for Force as to enable the Signals for Direction to be added hereafter.
7. That the officer of the Meteorological Department issuing the Storm Warning for Force should also at the same time, so far as he is able so to do, make, but not issue or publish, a prediction of the probable Direction of the coming gale, endeavouring in so doing to render it as specific as possible, *e.g.*, whether within any particular quarter of the circle.
8. That this officer shall note down at the time, and reduce into an exact shape afterwards, the maxims or principles which have guided him in making the Signal of Force or Prediction of Direction; the facts to which those maxims are applied; the mode in which he has applied and combined them, the value he has attached to each of them, and the value of the probability which he has thus obtained, and which is indicated by the Signal or Prediction.
9. That the maxims so acted upon shall be reduced into a clear and definite shape, and kept in the office ready for reference.*
10. That the present practice of collecting miscellaneous information concerning daily weather from newspapers and other sources be discontinued.
11. That a careful check upon the correctness of the predictions issued for Force, as well as upon those made, but not issued, for Direction shall be kept. If the recommendations we have made with regard to the collection of observations of the weather changes in the British Isles be adopted, such observations will provide this check; otherwise the observations and returns heretofore made to the Wreck Department of the Board of Trade should be continued, but with the addition, that a return should be made from every station of every gale felt there, whether a Storm Signal is hoisted there or not.
12. In whatever way these observations are made, the result should in each instance be carefully digested and compared with the Prediction, and with the reasons for making it. In case of error or omission, whether as regards Force, Direction, Time, or Place, it should be noted; and an endeavour should be made to ascertain how it occurred, and the maxims acted on should, when necessary, be modified accordingly.
13. If the observations are collected and digested by an office distinct from that which issues the Storm Signals, the Signals, with the reasons for them, and the results of the observations, should be mutually communicated by the officers to each other, so that the one may be a check on and assist the other. In this way the practice may be brought into the shape of a determinate system resting on a sound inductive basis.
14. In the meantime the returns already obtained by the Wreck Department of the Board of Trade, though not complete, inasmuch as they are only made when and where a Storm Signal is hoisted, afford valuable material for tracing the rise, progress, and direction of most, if not of all, the violent gales which have happened in the British Isles during the last five years. These returns should, if possible, be digested and utilized.
15. *Finally, we recommend that the Variations of the Weather in the British Isles and in the adjacent Ocean be carefully observed, charted, and discussed. We have entered so fully into the subject above that it is needless here to repeat our recommendations. We will only add that of all our recommendations on this part of the subject, it is in our opinion the most important.*

---

* See Appendix No. 7.

f. 20r

PART III.

Estimate of Cost.

43. *Cost of Existing Meteorological Department.*

We give in the Appendix* a full account of the cost of the Department from its institution in 1856 to the present time. The aggregate amount to the end of the financial year 1865 will have been about 45,000*l.* The annual expenditure has increased from 3,240*l.* to, say, 5,500*l.*; but was in one year, 1863–4, as much as 7,100*l.* The sums expended on instruments and other expenses connected with Ocean Statistics have greatly diminished, viz., from an average of 2,215*l.* 19*s.* 6*d.* for the years 1856 to 1860, to an average of 1,613*l.* 6*s.* for the years 1860 to 1865; whilst the expenditure has, in the latter years, been increased by a sum averaging 2,011*l.* a year spent on Telegraphy and Storm Warnings. The expenditure for 1864–5 was 1,144*l.* 14*s.* 8*d.* on instruments 2,735*l.* 10*s.* on Telegraphy and Storm Warnings, and 1,134*l.* 17*s.* on salaries, making 5,460*l.* in all.

44. *Recapitulation of Work to be done hereafter.*

We now proceed to consider in what manner and at what expense the work we have recommended can be done. That work is as follows:—

I. Ocean Statistics.

1. Completion of work now in progress, viz.:

a. Winds.

Charts for South Pacific.
Charts of Trade Winds for Indian and Pacific Oceans.
Winds generally. Arrangement of existing "Collecting" and "Grouping" Papers.

b. Ocean Currents.

Arrangement of existing "Collecting" and "Grouping" Papers.

c. Sea Temperature.

South Atlantic. "Collecting" to be completed.
Arrangement of existing "Collecting" Papers.

d. Temperature of the Air.

Tabulation and publication of results already obtained.
Arrangement of existing "Collecting" and "Grouping" Papers.

e. Vapour Tension.

Publication of monthly means of wet bulb as already obtained, and making and publishing comparison of monthly means of wet and dry bulbs.
Arrangement of existing "Collecting" and "Grouping" Papers.

f. Barometer.

Publication of monthly means already obtained.
Arrangement of "Collecting" and "Grouping" Papers.

2. Issuing instruments and registers to merchant ships.
3. Extracting the whole of the observations now in the office, and such other observations as may be hereafter obtained, to the number of (say) 1,650,000, in the manner explained above.†
4. Reducing, digesting, and tabulating the observations so extracted.

II. Weather Telegraphy: Foretelling Weather: and Observations affecting Weather in the British Isles.

1. Telegraphing to and from out-stations.
2. Examining telegrams daily for the purpose of remarks and of Storm Warnings, and recording progress.
3. Establishment and maintenance of six stations for Meteorological Observations in the British Isles.
4. Collection of observations from lighthouses or other intermediate stations and from the Atlantic.
5. Digesting, tabulating, charting, and publishing the results.

45. *Means and Method of Executing this Work.*

It is not within our province to suggest alterations in a Government Office, still less to propose the establishment of a new Office. But we can hardly estimate the cost of what we recommend without forming an hypothesis as to the way in which it should be done, and in forming such an hypothesis we have adopted what appears to us to be the most efficient as well as the most economical plan.

---

* See Appendix, No. 18.

† See pp. 6 and following.

The collection of Observations from the captains of ships is a function which can probably best be performed through the medium of such agencies as a Government Office can command, and which was in fact well performed by the Meteorological Department before its attention was devoted to the practice of foretelling weather. We assume, therefore, that this function will remain with the Board of Trade.

The Digesting and Tabulating Results of Observations is on the other hand a function which requires a large knowledge of what the state of the science for the time being requires, as well as exact scientific method. This function is one that has not been satisfactorily performed by the Meteorological Department. And we believe that it would be much better as well as more economically performed under the direction of a scientific body,—such as a Committee of the Royal Society or of the British Association, if furnished with the requisite funds by the Government,—than it will be if left to a Government Department. The establishment already existing at Kew might probably be easily developed so as to carry into effect such a purpose. It would in that case become a Meteorological centre to which all observations of value, whether made on land or at sea, and whether within the British Isles or not, would be sent for discussion and reduction. We have, therefore, in the following estimates assumed that all Meteorological Observations made on land, whether at the stations recommended by the Royal Society, or at the Lighthouses or Coast Guard Stations, as well as all observations at sea, shall be referred to and discussed under the direction of such a scientific body as we have mentioned; and we have also assumed that the aid afforded by Government would be in the shape of an annual vote so made as to leave the Royal Society, or other scientific body charged with the duty, perfectly free in their method and in their choice of labour, but upon the condition that an account shall be rendered to Parliament of the money spent and of the results effected in each year.

The completion of the work now in progress in the Meteorological Department may, on the above hypothesis, either be performed by that Department at once, or if the proposed change be made immediately, may be placed in the same hands in which the future discussion of Meteorological Observations is placed, and we have, in our estimates, dealt with it accordingly.

The procuring and sending of daily telegrams, and the issuing of Storm Warnings, is intimately connected with the discussion of Meteorological Observations in or near the British Isles, and ought, we think, to be placed under the same scientific body which superintends the discussion of those observations. For the convenience of telegraphing it will probably be necessary that part of the staff employed under this body, whilst in connexion with Kew, should occupy two or three rooms in London. But any expense in hiring such rooms will be less than the expense of the premises at present occupied by the Meteorological Department, which are, we understand, to be pulled down, whilst the persons employed for a part of the day on telegraphy, will be available during the greater part of the day for the discussion of observations.

The publication of results of Meteorological Observations at sea, which are of immediate utility to navigators, either in the shape of charts or otherwise, appears to be a function properly belonging to the Hydrographic Office of the Admiralty. We have accordingly assumed that it will be performed by that Office.

a. Estimated Cost of this Work.

On these assumptions we make the following estimate:—

	£
Ocean Statistics:	
Issue of Instruments and Registers, annually - - - -	1,500
Discussion and publication of results - - - - -	1,700
Total - -	3,200

This expenditure ought to terminate in about 15 years, as by that time a sufficient number of observations to determine the Meteorological Means will have been collected and discussed.

Weather Statistics in and near the British Isles:	
Six Stations with Self-Recording Instruments: Collecting Observations from intermediate Stations, Lighthouses, Ships, &c.; discussing Observations, Charting, and publishing Results, annually - - -	4,250
Besides an outlay, to begin with, of 2,500*l.* and whatever sums may be needed for additions to the buildings at Kew.	
Telegraphy and Storm Warnings, annually - - - -	3,000
Grand total annually - -	10,450

As regards expenses to be incurred by the Hydrographic Department in getting out and publishing charts, &c., for the immediate use of navigators, we are unable to say with precision what it may be found necessary to do, and we are therefore unable to give an estimate.

46. *Reasons for proposed Increase of Expense.*

The expense of what we propose is larger than the expense hitherto incurred. But this is unavoid able unless either the original object of the Meteorological Department or the system of Storm Warnings is to be abandoned. The Meteorology of the ocean is, as we have stated, as important an object now as it was in 1854; and we feel ourselves justified in believing (especially with such a promise of success as is held out by the Meteorological Registers already collected) that the Government and Parliament will not now abandon an object taken up by them after much consideration in 1854, and that they will not be satisfied to leave the matter in its present incomplete and useless condition. If the grant originally made had been steadily applied to this object and had not been diverted to other objects, the work would by this time have advanced far towards completion; and we do not doubt that it may be completed within the time, and for the sum we have mentioned above.

The prognostication of Storms is a branch of practical Meteorology which has been superadded to the original Functions of the Department, and to which a large part of the funds originally granted for the purpose of Meteorological Observations at Sea has been devoted. It is one far too important, too popular, and too full of promise of practical utility to be allowed to die. But the present treatment of it is, as we have shown, incomplete and unsatisfactory, and it cannot be made complete or satisfactory without the new system of observations, and consequent additional expense, which we have recommended.

These Observations are the foundation; the Telegraphy and Storm Warnings are the superstructure; and we have no hesitation in saying, in the interest of practical utility as well as of science, that if the expense we have recommended is thought to be too large, and any part of what we have proposed is to be postponed for the present on account of expense, the part to be postponed should be that part which recommends the present continuance of the attempts to prognosticate weather. To continue them in their present condition without an endeavour to determine the principles and rules on which they should be founded, would, in our opinion, be injurious to the fame of the eminent officer who has originated them and discreditable to the country.

For these reasons we have no hesitation in making the various proposals mentioned above, and in recommending the consequent increase of expenditure.

CONCLUSION.

47. *Answers to Questions put to us.*

In conclusion, we give seriatim in a concise form answers to the questions which have been put to us; but the nature of the subject renders it difficult to make these answers intelligible without reference to the more ample statements contained in the earlier parts of our Report.

Question 1. *What are the data, especially as regards Meteorological Observations at Sea, already collected by and now existing in the Meteorological Department of the Board of Trade?*

These data are described at length in Part I. of our Report.* As regards Meteorological Observations at Sea, they consist of about 550,000 observations, mostly, if not entirely, of good quality, contained in 1,298 Registers. The remaining data are of a miscellaneous character. Some of these data have been extracted and partially discussed by the Department, and some of the results have been published. But we think, for the reasons given above,† that this has been done in an imperfect manner.

Question 2. *Whether any and what steps should be taken for arranging, tabulating, publishing, or otherwise making use of such data?*

We are decidedly of opinion that steps should be taken for extracting and discussing the Meteorological Observations at Sea already existing in the Department, in common

---

* See pp. 6, 13, and 14.

† See pp. 8, 9 and 11.

with further observations to be taken hereafter. As regards the discussions and publications now in progress in the Department, we think that they should be brought to a close as soon as possible in the way pointed out above.* The process of extracting and discussing the observations on a better plan should be commenced *de novo*, and carried on till the work is complete in the manner indicated above.†

Question 3. *Whether it is desirable to continue Meteorological Observations at Sea, and if so, to what extent, and in what manner?*

We are of opinion that it is desirable to continue Meteorological Observations at Sea until a sufficient number of observations has been obtained to fulfil the requirements of the Royal Society for the accessible parts of the ocean.‡

Question 4. *Assuming that the system of Weather Telegraphy is to be continued, can the mode of carrying it on and publishing the results be improved?*

The system of Weather Telegraphy and of Foretelling Weather is not in a satisfactory state. It is not carried on by precise rules; and has not been established by a sufficient induction from facts. The Storm Warnings have, however, been to a certain degree successful, and are highly prized. We think that the Daily Forecasts ought to be discontinued, and that an endeavour should be made to improve the Storm Warnings, to define the principles on which they are issued, and to test those principles by accurate observation. Above all, we think that steps should be taken for establishing a full, constant, and accurate system of observing changes of Weather in the British Isles. Our detailed recommendations on these heads are given at the end of the Second Part of our Report.§

Question 5. *What Staff will be necessary for the above purposes?*

The answer to this question will be found at length in Part III. of our Report.‖

The cost of what we propose will be (say) 10,500*l.* a year, besides 2,500*l.* for outfit. Of the annual expense, 3,200*l.* should cease after 15 years.

48. *Weather Changes in all Parts of the World.*

We are aware that there is a still wider view of the whole subject of Meteorology and the phenomena connected with it, which we, limited as we are to the special functions of the Meteorological Department, can only glance at. Considering the wide extension of civilization and of British colonization and influence, it seems only reasonable that we should possess some regular record of the broad peculiarities of all the great weather changes that affect the globe. A knowledge of the varying regions of exceptional drought, of wet, of heat, or of cold, of the deflection of normal currents of air or of sea; of the variation in the limits of the polar ice and of other phenomena is required; and for this purpose much more of course will be needed than either the Ocean Statistics, referring to constant values, or the weather changes in and near the British Isles, limited as they are in their local area, which form the special subjects of our recommendations.

To obtain such a record it will be less necessary to create new stations of observation than to utilize the scattered efforts that are now made in extraordinary abundance, by bringing them, as it were, to a focus.

We look forward to the establishment at no distant period of a regular record of the Weather changes over the greater portion of the globe, through international effort, and especially by means of the observations of British subjects on shore and afloat; but for the present we make no recommendations on the subject, neither do we make any recommendations for the present on the publication of the five-day means of temperature at all fixed stations, recommended by the Royal Society in their letter of the 22d February 1855, or of the anemometrical records at five stations also mentioned in that letter, for we feel that these have their chief interest as being parts of the larger subject.

If, however, the suggestions we have made in Part III. with respect to Kew be adopted, we trust that it may prove to be a step in this direction. And we think that it may probably be found well worth while for such an Establishment to copy the Cards of Observations extracted from the Meteorological Registers in duplicate and to sort the duplicates according to date, so that trial charts of the Weather at given epochs over the whole globe, may, so far as such observations prove sufficient for the purpose, be occasionally made and published.

---

* See pp. 15, 16. † See pp. 9, 10, and 16. ‡ See pp. 5, 7, and 11.
§ See p. 37 and following. ‖ See p. 40.

f. 22

This ought to have been dated

49. *Periodical Revision.*

Assuming that the above recommendations are adopted, we recommend in addition that not more than three years shall be allowed to pass without a further inquiry into the manner in which the work is progressing. The collection and discussion of Meteorological statistics, however valuable in its ultimate results, is work of little immediate interest to the public, and is very likely, as past experience proves, to be neglected or postponed, especially in a Government Department, for objects appearing to be more immediately practical or popular. But it is on numerous exact and careful observations, and upon these alone, that the discovery of the laws which govern the atmosphere can be based; and practical results can be of little or no value unless they are founded on a knowledge of these laws. We, therefore, regard it as a matter of the utmost importance, practically as well as scientifically, that the progress made in collecting and discussing observations should be periodically reviewed and reported on.

50. *Final Remarks.*

Finally, we think it due to the Meteorological Department of the Board of Trade, and to ourselves, to make the following remarks. We have stated, without reserve or hesitation, our opinion concerning what we cannot but think to be defects in the practice of the Department, both as regards the discussion of Ocean Statistics and the system of Foretelling weather. But we should be doing great injustice to the Department, and especially to Mr. Babington, upon whom, since the commencement of Admiral FitzRoy's last illness, the burden and responsibility has mainly rested, if we did not express our strong sense of the intelligence, as well as of the zeal and industry, which the Department has evinced; and we think it only just to say this, lest in condemning what we believe to be defective methods, we should be supposed to intimate that there is in the Department or in its present head, any incapacity for properly fulfilling, under proper guidance, such functions as it may be thought proper to intrust it with.

We feel, moreover, that we should be doing great injustice to ourselves if we were to allow it to be supposed that we undervalue either what the late Admiral FitzRoy attempted or what he effected. To his zeal and perseverance is due the credit of establishing a system of Storm Warnings, which is already highly prized by the seafaring class. And if a more scientific method should hereafter succeed in placing the practice of Foretelling weather on a clear and certain basis, it will not be forgotten that it was Admiral FitzRoy who gave the first impulse to this branch of inquiry, who induced men of science and the public to take interest in it, and who sacrificed his life to the cause.

FRANCIS GALTON.
THOMAS HENRY FARRER.
FREDERICK JOHN EVANS.

APPENDIX TO REPORT.

No. in Appendix.	Page of Report.	Title of Paper.	Page in Appendix.
1	2	Correspondence between the Board of Trade, the Royal Society, and the Admiralty, from which the present inquiry originated - - - - - - -	ii
2	6 & 7	Letter of Royal Society, of February 22, 1855, and extract from subsequent letter, describing Functions of Meteorological Department - - - - - - -	viii
3	8	Statement of number of instruments supplied by Meteorological Department - - -	xvi
4	10	Chart, showing the Division of the Ocean into 10-degree Squares - - - -	xvii
5	22	Form of Tables for publishing Meteorological Results already obtained by the Meteorological Department - - - - - - - - - -	xviii
6	23	Form of Tables for publishing Meteorological Results to be obtained hereafter - -	xviii
7	29	Attempted Digest of Maxims employed by the Office in foretelling Weather - - -	xx
8	32	Extract from Record of Meteorological Department, illustrating the Comparison of Daily Forecasts with Facts, as made by the Department - - - - - -	xxii
9	35	Tables in form of Calendar, prepared by the Wreck Department, showing for the Year 1865, for the Ports of Plymouth and Shields, the Storm Warnings issued, the Forecasts of Force of Wind and the actual extreme Force of Wind for each day in the year - -	xxiv
10	35	Specimen of English Daily Weather Report and Forecasts, and Remarks as issued by the Meteorological Department of the Board of Trade - - - - - -	xxix
11	35	Specimen of French Weather Bulletin, as issued by M. Le Verrier - - - -	xxx
12	41	Specimen of Weather Report sent to Wreck Department of Board of Trade, by Officers of Coast Guard and Customs, subsequently to each Storm Warning - - - -	xxxi
13	43, 46	Analysis of Report made to the Wreck Department of the Board of Trade, upon the Weather which followed the Exhibition of the Storm Signals at all places warned, from 1 July to 31 December 1861 - - - - - - - -	xxxiii
14	44, 46	Analysis of Reports made to the Wreck Department of the Board of Trade, upon the Weather which followed the Exhibition of the Storm Signals at all places warned, for the month of December in each of the Years 1863, 1864, and 1865 - - - -	xxxiv
15	44, 46	Analysis of Reports made to the Wreck Department of the Board of Trade, upon the Weather which followed the Exhibition of the Storm Signals at Aberdeen, Galway, Harwich, Holyhead, Plymouth, Shields and Yarmouth, for the whole of the Years, 1863, 1864, and 1865	xxxv
16	46	Example of Diagram, showing both the Force and Direction of Wind, following a Storm Signal at each 4-hourly period of Observation for 72 hours after hoisting a Warning Signal - - - - - - - - - - - -	xxxvi
17	49	Abstract of Opinions from the Ports concerning the value attached to the Storm Warnings at the present time, 1866 - - - - - - - - -	xxxvii
18	57	Account of sums voted for and expended by the Meteorological Department of the Board of Trade, made up to 1 December 1865 - - - - - - - -	xxxviii

Appendix No. 1.

