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Meteorological Reports &c

Mr. F. Galton

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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.

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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.

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* See Appendix No. 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.

PART III.

Estimate of Cost.

CONCLUSION.

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-

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* 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

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* 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.

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.	*1758.*		*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 $\frac{1}{10}$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	$\frac{1}{4}$		
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.

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) „ (West)	In Squares of 2° Lat. 4° Long.		„
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.

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* 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	—
	Orkney { 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-

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* 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.

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* 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.¶

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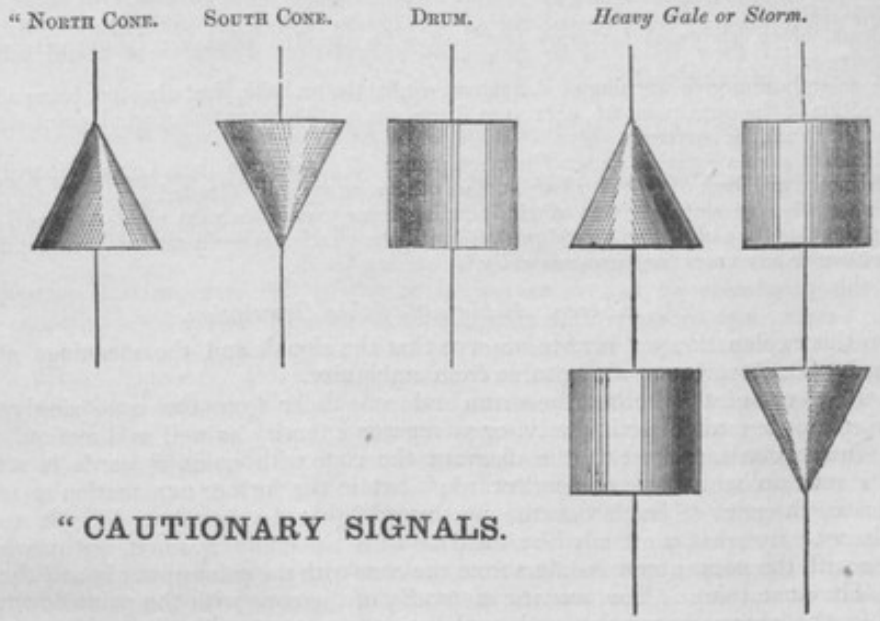
* Report of 1864, Appendix, p. 18.
† Report of 1864, Appendix, pp. 30, 31.
‡ Report of 1864, Appendix, pp. 33–36.
§ See Admiral FitzRoy's Report of 1863, p. vii.
‖ See Appendix, Nos. 10 and 11.
¶ See pp. 37, 38.

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.



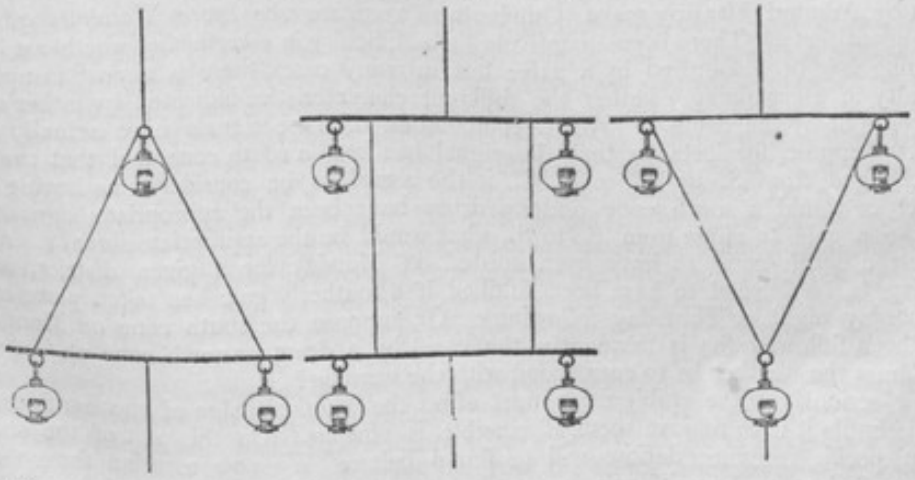
"CAUTIONARY SIGNALS.

"*Gale, "probably "from the "Northward.*	*Gale, probably from the Southward.*	*Gales successively.*	*Dangerous Winds probably at first from the Northward.*	*Dangerous Winds probably at first from the Southward.*

"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.

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* 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.

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* 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 gale 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.

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* 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.*

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.

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.*

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* See Appendix No. 7.

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.

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

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.

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.

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.

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* 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.

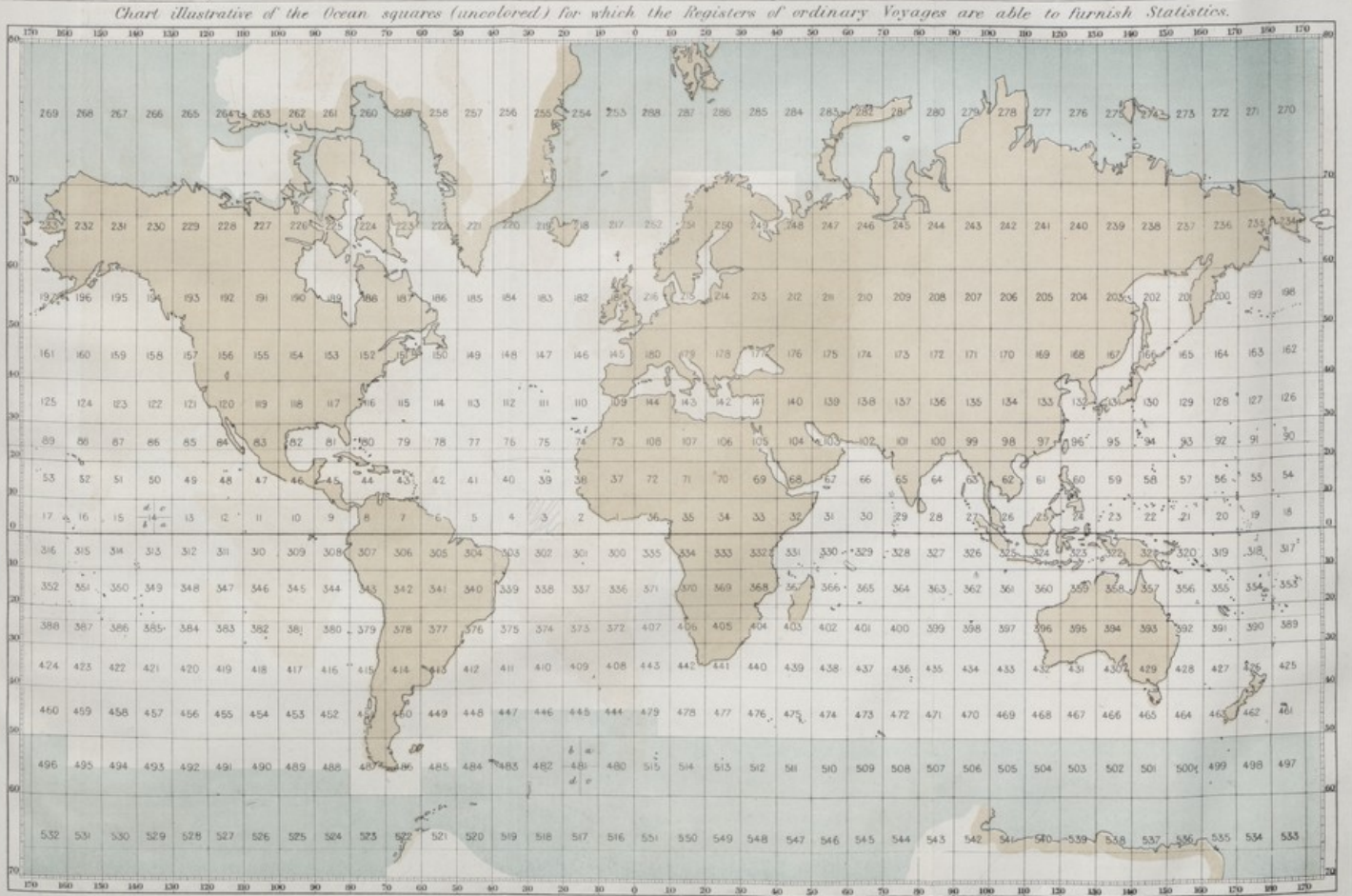
"It cannot be doubted that one of the most important objects of the Meteorological Department, both in a practical and a theoretical view, is the procurement of the statistics of the direction and force of the wind in different seasons of the year over those parts of the Atlantic Ocean which are most 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."