CORRESPONDENCE between the BOARD of TRADE, the ROYAL SOCIETY, and the ADMIRALTY, from which the present Inquiry originated.

SIR, Board of Trade, 26th May 1865.

I AM directed by the Lords of the Committee of Privy Council for Trade, on the occasion of the vacancy in the office of chief of the Meteorological Department, caused by the untimely death of Admiral FitzRoy, to request you to be so good as to bring under the notice of the President and Council of the Royal Society the correspondence which took place between that Society and this office at the time of the institution of the Meteorological Department as a branch of this Office, and particularly your letter of the 22nd of February 1855, in reply to that from this office of the 3rd of June 1854, in which, when about to institute the Department, my Lords had desired the opinion of the Royal Society as to what were the great desiderata in meteorological science. The recommendations of the Royal Society, conveyed in your letter of the 22nd of February 1855, were adopted as the basis of the proceedings of the Meteorological Department, instruments were provided, logs were prepared, furnished, and returned to the Office, and some progress was made in carrying into effect the original programme.

But in 1859 or 1860 the French Government having adopted a system of telegraphing and publishing the actual state of weather from one place to another, co-operation in which was urged on the Board of Trade by a Committee of the British Association and by Admiral FitzRoy, my Lords gave their sanction to what was proposed, and thenceforward a considerable part of the vote previously applied to obtaining and digesting observations was diverted to these telegrams. In 1861 Admiral FitzRoy grafted on this system of telegraphic communication a system of forecasting the weather, the forecasts being published in the daily papers, and, on occasion of anticipated storms, the giving of special warnings communicated by telegraph to the different ports, and there made known by hoisting certain signals. The whole, or almost the whole, of the funds originally voted for the purpose of observations were thus diverted from their original scientific object to an object deemed more immediately practical.

In 1863, on the occasion of an increased estimate for the purpose of these forecasts, it was determined to compare the forecasts and the warnings with the actual results.

As regards the daily forecasts, the daily reports of weather published by Admiral FitzRoy afforded and still afford ample means of checking them.

As regards the storm warnings detailed reports were called for from the places to which the warnings were sent. The results of these comparisons, for certain periods, were tabulated and laid before Parliament in a paper, copy of which is annexed. The data for continuing the return are still kept, and if it were thought right to incur the expense, it could be continued at any time.

My Lords at the same time addressed a further letter, dated 27th February 1863, asking the opinion of the Royal Society as to the course then being pursued by Admiral FitzRoy, and were favoured, in reply, by your letter of the 27th March 1863.

The vacancy in the Meteorological Department occasioned by the death of Admiral Fitz Roy has seemed to my Lords to present a fitting opportunity to review the past proceedings and present state of the Department, and with this view they are desirous of receiving any observations or suggestions with which the President and Council of the Royal Society may be willing to favour them on the constitution and objects of the Department, and the mode in which those objects may be most effectually attained.

The points on which the Board of Trade especially desire the opinion of the Royal Society are the following:—

1. Are the objects specified in the Royal Society's letter of the 22nd February 1855 still as important for the interests of science and navigation as they were then considered?

2. To what extent have any of these objects been answered by what has already been done by the Meteorological Department?

3. What steps should be taken for making use of any observations already collected or any compilations already made by the Department?

4. Is it desirable to make any, and what, further observations on any, and which, of the subjects mentioned in the Royal Society's letter of 22nd February 1855?

5. What is the nature of the basis on which the system of Daily Forecasts and of Storm Warnings established by Admiral FitzRoy rests? In other words, are they founded on scientific principles, so that they, or either of them, can be carried on satisfactorily, notwithstanding Admiral FitzRoy's decease?

6. If they, or either of them, can be carried on satisfactorily, can the Royal Society suggest any improvement in the form and manner of doing it?

7. Is it desirable to continue down to the present time the tables of results corresponding to the Forecasts and Storm Warnings which were made out for certain periods in the year 1863, and were presented to Parliament in April 1864?* The materials for doing this exist in the office, and only require clerical labour.

8. Assuming it to be desirable to continue the publication of the daily reports of weather received from various stations, can the Royal Society make any suggestions as to the extent to which it should be carried and the form in which it should be done?

---

* Parliamentary Paper, No. 200, Session 1864.

9. Have the Royal Society any general suggestions to make as to the mode, place, or establishment in, at, or by which the duties of the Meteorological Department can best be performed?

With respect to these heads of inquiry, my Lords desire to observe, in the first place, that they understand that the Admiralty are willing to undertake and to place in the hands of their Hydrographer all those observations which can properly be made use of in framing charts for purposes of navigation, but not those which relate to meteorology proper.

Secondly. That the Board of Trade will gladly place the knowledge and services of Mr. Babington, Admiral FitzRoy's second, at the disposal of the Royal Society, for the purpose of the above inquiries, and will also give them any help, clerical or otherwise, which the Royal Society may require, and which the Board of Trade may be able to give.

I have the honour to be, Sir,
Your obedient servant,
(Signed) T. H. FARRER.

The President, Royal Society.

The Royal Society, Burlington House,
June 15, 1865.

SIR,

IN replying to your letter of the 26th of May, the President and Council think it may be desirable to advert, in the first instance, to that which has constituted the chief occupation of Admiral FitzRoy's department in the last four or five years, viz., the systematic forecasting of the weather by means of telegrams received from stations comprised within a certain limited area; and, on occasions of anticipated storms, the giving special warnings conveyed by telegraph to the different ports in the United Kingdom, and there made known by hoisting certain signals.

The system of forecasting which Admiral FitzRoy instituted and pursued has been expressly described by himself as "an experimental process," based on the knowledge conveyed by telegraph of the actual state of the winds and weather and other meteorological phenomena within a specified area, and on a comparison of these with the telegrams of the preceding days, so as to obtain inferences as to the probable changes in the succeeding days. The proper test of the efficiency and usefulness of such a system of cautionary signals at the different ports is to be sought in the *measure of success which it appears to have attained;* always remembering that the system under consideration can only be regarded as in its infancy, and that, if continued, its improvement, and consequently its importance, may be expected to be progressive from year to year. In Admiral FitzRoy's Report to the Board of Trade, in May 1862, the opinions of the shipmasters at several ports in regard to the practical value which they attached to the storm-signals were given at length. Of the 56 replies published in the Appendix of that Report, 46 were decidedly favourable, three decidedly unfavourable, and seven expressing no decided opinion. A statement so favourable on the whole, obtained so very shortly after the system had been first brought into operation, must surely be considered to have fully justified the Board of Trade in directing its further prosecution.

The Return to the House of Commons, dated April 13, 1864, a copy of which accompanied your letter, presents a comparison of the probable force of the wind as indicated by the signals in the year commencing April 1, 1863, and terminating March 31, 1864, and its actual state as reported in the three days following the exhibition of the signals; and Mr. Babington has since been so obliging as to communicate in manuscript a return having the same object in view for the year April 1, 1864, to March 31st, 1865.

From the first of these documents, the President and Council learn (in page 7) that the whole number of signals which were hoisted at different places, and of which reports were received, between April 1, 1863, and March 31, 1864, amounted to 2,288; of these the number which proved correct in respect to the *force* of the wind equalling or exceeding "a fresh gale" was 1,284; in 462 cases the stations were reached by the gale (or a still stronger wind blew) before the signal was hoisted; and in 726 within 48 hours after the signal was hoisted. Hence we may conclude that (omitting the 96 cases in which the gale occurred between 48 and 72 hours after the signal was hoisted) 1,188 signals, or more than half the whole number of 2,288, were justified by the state of the weather, either when the telegraphic message reached the station, or within 48 hours afterwards.

With respect to *direction* of wind in a gale indicated by signal, the "warnings" are reported to have been much less frequent. Of the 402 signals indicating direction as well as force, 271 agreed, and 131 did not agree, with the real direction of the wind; being a proportion of about two correct to one incorrect.

The manuscript with which Mr. Babington has favoured the Council since the receipt of your letter of May 26, 1865, contains a summary of the cautionary signals between April 1, 1864, and March 31, 1865, with notes stating their success or failure. From these it appears that signals were hoisted on 40 days in the course of the year, 29 of which appear to have been justified by the event, eight to have been failures, either in respect to force or direction, and three were late, the gale having already commenced. There are also five cases in which it is admitted that signals might have been made with advantage when none were sent.

It seems not unreasonable to attribute to increased experience the marked improvement of these results upon those of the preceding year, and to anticipate still further improvement.

The method adopted in preparing the storm-warnings has been very ably and lucidly explained by Mr. Babington in a paper dated May 11, 1865, presented by him to Mr. Farrer, by whom a copy has been sent to the President and Council. Possibly it may be viewed as the best arrangement that this branch of the duties of the office should continue as at present under the direction of Mr. Babington, by whom it has been virtually carried on for several months past.

On the subject of storms of a cyclonic character originating in the British Islands or in their vicinity, the interest of which was adverted to in the reply from the Royal Society to the Board of

Trade, March 27, 1863, reference has been made to Mr. Babington for such further information as may have been subsequently obtained. His reply to General Sabine is as follows :—

" I can quite confirm your impression respecting Admiral FitzRoy's belief in the evidence of the " existence of small cyclonic storms in England itself, originating in or near our islands, and generated " in the brushing against each other of the N.E. and S.W. currents, and in reply to your question I " beg to say that I believe there is satisfactory evidence of the existence of such storms; but that " these small storms are not very frequent; three or four in a year perhaps, and that they are, I " think, more common in summer than in winter, although usually of less violence. The *direction* " of their motion is certainly almost invariably towards some point between N.N.E. and E.S.E. " With regard to the rapidity of their motion, I scarcely feel able to express an opinion; but at the " ordinary rate of progression it takes such a storm about 48 hours to pass from Ireland to the " Baltic. Not unfrequently, however, they appear to die out, as it were, before travelling so far."

The existence of such storms in our islands is a fact in meteorological science of considerable interest, for which we are indebted to the researches instituted and carried on by Admiral FitzRoy's department. Though not of very frequent occurrence, they constitute a class of phenomena well suited for telegraphic advertisement, especially on our eastern and north-eastern coasts. It might, perhaps, be practically desirable to indicate them by a special signal, distinguishing them from storms which have a more uniform direction. But however this may be, it seems to be desirable that the occurrence of such storms and their attendant phenomena, as obtainable at the time, should be carefully recorded, with a view to the records being ultimately put together in elucidation of a branch of the Meteorology of our islands which has hitherto been but imperfectly examined.

We proceed to notice the points on which we are informed that the Board of Trade especially desire the opinion of the Royal Society; and particularly the inquiry whether the objects specified in the Royal Society's letter of the 22nd February 1855 are still viewed as of the same importance for the interests of science and navigation as they were then considered.

The most prominent amongst these objects was the collection and co-ordination of meteorological observations made at sea, including such as are required to form a correct knowledge of the currents of the ocean, their direction, extent, velocity, and the temperature of the surface-water relatively to the ordinary ocean temperature in the same latitude; together with the variations in all these respects which currents experience in different parts of the year and in different parts of their course. These, as well as the facts connected with the great barometric elevations and depressions which we know to exist in several oceanic localities, and their influence on circumstances affecting navigation, were noticed as inquiries well deserving the attention of the country possessing such extensive maritime facilities and interests as ours, and as forming a suitable contribution on our part to the general system of meteorological inquiry which had been adopted by the principal continental states in Europe and America.

We have learned from Mr. Babington that much was done by Admiral FitzRoy in the three or four years succeeding the establishment of his office (and before the subject of storm-warnings had engrossed the greater part of his consideration), in directing the attention of many of the commanders of our merchant ships to the collection of suitable data, and in improving their habits of observation and of record. The logs of such vessels form at present a large collection of documents existing in the office of the Board of Trade, partially examined, and their contents partially classified. The President and Council are glad to learn by your letter that the further prosecution of this great and important branch of Hydrography is about to be placed in the hands of the distinguished officer who now presides over the Hydrographic Department of the Admiralty, to whose duties it appears indeed most appropriately to belong, and to whose office, no doubt, the documents already collected will be transferred, and made available for public purposes.

There remain, therefore, to be noticed solely the considerations which relate to "Meteorology proper," *i.e.*, to the Land Meteorology of the British Islands. We find that the principal States of the European Continent have almost without exception formed establishments for the collection and publication periodically of the meteorology of their respective countries. The arrangements consist usually of a central office, at which instruments and instructions are provided for a number of stations, greater or less, according to the area which they represent; at which stations observations are made and transmitted to the central office, where the results of all are reduced, co-ordinated, and published. The small extent of the area comprised by the British Islands, in comparison with the territories of many of the European States, may require *fewer* stations; but in a matter now so generally attended to and provided for, it seems scarcely fitting that our country should be behind others. There is moreover, a peculiarity in the meteorological position of the British islands in respect to Europe generally as its north-western outpost, in consequence of which an especial duty appears to devolve upon us. M. Matteucci, in a very recent publication, has already made the important remark that extensive atmospheric disturbances which first invade Ireland and England, are those which, in winter more especially, extend to and pass the Alps (although somewhat retarded by them) and spread over Italy; and thus that, though receiving telegrams announcing storms taking place in the north of Europe, in Germany, on the western coasts of France, and of those of Spain, he finds that it has in fact been most especially in the case of announcements from England that storms so telegraphed have actually reached Italy, and been found to correspond with the accounts subsequently received from Italian Mediterranean ports.

A few stations, say six, distributed at nearly equal distances in a meridional direction from the south of England to the north of Scotland, furnished with self-recording instruments supplied from and duly verified at one of the stations regarded as a central station, and exhibiting a continuous record of the temperature, pressure, electric and hydrometric state of the atmosphere, and of the force and direction of the wind, might perhaps be sufficient to supply authoritative knowledge of

those peculiarities in the meteorology of our country which would be viewed as of the most importance to other countries, and would at the same time form authentic points of reference for the use of our own meteorologists. The scientific progress of meteorology from this time forward requires, indeed, such continuous records, first, for the sake of the knowledge which they alone can effectively supply, and next, for comparison with the results of independent observation not continuous. The actual photograms, or other mechanical representations, transmitted weekly by post to the central station would constitute a lithographed page for each day in the year, comprehending the phenomena at all the six stations, each separate curve admitting of exact measurement from its own base-line, the precise value of which might in every case be specified.

The President and Council suggest that the Observatory of the British Association at Kew might, with much propriety and public advantage, be adopted as the central meteorological station. It already possesses the principal self-recording instruments, and the greater part of them have been in constant use there for many months. There will be no difficulty in obtaining, through the intervention of the Committee of Management, similar instruments for the affiliated meteorological stations, and in arranging for their verification and comparison with the Kew standards, as well as in giving to those in whose hands they may be placed such instructions as may ensure uniformity of operation. The records from the other stations may be received at Kew by post weekly, or more frequently if required, and may be at once arranged for such form of publication as may be most approved. It seems expedient that, if practicable, the stations which should be selected to act in concert and co-operation with Kew should be in localities where some permanent establishment of a scientific character exists, and where a certain amount of supervision may be secured. In this view the President and Council would suggest, as eligible, the following chain of stations, commencing from the south, viz. :—

		°	′
Falmouth.—Polytechnic Institution - - - - -	Lat.	50	9
Kew.—Observatory of the British Association - - - -	,,	51	28
Stonyhurst.—The College, which has already a Magnetical and Meteorological Observatory - - - - - - -	,,	53	0
Armagh.—Observatory - - - - - -	,,	54	21
Glasgow.—University and Observatory - - - -	,,	55	51
Aberdeen.—University - - - - -	,,	57	9

To these six stations the President and Council would have been very glad to have added two others, one in the south-west and one in the north-west of Ireland. For the former of these possibly Valentia may present a fitting locality, when an establishment shall have been formed there as the connecting link by means of the Atlantic telegraph between Europe and America.

Having answered thus generally, it may perhaps be desirable to add specific replies on the several points enumerated in Questions 1 to 9. Preserving the order in which the inquiries are made, the replies are as follows :—

Question 1. The President and Council are of opinion that the objects specified in he Royal Society's letter of February 22, 1855, are as important for the interests of science and navigation as they were then considered.

Question 2. Much has without doubt been accomplished in the collection of facts bearing on Marine Meteorology, but as no systematic publication of the results has yet been made, the President and Council are unable to reply more specifically.

Question 3. The President and Council recommend that the Sea Observations should be placed in the hands of the Hydrographer with a view to the introduction of the results into the Admiralty Charts. They, however, at present have not sufficient information on the subject of the Land Observations which may exist in the office of the Board of Trade to justify them in offering any recommendation thereon.

Question 4. The President and Council consider it very desirable that further observations should be made, especially with reference to oceanic currents and great barometric depressions, and generally on all subjects comprehended under the denomination of "Ocean Statistics."

Questions 5 and 6. It appears from the late Admiral FitzRoy's reports, as well as from the explanations of Mr. Babington, that the storm-warnings have been based on inferences drawn from observations extending over a considerable area; and the President and Council recommend that they should be continued under the superintendence of that gentleman. Respecting the daily forecasts of weather, however, they decline expressing any opinion.

Question 7. The President and Council are of opinion that it would be desirable that an annual report, in a modified form, should be made to the Board of Trade of the results from the storm-warnings in the preceding year, and should be communicated to Parliament, and thereby become known to the public.

Question 8. A proper reply to this question would require information, and involve considerations which would occasion an inconvenient delay in the transmission of this letter.

Question 9. The suggestions of the President and Council in regard to the mode in which it appears to them that the important subject of "Meteorology Proper," or the "Land Meteorology "of the British Islands," might be dealt with economically, and at the same time effectively, have been fully stated in the body of this letter.

I have the honour to be, Sir,
Your obedient servant,
(Signed) Edward Sabine,
President, R.S.

T. H. Farrer, Esq.,
&c. &c.
Board of Trade.

SIR Board of Trade, 24th October 1865.

I AM directed by the Board of Trade to acknowledge the receipt of your letter of the 15th June last, on the subject of the Meteorological Department of the Board of Trade, and to thank yourself and the Council of the Royal Society for the valuable information, advice, and suggestions which it contains.

The Council of the Royal Society discuss the system of Weather Telegraphy, and recommend that it shall be continued; they approve of the proposal to hand over to the Hydrographer to the Admiralty such part of the observations collected in the Meteorological Department of the Board of Trade as he can make use of in constructing charts for the use of seafaring men. And they discuss and recommend the adoption of a new system of making and recording meteorological observations on land.

As regards, however, one branch of the subject, viz., meteorological observations made at sea, which formed the original object of the Meteorological Department, and the chief subject of the letter from the Royal Society of the 22nd February 1855, the Board of Trade are not satisfied that they fully understand the present views of the Royal Society.

Your letter says, in answer to Question 1 contained in my letter of the 26th May last, asking, "Are the objects specified in the Royal Society's letter of the 22nd February 1855 still as important "for the interests of science and navigation as they were then considered?" that "The President "and Council are of opinion that the objects specified in the Royal Society's letter of February 22, "1855, are as important for the interests of science and navigation as they were then considered."

And it further says, in answer to Question 2, asking, "To what extent have any of these objects "been answered by what has already been done by the Meteorological Department?" that "Much "has without doubt been accomplished in the collection of facts bearing on Marine Meteorology, "but as no systematic publication of the results has yet been made, the President and Council are "unable to reply more specifically." It is probably for the reason contained in this answer that, whilst the other subjects above mentioned are fully discussed in your letter, the subject of these meteorological observations at sea is scarcely referred to. It is however essential that the Board of Trade should be rightly informed upon this point before they can determine what steps should be taken with regard to the Meteorological Department. What is the value of the observations at sea already collected? what steps should be taken to make them useful? and whether any, and, if any, what further observations of the same kind should be collected? are questions which must be answered before any final arrangement can be made with respect to the other points mentioned in your letter. With the view of clearing up these points, the Board of Trade are disposed to suggest the appointment of a small committee, consisting, say, of three or four persons, to examine the whole of the data already collected by the Meteorological Department; to inquire whether any and what steps should be taken for digesting and publishing them; and also to report whether it is desirable that observations of a similar kind shall still continue to be collected. Such a Committee would also, in all probability, be able to make valuable recommendations as to the mode in which the business of the Department (if continued) shall be conducted, and as to the form in which the daily Weather Reports (by whomsoever they may be made) should be published.

If the Royal Society concur in this suggestion, the Board of Trade would ask them to appoint, as a member of the Committee, some gentleman whose acquirements would enable him to give valuable advice on the scientific part of the subject; and they would also ask the Admiralty to appoint another member. The Board of Trade will feel much obliged if you will favour them with the opinion of the President and Council on this suggestion.

With reference to the subject of meteorological observations on land, the Board of Trade do not clearly understand whether the Royal Society think that they should be substituted for, or be in addition to, the meteorological observations at sea, which were originally suggested by the Royal Society. They are disposed to agree with the Royal Society in thinking that any observations of a scientific nature would be better conducted under the authority and supervision of a scientific body, such as the Royal Society or the British Association, than of a Government Department. But they do not see how they could advise the Government to sanction any plan which would involve the establishment of two separate offices for meteorological purposes, one under the Board of Trade at Whitehall, and the other at Kew. It seems to them obvious that any assistance to be given by Parliament for meteorological purposes will be more advantageously employed if concentrated at one place, and in one set of hands, than it can be if distributed among different establishments.

I have the honour to be, Sir,
Your obedient servant,
(Signed) T. H. FARRER.

The President of the Royal Society.

SIR, Burlington House, November 2, 1865.

I HAVE submitted your letter of the 24th of October to the Council of the Royal Society, and have now the honour to reply to it.

The President and Council fully concur with the Board of Trade regarding the importance of inquiries being made into the value of the observations obtained at sea under the direction and guidance of the Meteorological Department of the Board of Trade, and into the steps which should be taken to utilize the results, as well as the further question, Whether any, and, if any, what future observations of the same, or of a similar kind, bearing on Ocean Statistics should be collected? They will be quite ready to assist in this inquiry in the manner proposed, viz., by nominating one of their fellows conversant with such subjects as a member of the proposed Committee.

In reference to the last paragraph of your letter of the 24th October, they are of opinion that systematic meteorological observations at a few selected land stations in the British islands are desirable, in addition to the meteorological observations at sea, in order to complete a suitable contribution from this country to the meteorological observations now in progress in the principal states of Europe and America, under the authority of their respective Governments.

If, in the communication from the Royal Society to the Board of Trade, of February 22, 1855, which preceded the establishment of Admiral FitzRoy's office, the advantages to be derived from a continuous and well-directed system of maritime observations were more particularly pressed, it was because at that time neither the instruments nor the modes of observation suitable for a well-organized and efficient system of continuous land observation, were prepared. This was well stated by Lieut. Maury, in a letter addressed to the United States Government, dated November 6, 1852, subsequently transmitted by that Government to the Earl of Clarendon, and printed in the "Papers presented to the House of Lords in February 1853." This difficulty no longer exists, having been entirely obviated by the self-recording system of observation, for which the necessary instruments have been devised and brought into use at the Kew Observatory.

The President and Council are not aware of any inconvenience likely to arise from entrusting the scientific supervision of such a system as they have recommended to a body such as the Kew Committee, acting under the authorization and control, in regard to expenditure, of a public department. Precedents for such a course are not wanting.

I have the honour to be, Sir,
Your obedient servant,
(Signed) EDWARD SABINE,
President of the Royal Society.

T. H. Farrer, Esq.

SIR,

Board of Trade, 20th November 1865.

WITH reference to your letter of the 2nd November, stating the willingness of the President and Council of the Royal Society to appoint one of their fellows to represent the Society upon a Committee to examine and report on questions connected with the Meteorological Department of the Board of Trade, I am to inform you that Staff-Commander Evans has been nominated by the Admiralty, and Mr. Farrer by this Board, and I am at the same time to request you to be good enough to forward the name of the gentleman selected by the President and Council of the Royal Society.

The following are the points which the Board of Trade propose to refer to the Committee if the President and Council see no objection:—

1. What are the data, especially as regards meteorological observations made at sea, already collected by and now existing in the Meteorological Department of the Board of Trade?
2. Whether any and what steps should be taken for arranging, tabulating, publishing, and otherwise making use of such data.
3. Whether it is desirable to continue meteorological observations at sea, and, if so, to what extent and in what manner.
4. Assuming that the system of Weather Telegraphy is to be continued, can the mode of carrying it on and of publishing the results be improved?
5. What staff will be necessary for the above purposes?

I have the honour to be, Sir,
Your obedient servant,
(Signed) J. EMERSON TENNENT.

The President of the Royal Society.

The Royal Society, Burlington House,
November 22, 1865.

SIR,

I BEG to acknowledge the receipt of your letter of the 20th instant, and to inform you that the President and Council of the Royal Society have selected Mr. Francis Galton, F.R.S., and general secretary of the British Association, to represent the Royal Society upon a Committee to examine and report on questions connected with the Meteorological Department of the Board of Trade.

I have the honour to be,
Your obedient servant,
(Signed) EDWARD SABINE,
President Royal Society.

Sir J. Emerson Tennent.

SIR,

Board of Trade, 28th October 1865.

I AM directed by the Board of Trade to transmit to you the accompanying copy of a correspondence which they have had with the President of the Royal Society on the subject of the Meteorological Department of this Board.

I am specially to direct the attention of the Lords Commissioners of the Admiralty to their last letter, dated the 24th instant.

This letter contains a suggestion that a Committee be appointed to examine into the whole data collected at the Meteorological Department, and to report whether it is desirable to continue the collection of similar observations; and if so, what steps should be taken for their digestion and publication.

UNIVERSITY COLLEGE LONDON
GALTON PAPERS

You will observe that in consequence of the relation between the Hydrographer and the Admiralty and the Meteorological Department of the Board of Trade, this Board suggest that one of the members of the Committee should be appointed by the Admiralty, and I am to request that they may be informed whether the Lords Commissioners approve of the suggestion, and whether they will, in the event of the Royal Society agreeing to the suggestion, be willing to name an officer to act upon the Committee.

I have the honour to be, Sir,
Your obedient servant,
(Signed) T. H. FARRER.

The Secretary of the Admiralty.

SIR, Admiralty, 4th November 1865.

WITH reference to your letter of the 28th ultimo, I am commanded by my Lords Commissioners of the Admiralty to acquaint you that in the event of a Committee being appointed to examine and report on questions connected with the Meteorological Department, their Lordships will be prepared to nominate Staff-Commander Evans, the chief assistant in the Hydrographical Department, to sit on the Committee, and I am to request you will so inform the Lords of the Committee of Privy Council for Trade.

I am, Sir,
Your very humble servant,
(Signed) W. G. ROMAINE.

The Secretary, Board of Trade.

APPENDIX No. 2 (page 5).

LETTER of ROYAL SOCIETY of February 22, 1855, and Extract from subsequent Letter, describing Functions of METEOROLOGICAL DEPARTMENT.

Royal Society, Somerset House,
February 22, 1855.

SIR,

IN the month of June last, the Lords of the Committee of the Privy Council for Trade caused a letter to be addressed to the President and Council of the Royal Society, acquainting them that their Lordships were about to submit to Parliament an estimate for an office for the discussion of the observations on Meteorology to be made at sea in all parts of the globe, in conformity with the recommendation of a conference held at Brussels in 1853; and that they were about to construct a set of forms for the use of that office, in which they proposed to publish from time to time and to circulate such statistical results, obtained by means of the observations referred to, as might be considered most desirable by men learned in the science of Meteorology, in addition to such other information as might be required for the purposes of navigation.

Before doing so, however, their Lordships were desirous of having the opinion of the Royal Society, as to what were the great desiderata in meteorological science; and as to the forms which may be best calculated to exhibit the great atmospheric laws which it may be most desirable to develop.

Their Lordships further state, that as it may possibly happen that observations on land upon an extended scale may hereafter be made and discussed in the same office, it is desirable that the reply of the Royal Society should keep in view, and provide for, such a contingency.

Deeply impressed with a sense of the magnitude and importance of the work which has been thus undertaken by Her Majesty's Government, and confided to the Board of Trade, and fully appreciating the honour of being consulted, and the responsibility of the reply which they are called upon to make; considering also that by including the contingency of *land* observations, the inquiry is, in fact, co-extensive with the requirements of Meteorology over all accessible parts of the earth's surface,—the President and Council of the Royal Society deemed it advisable, before making their reply, to obtain the opinion of those amongst their foreign members who are known as distinguished cultivators of meteorological science, as well as of others in foreign countries, who either hold offices connected with the advancement of Meteorology, or have otherwise devoted themselves to this branch of science.

A circular was accordingly addressed to several gentlemen whose names were transmitted to the Board of Trade in June last, containing a copy of the communication from the Board of Trade, and a request to be favoured with any suggestions which might aid Her Majesty's Government in an undertaking which was obviously one of general concernment.

Replies in some degree of detail have been received from five of these gentlemen,* copies of which are herewith transmitted.

The President and Council are glad to avail themselves of this opportunity of expressing their acknowledgments to these gentlemen, and more particularly to Professor Dove, Director of the Meteorological establishments and institutions in Prussia, whose zeal for the advancement of Meteorology induced him to repair personally to England, and to join himself to the Committee by whom the present reply has been prepared. Those who are most familiar with the labours and writings of this eminent meteorologist will best be able to appreciate the value of his co-operation.

---

* Dr. Erman of Berlin; Dr. Heis of Münster; Prof. Kreil of Vienna; Lieut. Maury of Washington; and M. Quetelet of Brussels.

The President and Council have considered it as the most convenient course to divide their reply under the different heads into which the subject naturally branches. But before they proceed to treat of these, they wish to remark generally, that one of the chief impediments to the advancement of meteorology consists in the very slow progress which is made in the transmission from one country to another of the observations and discussions on which, under the fostering aid of different governments, so much labour is bestowed in Europe and America; and they would therefore recommend that such steps as may appear desirable should be taken by Her Majesty's Government to promote and facilitate the mutual interchange of meteorological publications emanating from the governments of different countries.

Barometer.

It is known that considerable differences, apparently of a permanent character, are found to exist in the mean barometric pressure in different places: and that the periodical variations in the pressure in different months and seasons at the same place are very different in different parts of the globe, both as respects period and amount; insomuch that in extreme cases, the variations have even opposite features in regard to period, in places situated in the same hemisphere and at equal distances from the equator.

For the purpose of extending our knowledge of the facts of these departures from the state of equilibrium, and of more fully investigating the causes thereof, it is desirable to obtain, by means of barometric observations strictly comparable with each other, and extending over all parts of the globe accessible by land or sea, *tables*, showing the mean barometric pressure *in the year*, *in each month of the year*, and *in the four meteorological seasons*,—on land, at all stations of observation,—and at sea, corresponding to the middle points of spaces bounded by geographical latitudes and longitudes, not far distant from each other.

The manner of forming such tables from the marine observations which are now proposed to be made, by collecting together observations of the same month in separate ledgers, each of which should correspond to a *geographical space* comprised between specified meridians and parallels, and to a *particular month*, is too obvious to require to be further dwelt upon. The distances apart of the meridians and parallels will require to be varied in different parts of the globe, so that the magnitudes of the spaces which they enclose, and for each of which a table will be formed, may be more circumscribed, when the rapidity of the variation of the particular phenomena to be elucidated is greatest in regard to geographical space. Their magnitude will also necessarily vary with the number of observations which it may be possible to collect in each space, inasmuch as it is well known that there are extensive portions of the ocean which are scarcely ever traversed by ships, whilst other portions may be viewed as the highways of a constant traffic.

The strict comparability of observations made in different ships may perhaps be best assured, by limiting the examination of the instruments to comparisons which it is proposed to make at the Kew Observatory, before and after their employment in particular ships. From the nature of their construction, the barometers with which Her Majesty's navy and the mercantile marine are to be supplied are not very liable to derangement, except from such accidents as would destroy them altogether. Under present arrangements they will all be carefully compared at Kew before they are sent to the Admiralty or to the Board of Trade; and similar arrangements may easily be made by which they may be returned to Kew for re-examination at the expiration of each tour of service. The comparison of barometers, when embarked and in use, with standards, or supposed standards, at ports which the vessels may visit, entails many inconveniences, and is in many respects a far less satisfactory method. The limitation here recommended is not, however, to be understood as applicable in the case of other establishments than Kew, where a special provision may be made for an equally careful and correct examination.

At land stations, in addition to proper measures to assure the correctness of the barometer and consequent comparability of the observations, care should be taken to ascertain by the best possible means (independently of the barometer itself) the height of the station above the level of the sea at some stated locality. For this purpose the extension of levels for the construction of railroads will often afford facilities.

It may be desirable to indicate some of the localities where the data, which tables such as those which have been spoken of would exhibit, are required for the solution of problems of immediate interest.

1°. It is known that over the Atlantic Ocean a low mean annual pressure exists near the equator, and a high pressure at the north and south borders of the torrid zone (23° to 30° north and south latitudes); and it is probable that from similar causes similar phenomena exist over the corresponding latitudes in the Pacific Ocean; the few observations which we possess are in accord with this supposition; but the extent of space covered by the Pacific is large and the observations are few; they may be expected to be greatly increased by the means now contemplated. But it is particularly over the Indian Ocean, both at the equator and at the borders of the torrid zone, that the phenomena of the barometric pressure not only annual, but also monthly, require elucidation by observations. The trade winds, which would prevail generally round the globe if it were wholly covered by a surface of water, are interrupted by the large continental spaces in Asia and Australia, and give place to the phenomena of monsoons, which are the indirect results of the heating action of the sun's rays on those continental spaces. These are the causes of that displacement of the trade winds, and substitution of a current flowing in another direction, which occasion the atmospheric phenomena over the Indian Ocean, and on the north and south sides of that ocean, to be different from those in corresponding localities over and on either side of the equator in the Atlantic Ocean, and (probably generally also) in the Pacific Ocean.

It is important alike to navigation and to general science to know the limits where the phenomena

of the trade winds give place to those of the monsoons; and whether any and what variations take place in those limits in different parts of the year. *The barometric variations are intimately connected with the causes of these variations, and require to be known for their more perfect elucidation.*

The importance, indeed, of a full and complete knowledge of the variations which take place in the limits of the trade winds, generally in both hemispheres, at different seasons of the year, has long been recognised. On this account, although the present section is headed "Barometer," it may be well to remark here, that it is desirable that the forms supplied to ships should contain headings, calling forth a special record of the latitude and longitude where the trade wind is first met with, and where it is first found to fail.

2°. The great extent of continental space in Northern Asia causes, by reason of the great heat of the summer and the ascending current produced thereby, a remarkable diminution of atmospheric pressure in the summer months, extending in the north to the Polar Sea, and on the European side as far as Moscow. Towards the east it is known to include the coast of China and Japan, but the extent of this great diminution of summer pressure beyond the coasts thus named is not known. A determination of the monthly variation of the pressure over the adjacent parts of the Pacific Ocean is therefore a desideratum; and for the same object it is desirable to have a more accurate knowledge than we now possess of the prevailing direction of the wind in different seasons in the vicinity of the coasts of China and Japan.

3°. With reference to regions or districts of increased or diminished *mean annual* pressure, it is known that in certain districts in the temperate and polar zones, such as in the vicinity of Cape Horn extending into the antarctic polar ocean, and in the vicinity of Iceland, the mean annual barometric pressure is *considerably* less than the average pressure on the surface of the globe generally; and that anomalous differences, also of considerable amount, exist in the mean pressure in different part of the arctic ocean. These all require special attention, with a view to obtain a more perfect knowledge of the facts, in regard to their amount, geographical extension, and variation with the change of seasons, as well as to the elucidation of their causes.

Dry Air and Aqueous Vapour.

The apparently anomalous variations which have been noticed to exist in the mean annual barometric pressure, and in its distribution in the different seasons and months of the year, are also found to exist in each of the two constituent pressures which conjointly constitute the barometric pressure. In order to study the problems connected with these departures from a state of equilibrium under their most simple forms,—and generally for the true understanding of almost all the great laws of atmospheric change,—it is necessary to have a separate knowledge of the two constituents (viz., the pressures of the dry air and of the aqueous vapour) which we are accustomed to measure together by the barometer. This separate knowledge is obtained by means of the hygrometer, which determines the elasticity of the vapour, and leads to the determination of that of the dry air, by enabling us to deduct the elasticity of the vapour from that of the whole barometric pressure. It is therefore extremely desirable that tables, similar to those recommended under the preceding head of the barometer, should be formed at every land station, and over the ocean at the centres of geographical spaces bounded by certain values of latitude and longitude, for the *annual*, *monthly*, and *season* pressures,—1. Of the aqueous vapour; and 2. Of the dry air; each considered separately. Each of the said geographical spaces will require its appropriate ledger for each of the twelve months.

It may be desirable to notice one or two of the problems connected with extensive and important atmospherical laws, which may be materially assisted by such tables.

1°. By the operation of causes which are too well known to require explanation here, the dry air should always have a minimum pressure in the hottest months of the year. But we know that there are places where the contrary prevails, namely, that the pressure of the dry air is greater in summer than in winter. We also know that when comparison is made between places in the same latitude, and having the same, or very nearly the same, differences of temperature in summer and in winter, the differences between the summer and winter pressures of the dry air are found to be subject to many remarkable anomalies. The variations in the pressure of the dry air do not therefore, as might be at first imagined, depend altogether on the differences between the summer and winter temperatures at the places where the variations themselves occur. The increased pressure in the hottest months appears rather to point to the existence of an overflow of air in the higher regions of the atmosphere from *lateral sources;* the statical pressure at the base of the column being increased by the augmentation of the superincumbent mass of air arising from an influx in the upper portion. Such lateral sources may well be supposed to be due to *excessive ascensional currents* caused by *excessive summer heats* in certain places of the globe (as, for example, in Central Asia). Now the lateral overflow from such sources, traversing in the shape of currents the higher regions of the atmosphere, and encountering the well-known general current flowing from the equator towards the pole, has been recently assigned with considerable probability (derived from its correspondence with many otherwise anomalous phenomena already known, and which all receive an explanation from such supposition) to be the original source or primary cause of the *rotating storms* or *cyclones*, so well known in the West Indies and in China under the names of hurricanes and typhoons. A single illustration may be desirable. Let it be supposed that such an excessive ascensional current exists over the greatly heated parts of Asia and Africa in the northern tropical zone,—giving rise, in the continuation of the same zone over the Atlantic Ocean, to a lateral current in the upper regions; this would then be a current prevailing in those regions from east to west; and it would encounter over the Atlantic Ocean the well-known upper current proceeding from the equator towards the pole, which is a current from the south-west. An easterly current impinging on a south-west current may give rise, by well-known laws, to a rotatory motion in the atmosphere, of which the direction may be the same as

that which characterizes the cyclones of the northern hemisphere. To test the accuracy of this explanation, we desire to be acquainted with the variations which the *mean pressure of the dry air undergoes in the different seasons* in the part of the globe where, according to this explanation considerable variations having particular characters ought to be found.