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	Barometer (corrected).			Temperature.			Aqueous Vapour.			Rain.	Cloud.	Wind.			Sea Surface.			Data.	
Months.	Mean.	Variability.		Mean.	Variability.		Mean Wet Bulb.	Mean Tension.	Mean Humidity.	Per Cent. of Observations.	Mean 0-10.	Mean Direction.	Mean Force.	Miles per Day.	Mean Temp.	Mean Drift.	Miles per Day.	No. of Observations.	Authorities.
		Highest.	Lowest.		Highest.	Lowest.													
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.																																		

xix

f. 32v

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

$$\frac{8 \times 8 \times 8}{10 \times 10 \times 10} = \text{about } \frac{2}{3}$$

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.

First Half of year 1865. Port of Plymouth.

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

Days of the Month	APRIL Warnings hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical	MAY Warnings hoisted	First Forecast	Second Forecast	Maximum Force of Wind	Duration of Wind	Typical	JUNE 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	x x
2		5.6	5.						5.				⊞	5.6	6.	4	8. „	x x
3		6.4						4.6	5.6				⊞	5.6	6.4	4	4. „	x x
4			5.6					5.	6.				⊞	5.4	5.4	3	4. „	x x
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. „	x x
30		5.4	6.4						5.				⊞	5.6	5.6	5	4. „	x x
31								5.	6.									

Day & Son (Limited) Lith.

Second Half of year 1865 — *Port of Plymouth*

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.									

Days of the Month	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.
1		5.	5.				⊞	8.4	6.5	3	4 hrs.	××	⊞	6.5	5.	1	16 hrs	××
2		5.6					⊞	6.5	5.6	1	12.	××	⊞ ▽	4.5	5.6	8	4.	‖
3			6.					5.	4.6				▽	5.6	5.8	4	8.	××
4		6.4	5.4					5.6	4.5				▽	6.		8	4.	‖
5		4.6	4.6					5.	4.5				▽		10.4	6	4.	××
6		5.	5.					4.6					▽	6.5	8.5	8	4.	‖
7		5.4	5.6	7	4 hrs	××			4.5				▽	6.5	6.8	8	4.	‖
8		6	6	8	4.	‖		4.5	5.6				▽	6.5	6.4	1	4.	××
9		6.		4	4.	××		6.4	6.				▽	5.6	4.	1	12.	××
10			6.8	4	4.	××		6.4	6.4					4.5	4.5			
11		6.	8.4	8	8.	‖		5.	5.					5.6				
12		6.4	8.5	4	4.	××		5.	4.6						5.6			
13		6.5	6.5	1	12.	××		4.6						5.6	5.6			
14		6.4	6.4						6.8					5.	5.			
15		6.	5.					6.	5.6					5.	5.			
16		4.6		7	4.	××		6.4	6.4	6	4.	××		5.	4.5			
17			6.	4	12.	××		5.	8.4	8	4.	‖		5.	5.			
18		6.4	5.8	5	4.	××		4.6	8.5	5	4.	‖		5.4				
19		6.4	8.	5	12.	××		6.5	5.6	7	4.	××			4.	5	4.	××
20		6.	6.	3	8.	××		6.		9	4.	‖	▽	4.5	5.6	5	4.	××
21		5.	6.	4	4.	××			4.10	9	4.	‖	▽	4.6	4.6	6	4.	××
22		6.	4.6	6	12.	××		6.	6.5	12	4.	‖	▽	5.6	6.	4	12.	××
23		5.6						5.6	8.6	5	4.	××			5.6	5.6			
24		6.	5.6	5	4.	××		6.	6.8	11	4.	‖			5.6	5.6			
25		6.	5.8	6	12.	××		6.	6.	12	4.	‖			5.6				
26		6.4	5.	8	12.	××		6	9.5	5	12.	××						
27		6.5		5	4.	××		5.8		7	4.	××			5.6				
28			5.6	9	4.	‖			5.8	9	4.	‖	▽	4.6	4.6	6	4.	××
29			5.6	9	4.	‖		6.5	8.5	5	8.	××	▽	4.6	5.8	9	4.	‖
30		4.6		8	12.	×		6.4	5.6	1	16.	××	▽	6.	10.	6	8.	×
31			8	6	4.	×							▽ ⊞	5.8	5.8	9	8.	‖

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First Half of year 1865. Port of Shields.

Days of the Month	Jan. Warnings Hoisted	Jan. First Forecast	Jan. Second Forecast	Jan. Maximum Force of Wind	Jan. Duration of Wind	Jan. Typical	Feb. Warnings Hoisted	Feb. First Forecast	Feb. Second Forecast	Feb. Maximum Force of Wind	Feb. Duration of Wind	Feb. Typical	Mar. Warnings Hoisted	Mar. First Forecast	Mar. Second Forecast	Mar. Maximum Force of Wind	Mar. Duration of Wind	Mar. 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	4 "	|		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	□		5.8	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	4 "	‖	△	6.		10	4 "	‖
21		5.	2.6						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 "	×	□	4.6	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	Apr. Warnings hoisted	Apr. First Forecast	Apr. Second Forecast	Apr. Maximum Force of Wind	Apr. Duration of Wind	Apr. Typical	May Warnings hoisted	May First Forecast	May Second Forecast	May Maximum Force of Wind	May Duration of Wind	May Typical	June Warnings hoisted	June First Forecast	June Second Forecast	June Maximum Force of Wind	June Duration of Wind	June 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		6.4						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.	5.6					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					4.	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.

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Second Half of year 1865 — Port of Shields

Days of the Month	July: Warnings Hoisted	July: First Forecast	July: Second Forecast	July: Maximum Force of Wind	July: Duration of Wind	July: Typical	August: Warnings Hoisted	August: First Forecast	August: Second Forecast	August: Maximum Force of Wind	August: Duration of Wind	August: Typical
1	□	6.4	6.	6	20	×			4.6			
2	□	6.4	6.5	6	16	×		5.	6.8			
3		5.						5.6	5.6			
4			5.					4.6	4.6			
5		5.	5.6					6.4	6.4			
6		4.6	5.6					4.5	4.			
7	□	5.6	4.6	8	4 „	|		4.5				
8	□	6.5	5.6	8	4 „	|			5.			
9	□	6.5	6.5	6	16 „	×		5.6	5.			
10	□	5.4		6	16 „	×		5.6	4.6			
11			5.					5.6	5.6			
12		5.	4.6					6.4	6			
13		5.6	4.6					6.4	6.4			
14		5.	5.6					4.6				
15	□	6.5	6.5	9	4 „	‖	□		5.6	5	12 „	×
16	□	5.4	6.5	9	4 „	‖	□	5.6	5.6	6	8 „	×
17	□	5.4		6	4 „	×	□	6.	6.	5	24 „	×
18	□		4.	4	12 „	×	□	5.6	5.6	5	12 „	×
19		5.	4.					5.	5.			
20		5.6	5.6					4.6	4.5			
21		5.6	5.6					4.6				
22		5.6	5.						4.5			
23		5.4	5.4					5.	4.5			
24		4.5						4.6	4.6			
25			2.4					6.4	5.4			
26		4.5	4.5					5.	5.			
27		4.5	4.					5.	4.5			
28		4.5	4.5					4.5				
29		4.5	5.						5.			
30		5.4	5.4					4.6	4.6			
31		5.						5.6	5.			

Days of the Month	September: Warnings Hoisted	September: First Forecast	September: Second Forecast	September: Maximum Force of Wind	September: Duration of Wind	September: Typical	October: Warnings hoisted	October: First Forecast	October: Second Forecast	October: Maximum Force of Wind	October: Duration of Wind	October: Typical
1		6.4	5.6					5.	4.6			
2		6.4	6.4					5.				
3		5.	5.						6.			
4		4.6						6.4	6.4			
5			4.5					4.6	4.6			
6		4.5	4.5					6.5	6.5			
7		5.6	4.					5.	4.6			
8		6.4	4.5					4.6	6.4			
9		5.4	5.				□	5.6		10	12 „	‖
10		6.4	5.				□		6.8	10	24 „	‖
11		4.6					□	6.	8.5	10	4 „	‖
12			4.5				□	6.4	9.5	8	4 „	|
13		5.6	2.4					6.4	8.4			
14		4.5	4.5					6.4	6.4			
15		6.5	5.					6.	4.			
16		5.	5.					4.6				
17		4.6	4.6				□		5.6	8	4 „	|
18		5.6					□	6.4	8.5	10	16 „	‖
19			4.				□	6.	8.	10	16 „	‖
20		4.5	4.5				□	8.4	8.4	6	12 „	×
21		5.	4.6					5.	6.			
22		6.4	5.6					5.6	4.6			
23		6.4	5.					6.4				
24		5.4	5.4				□		5.6	6	8 „	×
25		5.					□	6.	5.8	9	4 „	‖
26			5.4				□□	6.4	8.5	10	8 „	‖
27		4.5	4.5				□□	6.4	8.4	7	4 „	×
28		4.6	4.6				□	6.5		9	4 „	‖
29		6.4	5.				□		6.5	9	4 „	‖
30		5.	4.5				▽□	5.		5	12 „	×
31							▽□		6.8	6	12 „	×

Days of the Month	November: Warnings hoisted	November: First Forecast	November: Second Forecast	November: Maximum Force of Wind	November: Duration of Wind	November: Typical	December: Warnings hoisted	December: First Forecast	December: Second Forecast	December: Maximum Force of Wind	December: Duration of Wind	December: Typical
1	▽□	8.4	8.5	6	24 „			6.5	5.	6	4	×
2	▽□	6.5	5.6	6	12 „		□	4.5	5.	10	16 „	‖
3		5.	4.6				□	5.6	6.	10	12 „	‖
4		5.6	4.5				□	6.		10	4 „	‖
5		5.	4.				□		5.8			
6		4.6						6.5	8.5			
7			4.6					6.4	6.8			
8		4.5	6.					6.5	6.5			
9		6.4	6.					5.6	4.			
10		6.4	6.4					4.5	4.5			
11		5.	4.5					5.6				
12		5.	5.6						5.6			
13		4.6						4.5	4.5			
14			5.8					4.5	4.5			
15		6.	6.4					4.5	4.5			
16		6.4	5.					5.	5.			
17		5.	6.					5.6	4.6			
18		4.6	8.5					4.6				
19	□	6.4	4.6	8	4 „	|			4.			
20	□	6.		8	4 „	|		4.	5.6			
21	□		4.10	9	8 „	‖	▽	4.6	5.6	10	4 „	‖
22	□▽	6.	6.5	10	4 „	‖	▽	5.6	6.	8	8 „	×
23	▽	5.6	8.6	9	4 „	‖	▽	5.6	5.6	7	4 „	×
24	▽	6.	6.10	10	4 „	‖	▽	5.6	4.5	8	8 „	|
25	▽□	6.	8.5	10	8 „	‖		5.6				
26	□	6.	8.	10	8 „	‖						
27	□□	5.8		7	4 „	×			5.			
28	□□		5.6	9	8 „	‖	▽	4.6	4.5	6	8 „	×
29	□	6.5	8.5	10	4 „	‖	▽	4.6	5.8	10	4 „	‖
30	□	6.4	5.6	9	4 „	‖	▽	6.	10.	10	4 „	‖
31							▽	5.8	5.8	10	4 „	‖

Day & Son, Limited, Lith.

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	46	N.N.W.	4	10	N.W.	h. r.	0·38	6
Liverpool	29·16	42	N.N.W.	1	8	W.	c. o.	0·07	2
Holyhead	29·09	45	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	29·37	41	N.W.	8	9	W.N.W.	t. c.	0·24	8
L'Orient	29·37	45	W.N.W.	5	9	W.	o. c.	0·20	7
Rochfort	29·73	45	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	29·05	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.
As above.	Western. As above.	
Similar to above.	Southern. Similar to above.	
Similar.	Eastern. 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, lith^e^. No. 8 Rue d'Ulm.

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

Janvier 1865.
Mercredi 10. Page 1^re^.

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

Stations.	Pression 0°.	Temp^re^.	Vents Inférieurs.	Etat du Ciel.	Etat de la Mer.	Vents hier au fort.	Arrivée.
Paris	746·5	3·8	O.S.O. assez fort	Peu nuageux	„	O.S.O. modéré	h.
Strasbourg	749·1	3·0	O. faible	Pluie	„	O. assez 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. assez fort	Tr. nuageux	Grosse	O. tr. fort	9·0
Lorient	752·9	6·2	O.N.O. assez fort	Nuageux	Grosse	O. tr. fort	9·0
Napoléon V^dee^	753·6	7·0	O. assez 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	2·9	O. assez fort	Couvert	„	N.O. faible	9·0
Montauban	759·1	5·0	S.O. faible	Nuageux	„	S.O. assez fort	9·0
Bordeaux	759·0	5·8	N.O. fort	Pluie	„	O. Impétueux par bourrasque	9·0
Bayonne	760·0	7·0	N.O. violent	Pluie	Furieuse	„	9·0
Celte	756·0	6·0	N.O. assez 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. assez 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. assez 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. assez 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
Scarborough	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. assez fort	Couvert	Houleuse	„	11·20
Nicolaieff	754·2	3·3	S.E. assez fort	Couvert	„	„	11·20
Nairn	738·8	1·7	O. faible	Pr. couvert	Belle	N.O. un peu fort	11·20
Libau	733·3	2·5	O. „	Couvert	„	„	11·25
Riga	733·5	1·1	S. assez 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 281^mm^.

(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 251^mm^ 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. 23.
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., "blue sky," "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.

I 4

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.												No. of Signals hoisted.			
		but reached Force									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.	Drum.	S. Cone.	N. Cone.	Total.
		0	1	2	3	4	5	6	7	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.

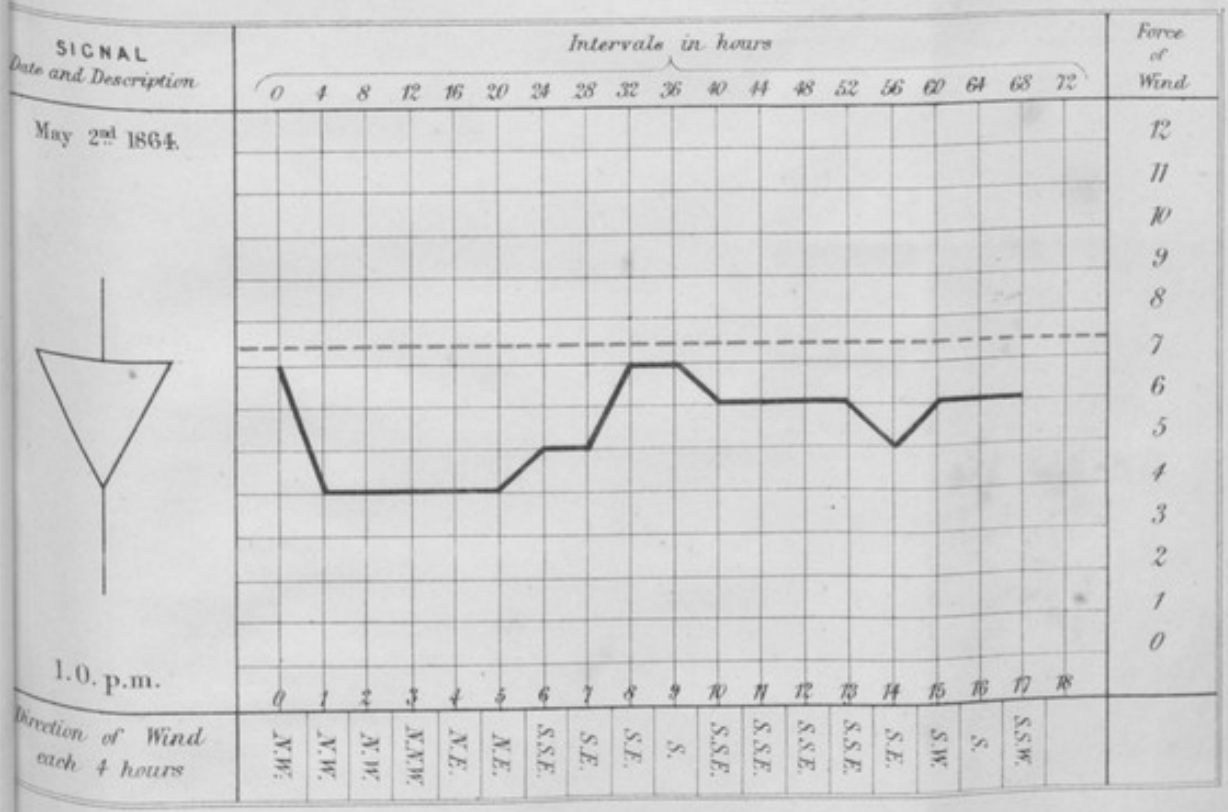
Aberdeen	25	–	–	–	–	2	1	–	6	9	3	–	1	3	2	–	1	4	1	1	–	16	2	10	5	1	16
Galway	32	–	–	–	–	2	1	8	4	15	–	2	2	4	1	2	–	2	3	1	–	17	3	7	10	–	17
Harwich	23	–	–	–	–	–	1	1	11	13	–	1	2	2	–	–	–	2	–	3	–	10	2	7	3	–	10
Holyhead	28	–	–	–	–	1	5	5	9	20	–	1	2	1	–	1	2	–	–	1	–	8	3	4	4	–	8
Plymouth	23	–	–	–	–	1	2	7	4	14	1	1	2	–	–	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