2°. We have named one of the explanations which have been recently offered of the primary cause of the northern cyclones. Another mode of explanation has been proposed, by assuming the condensation of large quantities of vapour, and the consequent influx of air to supply the place. In such case the phenomena are to be tested in considerable measure by the variations which the *other constituent* of the barometric pressure, namely, the *aqueous vapour* undergoes.

3°. The surface of sea in the southern hemisphere *much* exceeds that in the northern hemisphere. It is therefore probable that at the season when the sun is over the southern hemisphere, evaporation over the whole surface of the globe is more considerable than in the opposite season, when the sun is over the northern hemisphere. Supposing the pressure of the dry air to be a constant, the difference of evaporation in the two seasons may thus produce for the whole globe an *annual barometric variation*, the aggregate barometric pressure over the *whole* surface being highest during the northern winter. The separation of the barometric pressure into its two constituent pressures would give direct and conclusive evidence of the cause to which such a barometric variation should be ascribed. It would also follow that evaporation being greatest in the south, and condensation greatest in the north, the water which proceeds from south to north in a state of vapour would have to return to the south in a liquid state, and might possibly exert some discernable influence on the currents of the ocean. The tests by which the truth of the suppositions thus advanced may be determined are the variations of the meteorological elements in different seasons and months, determined by methods and instruments strictly comparable with each other, and arranged in such tables as have been suggested. A still more direct test would indeed be furnished by the fact (if it could be ascertained), that the quantity of rain which falls in the northern is greater than that which falls in the southern hemisphere, and by examining its distribution into the different months and season of its occurrence. Data for such conclusions are as yet very insufficient; they should always, however, form a part of the record at all land stations where registers are kept.

In order that all observations of the elasticity of the aqueous vapour may be strictly comparable, it is desirable that all should be computed by the same tables; those founded upon the experiments of MM. Regnault and Magnus may be most suitably recommended for this purpose, not only on their general merits, but also as being likely to be most generally adopted by observers in other countries.

Temperature of the Air.

Tables of the mean temperature of the air in the year, and in the different months and seasons of the year, at above 1,000 stations on the globe, have recently been computed by Professor Dove, and published under the auspices of the Royal Academy of Sciences at Berlin. This work, which is a true model of the method in which a great body of meteorological facts, collected by different observers and at different times, should be brought together and co-ordinated, has conducted, as is well known, to conclusions of very considerable importance on their bearing on climatology, and on the general laws of the distribution of heat on the surface of the globe. These tables have, however, been formed exclusively from observations made *on land*. For the completion of this great work of physical geography, there is yet wanting a similar investigation for the *oceanic* portion: and this we may hopefully anticipate as likely to be now accomplished by means of the marine observations about to be undertaken. In the case of the temperature of the air, as in that of the atmospheric pressure previously adverted to, the centres of geographical spaces bounded by certain latitudes and longitudes will form points of concentration for observations which may be made within those spaces, not only by the same but also by different ships; provided that the system be steadily maintained of employing only instruments which shall have been examined, and their intercomparability ascertained, by a competent and responsible authority; and provided that no observations be used but those in which careful attention shall have been given to the precautions which it will be necessary to adopt, for the purpose of obtaining the correct knowledge of the temperature of the external air, amidst the many disturbing influences from heat and moisture so difficult to escape on board ship. In this respect additional precautions must be used, if *night observations* are to be required, since the ordinary difficulties are necessarily much enhanced by the employment of artificial light. Amongst the instructions which will be required perhaps there will be none which will need to be more carefully drawn than those for obtaining the correct temperature of the external air under the continually varying circumstances that present themselves on board ship.

In regard to *land stations* Professor Dove's tables have shown that data are still pressingly required from the British North American possessions intermediate between the stations of the Arctic Expeditions and those of the United States; and that the deficiency extends across the whole North American Continent in those latitudes from the Atlantic to the Pacific. Professor Dove has also indicated as desiderata observations at the British Military stations in the Mediterranean (Gibraltar, Malta, and Corfu), and around the Coasts of Australia and New Zealand: also that *hourly* observations, continued for at least one year, are particularly required at some one station in the West Indies, to supply the diurnal corrections for existing observations.

Whilst the study of the distribution of heat at the surface of the globe has thus been making progress, in respect to the *mean annual temperature* in different places, and to its *periodical variations* in different parts of the year at the same place, the attention of physical geographers has recently been directed (and with great promise of important results to the material interests of men as well as to general science) to the causes of those fluctuations in the temperature, or departures

from its mean or normal state at the same place and at the same period of the year, which have received the name of "non-periodic variations." It is known that these frequently affect extensive portions of the globe at the same time; and are generally, if not always, accompanied by a fluctuation of an opposite character, prevailing at the same time in some adjoining but distant region; so that by the comparison of synchronous observations a progression is traceable, from a locality of maximum increased heat in one region, to one of maximum diminished heat in another region. For the elucidation of the non-periodic variations even *monthly* means are insufficient; and the necessity has been felt of computing the mean temperatures for periods of much shorter duration. The Meteorological Institutions of those of the European States which have taken the foremost part in the prosecution of meteorology, have in consequence adopted *five-day means*, as the most suitable intermediate gradation between daily and monthly means; and as an evidence of the conviction which is entertained of the value of the conclusions to which this investigation is likely to lead, it has been considered worth while to undertake the prodigious labour of calculating the five-day means of the most reliable existing observations during a century past. This work is already far advanced; and it cannot be too strongly recommended, that at all fixed stations, where observations shall hereafter be made with sufficient care to be worth recording, five-days means may invariably be added to the daily, monthly, and annual means into which the observations are usually collected. The five-day means should always commence with January 1, for the purpose of preserving the uniformity at different stations, which is essential for comparison: in leap years, the period which includes the 29th of February will be of six days.

In treating climatology as a *science*, it is desirable that some correct and convenient mode should be adopted for computing and expressing the *comparative variability* to which the temperature in different parts of the globe, and in different parts of the year in the same place, is subject from non-periodic causes. The *probable variability*, computed on the same principle as the *probable error* of each of a number of independent observations, has recently been suggested as furnishing an index "of the probable daily non-periodic variation" at the different seasons of the year; and its use in this respect has been exemplified by calculations of the "index" from the five-day means of twelve years of observations at Toronto, in Canada (Phil. Trans. 1853, Art. V.) An index of this description is of course of absolute and general application; supplying the means of comparing the probable variability of the temperature in different seasons at *different places* (where the same method of computation is adopted) as well as at the *same place*. It is desirable that this (or some preferable method, if such can be devised for obtaining the same object) should be adopted by those who may desire to make their observations practically useful for sanitary or agricultural purposes, or for any of the great variety of objects for which climatic peculiarities are required to be known. Having these three data, viz., the mean annual temperature,—its periodical changes in respect to days, months, and seasons,—and the measure of its liability to non-periodic (or what would commonly be called irregular) variations, we may consider that we possess as complete a representation of the climate of any particular place (so far as temperature is concerned) as the present state of our knowledge permits.

It is obvious that much of what has been said under this Article is more applicable to land than to sea observations; but the letter of the Board of Trade, to which this is a reply, requests that both should be contemplated.

Temperature of the Sea, and Investigations regarding Currents.

It is unnecessary to dwell on the practical importance to *navigation* of a correct knowledge of the currents of the ocean; their direction, extent, velocity, and the temperature of the surface water relatively to the ordinary ocean temperature in the same latitude; together with the variations in all these respects which currents experience in different parts of the year, and in different parts of their course. As the information on these points, which may be expected to follow from the measures adopted by the Board of Trade, must necessarily depend in great degree on the *intelligence*, as well as the *interest* taken in them by the observers, it is desirable that the instructions to be supplied with the meteorological instruments should contain a brief summary of what is already known in regard to the principal oceanic currents; accompanied by charts on which their supposed limits in different seasons, and the variations in those limits which may have been observed in particular years, may be indicated, with notices of the particularities of the temperature of the surface-water by which the presence of the current may be recognised. Forms will also be required for use in such localities, in which the surface temperatures may be recorded at hourly or half-hourly intervals, with the corresponding geographical positions of the ship, as they may be best inferred from observation and reckoning. For such localities also it will be necessary that the tables, into which the observations of different ships at different seasons are collected, should have their bounding lines of latitude and longitude brought nearer together than may be required for the ocean at large.

In looking forward to the results which are likely to be obtained by the contemplated marine observations, it is reasonable that those which may bear practically on the interests of navigation should occupy the first place; but, on the other hand, it would not be easy to over-estimate the advantages to physical geography, of general tables of the surface temperature of the ocean in the different months of the year, exhibiting, as they would do, its normal and its abnormal states, the mean temperature of the different parallels, and the deviations therefrom, whether permanent, periodical, or occasional. The knowledge which such tables would convey is essentially required for the study of climatology *as a science*.

The degree in which climatic variations extending over large portions of the earth's surface may be influenced by the variable phenomena of oceanic currents in different years, may perhaps be illustrated by circumstances of known occurrence in the vicinity of our own coasts. The admirable researches

of Major Rennell have shown that in ordinary years the warm water of the great current known by the name of the Gulf stream is not found to the east of the meridian of the Azores; the sea being of ordinary ocean temperature for its latitude at all seasons, and in every direction, in the great space comprised between the Azores and the coasts of Europe and North Africa; but Major Rennell has also shown that on two occasions, viz., in 1776 and in 1821–1822, the warm water by which the Gulf stream is characterised throughout its whole course (*being several degrees* above the ordinary ocean temperature in the same latitude), was found to extend across this great expanse of ocean, and in 1776 (in particular) was traced (by Dr. Franklin) quite home to the coast of Europe. The presence of a body of unusually heated water, extending for several hundred miles both in latitude and in longitude, and continuing for several weeks, at a season of the year when the prevailing winds blow from that quarter on the coasts of England and France, can scarcely be imagined to be without a considerable influence on the relations of temperature and moisture in those countries. In accordance with this supposition, we find in the Meteorological Journals of the more recent period (which are more easily accessible), that the state of the weather in November and December 1821 and January 1822 was so unusual in the southern parts of Great Britain and in France as to have excited general observation; we find it characterised as "most extraordinarily hot, damp, stormy, and oppressive," that "the gales from the W. and S.W. were almost without intermission," "the fall of rain was excessive," and "the barometer lower than it had ever been known for 35 years before."

There can be little doubt that Major Rennell was right in ascribing the unusual extension of the Gulf-stream in particular years to its greater initial velocity, occasioned by a more than ordinary difference in the levels of the Gulf of Mexico and of the Atlantic in the preceding summer. An unusual height of the Gulf of Mexico at the head of the stream, or an unusual velocity of the stream at its outset in the Strait of Florida, are facts which may admit of being recognised by properly directed attention; and as these must precede, by many weeks, the arrival of the warm water of the stream at above 3,000 miles distant from its outset, and the climatic effects thence resulting, it might be possible to anticipate the occurrence of such unusual seasons upon our coasts.

Much, indeed, may undoubtedly be done towards the increase of our partial acquaintance with the phenomena of the Gulf-stream, and of its counter currents, by the collection and co-ordination of observations made by casual passages of ships in different years and different seasons across different parts of its course; but for that full and complete knowledge of all its particulars, which should meet the maritime and scientific requirements of the period in which we live, we must await the disposition of Government to accede to the recommendation, so frequently made to them by the most eminent hydrographical authorities, of a specific survey of the stream by vessels employed for that special service. What has been recently accomplished by the Government of the United States in this respect shows both the importance of the inquiry and the great extent of the research, and lends great weight to the proposition which has been made to Her Majesty's Government on the part of the United States, for a joint survey of the whole stream by vessels of the two countries. The establishment of an office under the Board of Trade specially charged with the reduction and co-ordination of such data may materially facilitate such an undertaking.

Storms or Gales.

It is much to be desired, both for the purposes of navigation and for those of general science, that the captains of Her Majesty's ships and masters of merchant vessels should be correctly and thoroughly instructed in the methods of distinguishing *in all cases* between the rotatory storms or gales, which are properly called *Cyclones*, and gales of a more ordinary character, but which are frequently accompanied by a veering of the wind, which under certain circumstances might easily be confounded with the phenomena of Cyclones, though due to a very different cause. It is recommended, therefore, that the instructions proposed to be given to ships supplied with meteorological instruments should contain clear and simple directions for distinguishing *in all cases*, and *under all circumstances*, between these two kinds of storms; and that the forms to be issued for recording the meteorological phenomena during great atmospheric disturbances should comprehend a notice of all the particulars which are required for forming a correct judgment in this respect.

Thunder-storms.

It is known that in the high latitudes of the northern and southern hemispheres thunder-storms are almost wholly unknown; and it is believed that they are of very rare occurrence over the ocean in the middle latitudes when distant from continents. By a suitable classification and arrangement of the documents which will be henceforward received by the Board of Trade, statistical tables may in process of time be formed, showing the comparative frequency of these phenomena in different parts of the ocean and in different months of the year.

It is known that there are localities on the globe where, during certain months of the year, thunder-storms may be considered as a periodical phenomenon of daily occurrence. In the Port Royal Mountains in Jamaica, for example, thunder-storms are said to take place *daily* about the hour of noon from the middle of November to the middle of April. It is much to be desired that a full and precise account of such thunder-storms, and of the circumstances in which they appear to originate, should be obtained.

In recording the phenomena of thunder and lightning, it is desirable to state the duration of the interval between the flashes of lightning and the thunder which follows. This may be done by means of a seconds-hand watch, by which the time of the apparition of the flash, and of the commencement (and of the conclusion also) of the thunder may be noted. The interval between the flash and the commencement of the thunder has been known to vary in different cases, from

less than a single second to between 40 and 50 seconds, and even on very rare occasions to exceed 50 seconds. The two forms of ordinary lightning, viz., zigzag (or forked) lightning and sheet lightning, should always be distinguished apart; and particular attention should be given both to the observation and to the record, in the rare cases when zigzag lightning either bifurcates, or returns upwards. A special notice should not fail to be made when thunder and lightning, or either separately, occur in a perfectly cloudless sky. When globular lightning (balls of fire) are seen, a particular record should be made of all the attendant circumstances. These phenomena are known to be of the nature of lightning, from the injury they have occasioned in ships and buildings that have been struck by them; but they differ from ordinary lightning not only by their globular shape, but by the length of time they continue visible, and by their slow motion. They are said to occur sometimes without the usual accompaniments of a storm, and even with a perfectly serene sky. Conductors are now so universally employed in ships that it may seem almost superfluous to remark that should a ship be struck by lightning, the most circumstantial account will be desirable of the course which the lightning took, and of the injuries it occasioned; or to remind the seaman that it is always prudent, after such an accident has befallen a ship, to distrust her compasses until it has been ascertained that their direction has not been altered. Accidents occurring *on land* from lightning will, of course, receive the fullest attention from meteorologists who may be within convenient distance of the spot.

Auroras and Falling Stars.

Auroras are of such rare occurrence in seas frequented by ships engaged in commerce, that it may seem superfluous to give any particular directions for their observation *at sea;* and land observatories are already abundantly furnished with such. It is, of course, desirable that the meteorological reports received from ships should always contain a notice of the time and place where Auroras may be seen, and of any remarkable features that may attract attention.

The letter from Professor Heis, which is one of the foreign communications annexed, indicates the principal points to be attended to in the instructions which it may be desirable to draw up for the observation of "Falling Stars." For directions concerning Halos and Parhelia, a paper by Monsieur Bravais in the "Annuaire Météorologique de la France" for 1851, contains suggestions which will be found of much value.

Charts of the Magnetic Variation.

Although the variation of the compass does not belong in strictness to the domain of meteorology, it has been included, with great propriety, amongst the subjects treated of by the Brussels Conference, and should not therefore be omitted here. It is scarcely necessary to remark, that whatever may have been the practice in times past, when the phenomena of the earth's magnetism were less understood than at present, it should in future be regarded as indispensable, that variation-charts should always be constructed for a *particular epoch* and that *all parts* of the chart should show *the variation corresponding to the epoch for which it is constructed.* Such charts should also have, either engraved on the face or attached in some convenient manner, a table, showing the approximate annual rate of the secular change of the variation in the different latitudes and longitudes comprised: so that by means of this table, the variation taken from the chart for any particular latitude and longitude may be corrected to the year for which it is required, if that should happen to be different from the epoch for which the chart is constructed.

A valuable service would be rendered to this very important branch of hydrography if, under the authority of the new department of the Board of Trade, variation-charts for the North and South Atlantic Oceans, for the North and South Pacific Oceans, for the Indian Ocean, and for any other localities in which the requirements of navigation might call for them, were published at *stated intervals*, corrected for the secular change that had taken place since the preceding publication. Materials would be furnished for this purpose by the observations which are now intended to be made, supposing them to be collected and suitably arranged with proper references to date and to geographical position, and to the original reports in which the results and the data on which they were founded were communicated. By means of these observations the tables of approximate correction for secular change might also be altered from time to time as occasion should require, since the rate of secular change itself is not constant.

All observed variations, communicated or employed as data upon which variation-charts may be either constructed or corrected, should be accompanied by other observational data (the nature of which ought now to be well understood) for correcting the observed variation for the error of the compass occasioned by the ship's iron. It is also strongly recommended that no observations be received as data for the formation or correction of variation-charts, but such as are accompanied by a detailed statement of the principal elements both of observation and of calculation. Proper forms should be supplied for this purpose; or, what is still better, books of blank forms may be supplied, in which the observations themselves may be entered, and the calculation performed by which the results are obtained. Such books of blank forms would be found extremely useful both for the variation of the needle, and for the chronometrical longitude (as well as for lunar observations, if the practice of lunar observations be not, as there is too much reason to fear it is, almost wholly discontinued). By preparing and issuing books of blank forms suitable for these purposes, and by requesting their return in accompaniment with the other reports to be transmitted to the Board of Trade at the conclusion of a voyage, the groundwork would be laid for the attainment of greatly improved habits of accuracy in practical navigation in the British mercantile marine.

The President and Council are aware that they have not exhausted the subject of this reply in what they have thus directed me to address to you; but they think that perhaps they have noticed as many points as may be desirable for *present* attention; and they desire me to add, that they will be at all times ready to resume the consideration if required, and to supply any further suggestions which may appear likely to be useful.

I have the honour to be, Sir,
Your obedient Servant,
W. SHARPEY, Sec.

To the Secretary of the Lords of the
Committee of Privy Council for Trade.

A subsequent correspondence passed, in May and June 1856, between the Royal Society and the Board of Trade. The following is an extract from one of the letters of the Royal Society in that correspondence.

EXTRACT.