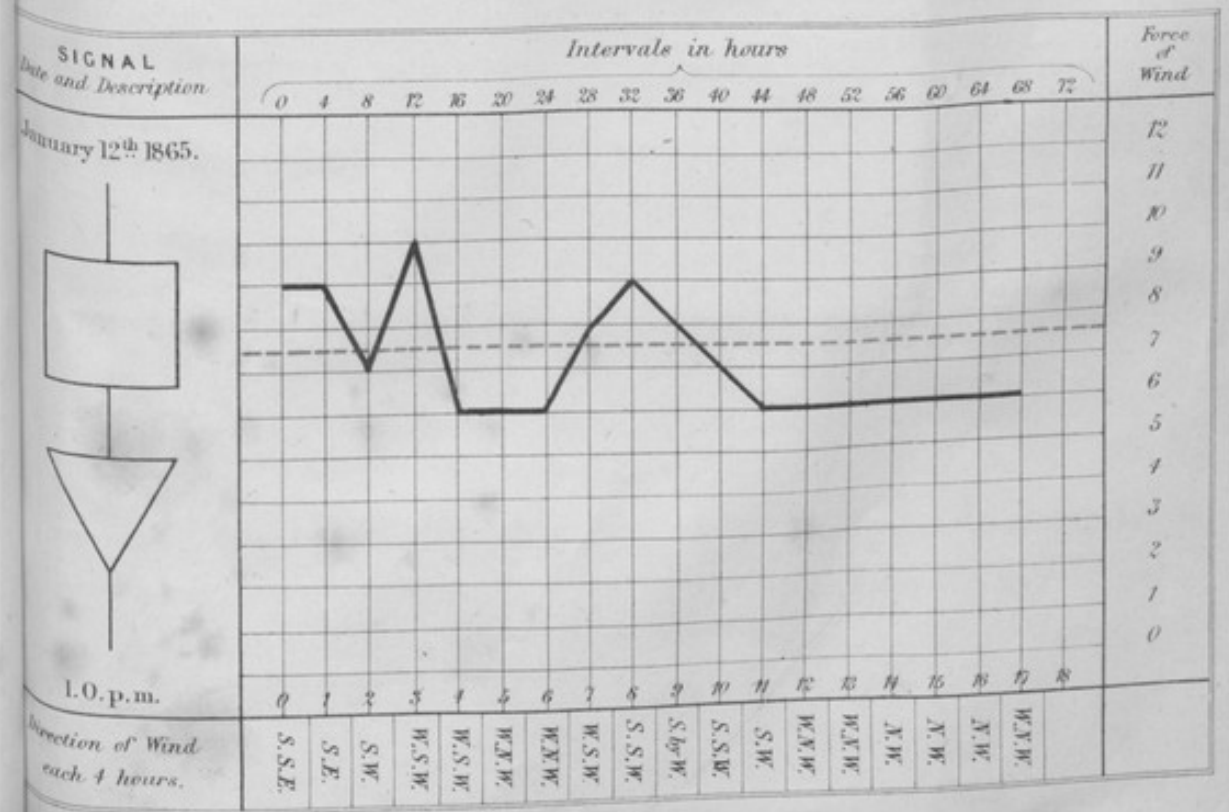
Table 3.—January 1st to December 31st, 1865.

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





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.

REPORT

OF THE

METEOROLOGICAL COMMITTEE OF THE ROYAL SOCIETY,

For the Year ending 31st December 1867.

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

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

1868.

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CONTENTS.

REPORT

OF THE

METEOROLOGICAL COMMITTEE OF THE ROYAL SOCIETY,

FOR THE YEAR ENDING DECEMBER 31, 1867.

In this their first Report, the Meteorological Committee of the Royal Society propose to give a history of their appointment, to explain their constitution, and the general functions they are called upon to exercise, as well as to show how the funds placed at their disposal have been expended.

The somewhat complicated history of the office that preceded them, i.e., the Meteorological Department of the Board of Trade, formerly presided over by Admiral FitzRoy, has already been fully described in a Report by the Committee of Inquiry nominated by the Royal Society, the Board of Trade, and the Admiralty respectively, which was printed and presented to Parliament in 1866,* and to these pages is appended the whole of the subsequent correspondence that has passed between the Board of Trade and the Royal Society.

The following brief statement will be sufficient to explain the general purport of that correspondence, and the steps by which the Meteorological Department of the Board of Trade became superseded by the Meteorological Committee of the Royal Society.

On Aug. 30, 1866,† the Board of Trade stated that they and the Admiralty were prepared to support the course proposed in the Report of the Committee of Enquiry, but before taking further steps, they desired the opinion of the President and Council of the Royal Society thereupon. On Oct. 27, 1866,† the President and Council of the Royal Society sent their reply, of which the greater part is here reprinted, because the Report of the Committee of Inquiry, as modified by this letter, defines the constitution

* Report of a Committee appointed to consider certain questions relating to the Meteorological Department of the Board of Trade. 1866.

The Committee was appointed at the request of the Board of Trade, and consisted 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.

† App. II.

and functions of the Meteorological Committee of the Royal Society.

EXTRACT FROM THE LETTER.

a. The President and Council entirely concur in the opinion of the Committee (viz., the Committee of Inquiry), that "the collection of observations from captains of ships is a function which can probably be best performed through the medium of such agencies as a Government office can command."

b. The President and Council also concur with the Committee in the opinion that "the digesting and tabulating results of observations is 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." They believe that this "would be much better, as well as more economically, performed under the direction of a scientific body, furnished with requisite funds, than it will be if left to a Government department." They would, however, limit the sea observations to those collected by British observers, and the land observations to those made within the British Isles, including those made at the lighthouses and coastguard stations. The President and Council assume, with the Committee, 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."

c. The President and Council, referring to the 4th paragraph in § 45, are of opinion that the reduction of a considerable amount of arrears of observations, both at sea and on land, will probably be desirable, and that it "may be placed in the same hands in which the future discussion of meteorological observations is placed."

d. In reference to the 5th paragraph of § 45, as to the issuing of storm warnings, the President and Council do not concur in the recommendation that the issue of storm warnings should be placed under the superintendence of the scientific body under whose direction the meteorological observations are discussed. At present these warnings are founded on rules mainly empirical. In a few years they may probably be much improved by deductions from the observations in land meteorology, which will by that time have been collected and studied. The empirical character may thus be expected to give way to one more strictly scientific, in which case the management of storm warnings might be fitly undertaken by a strictly scientific body.

It must not be forgotten that storm warnings did not originate in any recommendation from the Royal Society. If their present continuance be deemed of sufficient importance by the Government, it must be for them to consider the means of carrying them on.

e. The President and Council consider, with the committee, that the publication of results of meteorological observations at sea, referred to in the 6th paragraph, § 45, of the Report, is a function properly belonging to the Hydrographic Office of the Admiralty. It would seem desirable, therefore, that the Hydrographer should himself be a member of the superintending committee.

3rdly, You ask for a detailed statement of the establishment which will be necessary at Kew, for the purpose of receiving and discussing Meteorological Observations.

4thly, A similar statement with respect to local observations in the United Kingdom.

5thly. An estimate of the cost of both.

The President and Council have no reason to question the general sufficiency of the estimate contained in the Report, § 45, p. 40; but any detailed statement, either of the staff required or the amount of salaries to be paid, would be at present premature.

> Finally, You desire to have the views of the President and Council with respect to the body under whose management and responsibility the establishments in question should be placed.

The President and Council consider that the department under whose care the observations, reductions, and tabulations are to be made should be under the direction and control of a Superintending Scientific Committee, who should have (subject to the approval of the Board of Trade) the nomination of all appointments, as well as the power of dismissal, of the several officials receiving salaries or remuneration.

The services of the members of this committee will be gratuitous, but they would necessarily require the assistance of a competent paid secretary, whose salary will be included in the estimates requested.

Should the nomination of the Superintending Committee be entrusted to the President and Council, they would be prepared to recommend gentlemen competent to undertake the duties.

The Board of Trade thereupon issued a circular dated Nov. 9, 1866,* to suspend the issue of Storm Warnings and they wrote on Dec. 5, 1866,* stating that the Board of Trade, the Admiralty, and the Treasury agreed to the original proposals, (viz. those of Aug. 30, 1866,) subject to the modifications proposed by the President and Council of the Royal Society in their letter of Oct. 27, 1866, and just quoted. Thereupon the President and Council of the Royal Society passed a resolution and communicated it to the Board of Trade on Dec. 15, in the following words.*

"Resolved,—That a Standing Committee be appointed for the purpose of superintending the Meteorological Observations to be made for the Board of Trade, in accordance with the foregoing letter.

"That the following gentlemen be nominated as members of this Committee:—

" Lieut.-General Sabine,
" Mr. Gassiot,
" Dr. W. A. Miller,
" Mr. De la Rue,
} Members of the Kew Committee.

" Mr. Francis Galton,
" Mr. W. Spottiswoode,
} Officers of the British Association.

" The Hydrographer to the Admiralty.
" Colonel Smythe.

" That this Committee place themselves in communication with the Board of Trade.

" That in the event of a vacancy occurring in the Committee, the fact be communicated to the Council of the Royal Society in order that they may appoint a new member."

The Meteorological Committee above named met, for the first time, at Burlington House, on the 3rd of January 1867, and at

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* App. II.

once selected the following gentlemen to fill the superior offices at the disposal of the Committee :—

Mr. Robert H. Scott, Director of the Office.
Capt. Henry Toynbee, of the Mercantile Marine, as Marine Superintendent.
Mr. Balfour Stewart, as Secretary to the Committee and Director of the Normal (Kew) Observatory.

On the 7th February, Mr. Scott took charge of the office,* which since that date has been conducted under his superintendence.

Functions of the Committee.

The functions of the present Committee are divided into three great branches.

I. *Ocean Meteorology.*—The object of this branch is to deduce the meteorology of all parts of the ocean from observations made by ships. The surface of the ocean is conventionally portioned off by lines of latitude and longitude into a vast number of sections, and the meteorology of each section is discussed as though it were an independent district. The issue of instruments to ships is also undertaken by this branch.

II. *Telegraphic Weather Information.*—This branch of the functions of the Committee comes most prominently before the public, but it must not therefore be assumed that it is the most useful or important part of their work.

III. *Land Meteorology of the British Isles.*—The new feature of this branch consists in the establishment of seven land observatories provided with self-recording instruments. Its object is two-fold; first, to give accurate data for a discussion of the law of storms and weather changes; and, secondly, to ascertain meteorological constants, thereby performing with great precision for the land stations that which is accomplished with moderate precision by Branch I. for the entire ocean.

I.—Ocean Meteorology.

The method adopted by the office as regards the collection of statistics bearing on ocean meteorology, has been to lend to captains in the mercantile marine, instruments which have been verified at Kew, and which are returned for re-comparison with

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* The office at this date was in charge of the Chief Clerk, Mr. Simmonds, as Mr. T. H. Babington, who had superintended it since the death of Admiral FitzRoy, had left it at the beginning of December 1866.

standards as soon as the voyage is completed. Captains are also permitted to purchase any of these instruments at cost price.

The complete set of instruments now issued is,

1 Barometer (Kew pattern),
6 Thermometers,
1 Thermometer screen,
4 Hydrometers,

and in exceptional cases, an azimuth compass.

The observations are recorded in registers prepared in close accordance with that adopted at the Brussels Conference in 1853.

In addition to this duty, the office has from its first establishment, undertaken the entire responsibility of supplying Her Majesty's Navy with meteorological instruments, a special grant being sanctioned by the Admiralty for this purpose.* In the case of such supply, the duty of returning kept registers to the office is not compulsory. However, some of the most valuable registers which have been received have been kept on board ships belonging to the Royal Navy.

The "Committee of Enquiry" in their Report went at some length into the method adopted by the office for the discussion of such returns, and gave a list of the results, which had been published by the late Admiral FitzRoy in the form of "Meteorological Papers" (of which 14 numbers in all appeared†) and also of the work on this branch of the subject which was in progress at the date of their enquiry.

When the Committee took charge of the office the only portions of this work which were still in hand were the discussion of data for sea surface temperatures in the South Atlantic, and for wind charts for the South Pacific.

These were completed before the end of March, and the staff of the office were set free to commence operations on a system which was a modification of that which had previously been followed.

The method suggested by the "Committee of Enquiry" was, that each set of observations should be copied on a separate card, bearing once for all, a reference to the register, the date and hour, and the latitude and longitude. By this means all the information contained in the registers would be transferred to cards with more certainty and at less expense of time and trouble than if each separate element were extracted on a different sheet. The adoption of cards had another apparent advantage, viz., the facility which it afforded for the sorting or grouping of the materials in any order which might be desirable for the purpose of any special investigation.

In order to test this method thoroughly, a large supply of such cards was procured, and about 700 were filled up. By this means the rate at which the observations could be entered on them was

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* See page 25.

† See Report, pp. 13, 14.

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fairly tested, as well as the facilities for sorting and grouping which were really afforded by the fact of the cards being loose and separate. It was found that the rate at which observations could be transferred from the register to the cards was a slow one; that it was very troublesome to re-extract any element such as the readings of the barometer from such cards, for the purpose of special investigations; and, lastly, the conveniences for sorting and grouping were more than counterbalanced by the difficulty of managing so large a number of loose documents.

It was finally resolved to abandon this plan, and in place thereof to extract into large *data* books, ruled in columns corresponding closely to those of the registers. A specimen of such a book is given in App. III. Its pagination has been devised on the following plan. The surface of the globe has been divided into spaces comprising 10 degrees of latitude and longitude, which are called 10 degree squares, from their shape, which is rectangular on a chart on Mercator's projection. Each of these spaces comprises 100 single degree squares, and each opening of a data book corresponds to one of these smaller divisions. Thus each 10 degree square requires 100 openings of a data book which are numbered from 00 to 99. Each of these books corresponds to one month

f. 61

It is hoped that the advantages which this plan offers in the way of simple systematic arrangement, and of facility of reference to volumes bound and uniformly paged, will more than compensate for the temporary convenience, as to sorting and grouping for any special investigation, afforded by the method of cards. It is also evident that by this system results can, if necessary, be obtained for spaces of one degree square, while there is no difficulty in throwing a number together so as to obtain means for larger areas in parts of the ocean where minute subdivision is not requisite. It seems scarcely necessary to make provision for a subdivision of the space into smaller areas than single square degrees, as there is always an amount of uncertainty about a ship's position; more especially when this has been interpolated in the entry in the data book, as in general it must be for all observations except those taken at noon. However, the data books contain, for each observation, an entry of the exact position of the ship, as far as it could be ascertained, so that all possible minuteness of subdivision is attainable.