"It cannot be doubted that one of the most important objects of the Meteorological Department, both in a practical and a theoretical view, is the procurement of the statistics of the direction and force of the wind in different seasons of the year over those parts of the Atlantic Ocean which are most usually traversed by ships. The records kept by the vessels themselves, suitably co-ordinated, may be expected in the course of time to do much towards this very important purpose; but the Committee are desirous of bringing under the consideration of the Board of Trade the advisability of aiding and expediting the inquiry by establishing, as far as may be found convenient, self-recording anemometrical instruments on some of the islands of the Atlantic. Detached observations of the wind, taken at intervals on board ship, may be most valuable in filling up the spaces between fixed and unerring self-recording instruments, but are scarcely sufficient to procure such exact knowledge of the variations as is required not less for the purposes and improvement of navigation than for the complete theory of the laws which regulate these variations. The Azores, Madeira, Bermuda, Ascension, and St. Helena are all stations where continuous and exact anemometrical records might be obtained, probably with very little inconvenience and at a comparatively small cost, and would be most valuable in the relation above stated. A self-recording anemometer quite suitable for this purpose is now under construction at the Kew Observatory; and instruments on the same model might be procured complete, it is believed, at a cost of less than 50*l*., requiring no other alteration than the change, once in twenty-four hours, of the paper on which the instrument itself records the direction and force of the wind."

---

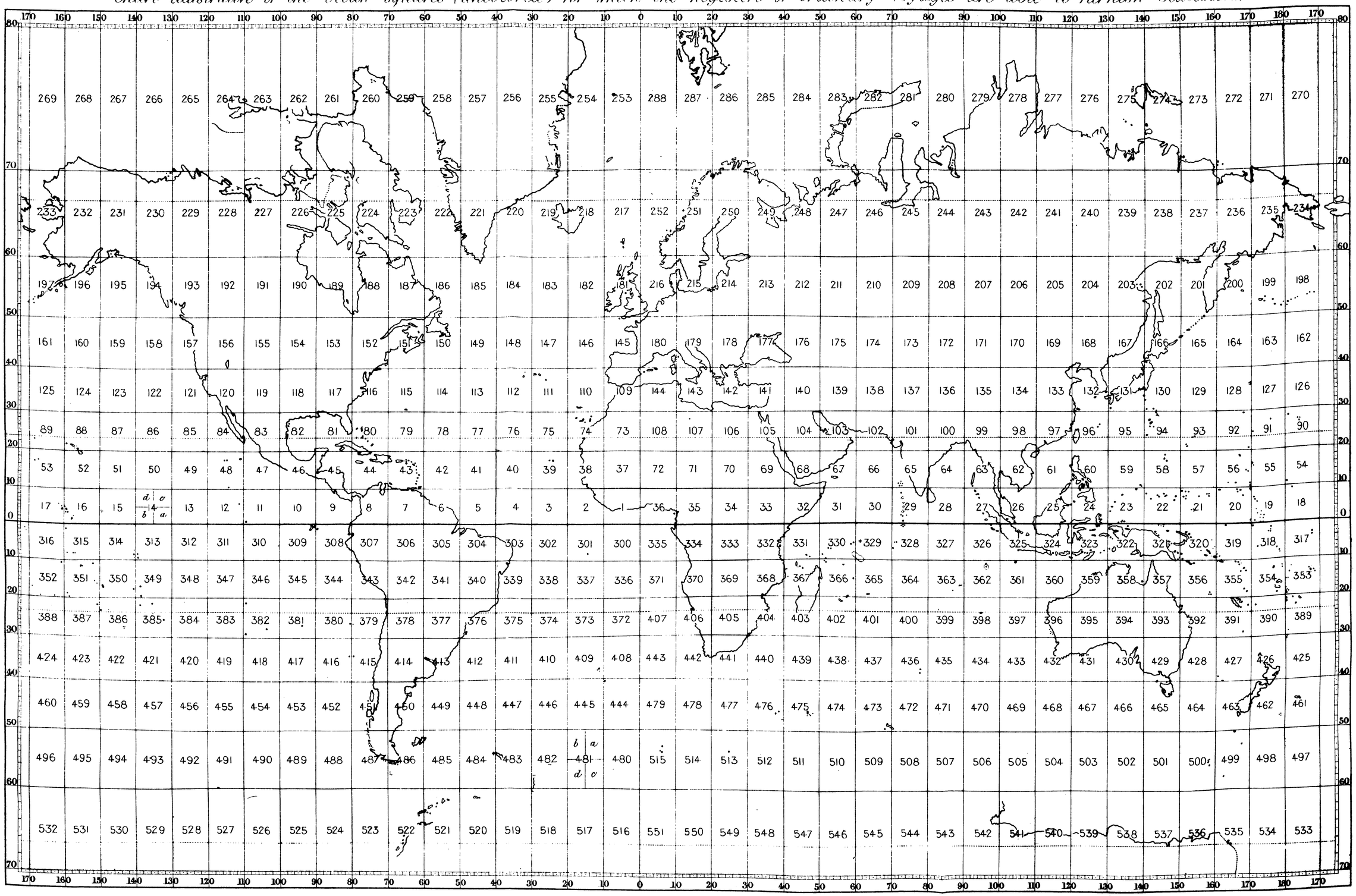
f. 30v

Appendix No. 3 (page 6).

Statement of Number of Ships supplied with Instruments by the Meteorological Department.

Year.	Ships supplied with Instruments.	
	Merchant.	Royal Navy.
1855	105	32
1856	109	59
1857	152	115
1858	152	107
1859	141	139
1860	111	118
1861	80	129
1862	54	111
1863	46	101
1864	26	96
1865	16	80
Total -	992	1,087

Chart illustrative of the Ocean squares (uncolored) for which the Registers of ordinary Voyages are able to furnish Statistics.



Appendix No. 5 (page 16).

Form of Tables for publishing Meteorological Results already obtained by Meteorological Department.

Lat. - to -
Long. - to — No. of Square.

—	Barom. Mean.	Therm. Mean.	Wet Bulb Mean.	Vapour Tension.	No. of Obser.
January - - -					
February - -					
March - - -					
April - - -					
May - - -					
June - - -					
July - - -					
August - - -					
September - -					
October - - -					
November - -					
December - -					
Annual - - -					
Quarterly. 1. Dec., Jan., Feb. 2. Mar., April, June. 3. July, Aug., Sept. 4. Aug., Nov., Dec.					

Appendix No. 6 (page 17).

Form of Tables suggested in page 17 for future publication of the Meteorological Means.

The following remarks on the Table (p. xvii) are added by way of explanation. The following Form would contain the whole of the Meteorological Means that are to be extracted from the Register,* and it appears suitable to all of the Squares, except in two cases. 1st. In those where the seasons disagreed in a marked manner with any one of the calendar months, where it would simply be necessary to divide that month into two parts thus :—

February, 1–20
„ 20–28

2nd. When a Five-degree Square was the seat of two distinct meteorological systems. Here the Square would have to be treated in two separate divisions, on two different pages.

The Table, which is here necessarily given in folio, should be printed in a more compact form, across a 4to. page, such as is commonly employed for Meteorological Tables.

The Probable Precision of the entries in the table, is supposed to be partially indicated by the extent to which decimals would be employed; for in every entry, the last figure but one should be considered as *accurate*, and the last figure as *approximate* only. Thus Barom. 29·75 would mean uncertainty in the 5 certainty in the 7; 29·7 would mean uncertainty in the 7, certainty in the 9. Thermometer 71·0 would mean that the 1 was accurate; but 71 would mean that the 1 was approximate only.

We assume, in pursuance of our recommendation, p. 11, that the entries of the Mean Barometer, Mean Vapour tension, and Mean Humidity, will never consist of more than two decimal places. That those of Highest and Lowest Barometer, Mean Temperature, and Mean Wet bulb, will never consist of more than one decimal place; and that the entries of all the rest will consist of integers only.

The remainder of the results concerning the Square would be less suitable to a fixed Tabular Form, because they are very different in character in the different Squares. They might be printed on the page that faced the Table, or separately; as might be found most convenient when the manuscript had been prepared. They would refer to the Ocean currents within the Square and to their Temperatures, and the variation of their limits in different seasons, and during the different years of observation, and the Magnetic Variations. The rest of the page would be occupied with descriptive text. It should be written concisely and methodically, and be so arranged that the same class of information should occupy, as nearly as may be, the same position in every page.

* See p. 10.—The upper current of the wind is rarely noticed by navigators, and therefore it would be utilized only in the case of a uniform drift, as in the Anti-Trades. Its existence would be noticed in the text descriptive of the contents of the Table.

Meteorological Means, between S. Lats. 0° and 10°, W. Longs. 30° and 40°. Square 303.a.

Years of Observations, 18 to 18 . Months.	Barometer (corrected). Mean.	Barometer (corrected). Variability. Highest.	Barometer (corrected). Variability. Lowest.	Temperature. Mean.	Temperature. Variability. Highest.	Temperature. Variability. Lowest.	Aqueous Vapour. Mean Wet Bulb.	Aqueous Vapour. Mean Tension.	Aqueous Vapour. Mean Humidity.	Rain. Per Cent. of Observations.	Cloud. Mean 0–10.	Wind. Mean Direction.	Wind. Mean Force.	Wind. Miles per Day.	Sea Surface. Mean Temp.	Sea Surface. Mean Drift.	Sea Surface. Miles per Day.	Data. No. of Observations.	Data. Authorities.
January - -																			
February - -																			
March - -																			
April - - -																			
May - - -																			
June - - -																			
July - - -																			
August - -																			
September - -																			
October - -																			
November - -																			
December - -																			
Annual - -																			
Quarterly. 1. Dec., Jan., Feb.																			
2. Mar., Apr., June																			
3. July, Aug., Sept.																			
4. Oct., Nov., Dec.																			

Per-centages of the Direction of the Wind, and the Wind's Mean Force (0 to 12).

Months.	N. Force.	N.N.E. Force.	N.E. Force.	E.N.E. Force.	E. Force.	E.S.E. Force.	S.E. Force.	S.S.E. Force.	S. Force.	S.S.W. Force.	S.W. Force.	W.S.W. Force.	W. Force.	W.N.W. Force.	N.W. Force.	N.N.W. Force.	CALM.	Number of Observations.
January - -																		
February - -																		
March - -																		
April - - -																		
May - - -																		
June - - -																		
July - - -																		
August - -																		
September - -																		
October - -																		
November - -																		
December - -																		
Annual - -																		
Quarterly. 1. Dec., Jan., Feb.																		
2. Mar., Apr., May																		
3. June, July, Aug.																		
4. Sept., Oct., Nov.																		

Appendix No. 7 (page 20).

Attempted Digest of Maxims employed by the Office in forecasting Weather.

In the following list we have endeavoured to collect and throw into a compact and methodical shape what appear to be the principal maxims employed by the Meteorological Department, when determining the forecasts. Considering the circumstances stated in our Report, it is obvious that this digest can be regarded as tentative only, as our means of determining these maxims are very imperfect. It is evident that the respective values of these maxims are widely different. Some of them rank among the long established truths of meteorological science, while others are clearly open to considerable doubt.

1. In the latitudes of the British Isles and of North-western Europe generally there are two, and only two, essentially different atmospheric currents of importance, one S.W., running from the equator towards the pole, and the other N.E., running from the pole towards the equator.
2. The weather in this country depends almost wholly on the conflict, combination, alternate preponderance, or alternate succession, of portions of these opposite currents.
3. The characteristics of the S.W. current lie not only in its general direction, but also in its quality, for it is light, warm, and moist. In other words, its presence is shown by a low barometer, by a high thermometer, and by a small difference between the wet and dry bulb thermometers.
4. In a similar way the characteristics of the N.E. current lie not only in its general direction, but also in its quality, for it is heavy, cold, and dry. In other words, its presence is shown by a high barometer, by a low thermometer, and by a large difference between the wet and dry bulb thermometers.
5. Not only is the actual presence of either current shown by its corresponding instrumental tests, but an approaching change from one current to the other is foretold by the instruments beginning to change their indications. [Hence, as changes of weather must necessarily commence at some places earlier than at others, there is great advantage in receiving by telegraph, information of the state of the weather, and of the instruments at many stations.]
6. Owing to the frequent conflicts of portions of the S.W. and N.E. currents, followed by a temporary variation in their courses, the direction of the wind is by no means a certain test of the nature of the current of which it forms a part. A volume of air may even become wholly detached from its parent current, and be enclosed in that of its antagonist, and be drifted along with it.
7. When the S.W. and N.E. currents intermingle, water is precipitated in the form of cloud, rain, or snow.
8. Most of our violent storms travel bodily in a N.E. direction.
9. The whole body of the atmosphere in our country travels in an E. direction, at the rate of from two to eight miles and hour.
10. When S.W. and N.E. currents alternately prevail, the wind blowing over any station has a strong tendency to "veer," and not to "back." That is to say, the general order of the changes is N., E., S., W., N., and not N., W., S., E., N.
11. The result of all rapid changes in the weather, or in any of the instrumental indications, is brief in duration, while that of a gradual change is more durable.
12. Rapid changes of all kinds commonly presage violent atmospheric commotion.
13. The wind usually blows from a region where the barometer is high to one where the barometer is low.
14. The force of the wind is usually proportionate to the differences of barometric pressure, at adjacent places. In other words, the greater the barometric tension, the stronger the wind.
15. Strong winds are far more steady in direction, than light or moderate winds.
16. Great storms are usually shown by a fall of the barometer, exceeding 1 inch in 24 hours, or by a fall of nearly one-tenth of an inch in one hour.
17. The barometer frequently continues high during a N.E. storm, but there is a fall of the thermometer.
18. Gradual changes of weather are shown by a gradual rise or fall of the barometer ; for instance, at the rate of one-hundredth of an inch in an hour.
19. Great differences of temperature at the same or at adjacent places are followed by changes of weather.
20. It is concluded from the foregoing remarks that a knowledge of the differences in the barometer and thermometer at different times in the same place, are no less important than a knowledge of those simultaneously observed at different places.
21. Sea disturbance often precedes gales.
22. Great storms are frequently preceded by excessive meteorological disturbance, as by heavy falls of rain or snow, by much lightning, by unusual cold, or by excessive heat.
23. Calms may be due to either of three different states of weather :—
    (1.) The appulse of winds coming together from opposite quarters.
    (2.) The divergence of winds going towards opposite quarters.
    (3.) The centre of cyclonic storms.

The barometer rises in (1) and sinks in (2). It is extremely low in (3).

24. A considerable stress is laid by Admiral FitzRoy on the electrical indication of approaching weather. But as no returns of atmospheric electricity are received from the stations, and as no direct employment of these indications appears to be made in determining the forecasts, we have not included them among these maxims.

In making forecasts, the area of the British Isles is divided into six districts; and the average state of the weather in each district, is deduced from the weather reports received from the stations contained within it.

A forecast for each district is then made provisionally, based upon the foregoing maxims.

The separate forecasts are next collated and revised, regard being paid to the following particulars:—

(*a.*) The mutual actions of the estimated weather in each of the six districts of the British Isles.
(*b.*) Scattered information in respect to such distant areas of high and low barometer, as the limited number of continental stations can afford.
(*c.*) Geographical conditions of mountain, plain, or sea, by which the free movements of the air may be affected.

We are unable to offer any satisfactory account of the method on which (*a.*) is discussed. Admiral FitzRoy states the conditions of this singularly complex problem of motion in a vapour-bearing elastic fluid to consist in "the energies exerted in specific directions, proportional to the respective "differences of statical quantities at stations, to the distances between them and other stations "(or groups of stations), and to the moments (or potentials) of these prevalent or approaching "currents."—*Weather Book*, p. 217.

It is the custom of the Office to perform the whole of the foregoing operations, and to determine the forecast, after a simple inspection of the list of weather returns. No notes or calculations upon paper are ever made. The operation occupies about half an hour, and is conducted mentally.

The importance of a precise value being ascertained for each of the foregoing maxims, is clearly seen by taking a special case.

Suppose—
(1.) A current over England from the N.E.;
(2.) The barometer lowering, the thermometer rising, and S.W. winds beginning in places;
(3.) The changes of barometer and thermometer to have been gradual;
(4.) The barometer to be considerably lower to the S.E. on the continent.

Then the forecast would be:—
On account of (2), by maxims 5 and 3, an equatorial current appears about to set in.
On account of (3), by maxim 11, its duration will be considerable.
On account of (4), by maxim 13, the current will be deflected, and changed into a W. or N.W. wind.

Now, what is the probability that this forecast will be correct?

Its value, so far as the above maxims can help us, is clearly compounded of the values of three separate probabilities. If we are ignorant of the nature of each of these values, a very great uncertainty must attach itself to the value of the forecast.

For, let us first take the value of the separate probabilities as being $\frac{9}{10}$ respectively; that is to say, nine out of ten similar cases are supposed to be in accordance with the maxim, and one to disaccord with it. In other words, the odds in favour of each of the three maxims being true, are supposed to be as 9 to 1.

Then the probability in favour of the truth of the forecast is—

$$\frac{9 \times 9 \times 9}{10 \times 10 \times 10} = \frac{729}{1{,}000} = \frac{3}{4} \text{ pretty nearly.}$$

This would be a valuable forecast, because out of four such predictions three might be expected to succeed. In other words, the odds are 3 to 1 in favour of the forecast.

But if the separate chances are $\frac{8}{10}$ respectively, or, in other words, if the odds are 4 to 1, the value of the forecast sinks to

$$\frac{8 \times 8 \times 8}{10 \times 10 \times 10} = \text{about } \frac{2}{4}$$

that is, out of four such predictions only two may be expected to succeed; or, the odds are *equal* that it will succeed or fail.

Lastly, if we estimate the separate chances at $\frac{6\frac{1}{2}}{10}$, or the odds at a little better than 2 to 1, then out of four such predictions only one may be expected to succeed. In other words, the odds are 3 to 1 against success.

The uncertainty and possible diminution of the value of the forecast, would range within considerably wider limits if it depended, as must often be the case, upon a yet longer chain of contingencies. If the value of the probability indicated by any of the maxims depended on should be of no value at all, as may appear to some to be the case with 7, 9, 17, 18, 19, and perhaps, to some extent, with 5 and 11 of the above list, then the introduction of any one of them into a chain of contingencies will diminish the value of the forecast by $\frac{5}{10}$, or by one half.

Appendix No. 8 (page 22).

Extract from Record of Meteorological Department, illustrating the Comparison of daily Forecast with Facts.

For an example, a forecast has been selected at haphazard from pp. 164–5 of the Eleventh No. of the published *Meteorological Papers*. It seems to be a fair and typical instance of the contents of that publication. It was made on Wednesday, December 4, 1861, and refers to the weather till the following Friday.

The forecast for *North Britain* is—
"E. to S. and W.; fresh to strong; some rain."

The facts given in the report of the following day are as follows:—

—	Direction.	Force.	Cloud.	Atmosphere.	Sea Disturbance.
Nairn - - -	E.S.E.	3	2	Blue sky.	2
Aberdeen - -	S.S.W.	3	3	Clouds (detached).	2
Leith - - -	S.W.	2	2	Blue sky.	2
Berwick - -	W.	2	8	Fog.	2
Ardrossan - -	W.	4	3	Clouds (detached).	4

In addition we find, on reference to the record, which, as is stated in the Report, is kept in the Office, and is made up from *newspapers*, the following particulars:—
Nairn—S.E. to S.; fresh, moderate, overcast.
Aberdeen—S.W. to S.; b. c., and at night stormy, with rain.
Leith—4 p.m. to 10.30 p.m. gale W.S.W., showers.
Ardrossan—S.E. to S.; overcast to rain.
Cromarty—S.S.W.; fresh, fine.

The conclusion drawn by the Office from these facts is—
"North Britain, E.S.E. to W.S.W. and W., strong to moderate; generally fine, some rain and "hail in places."