A scheme of extraction having thus been selected, the next step was to choose the district on which operations should be commenced. The region chosen was that part of the Atlantic which lies between the parallels of 20° N. and 10° S. Its northern limit is permanently within the region of the north-east, and its southern of the south-east trade. Between these trade winds is included the belt known familiarly as the "Equatorial Doldrums," whose annual oscillation in position extends from the neighbourhood of the equator to about the parallel of 15° N.

It is evident that the periodical changes which take place in

this part of the ocean could not be traced, unless the observations were subjected to such a minute examination as is requisite in order to obtain monthly means for single square degrees.

It is hoped that, by means of this investigation, a solution may be furnished to the question so frequently asked by Commanders who have kept registers for the Meteorological Department, viz., what is the best route for crossing the equator in each month? The registers of one month abound with bitter complaints against the westerly route, while those of another month are as full of its praise.

Again there seems to be a space lying to the westward of "south-west monsoon of the line," on the coast of Africa, which at certain seasons should be avoided, as it is found that ships in this space have been doing little or nothing, while those further to the eastward have made good way to the southward.

A very cursory examination of the registers is sufficient to show that, similarly, at certain seasons of the year ships, bound to the southward, should avoid the coast of South America, or else their passage will be prolonged quite as much as it would be at other seasons by their keeping too close to the African coast.

It seems also probable that by investigating the region lying to the eastward of the West Indian Islands it may be possible to trace the origin of some of the hurricanes with which those Islands are so frequently visited.* During the hurricane season it has been found at times that ships passing to the westward of the Cape Verde Islands, have felt a south-east gale, which may turn out to have been the north-east quarter of one of these storms, which are seldom noticed until they travel many degrees to the westward of the meridian of the Cape Verdes.

Lastly, much has to be learnt with reference to the currents of this part of the sea, especially in the Gulf of Guinea.

We find the Guinea current with a temperature of 80° or 90° running to the eastward, while in close proximity to it, on its southern edge, we meet the equatorial current running to the westward with a temperature of 70° or even lower. One very careful observer has recorded a temperature of only 66° in the Guinea current itself, showing that variations in surface temperature, similar to those known to exist in the Gulf Stream, are traceable in this current, so close to the equator.

The question of the surface temperature of the sea, the discussion of which throws such an important light on the course of ocean currents, has also attracted the notice of the Committee in a special way. In order to collect materials for a more comprehensive investigation of this subject, it was resolved to make application to the principal lines of Transatlantic steamers. The appeal was met with the utmost readiness by the respective directors, and before the end of the year several lines of steamers

* They make their first appearance at the Windward Islands as cyclones completely developed, and therefore must have taken their rise somewhere within the district under discussion.

were engaged in making regular observations in aid of this enquiry.*

It is hoped by this means to obtain within a brief period of time a mass of material which will be beyond comparison more complete than any which has as yet been collected.

The former investigation in this direction which had been undertaken by the office was unfortunately on a plan which hardly admitted of the results being turned to practical use in the tracing of currents.

The observations had been discussed with the view of giving monthly mean temperatures for each five degree square. But in certain parts of the ocean the boundaries between currents of very different characters are very sharply defined; so that if observations taken in different currents are thrown together, as they must be in taking means for so large a space, the phenomena would be entirely masked.

The Royal Meteorological Institute of the Netherlands in its Ocean Temperature Charts published in 1865,† has taken the means for strips of 5° longitude and 1° latitude. This method offers an obvious advantage in tracing the course of currents which flow in an east and west direction. Even this subdivision is very far from being minute enough for all purposes, and accordingly the method now followed in the office will render it possible to prepare single degree charts, should such minuteness be required, as most probably will be the case. The Dutch Institution is at present engaged in the preparation of temperature charts for single degree squares, for the region lying around the South of Africa.

In order that the whole of the work which has been already done in the office in the direction of Sea Temperature, should be rendered available to the public, and that at the same time the results already obtained in Holland should be published in a form acceptable to English readers, it was resolved to prepare for the South Atlantic Ocean, monthly charts containing all the information contained in the Dutch charts reduced to the Fahrenheit scale, together with the means for five degree squares obtained from the discussion of the Board of Trade registers. These charts are now being lithographed, and will be supplemented by copious notes, consisting of extracts from the registers of any captains who have recorded sudden changes of temperature or other remarkable phenomena, bearing on the question under discussion.

It will be seen that such a publication does not in any way interfere with the future preparation of more perfect charts. Inasmuch as the materials already extracted could not be made use of for any spaces smaller than 5° squares, without referring in each instance to the original register, the Committee have deemed it advisable to print these charts in their present condition, with

* Those at present engaged, (April 1868,) are The Royal Mail Steam Packet Co., The British and North American Royal Mail Co., The Liverpool, New York, and Philadelphia Screw Steamship Co., The Panama and New Zealand Royal Mail Co., The African Steamship Co., The Cunard Line (Halifax to Bermuda), and Messrs. Lamport and Holt's Line to the Brazils.

† Ondersoekingen met den Zeethermometer; Utrecht, 1861.

the hope of hereafter bringing forward others more commensurate with the ample materials which already exist, and which are rapidly receiving additions.

The other investigations which had been left in an unpublished state by Admiral FitzRoy consisted chiefly of wind data for the Atlantic, and of general meteorological information for the Pacific Ocean and China Seas. The various parts of this vast region were very unequally represented. For portions data had been obtained for each month in the year, while in other parts the work had barely been commenced, owing to want of material.

It was determined to print the Atlantic wind data in a tabular form, and to publish some portion of the information concerning the Pacific. As a commencement the south eastern portion of the Ocean lying along the coast of South America, the China Seas, and the neighbourhood of Vancouver Island were taken up. It is hoped that all these various publications will be presented to the public in the course of this summer.

It will at once be seen that the immense number of registers, upwards of 2,000, which have accumulated in the office, and of which the amount is continually increasing, renders it quite impossible for the office, with its limited staff, to make much impression on the mass of observations which they contain, so that some time must necessarily elapse before the materials for the comparatively small district now under investigation, are ready for discussion.

The maximum rate of extraction from the registers into the data books, allowing for the necessary corrections to the latitude and longitude, and to the readings of the instruments, &c., has been found to be 45 sets of observations, per day of six hours, for one person.

For the district under discussion each register yields on an average 90 sets of observations on the outward and as many on the homeward voyage. Thus each Register would require four days for its complete extraction.

If the discussion of 1,000 Registers be considered as enough to give mean results of sufficient accuracy for the area under investigation, it appears that its completion will require 4,000 days. The statement in App. VII. shows that only three persons can be spared for this duty, and of their time a third part is diverted to the preparation of the Daily Weather Reports. Accordingly the Committee are obliged to state that unless they are enabled to increase their available staff for this service, which the funds at their disposal will scarcely allow them to do, there is but little chance of results being published for the space of upwards of four years.

The Committee have accordingly met with the greatest promptitude the proposal first made by Mr. Meldrum, the Secretary of the Meteorological Society of the Mauritius, that he should be allowed to obtain copies of certain observations bearing on the district of the Indian Ocean to which his attention has been more especially attracted. According to the practice now established, any public body that wishes to discuss any unpublished meteorological information which is in the office can obtain it,

by stating the nature of the information required, and the object for which it is wanted, and by paying the expense of copying. The Scottish Meteorological Society has already availed itself of the facilities afforded, and materials have thus been supplied to them in aid of an investigation of storms in North America, which has been undertaken by Mr. Buchan, the secretary, by direction of the Council of the society. The Meteorological Committee of Calcutta, whose secretary Mr. Blanford, was in England in the course of last summer, have expressed their intention of following Mr. Meldrum's example, and they have already received some information bearing on the cyclone of October 1865, and have applied for similar information as regards the cyclones of the latter part of 1867. Lastly, M. Le Verrier, acting on behalf of a scientific association in France,* having asked for copies of observations made in the Atlantic, to aid in the preparation of his synoptic charts of the year 1865, has received all the information which it was in the power of the office to afford him. In this case the Committee have not considered it necessary to require M. Le Verrier, to whom they are indebted for most cordial co-operation in the work of international meteorological telegraphy, to bear the cost of copying the documents.

By affording, in this manner, facilities of access to the information which they have better opportunities of collecting than any one else, the Committee hope that results may be published in a far shorter time than if such materials had been retained exclusively in their own hands.

The Committee would, before concluding this portion of their report, subjoin the statement of the number of instruments at present in use in Her Majesty's Navy and in the Merchant Service.

INSTRUMENTS supplied &c. to the Royal Navy.

——	Barometers.	Aneroids.	Thermometers.	Hydrometers.
Jan. 1, 1867, afloat -	216	406	866	316
Issued in 1867 - -	63	112	270	69
	279	518	1,136	385
Returned in 1867 (including damaged instruments) - -	67	98	255	152
Jan. 1, 1868, afloat -	212	420	881	233

These instruments are those at present in use in the Navy. As has already been explained, each ship of war is supplied with instruments by the office out of the grant sanctioned by the Admiralty. Such instruments are not necessarily employed for the purpose of supplying data to the Meteorological Office, being required as a portion of the regular outfit of the ship.

* L'Association Scientifique de France.

INSTRUMENTS supplied to the Mercantile Marine.

——	Barometers.	Compasses.	Thermometers.	Hydrometers.
Jan. 1, 1867, afloat -	46	18	226	133
Issued in 1867 - -	48	12	268	174
	94	30	494	307
Returned in 1867 including damaged instruments) - -	36	12	162	87
Jan. 1, 1868, afloat -	58	18	332	220

As regards the amount of information which reached the office, the number of Meteorological documents received in 1867 was 68, being a decrease of 59 on the number sent in during the previous year.

Of these documents 41 were reports from foreign lighthouse stations, &c., so that only 27 were *bonâ fide* Meteorological Registers.

The number of merchant ships supplied was 37 as against 24 in 1866. It appears from the foregoing return that a larger number of instruments was issued than would be required for that number of ships. The discrepancy arises from the fact that some of the instruments were supplied to the steam companies for their respective vessels, and were not actually at sea before December 31.

In App. IV. will be found a list of the Meteorological documents received in the course of the year 1867.

The Committee have thought it best, for the present, not to be too anxious to collect information, inasmuch as the staff at their disposal for its discussion is already entirely insufficient, for some time at least, to complete the investigation of the materials already accumulated in the office.

II.—TELEGRAPHIC WEATHER INFORMATION.

The issue of daily telegraphic weather reports had been set on foot by Admiral FitzRoy in the year 1860 (See his Report published in 1862). The main features of the plan were as follows: A number of stations situated on the coasts of the British Islands, and possessing telegraphic communication with London, were selected, and arrangements were made with the Electric and the Magnetic Telegraph Companies, for observations to be made at these stations by their officers at 8 a.m. and reported daily to London. The instruments supplied were two barometers (Kew pattern), two ordinary thermometers, a maximum and a minimum thermometer and a rain gauge. The number of these stations at present in operation in Great Britain and Ireland is 18, viz., nine in England (North Shields, Scarborough, Yarmouth, London, Portsmouth, Weymouth, Plymouth, Penzance, and Liverpool), one in Wales (Holyhead), four in Ireland (Greencastle, Valencia, Cape Clear, and Roche's Point at the

mouth of Cork harbour), and four in Scotland (Nairn, Aberdeen, Leith, and Ardrossan).

Up to the date at which the Committee assumed the superintendence of the office, no inspection of any kind had been undertaken with the view of ascertaining either the position of the instruments at these stations, or the capability of the observers to report correctly. The stations were all visited in the course of last summer, and were found to be in urgent need of inspection. In three instances the thermometers were kept under the roof of a railway station, and in one case in a box which was almost completely closed. Thermometers were found coated with dust, and as for the wet bulb thermometer it was only properly managed at one station. In one case this latter instrument was found completely coated with carbonate of lime, and in another with its bulb totally immersed in water. The wind reports were given sometimes by true and sometimes by magnetic bearings, while the force was estimated by the merest guess work. In several instances, the clerks stated that they had never received any instruction in this special duty of reporting, and were totally unaware that their reports were necessarily untrustworthy owing to the situation of their instruments.

Since the date of the inspection the quality of the reports received has improved to a remarkable extent, and there is fair reason to hope for still greater improvement.

In addition to the information derived from British sources, arrangements have been made with the French authorities for the regular interchange of meteorological intelligence.

M. Le Verrier, to whose unceasing efforts the establishment of international telegraphy is in a great measure due, has organized a system by means of which he receives reports from various European stations for publication in the daily bulletin of the Observatoire Impérial.

To him the office has sent reports daily from Nairn, Scarborough, Yarmouth, Penzance, Valencia, and Greencastle, and, in addition, an afternoon report from Valencia, and it sends also by telegraph to the Ministry of Marine in Paris a daily abstract of the information received from British stations.

In return for these services the office receives from M. Le Verrier daily reports from Skudesnaes, the Helder, and Corunna, and from the Ministry of Marine reports from Brest, Lorient, and Rochefort.

On application being made to M. Le Verrier in the month of November to furnish information from stations situated in the interior of the continent, he has with the utmost readiness acceded to the request, and has promised daily reports from Paris, Brussels, Strasbourg, and Lyons, only requiring in return an afternoon report from Greencastle.*

* This system was set in operation at the beginning of January, and since that date the Ministry of Marine has also readily consented to send reports from three additional stations, viz., Cape Gris Nez, Biarritz, and Cape Sicié near Toulon, without requiring any additional information in return.

In the course of the month of November, the Committee received from Mr. J. C. Deane, Secretary of the Anglo-American Telegraph Company, a letter in which he stated that he had received authority from the Directors of that Company to offer a daily service of meteorological reports from Heart's Content in Newfoundland, on terms which were beyond all comparison lower than the regular tariff charged by the Company.

This munificent offer was accepted by the Committee on the understanding that if copies of such messages were sent to any foreign government, the government in question should be required to contribute to the expense of transmission; the amount so contributed to be added to the sum payable by this office to the Company.

The French Government have been induced by M. Le Verrier to accede to the proposal, and have consented to pay a proportionate amount.

Arrangements have accordingly been made to try the service on these terms for a period of three months. It will then, it is hoped, be seen whether the value of the intelligence received is commensurate with its cost, and consequently whether or not it is advisable to conclude more permanent arrangements.

It appears by reference to the list of stations that, while the coast of England is very well represented, additional stations, especially in the West and North of these islands, would be desirable in order to render the system more complete. The choice of situations is of course limited by the necessity of the existence of telegraphic communication; but among the most obvious positions which supply this condition the Committee may name Pembroke, Galway or Westport, Oban and some station on the east coast of Sutherlandshire; Wick is at present beyond the telegraphic area.

The annual cost of such stations, especially of those in Ireland, is considerable, and the Committee regret that the funds at their disposal afford no present prospect of increasing their number, at all events within the coming year.

In one particular, however, they think it necessary to make an exception. Reports were formerly received from Heligoland, but the direct telegraphic communication with that island has been interrupted for more than two years. The only station on the eastern coasts of the North Sea which at present sends reports to London is Skudesnaes, and accordingly the Committee are in treaty with the newly established Norddeutsche Seewarte at Hamburg for the supply of daily reports from Cuxhaven, to be sent at the expense of this office, unless the town council of Hamburg should be disposed to receive in exchange daily reports from a British station.

The "Committee of Enquiry" in their Report entered into a minute discussion of the agreement of the "Storm Warnings" and the "Weather Forecasts" issued by the Meteorological Department of the Board of Trade with the weather subsequently experienced. This comparison, in the case of the

Weather Forecasts, as applied for one month, December 1865, was decidedly unfavourable. As to the Storm Warnings it appeared that on an average of three years, ending April 1st, 1865, the per-centagesof correct warnings were 75 per cent. as to *force*, but only 38 per cent. as to *direction*. Subsequent to the publication of the report, Captain De Rostaing, chief of the Meteorological Department of the Ministry of Marine in Paris, has published the results of an investigation into the correctness of the warnings issued by the Meteorological Department of the Board of Trade for French ports. He finds that 76 per cent. of the predictions of strong windsissued by the Meteorological Department were fulfilled, while 89 per cent. of the strong winds which were actually experienced on the French coast were foretold by the office in London. It will be seen that a comparison of the warnings with the facts in this precise sense had not been undertaken by the Committee of Enquiry. The results of the two enquiries as to the correctness of predictions regarding the force of the wind are practically identical.