The forecast for *Ireland* is—
"S. to W., fresh; some rain, and to a gale."

The facts given in the report of next day are as follows:—

—	Direction.	Force.	Cloud.	Atmosphere.	Sea Disturbance.
Portrush - -	S.E.	1	2	Blue sky.	2
Galway - -	W.	2	5	Clouds (detached).	1
Valentia - -	W.N.W.	5	9	Overcast.	6
Queenstown - -	W.N.W.	1	1	Blue sky.	1

In addition we find in the record made up from *newspapers*:—
Portrush—S. to S.E.; light to moderate, overcast to rain.
Belfast—S.W.; stormy, rain.
Limerick—S.W.; rain.
Wicklow—S.; fresh.
Strangford—S.S.W.; stormy, rain.
Galway—moderate to stormy, overcast to rain.

The conclusion drawn by the Office from these facts is that the weather in Ireland on Thursday was—
"Wind S.W. to W.N.W., light to strong; weather fine, but showery at times."

The forecast for the *Central District* is—
"S.E. to S.W.; fresh to a gale from S.W."
The reports give—

—	Direction.	Force.	Cloud.	Atmosphere.	Sea Disturbance.
Liverpool - -	W.S.W.	2	4	Clouds (detached).	1

In addition we find in the record made up from *newspapers*:—
Liverpool—S.E., light; misty.
Bristol—S.; stormy, cloudy.
Portmadoc—S.S.W.; stormy, dry.

The conclusion drawn by the Office from these facts is that the—
"Wind was from S.S.E. to W., light to strong, with fine clear weather."

The forecast for the *East Coast* is—
"S.E. to S. and W., fresh to strong."
The reports give—

—	Direction.	Force.	Cloud.	Atmosphere.	Sea Disturbance.
Shields - -	W.N.W.	3	6	Overcast.	4
Scarborough - -	W.N.W.	1	8	Rain.	4
Yarmouth - -	S.	3	8	Rain.	4

In addition we find in the record made up from *newspapers*:—
Sunderland—S.W., light, variable; fine.
Lynn—E.S.E., light; fine, frosty.
Hull—S.W., moderate to stormy; fine.
Scarborough—S.S.W. to W., moderate to stormy; fine to o. q.
Orford—Southerly; stormy.

The conclusion drawn by the Office from these facts is that the—
"Wind was from S. to W. and N.N.W., fresh, with rain, to moderate and fine."

The forecast for *South England* is—
"S.E. to S. and W., fresh to strong, some rain, increasing to a gale"
The reports give—

—	Direction.	Force.	Cloud.	Atmosphere.	Sea Disturbance.
London - -	W.	3	9	Overcast.	—
Dover - - -	S.W.	3	9	Rain.	3
Portsmouth - -	N.W.	3	6	Overcast.	2
Portland - -	N.W.	1	1	Blue sky.	4
Plymouth - -	N.W.	3	1	Blue sky.	2
Penzance - -	N.W.	2	5	Clouds (detached).	2

In addition we find in the record made up from *newspapers*:—
Penzance—W.; overcast.
Shoreham—S.E. to S., fresh and fine.
Dover—S. by E. to S., moderate; fine.
London—E., light and foggy, to S.E., fine.
Weymouth—S.E. to S.S.W., fresh to light; c., fine.

The conclusion drawn by the Office from these facts is that the—
"Wind was S. to W. and N.W., strong to moderate; rain in the early part of the morning, "but fine during the day."

On the Wednesday evening a south cone (▽) warning was hoisted, and on the Thursday morning it was hauled down again.

The Meteorological Department conclude from the above particulars, that for this day the forecast is a good one. This instance, which is taken entirely at random, is given to show how vague is the language employed by the Office, and how inadequate are the data in its possession for a just comparison of the forecasts with the facts that ensue.

Tables in form of Calendar (prepared by the Wreck Department) shewing for the year 1865 for the Ports of Plymouth and Shields respectively;- the storm warnings issued, the Forecasts of Force of wind for each day of the year and the actual extreme Force of wind for each day in respect of which a warning was issued.

The first column shews in black characters the warning signal: drum, north cone, or south cone as the case may be. Where they are connected by a line it shews the two or three days over which according to Admiral FitzRoy's interpretation, the warning extends- where a second drum or cone is placed alongside it indicates a further separate warning.

The second and third columns shew in black Figures the No in the Daily Forecast indicating the Force of wind predicted by the Forecast

The fourth column shews in blue figures the actual extreme Force of wind in 24 hours.

The fifth shews in blue figures the duration of wind at its highest force during the 24 hours

The sixth column contains opposite the days covered by each storm warning a blue cross thus × when the actual force of wind did not reach 8:- the symbol or single blue line thus | when it did reach Force 8: and the symbol or double blue line thus || when it exceeded Force 8: so that a glance at this column compared with the first column will shew how far the force of wind corresponded with the storm warning - The predictions are shewn in black and the actual facts in blue.

Meteorological Report App. No 9 (continued)

First Half of year 1865. Port of Plymouth.

Days of the Month	JANUARY						FEBRUARY						MARCH					
	Warnings Hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical	Warnings Hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical	Warnings Hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical
1								6.5	10.4	6	8 hrs			4.2	6.4			
2								6.4	8.	6	4 "			5.4	5.4			
3			6.					6.8	6.8	4	4 "			4.6	4.6			
4		6.8	4.8					4.8	5.8	4	8 "			5.4	5.4	8	4 hrs	
5		6.4	6.4					8.4	4.6					5.6	5.8	5	8 "	
6		5.4	5.4					5.						6:8		5	8 "	
7		4.	6 5						5.6						8.4	7	8 "	
8		4.6	4.6					5.	5.4					6	6.	9	12 "	
9		6.		6	4 hrs			5.	5.					5.6	6 4	6	12 "	
10			5.8	8	4 "			5.	5.					5.6	5.	2	8 "	
11		6.	6.	6	4 "			5.	5.					4.6	5.6			
12		6.5	6.8	9	8 "			5.	5.6					8.	6.8			
13		6.4	8.5	9	3 "			5.6						6.8				
14		6.5	6.8	10	20 "				6.						5.8			
15		6.8	6.10	6	8 "			6.5	5.					6.4	6.4			
16		8.		4	4 "			5.	5.					5.	5.4			
17		.	8.5	7	4 "			5	4.6	7	4 "			4.5	4.5			
18		8.4	8.4	6	8 "			6.8	6.	7	4 "			5.6	5.6	10	4 "	
19		5.4	4.6	0	12 "			6.8	6.8	10	8 "			5.6	6.	10	12 "	
20		6.4	6.4					6.		6	4 "			6.		9	4 "	
21		5.	4.5						6.4						5.4	7	4 "	
22		5.	5.					5.6	5.					4.	5.			
23		5.						4.5	4.					5.	5.			
24								2.5	5.	7	4 "			5.	5.			
25								5.6	8.	7	4 "			5.6	5.6	6	8 "	
26				4	4 "			6.	4.6	6	4 "			6.8	6.8	6	8 "	
27				9	4 "			5.8		0	12 "			4.8		4	16 "	
28				4	4 "				5.4						5.6	5	4 "	
29				9	12 "									5.6	4.6			
30				4	4 "									4 5	4.5			
31				7	4 "									4.6	4.5			

Days of the Month	APRIL						MAY						JUNE					
	Warnings hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical	Warnings hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical	Warnings Hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical
1		4.6	4.6					5.						5.6	4.6	4	4 hrs	
2		5.6	5.						5.					5.6	6.	4	8 "	
3		6.4						4.6	5.6					5.6	6.4	4	4 "	
4			5.6					5.	6.					5.4	5.4	3	4 "	
5		4.6	5.					6.	5.6					5.4				
6		2.6	5.					4.6	4.6						5.			
7		5.6	5.					6.4	6.4					5.	4.			
8		5.6	4.6					5.						4.5	5.			
9		6.5	4.6						5.					5.	5.			
10		6.4						5.	5.					5.	5.			
11			2.5					4.5	6.					5.	5.			
12		4.5	2.4					4.6	4.6					5.				
13		4.	4.					5.6	5.6						5.			
14		4.5	4.5					5.6	5.6					5.	5.			
15		4.6						5.4						5.	2.5			
16			4.6						5.6					5.	2.4			
17		5.6						5.	6.5					2.5	5.			
18			2.5					5.	5.6					5.6	5.6			
19		4.5	5.6					5.6	5.					5.4				
20		4.5	4.5					4.6	4.6						5.4			
21		4.6	5.4					6.4	5.4					5.	4.5			
22		4.5	5.6					4.6						5.	4.5			
23		4.6	4.6						4.5					5.	2.5			
24		6.4						5.4	4.5					4.6	4.6			
25			5.					5	5.					5.6	5.			
26		5.	5.4						5.					5.6				
27		4.5	2.5					4.6	5.6						5.			
28		5.	2.4					6.4	6.5					5.6	2.5			
29		4.5	2.5					5.						4.6	5.6	3	4 "	
30		5.4	6.4						5.					5.6	5.6	5	4 "	
31								5.	6.									

Day & Son, (Limited) Lith.

Second Half of year 1865.

Days of the Month	JULY						AUGUST						SEPTEMBER					
	Warnings Hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical	Warnings Hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical	Warnings Hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical
1	⊞	6.4	6.	4	8 hrs	××			4.6					6.4	6.5			
2	⊞	6.4	6.5	3	4 "	××		5.	6.					5.	5.4			
3		5.						5.6	5.6					5.	5.			
4			4.5					4.6	4.6					4.6				
5		5.	5.6					6.4	6.4						2.5			
6		5.6	5.6					4.5	4.5					5.	4.5			
7	⊞	5.6	5.6	7	4 "	××		4.5						5.6	4.5			
8	⊞	5.	5.6	6	12 "	××			5.					5.	2.5			
9	⊞	6.5	6.5	6	4 "	×××		5.6	5.					5.4	4.6			
10	⊞	5.		5	8 "	×××		5.6	4.6					6.4	5.			
11			5.					5.6	5.6					4.6				
12		5.	5.					6.4	6.						4.5			
13	▽	5.6	5.	6	4 "	××		6.4	6.4					5.6	2.4			
14	▽	5.	5.6	6	8 "	××		4.6						4.5	4.5			
15	▽	6.5	6.5	6	4 "	××	⊞		4.6	6	4 hrs	××		5.4	5.			
16	▽	5.4	6.	3	8 "	××	⊞	5.6	5.8	6	4 "	××		5.	5.			
17		5.6					⊞	6.	6.	5	8 "	××		5.	5.			
18			4.				⊞	6.5	6.	2	8 "	××		5.6				
19		5.	5.					5.	5.						4.5			
20		6.	6.					4.6	4.5					5.	5.			
21		5.6	5.6					4.6						5.	5.6			
22		6.5	6.4						4.6					5.	4.6			
23		5.4	5.4					5.6	5.6					6.4	5.			
24		4.5						4.6	5.6					4.5	5.			
25			4.					5.4	5.					5.				
26		4.5	4.5					5	5.6						5.			
27		5.	4.5					5.	5.					5.	4.6			
28		4.5	5.					5.						5.4	5.			
29		5.4	5.						6.5					6.5	5.			
30		5.4	5.4					5.6	5.6					5	5.			
31		5.						5.6	5.									

Port of Plymouth.

OCTOBER						NOVEMBER						DECEMBER.					
Warnings hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical	Warnings hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical	Warnings hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical
	5.	5.					8.4	6.5	3	4 hrs	× ×		6.5	5.	1	16 hrs	× ×
	5.6						6.5	5.6	1	12 "	× ×		4.5	5.6	8	4 "	
		6.					5.	4.6					5.6	5.8	4	8 "	× ×
	6.4	5.4					5.6	4.5					6.		8	4 "	
	4.6	4.6					5.	4.5						10.4	6	4 "	× ×
	5.	5.					4.6						6.5	8.5	8	4 "	
	5.4	5.6	7	4 hrs	× ×			4.5					6.5	6.8	8	4 "	
	6	6	8	4 "			4.5	5.6					6.5	6.4	1	4 "	× ×
	6.		4	4 "	× ×		6.4	6					5.6	4.	1	12 "	× ×
		6.8	4	4 "	× ×		6.4	6.4						1.5	4.5		
	6.	8.4	8	8 "			5.	5					5.6				
	6.4	8.5	4	4 "	× ×		5.	4.6						5.6			
	6.5	6.5	1	12.	× ×		4.6						5.6	5.6			
	6.4	6.4						6.8					5.	5.			
	6.	5.					6.	5.6					5.	5.			
	4.6		7	4 "	× ×		6.4	6.4	6	4 "	× ×		5.	4.5			
		6.	4	12.	× ×		5.	8.4	8	4 "			5.	5.			
	6.4	5.8	5	4 "	× ×		4.6	8.5	5	4 "	× ×		5.1				
	6.4	8.	5	12.	× ×		6.5	5.6	7	4 "	× ×			4.	5	4 "	× ×
	6.	6.	3	8 "	× ×		6.		9	4 "			4.5	5.6	5	4 "	× ×
	5.	6.	4	4 "	× ×			4.10	9	4 "			4.6	4.6	6	4 "	× ×
	6.	4.6	6	12.	× ×		6.	6.5	12	4 "			5.6	6.	4	12 "	× ×
	5.6						5.6	8.6	5	4 "	× ×			5.6	5.6		
		5.6	5	4 "	× ×		6.	6.8	11	4 "				5.6	5.6		
	6.	5.8	6	12.	× ×		6.	6.	12	4 "				5.6			
	6.4	5.	8	12.			6	9.5	5	12.	× ×						
	5.	8.5	7	4 "	× ×		5.8		7	4 "	× ×				5.6		
	6.5		5	4 "	× ×			5.8	9	4 "			4.6	4.6	6	4 "	× ×
		5.6	9	4 "			6.5	8.5	5	8 "	× ×		4.6	5.8	9	4 "	
	4.6		8	12.			6.4	5.6	1	16 "	× ×		6.	10.	6	8 "	× ×
		8	6	4 "	× ×								5.8	5.8	9	8 "	

Day & Son, Limited, Hall.

First Half of year 1865. Port of Shields.

Days of the Month	JANUARY							FEBRUARY							MARCH						
	Warnings Hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical		Warnings Hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical		Warnings Hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical	
1									6.4	6.8	8	8 hrs				4.2	6.4				
2				8	4 hrs				6.4	4.10	6	24				5.4	6.4				
3			6.5	6	8 „				8.5	8.5	8	1 „				4.6	4.6				
4		6.5	4.8	10	4 „				4.6	4.6	9	8 „				6.4	5.4	8	4 hrs		
5		6.4	6.5	8	4 „				5.6	5.6	8	4 „				5.6	6.	8	8		
6		5.4	5.4						5.6							6.5		6	24 „		
7		4.5	8.5							5.6							6.8	7	16 „		
8		4.6	2.6						6.4	6.4						6.	6.	9	8		
9		5.6		8	8 „				5.4	5.6						5.6	5.6	8	4 „		
10			5.6	8	4 „				6.4	6.5						6.5	6.5	9	8 „		
11		5.	6.5	8	4 „				5.	6.2						5.	6.8	10	8 „		
12		6.4	6.	9	12 „				4.5	6.8						8.	5.6	7	4 „		
13		6.4	8.5	10	4 „				6.							6.5		5	20 „		
14		6.5	6.8	8	4 „					6.8							6.				
15		8.	8.	6	12 „				6.5	6.4						6.4	6.5				
16		8.		6	8 „				5.4	5.						5.4	5.4				
17			8.5	6	24 „				6.4	4.6	5	12 „				4.	4.2				
18		4.8	4.8	8	4 „				5.6	5.6	7	8 „				4.	4.	10	4 „		
19		5.6	4.8	7	8 „				6.	5.6	10	12 „				5.	6.	10	24 „		
20		4.6	4.6						5.6		9	1 „				6.		10	4 „		
21		5.	3.6							8.5							5.4	6	16 „		
22		5.	5.						5.6	6.4						5.	6.4				
23		6.4							4.5	4.						5.4	6.5				
24									2.5	4.5	6	8 „				5.	5.				
25									5.	6.	6	12 „				1.6	5.6	6	12 „		
26									6.	5.6	7	12 „				6.8	6.8	9	20 „		
27									6.		6	16 „				4.8		9	4 „		
28										5.2							5.6	6	12 „		
29																5.6	4.5				
30				10	12											4.5	4.5				
31		6.8		10	12 „											5.	4.5				

Days of the Month	APRIL							MAY							JUNE						
	Warnings hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical		Warnings hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical		Warnings hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical	
1		4.6	5.						5.							5.6	5.	9	12 „		
2		5.6	4.5							5.						5.	5.6	6	12 „		
3		5.							6.5	5.6						5.6	5.6				
4			4.6						5.	5.6						5.4	6.4				
5		4.5	5.						5.6	5.6						5.4					
6		2.6	5.						4.6	4.6							4.5				
7		5.	5.						6.4	6.4						4.5	4.				
8		5.6	5.						5.4							4.5	4.5				
9		6.5	4.6							5.						5.4	6.4				
10		6.1							5.4	5.						5.	4.				
11			2.4						5.6	6.4						4.5	5.				
12		2.5	2.4						4.6	6.4						5.					
13		4.5	2.4						5.6	5.6							5.				
14		4.	4.						5.6	5.6						5.	5.				
15		5.							5.4							5.	2.5				
16			5.6							5.6						5.	2.5				
17		5.6							5.	6.6						4.5	5.				
18			2.5						5.	5.6						5.	5.4				
19		4.5	4.6						5.6	5.						5.4					
20		4.5	5.6						4.6	4.6							5.4				
21		5.6	5.						6.4	4.						5.	4.5				
22		4.5	5.6						4.6							5.	4.				
23		6.4	6.4							4.5						4.5	4.5				
24		6.4							5.4	5.2						1.	4.6				
25			5.						5.							5.6	5.				
26		5.	5.4						4.5							5.6					
27		4.	2.5						4.6	4.5							5.6				
28		5.	4.						6.4	5.4						5.6	5.				
29		4.5	4.5						5.							4.6	4.6	6	8 „		
30		5.4	6.5							5.	6	4				5.6	5.6	7	8 „		
31									5.	6.5	6	8									

Day & Son, Limited, Lith.

Meteorological Report App. N°9 (continued)

Second Half of year 1865

Days of the Month	JULY						AUGUST						SEPTEMBER					
	Warnings Hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical	Warnings Hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical	Warnings Hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical
1	⊞	6.	4. 6.	6	20	××			4. 6					6.	4. 5. 6			
2	⊞	6.	4. 6.	5. 6	16	××		5.	6. 8					6.	4. 6.	4.		
3		5.						5.	6. 5.	6				5.	5.			
4			5.					4.	6. 4.	6				4.	6			
5		5.	5.	6				6.	4. 6.	4					4.	5		
6		4.	6. 5.	6				4.	5. 4.					4.	5. 4.	5		
7	⊞	5.	6. 4.	6 8	4 „	|		4.	5					5.	6. 4.			
8	⊞	6.	5. 5.	6 8	4 „	|			5.					6.	4. 4.	5		
9	⊞	6.	5. 6.	5. 6	16 „	××		5.	6. 5.					5.	4. 5.			
10	⊞	5.	4.	6	16 „	××		5.	6. 4.	6				6.	4. 5.			
11			5.					5.	6. 5.	6				4.	6			
12		5.	4. 6.					6.	4. 6						4.	5		
13		5.	6. 4.	6.				6.	4. 6.	4				5.	6. 2.	4		
14		5.	5. 6					4.	6					4.	5. 4.	5		
15	⊞	6.	5. 6.	5 9	4 „	||	⊞		5.	6. 5	12 „	××		6.	5. 5.			
16	⊞	5.	4. 6.	5 9	4 „	||	⊞	5.	6. 5.	6	8 „	××		5.	5.			
17	⊞	5.	4	6	4 „	××	⊞	6.	6.	5	24 „	××		4.	6. 4.	6		
18	⊞		4.	4	12 „	××	⊞	5.	6. 5.	6	12 „	××		5.	6			
19		5.	4.					5.	5.						4.			
20		5.	6. 5.	6				4.	6. 4.	5				4.	5. 4.	5		
21		5.	6. 5.	6				4.	6					5.	4.	6		
22		5.	6. 5.						4.	5				6.	4. 5.	6		
23		5.	4. 5.	4				5.	4.	5				6.	4. 5.			
24		4.	5					4.	6. 4.	6				5.	4. 5.	4		
25			2.	4				6.	4. 5.	4				5.				
26		4.	5. 4.	5				5.	5.						5.	4		
27		4.	5. 4.					5.	4.	5				4.	5. 4.	5		
28		4.	5. 4.	5				4.	5					4.	6. 4.	6		
29		4.	5. 5.						5.					6.	4. 5.			
30		5.	4. 5.	4				4.	6. 4.	6				5.	4. 5.			
31		5.						5.	6. 5.									

Port of Shields

OCTOBER						NOVEMBER						DECEMBER					
Warnings hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical	Warnings hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical	Warnings hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical
	5.	4.6					8.4	8.5	6	24 "			6.5	5.	6	4	
	5.						6.5	5.6	6	12 "			4.5	5.	10	16 "	
		6.					5.	4.6					5.6	6.	10	12 "	
	6.4	6.4					5.6	4.5					6.		10	4 "	
	4.6	4.6					5.	4.						5.8			
	6.5	6.5					4.6						6.5	8.5			
	5.	4.6						4.6					6.4	6.8			
	4.6	6.4					4.5	6.					6.5	6.5			
	5.6		10	12 "			6.4	6.					5.6	4.			
		6.8	10	24 "			6.4	6.4					4.5	4.5			
	6.	8.5	10	4 "			5.	4.5					5.6				
	6.4	9.5	8	4 "			5.	5.6						5.6			
	6.4	8.4					4.6						4.5	4.5			
	6.4	6.4						5.8					4.5	4.5			
	6.	4.					6.	6.4					4.5	4.5			
	4.6						6.4	5.					5.	5.			
		5.6	8	4 "			5.	6.					5.6	4.6			
	6.4	8.5	10	16 "			4.6	8.5					4.6				
	6.	8.	10	16 "			6.4	1.6	8	4 "				4.			
	8.4	8.4	6	12 "			6.		8	4 "			4.	5.6			
	5.	6.						4.10	9	8 "			4.6	5.6	10	4 "	
	5.6	1.6					6.	6.5	10	4 "			5.6	6.	8	8 "	
	6.4						5.6	8.6	9	4 "			5.6	5.6	7	4 "	
		5.6	6	8 "			6.	6.10	10	4 "			5.6	4.5	8	8 "	
	6.	5.8	9	4 "			6.	8.5	10	8 "			5.6				
	6.4	8.5	10	8 "			6.	8.	10	8 "							
	6.4	8.4	7	4			5.8		7	4 "				5.			
	6.5		9	4 "				5.6	9	8 "			4.6	4.5	6	8 "	
		6.5	9	4 "			6.5	8.5	10	4 "			4.6	5.8	10	4 "	
	5.		5	12 "			6.4	5.6	9	4 "			6.	10.	10	4 "	
		6.8	6	12 "									5.8	5.8	10	4 "	

Page LXVIII in Appendix.

f. 39

Day & Son Limited Lith

f. 40r

Appendix No. 10 (page 24).

Specimen of English Daily Weather Report, Forecasts, and Remarks as issued by the Meteorological Department of the Board of Trade.

THE WEATHER.—METEOROLOGICAL REPORTS.

Wednesday, January 10, 8 a.m., 1866.	B.	T.	W.	F.	Ex.	D.	I.	R.	S.
Nairn	29·07	34	W.	2	6	N.W.	c. o.	0·06	2
Aberdeen	29·00	36	W.N.W.	3	3	W.S.W.	r. o.	0·12	3
Leith	29·12	36	N.	4	3	S.W.	o. s.	0·04	3
Ardrossan	29·11	39	N.	2	5	N.W.	c.	0·16	2
Greencastle	29·24	38	N.N.E.	2	5	W.	h. c.	0·40	1
Valentia	29·38	40	N.N.W.	4	10	N.W.	h. r.	0·38	6
Liverpool	29·10	42	N.N.W.	1	8	W.	c. o.	0·07	2
Holyhead	29·09	43	W.N.W.	6	9	W.	c. o.	0·10	6
Penzance	29·46	44	W.N.W.	6	9	W.N.W.	s. r. c.	0·31	5
Brest	29·57	41	N.W.	8	9	W.N.W.	t. c.	0·24	8
L'Orient	29·57	43	W.N.W.	5	9	W.	o. c.	0·20	7
Rochfort	29·73	43	W.	7	9	N.W.	r. c.	0·55	8
Plymouth	29·39	41	W.N.W.	8	2	N.W.	s. r. o.	0·17	5
Weymouth	29·29	43	W.N.W.	5	8	W.N.W.	l. c.	0·05	4
Portsmouth	29·24	41	W.	6	8	N.N.W.	s. o.	0·13	5
London	29·15	39	W.N.W.	4	8	W.	l. c.	—	—
Yarmouth	29·03	37	W.N.W.	6	10	W.N.W.	c. o.	—	1
Scarborough	28·98	38	N.W.	2	6	W.N.W.	c. o.	0·16	3
Shields	28·94	40	N.W.	2	3	N.W.	c.	—	2
Helder	28·89	42	W.S.W.	7	—	—	o.	—	6

Explanation.

B.—Barometer, corrected and reduced to 32° at half-tide level; each 10 feet of vertical elevation causing about one-hundredth of an inch diminution, and each 10° above 32° causing nearly three-hundredths increase. T.—Thermometer exposed in shade. W.—Wind, direction, of (*true*—two points *left* of magnetic). F.—Force (1 to 12—estimated). Ex.—Extreme force since last report. D.—Direction of *extreme* force. I.—Initials:—b., blue sky c., clouds (detached); f., fog; h., hail; l., lightning; m., misty (hazy); o., overcast (dull); r., rain; s., snow; t., thunder. R.—Rainfall, snow or hail (melted), since last report. S.—Sea disturbance (1 to 9). Z.—Calm.

Remarks.

Yesterday barometric pressure was as low as 28·4 in. on the coast of Norway; it was also low over the British Isles, and the greater part of the Baltic. Further to the eastward it increased rapidly—from 29·4 in. at Riga to 30·3 in. at Moscow, with a temperature of only 7° Fahrenheit. Over the eastern portion of the Baltic the winds were very strong from south-east; over the extensive area of very low pressure—extending from Scotland across the North Sea to Norway—there was less wind then elsewhere. It again blew hard from west and north-west last night on our western and southern coasts, and the sea is very high on the coast of France. Snow has fallen in several places, and much lightning has been observed. Pressure has increased since yesterday, but it is again diminishing in the west of Ireland, and the weather appears likely to continue very unsettled for some days.

Probable.

Thursday.	On Northern Coasts.	Friday.
Chiefly north-westerly, varying from a gale to moderate; some snow or rain.		N.N.W. to W.S.W., fresh to strong, squally.
	Western.	
As above.		As above.
	Southern.	
Similar to above.		Similar to above.
	Eastern.	
Similar.		Similar.

Northern=Scotland. Western=Ireland, Wales, and adjacencies, Southern=English Channel, and Bay of Biscay. Eastern=Eastward England and North Sea.

Appendix No. 11 (page 24).

Specimen of French Weather Bulletin as issued by M. Le Verrier.

Bulletin International de l'Observatoire Impérial de Paris. 310 numéros. 2 forts volumes in-folio par an. Abonnements chez Chauvin, lithe. No. 8 Rue d'Ulm.

France : 36 fr. par an.
Etranger : Frais de porte en sus.

Janvier 1865.
Mercredi 10. Page 1re.

Etat atmosphérique de l'Europe à 8 h. du Matin.

Stations.	Pression 0°.	Tempre.	Vents Inférieurs.	Etat du Ciel.	Etat de la Mer.	Vents hier au fort.	Arrivée.
Paris	746·5	3·8	O.S.O. au-fort	Peu nuageux	„	O.S.O. modéré	h,
Strasbourg	749·1	3·0	O. faible	Pluie	„	O. au-fort	9·0
Mézières	744·5	„	O. faible	Couvert	„	N.E. faible	9·0
Dunkerque	741·0	5·0	O.N.O. fort	Couvert	Tr. houleux	O. fort	9·0
Boulogne	741·0	7·0	O. violent	Couvert	Tr. grosse	O. tr.-fort	9·0
Le Havre	747·3	6·2	N.O. tr. forte	Neige	Tr. grosse	N.O. tr.-fort	9·0
Cherbourg	747·3	7·0	- -	Tr. nuageux	„	N.O. fort	9·0
Brest	751·8	5·5	O.N.O. au-fort	Tr. nuageux	Grosse	O. tr. fort	9·0
Lorient	752·9	6·2	O.N.O. au-fort	Nuageux	Grosse	O. tr. fort	9·0
Napoléon Vdee	753·6	7·0	O. au-fort	Un peu nuageux	„	N.O. fort	9·0
Rochefort	754·9	6·2	O. tr. fort	Nuageux	Tr. grosse	N.O. ouragan	9·0
Limoges	755·3	2·0	O. au-fort	Couvert	„	N.O. faible	9·0
Montauban	759·1	5·0	S.O. faible	Nuageux	„	S.O. au-fort	9·0
Bordeaux	759·0	5·8	N.O. fort	Pluie	„	O. Impétueux par bquere	9·0
Bayonne	760·0	7·0	N.O. violent	Pluie	Furieuse	„	9·0
Celte	756·0	6·0	N.O. au-fort	Peu nuageux	Calme	N.O. modéré	9·0
Marseille	756·1	5·9	N.O. fort	Nuageux	Grosse	O. modéré	9·0
Toulon	754·0	6·0	N.O. violent	Peu nuageux	Grosse	N.O. faible	9·0
Antibes	„	„	O. tr. fort	Nuageux	Calme	O.S.O. fort	9·0
Lyon	757·4	7·0	S. faible	Un peu nuageux	„	S. faible	9·0
Besançon	753·3	3·5	O. fort	Couvert	„	N.E. fort	9·0
Ancône	743·4	5·9	O.N.O. au-fort	Couvert	Grosse	S.E. faible	9·0
Livourne	749·4	10·5	O.S.O. tr. fort	Beau	Furieuse	„	9·0
Florence	746·9	3·1	- -	Beau	„	„	9·0
Trieste	744·6	3·6	N.N.E. modéré	Pluvieux	Calme	„	10·0
Vienne	745·9	2·0	N.O. faible	Couvert	„	S. au-fort	10·0
Messina	741·4	10·0	O.N.O. tr. fort	Tr. nuageux	Clapoteuse	- -	10·0
Naples	748·4	7·0	O.S O. tr. fort	Nuageux	Tr. agitée	S.S.O. tr. faible	10·0
Bruxelles	741·1	4·0	S.S.O. faible	Nuageux	„	„	9·0
Greenwich	740·8	3·9	O. modéré	Beau	„	„	10·0
Berne	750·3	0·2	S.O. fort	Couvert, neige	„	S.O. tr. fort	10·0
Le Helder	733·7	5·8	O. au-fort	Couvert	Tr. houleuse	„	11·0
Gröningue	734·0	2·9	S.O. faible	Pluie	„	„	11·0
Yarmouth	738·4	2·8	O.N.O. un peu fort	Nuageux	Calme	O.N.O. tr. fort	11·0
Scarboroug	736·4	3·3	N.O. faible	Pr. couvert	Peu agitée	O.N.O. un peu fort	11·0
Penzance	748·4	6·7	O.N.O. un peu fort	Nuageux	Houleuse	O.N.O. fort	11·0
Odessa	750·5	„	O.S.O. au-fort	Couvert	Houleuse	„	11·20
Nicolaieff	754·2	3·3	S.E. au-fort	Couvert	„	„	11·20
Nairn	738·8	1·7	O. faible	Pr. couvert	Belle	N.O. un pen fort	11·20
Libau	733·3	2·5	O. „	Couvert	„	„	11·25
Riga	733·5	1·1	S. au-fort	Couvert	„	„	11·25
Bilbao	760·6	8·2	N.O. fort	Couvert	Tr. agitée	„	11·30

Berne - - Hier soir, pluie ; dans la nuit, neige.
Florence - - Pluie dans la nuit.
Vienne - - Hier, neige ; O.F.
Naples - - Orage avec forte pluie à 2 h. après minuit, en direction O.S.O. tr. fort.
Trieste - - Pluie et grêle 281mm.

(Here is given a map of Europe, showing the barometric pressure by curves and figures, and the direction of the wind by arrows.)

Situation Générale.

Tandis que le centre de la grande bourrasque qui sévit sur la Manche et sur l'Océan Atlantique se transporte lentement vers l'E., le baromètre a descendu rapidement depuis hier Mardi sur l'Italie, la mer Adriatique, et les côtes de Provence.

Cette baisse est due au mouvement orageux signalé hier dans les Pays-Bays, lequel se dirigeant vers les Alpes et l'Adriatique, a signalé sa présence par quelques éclairs vus hier soir à Paris, un violent orage qui éclate à 6 heures à Antibes, un autre à 2 h. du matin à Naples, et un dernier à Trieste, avec pluie et grêle amenant 251mm d'eau.

Ce matin la neige tombait au Hâvre et à Berne.

Nous n'avons rien reçu de Suède, de Norwége, ni de Portugal. L'Espagne ne nous a envoyé que Bilbao.

Appendix No. 12 (page 28).

Specimen of Weather Report sent to the Wreck Department of the Board of Trade by Officers of Coast Guard and Customs subsequently to each Storm Warning.

Form Wr. 25.
Issued by the Board of Trade.

Inspecting Officer's Division or Receiver's District } *Plymouth.*

Report by Inspecting Officer of Coast Guard or Receiver of Wreck of the Warning Signals hoisted by Directions of Rear-Admiral FitzRoy, and of the State of the Weather during the 72 Hours following the Time of hoisting.

(This Form is to be addressed to "The Secretary, Marine Department, Board of Trade," as soon as possible after the last Observation is recorded herein.)

PARTICULARS OF SIGNAL AND DATE AND HOUR OF HOISTING.

Description of Signal. (Here state whether "Cone with point up," "Cone with point down," "Drum alone," "Cone above drum," or "Cone under drum," &c. &c., as the case may be.) 1.	Place of hoisting Signal. 2	Date of Warning. 3.			
		Year.	Month.	Day.	Hour.
South Cone - - -	*Plymouth* -	1863	*Dec.*	1	11 *A.M.*

State of Weather, to be recorded at the Time of hoisting the Signal, and, as far as practicable, once every Four Hours during the 72 Hours following.

Date and Hour of Observations. 4.		Direction of the Wind. (Here state the true direction of the wind, not the magnetic.) 5.	Force of the Wind. (Here state the force, according to the notation on the Forms Wr. 1.) 6.	State of the Weather. (Here state briefly the state of the weather, e.g., "bluesky," "fog," "mist," "rain," "snow," "lightning," "hail," &c. &c.) 7.	Remarks. (If the greatest violence of the wind occurs at a time not stated in column 4, the fact should be noted in this column with the date and hour of the occurrence, and with the direction and force of the wind. —See also foot note.) 8.
Dec. 1.	*11* o'clock *A.* M. First observation.	*S.S.W.*	*No. 6*	Cloudy	*With rain.*
	3 o'clock *P.* M. Second observation.	*W.S.W.*	,, *4*	,,	,, ,,
	7 o'clock *P.* M. Third observation.	*S.S.W.*	,, *5*	,,	,, ,,
	11 o'clock *P.* M. Fourth observation.	*S.*	,, *9*	,,	*With heavy rain.*
,, *2.*	*3* o'clock *A.* M. Fifth observation.	*S.S.W.*	,, *6*	,,	,, ,, ,,
	7 o'clock *A.* M. Sixth observation.	*W.*	,, *4*	,,	,, ,, ,,
	11 o'clock *A.* M. Seventh observation.	*W.N.W.*	,, *8*	,,	*2/12/63. A.M. 10., Wind N.W. No. 10. with showers of rain.*
	3 o'clock *P.* M. Eighth observation.	*W.*	,, *6*	,,	*Telegram to hoist drum received at noon. 2/12/63.*
	7 o'clock *P.* M. Ninth observation.	*W.S.W.*	,, *4*	,,	*With rain.*
	11 o'clock *P.* M. Tenth observation.	*S.S.W.*	,, *6*	,,	,, ,,
,, *3.*	*3* o'clock *A.* M. Eleventh observation.	*S.W.*	,, *7*	,,	,, ,,
	7 o'clock *A.* M. Twelfth observation.	*N.W.*	,, *7*	,,	
	11 o'clock *A.* M. Thirteenth observation.	*N.W.*	,, *10*	,,	*With heavy showers of hail and rain.*
	3 o'clock *P.* M. Fourteenth observation.	*N.N.W.*	,, *10*	,,	,, ,, ,,
	7 o'clock *P.* M. Fifteenth observation.	*N.W.*	,, *9*	,,	,, ,, ,,
	11 o'clock *P.* M. Sixteenth observation.	*N.W.*	,, *5*	Clear.	
,, *4.*	*3* o'clock *A.* M. Seventeenth observation.	*W.N.W.*	,, *4*	,,	
	7 o'clock *A.* M. Eighteenth observation.	*W.N.W.*	,, *3*	,,	

N.B.—The time at which the wind is at its *greatest force* should in all cases be *specially* noted, and particulars should be given. If the greatest force *does not* happen near the time of one of the four-hourly observations, the particulars should be entered in addition to the usual observations.

Signature of Officer forwarding the Report.

DIRECTIONS ON THE BACK OF THE FORM Wr. 25.

The Receiver is informed that directions have been issued by Admiral FitzRoy, to the effect that the warning signal named in column 1 is to be hoisted at the place named in column 2.

The Receiver is requested to cause one of these forms Wr. 25, to be returned to the Board of Trade, with a report in columns 5, 6, 7, and 8, showing as far as he is able, the direction and force of the wind, and the state of the weather during the 72 hours following the warning.

In order that the Form Wr. 25 may be filled up readily and accurately, some person in the service of the Coast Guard or Customs should be directed to observe and keep a note of the state of the weather whenever and as soon as a signal is hoisted, and, as far as possible, at intervals of four hours during the subsequent three days.

This Form need not be inclosed in an envelope when returned to the Board of Trade.

T. H. Farrer, Secretary.

Appendix No. 13 (pages 29 and 32).

Analysis of Reports (made to the WRECK DEPARTMENT OF THE BOARD OF TRADE) upon the Weather which followed the Exhibition of Storm Signals, from 1st July to 31st December 1861, showing the number of places warned, the nature of the Signals, the number of places at which the Wind did and did not reach a force above seven (i.e. 8 to 12); the time within which it reached such a point, and the number of places at which the direction of the Wind accorded with the prediction.

Date of Warning.	Nature of Signal.	Number Places of warned.	*Force of Wind.* Number of Places where Wind after Warning Rose above 7. During first 12 hours.	During second 12 hours.	During third 12 hours.	During fourth 12 hours.	After 48 hours.	And at its maximum reached 8	9	10	11	12	Total.	Did not rise above 7.	*Direction of Wind.* Number of places where Wind at highest after warning agreed in any part of compass with Signal. When below 7.	When above 7.	Total.
Col. 1.	Col. 2.	Col. 3.	Col. 4.	Col. 5.	Col. 6.	Col. 7.	Col. 8.	Col. 9.	Col. 10.	Col. 11.	Col. 12.	Col. 13.	Col. 14.	Col. 15.	Col. 16.	Col. 17.	Col. 18.
July 4	Drum	14	2	0	0	0	0	2	0	0	0	0	2	12	—	—	—
„ 5	Cone point up	9	0	0	0	0	0	0	0	0	0	0	0	9	1	0	1
„ 25	Ditto	9	1	0	0	0	0	1	0	0	0	0	1	8	5	0	5
September 13	Ditto	24	11	3	0	1	1	4	7	4	0	1	16	8	6	6	12
„ 21	Drum	18	0	0	5	5	2	6	3	3	0	0	12	6	—	—	—
„ 24	Cone point down	19	0	2	1	0	1	3	1	0	0	0	4	15	7	3	10
October 11[1]	Cone point up	26	11	5	3	0	0	4	6	5	3	1	19	7	0	0	0
„ 11[2]	Drum	7	3	1	0	0	0	3	0	1	0	0	4	3	0	0	0
„ 11[3]	Cone point down	7	4	1	1	0	0	2	1	3	0	0	6	1	0	0	0
November 2	Drum	22	17	0	0	0	1	5	9	2	1	1	18	4	—	—	—
„ 11	Cone point up	20	1	0	1	8	2	3	6	2	0	1	12	8	8	11	19
„ 13	Drum	30	8	4	1	0	0	5	6	2	0	0	13	17	—	—	—
„ 20	Cone point down	27	4	8	1	2	2	3	7	6	1	0	17	10	10	7	17
„ 21	Drum	6	4	0	1	0	0	2	1	2	0	0	5	1	—	—	—
„ 22	Cone point up	12	0	0	0	2	10	5	0	6	1	0	12	0	0	0	0
„ 25	Drum	31	23	1	0	0	0	7	7	7	2	1	24	7	—	—	—
December 5	Cone point down	40	4	1	1	1	4	5	3	2	1	0	11	29	19	9	28
„ 7	Drum	38	8	2	2	1	2	6	6	3	0	0	15	23	—	—	—
„ 13[1]	Cone point down	30	6	4	4	0	1	7	5	1	1	1	15	15	6	8	14
„ 13[2]	Drum	24	5	3	0	0	0	2	4	1	1	0	8	16	—	—	—
		413*	112	35	21	20	26	75	72	50	11	6	214	199	62	44	106

* Out of which 223 denote direction.

Signification of Signals.

- Drum - - - - - - { Gales successively. No quarter particularized.
- Cone with point up - - - - { Gales repeated, probably from the north.
- Cone with point down - - - { Gales probably from the south.

Number denoting force of Wind.

0. Calm.
1. Light air.
2. Light breeze.
3. Gentle breeze.
4. Moderate breeze.
5. Fresh breeze.
6. Strong breeze.
7. Moderate gale.
8. Fresh gale.
9. Strong gale.
10. Whole gale.
11. Storm.
12. Hurricane.

Appendix No. 14 (pages 30 and 32).

Analysis of Reports (made to the Wreck Department of the Board of Trade) upon the Weather which followed the Exhibition of the Storm Signals at all the Places warned during the Month of December in each of the Years 1863, 1864, and 1865.

Table 1, December 1863.

Date of Warning.	Nature of Warning.	Number of Places from which Reports received.	Number of Places at which the Wind at its *greatest force* did not reach Force 8, but reached force 0	1	2	3	4	5	6	7	Total.	Number of Places at which the Wind at its *greatest force* reached Force 8 or upwards. At the time of hoisting the Signal.	Within 4 hours.	Within 8 hours.	Within 12 hours.	Within 16 hours.	Within 20 hours.	Within 24 hours.	Within 36 hours.	Within 48 hours.	Within 60 hours.	Within 72 hours.	Total.	and at which the *actual* direction agreed with the direction *indicated* by the Warning.
Dec. 1	South Cone.	67	–	–	–	–	–	1	–	3	4	3	3	1	1	4	4	1	6	30	10	–	63	21
„ 2	Drum.	25	–	–	–	–	–	–	–	3	3	1	5	–	–	6	2	3	5	–	–	–	22	—
„ 5	South Cone.	68	–	–	–	..	–	1	11	15	27	4	4	1	1	–	–	1	3	5	11	11	41	34
„ 16	„	70	–	–	–	–	–	3	12	7	22	7	3	6	10	11	6	5	–	–	–	–	48	3
„ 27	„	69	–	–	2	–	1	14	23	15	55	2	3	2	2	–	–	–	–	2	2	1	14	4
„ 31	Drum.	67	–	–	2	–	–	5	16	9	32	8	5	6	6	1	–	2	2	5	–	–	35	—
Totals -		366	–	–	4	–	1	24	62	52	143	25	23	16	20	22	12	12	16	42	23	12	223	62

Table 2, December 1864.

Dec. 13	Drum.	70	–	–	–	2	5	9	27	11	54	4	3	1	–	–	–	–	2	1	2	3	16	—
„ 22	North Cone.	15	–	–	–	–	–	1	7	5	13	2	–	–	–	–	–	–	–	–	–	–	2	1
Totals -		85	–	–	–	2	5	10	34	16	67	6	3	1	–	–	–	–	2	1	2	3	18	1

Table 3, December 1865.

Dec. 1	South Cone.	27	–	–	–	–	1	3	6	3	13	–	4	1	–	1	–	1	4	1	1	1	14	12
„ 2	„	16	–	–	–	–	–	–	–	–	–	4	2	1	–	–	–	–	6	2	1	–	16	16
„ 2	Drum.	24	–	–	–	–	–	–	6	3	9	1	3	1	1	–	–	1	4	3	1	–	15	—
„ 4	„	30	–	–	–	–	–	–	3	2	5	10	2	–	4	–	–	–	2	3	4	–	25	—
„ 6	South Cone.	15	–	–	–	–	–	1	8	5	14	–	1	–	–	–	–	–	–	–	–	–	1	1
„ 19	„	42	–	–	–	–	–	1	8	10	19	3	3	4	–	1	–	3	3	4	1	1	23	21
„ 21	„	10	–	–	–	–	–	4	2	2	8	1	–	1	–	–	–	–	–	–	–	–	2	2
„ 23	„	32	–	–	–	–	–	1	3	7	11	4	2	–	–	2	2	–	4	4	3	–	21	20
„ 28	„	70	–	–	–	–	–	–	1	1	2	4	7	8	4	9	10	16	8	1	1	–	68	61
„ 30	Drum.	69	–	–	–	–	–	–	–	1	1	13	11	19	18	4	2	–	–	1	–	–	68	—
Totals - -		335	–	–	–	–	1	10	37	34	82	40	35	35	27	17	14	21	31	19	12	2	253	133

Appendix No. 15 (pages 30 and 32).

Analysis of Reports (made to the Wreck Department of the Board of Trade) upon the Weather which followed the Exhibition of the Storm Signals at Aberdeen, Galway, Harwich, Holyhead, Plymouth, Shields, and Yarmouth for the whole of the Years 1863, 1864, and 1865.

Table 1.—December 1st to January 31st, 1863.

Places warned.	No. of Reports received.	Number of Times at which the Wind, at its *greatest force* did not reach Force 8									Number of Times at which the Wind, at its *greatest force* reached Force 8, or upwards.														
		but reached Force								Total.	At the Time of hoisting the Signal.	Within 4 hours.	Within 8 hours.	Within 12 hours.	Within 16 hours.	Within 20 hours.	Within 24 hours.	Within 36 hours.	Within 48 hours.	Within 60 hours.	Within 72 hours.	Total.	And at which the *actual* Direction agreed with the Direction *indicated* by the Warning.	No. of Signals hoisted.			
		0	1	2	3	4	5	6	7															Drum.	S. Cone.	N. Cone.	Total.
Aberdeen	39	–	–	–	–	2	3	5	15	25	3	1	1	2	–	–	1	1	–	4	1	14	2	9	3	2	14
Galway	40	–	–	–	–	1	4	4	5	14	6	2	6	1	1	1	–	2	2	2	3	26	1	19	5	2	26
Harwich	25	–	–	–	–	1	–	–	2	3	–	3	5	5	1	1	2	1	–	3	1	22	4	17	4	1	22
Holyhead	39	–	–	–	–	2	2	4	13	21	4	1	4	2	–	1	1	–	5	–	–	18	3	11	7	–	18
Plymouth	35	–	–	–	–	3	1	14	6	24	3	3	–	–	–	1	2	–	1	1	–	11	2	8	3	–	11
Shields	38	–	–	–	–	–	3	2	1	6	15	–	3	2	2	2	1	3	3	1	–	32	4	26	3	3	32
Yarmouth	38	–	–	–	1	4	1	10	13	29	–	2	2	2	–	–	2	–	1	–	–	9	–	8	–	1	9
Totals	254	–	–	–	1	13	14	39	55	122	31	12	21	14	4	6	9	7	12	11	5	132	16	98	25	9	132

Table 2.—January 1st to December 31st, 1864.

Aberdeen	25	–	–	–	–	2	1	–	6	9	3	–	1	3	2	–	1	4	1	1	–	16	2	10	5	1	16
Galway	32	–	–	–	–	2	1	8	4	15	–	2	2	4	1	2	–	2	3	1	–	17	3	7	10	–	17
Harwich	23	–	–	–	–	–	1	1	11	13	–	1	2	2	–	–	–	2	–	3	–	10	2	7	3	–	10
Holyhead	28	–	–	–	–	1	5	5	9	20	–	1	2	1	–	1	2	–	–	1	–	8	3	4	4	–	8
Plymouth	23	–	–	–	–	1	2	7	4	14	1	1	2	–	–	1	–	2	1	1	–	9	3	5	4	–	9
Shields	21	–	–	–	–	–	1	–	7	8	4	1	2	–	–	1	–	1	3	1	–	13	4	8	5	–	13
Yarmouth	19	–	–	–	2	–	–	5	7	14	–	1	1	–	–	1	–	–	–	1	1	5	1	4	1	–	5
Totals	171	–	–	–	2	6	11	26	48	93	8	7	12	10	3	6	3	11	8	9	1	78	18	45	32	1	78

Table 3.—January 1st to December 31st, 1865.

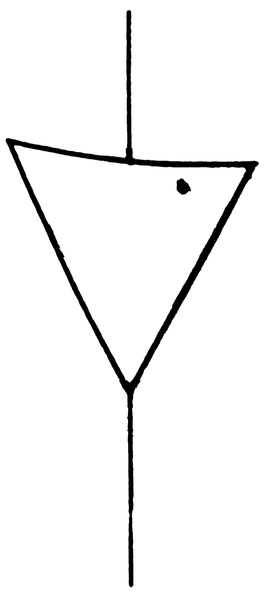
Aberdeen	37	–	–	–	1	1	2	6	10	20	1	2	2	2	–	1	–	4	1	4	–	17	3	12	2	3	17
Galway	37	–	–	–	2	3	6	12	5	28	–	2	2	–	–	1	–	2	–	2	–	9	2	5	3	1	9
Harwich	32	–	–	–	–	1	4	3	9	17	1	–	1	2	2	1	–	1	4	3	–	15	1	13	1	1	15
Holyhead	34	–	–	–	–	1	2	4	14	21	–	1	–	1	2	2	–	–	2	3	2	13	1	11	1	1	13
Plymouth	34	–	–	–	–	1	2	6	5	14	1	5	–	1	–	1	3	1	3	3	2	20	4	15	4	1	20
Shields	31	–	–	–	–	–	–	2	2	4	3	5	3	3	1	–	1	3	4	4	–	27	3	23	3	1	27
Yarmouth	31	–	–	–	–	3	3	6	5	17	2	–	–	1	2	–	1	3	–	2	3	14	1	12	1	1	14
Totals	236	–	–	–	3	10	19	39	50	121	8	15	8	10	7	6	5	14	14	21	7	115	15	91	15	9	115

EXAMPLE OF A DIAGRAM PREPARED IN THE WRECK DEPARTMENT SHEWING THE FORCE AND DIRECTION OF WIND FOLLOWING A STORM SIGNAL AT EACH FOUR HOURLY PERIOD OF OBSERVATION DURING 72 HOURS AFTER HOISTING THE SIGNAL AT 18 INTERVALS OF 4 HOURS EACH.

SHIELDS

SIGNAL
Date and Description

May 2nd 1864.



1.0. p.m.

Intervals in hours

0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72

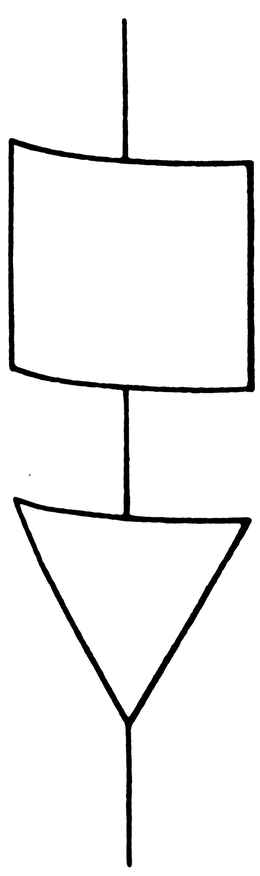
Force of Wind

12 11 10 9 8 7 6 5 4 3 2 1 0

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Direction of Wind each 4 hours	N.W.	N.W.	N.W.	N.N.W.	N.E.	N.E.	S.S.E.	S.E.	S.E.	S.	S.S.E.	S.S.E.	S.S.E.	S.S.E.	S.S.E.	S.E.	S.W.	S.	S.S.W.

SIGNAL
Date and Description

January 12th 1865.



1.0. p.m.

Intervals in hours

0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72

Force of Wind

12 11 10 9 8 7 6 5 4 3 2 1 0

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Direction of Wind each 4 hours.	S.S.E.	S.E.	S.W.	W.S.W.	W.S.W.	W.N.W.	W.N.W.	W.S.W	S.S.W.	S.by W.	S.S.W.	S.W.	W.N.W.	W.S.W.	W.N.W.	N.W.	N.W.	N.W.	W.N.W.

APPENDIX No. 17 (page 34).

ABSTRACT of OPINIONS from the Ports concerning the value attached to the Storm Warnings at the present time (1866).

Questions.

AN inquiry is being made into the Meteorological Department of the Board of Trade, and we are anxious to learn, after some years' experience, what is the real opinion of seafaring men concerning the value of the late Admiral FITZROY's signals. Can you help us by telling me what is thought of them by those most competent to judge, at ( ).

I remain, &c. &c.

(Signed) T. H. FARRER.

ANSWERS to the above.

Captain Rutherford, R.N. -	Wick, N.B.	Signals not hoisted so far north.
Mr. James Kellas, Secretary to the Local Marine Board.	Aberdeen - -	"The utility of the signals is generally acknowledged, and for some time back the subject has obtained more attention among seafaring men."
		"The signals for a considerable time have been very accurate."
Mr. Anthony Trail, Examiner in Seamanship, Local Marine Board.	Dundee - -	"The correctness of the Storm Signals at this port is a matter of common remark;" they "are very generally appreciated."
Shipowners' Society, through Mr. Ingham, M.P.	South Shields -	"The exhibition of the Storm Signals are of much practical value, by giving timely warning of approaching storms."
The Pilots, through Mr. Ingham, M.P.	South Shields -	"The Storm Signals are of great importance and great practical value, as affording timely and very correct intimations of coming gales and storms."
Mr. John Lambton, Superintendent Mercantile Marine Office.	Sunderland -	"The Signals are regarded as decidedly valuable." A daily account of the weather kept by the dock master "shows that the warnings have for some time now been more correct and reliable than formerly."
Mr. John Mackenzie, Collector of Customs.	West Hartlepool -	"The general feeling is in favour of the utility of the Signals, which are much more trusted and attended to by seafaring men than when the system was first established."
Mr. C. J. Palmer, Receiver of Wreck.	Great Yarmouth -	"There is a general and growing admission that the Signals are correct;" they "are watched by seafaring men, and I have heard the admission that they have improved in accuracy, especially lately."
Mr. G. J. Flower, Collector of Customs.	Deal - -	"There is but one real opinion concerning the value of the Signals. They have been the means of saving life and property to an immense extent."
Mr. J. Kelly, Secretary to the Local Marine Board.	Plymouth - -	Those most likely to be informed on the subject, "Do not consider that the Signals are in any great degree of value to seafaring persons."
Mercantile Marine Association.	Liverpool - -	"Decidedly in favour of the Signals being continued."
Mr. Towson, Secretary and Examiner in Navigation, Local Marine Board.	Liverpool - -	"There exists an universal opinion that these Signals are very valuable; that the amount of accuracy has gradually increased."

Appendix No. 18 (page 39).

A Return of Sums voted for and expended by the Meteorological Department of the Board of Trade made up to the 1st December 1865, the Pay of the Clerks being calculated to the 30th September only of that year. The Return of Expenditure for 1865-6 is of course incomplete in this as well as in other respects.

For the Year	Parliamentary Vote.		Expenditure charged to Parliamentary Vote.						Additional Salaries paid out of Vote for Board of Trade Establishment.	Total Expenditure on Account of Meteorological Department.
			For Telegraphy and Storm Warnings.	For Instruments and Incidental Expenses.		Salaries.				
	Board of Trade.	Admiralty.	Board of Trade.	Board of Trade.	Admiralty.	Board of Trade.	Admiralty.			
	£	£	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.		£ s. d.	£ s. d.
1856–7	3,200	1,000	—	1,772 8 4	394 15 0	350 8 0	354 12 0		368 15 0	3,240 18 4
1857–8	3,200	1,000	—	1,212 3 3	1,237 3 0	359 17 0	326 12 0		511 5 0	3,647 0 3
1858–9	3,200	1,000	—	1,731 18 1	554 19 0	561 14 6	364 10 0		400 9 9	3,613 11 4
1859–60	2,400	1,000	—	1,203 7 8	757 3 9	643 3 5	387 15 0		353 15 0	3,345 4 10
1860–1	2,300	1,000	218 1 5	868 1 5	519 12 2	711 18 0	410 15 4		378 15 0	3,107 3 4
1861–2	2,800	1,000	1,778 0 8	1,360 12 3	547 6 2	804 18 6	430 8 4		403 15 0	5,325 0 11
1862–3	3,800	1,000	2,334 15 0	630 17 1	618 13 6	829 9 10	430 8 4		366 5 0	5,210 8 9
1863–4	3,800	1,000	2,989 0 11	1,650 4 0	726 8 9	603 9 8	205 16 8		929 0 4	7,104 0 4
1864–5	3,700	570	2,735 10 0	314 2 8	830 12 0	246 11 10	—		1,333 13 11	5,460 10 5
1865–6 incomplete.	4,200	570	1,567 2 1	198 10 2	155 18 10	54 8 4	—		344 12 7	2,320 12 0
Total -	32,600	9,140	11,622 10 1	10,942 4 11	6,342 12 2	5,165 19 1	2,910 17 8		5,390 6 7	42,374 10 6

LONDON :
Printed by George E. Eyre and William Spottiswoode,
Printers to the Queen's most Excellent Majesty.
For Her Majesty's Stationery Office.