The "Committee of Enquiry" in their Report, section 42, made several recommendations as to this subject, suggesting that the weather forecasts should be discontinued, but the storm warnings retained in a form modified from that which had been the former practice of the office.

The Royal Society, in their letter of October 27th, 1866,* stated:—

"The President and Committee do not concur in the recommendations that the issue of storm warnings should be placed under the superintendence of the scientific body under whose direction the meteorological observations are discussed . . . . . It must not be forgotten that storm warnings did not originate in any recommendation of the Royal Society. If their present continuance be deemed of sufficient importance by the Government, it must be for them to consider the means of carrying them on."

They were accordingly suspended by circular from the Board of Trade dated November 29th, 1866,* and subsequently the Treasury, in a letter to the Board of Trade,† stated "It appears to "my Lords, that if the other branches of the Meteorological "Department are to be transferred to the Royal Society, a very "strong case ought to be made out for the utility of these "warnings, before they could consent to retaining under the "superintendence of the Board of Trade, or of establishing under "some other Government Department, a separate staff for the mere "purpose of continuing them, and they are not disposed, with "the information at present before them, to sanction any expendi-"ture on that account."

As soon as the circular above referred to had appeared, several memorials were addressed to the Board of Trade, praying for the speedy resumption of the storm warnings.

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* App. II. † Parliamentary Paper 240, 1867.

The Committee, early in March 1867, framed a circular in which they expressed their willingness to communicate by telegraph any information which had been received at the office, provided that the parties applying for the intelligence would bear half the cost of its transmission. This was issued to all ports from which memorials relating to the storm warnings had been received.

On the 31st of May the Board of Trade asked the Committee "whether it might not be possible for the Committee appointed "by the Royal Society, upon such conditions and under such "limitations as they may think fit," to give "some warning of "apprehended danger from storms."

The answer of the Committee was couched in the following words:—

Meteorological Department, 2, Parliament Street,
London, S.W., 8th June 1867.

SIR,

IN reply to your letter of the 31st ult., in which you ask "whether it might not be possible for the Committee appointed by the "Royal Society" to give "some warning of apprehended danger from "storms," I am directed by the Committee to state,—

1. Though they distinctly decline to prognosticate weather, or to transmit what have been called "storm warnings," they are collecting information which they confidently anticipate will enable them, sooner or later, to frame rules by which such prognostications can be made; and that one of the main objects which they propose to themselves is the advancement of meteorological science in this important practical direction.

2. That their Observatories for continuous registration are not as yet in practical operation, nor can they be put into operation until the necessary funds have been voted by Parliament.

3. That the stations on the coasts from which reports are daily received by this office, and transmitted by it to the daily papers for publication, are in process of careful inspection, with a view to rendering the observations collected more trustworthy.

4. That, at an early period after commencing their labours, the Committee directed the following lithographed circular to be addressed to all parties applying to the office for information on the subject of storm warnings:—

"SIR,

"I AM directed by the Meteorological Committee to acknowledge the receipt of . . . . and to inform you that this office is prepared to forward each day, by post, to any port which may require it, a copy of the daily weather report, the same as that furnished to the second edition of the London morning papers. This copy will be forwarded free of expense.

"Should the . . . . at . . . require regular or occasional telegraphic intelligence, you are requested to inform them that on receipt of an application stating the precise nature and amount of information required, this office is prepared to furnish, without unnecessary delay, any telegraphic information which it may have received.

"In the case of telegraphic communications of this nature, half of the expense of the transmission is to be borne by the local authorities.

"I have, &c.

. . . . . .

"By order of the Committee, Secretary of the Committee.
"Edward Sabine, Chairman."

5. With the view of collecting and distributing such information, the Committee included a sum of 3,000*l.* in their estimate, and they are willing to communicate information to any accessible place upon the terms laid down in their circular, and to an extent limited only by the sum placed at their disposal for the purpose.

The information conveyed by telegraph to each station would be of the following kind, one uniform signal being hoisted on the coast:—

"Storm from west at Penzance and south coast, hoist signal." Masters of coasters and others, on seeing the signal, might apply to know the nature of the information which had been received from the central office.

I have, &c.

The Secretary,
Board of Trade.

(Signed) Robert H. Scott,
Director.

The further correspondence on this subject will be found in Appendix V.

The Committee, on receipt of the letter of May 31, took in hand the devising of a simple system of signals which should convey intelligence of facts. The combinations of drums and cones which had been employed by Admiral FitzRoy in his system of storm warnings were inadmissible. The object for which these were intended was solely to convey an intimation of the wind which was likely to blow at the station where the signals were hoisted. The object to be attained by the new signals was to convey to one station intelligence of the wind which was blowing on a certain line of coast, and also of the locality where that wind was blowing.

Accordingly a more complicated system was requisite for the latter than for the former purpose.

The Committee ultimately resolved to adopt provisionally an apparatus devised by Captain Toynbee. This consists of a semaphore, which is intended to show the direction and force of the wind and the district where it is blowing. Specimen semaphores were ordered to be prepared in the course of the autumn with the view of having them tested for a time at some of the principal seaports before the question of their adoption was finally decided. The order was not completed by the engineers to whom it was entrusted before the end of December, so that the trial had not commenced before the end of the year.*

At the end of the month of October, as is shown by the correspondence in Appendix V., the Committee were requested by the Board of Trade to make arrangements for giving some notice of storms, and they resolved to employ the "drum," formerly used by Admiral FitzRoy, as the "Uniform Signal" mentioned in their letter of the 8th of June, at least as a temporary measure, until a more complete system of signals should be finally adopted by them.

* These semaphores were completed in the beginning of February. The Elder Brethren of the Trinity House have kindly consented to allow two to be tested at their Wharf, Blackwall. The Mersey Dock Board have agreed to test one at Liverpool, and the Corporation of Tynemouth to test one at North Shields, so that it is hoped before long that a definite conclusion will be arrived at on this matter.

This determination having been communicated to the Board of Trade, the following circular was issued on the 30th of November:—

TELEGRAPHIC WEATHER INFORMATION.

I AM directed by the Board of Trade to acquaint you that they have been informed by the Meteorological Committee appointed by the Royal Society, that that committee are now prepared to issue, free of cost, to ports and fishing stations which are accessible by telegraph, notice of serious atmospherical disturbances on the coasts or in the vicinity of the British Islands.

The conditions on which these notices will be issued are as follows, viz. :—

They will be forwarded, in each case, as soon as information of the atmospherical disturbance shall have been received at the Meteorological Office, and the ports or fishing stations to which they are to be sent will be determined by the Board of Trade; when the list of places to which notices may be sent has been determined by the Board of Trade, it will rest with the Meteorological Committee, in each case of atmospheric disturbance, to send notices to all or any of those places, as the circumstances of the particular case may appear to the Meteorological Office to be advisable.

When a telegraphic notice of atmospherical disturbance is received at one of the places named on the Board of Trade list, its receipt is to be made public by hoisting one of the late Admiral FitzRoy's drums, and the drum is to remain hoisted for thirty-six hours after the receipt of the telegraph message containing the notice. One telegraphic notice implies that the drum is to remain hoisted for thirty-six hours, and no longer. Should the Meteorological Committee think it necessary that a drum should remain hoisted for more than thirty-six hours, in any case, they will send messages to that effect, and continue them from day to day, so long as it appears desirable, or until the storm shall have abated.

If the authorities at any port or fishing station wish to receive intelligence of atmospherical disturbances, and will undertake to hoist the drum, subject to the conditions named, and subject to such regulations or directions as may from time to time be issued by the Meteorological Office, an application should be addressed to the Secretary to the Meteorological Committee, 2, Parliament Street, Westminster, S.W., in order that the necessary steps may be taken to place the name of the station on the Board of Trade list, and to provide the flagstaff and drum.

It is to be understood that where the place or station can pay for a flagstaff and drum, they will be expected to do so, if a staff and drum are not already provided; and that where it is made to appear to the Board of Trade that no staff and drum are provided, and that the place is too poor to bear the expense, then the cost will be defrayed by the Meteorological Office, with the sanction of the Board of Trade.

But in all cases, whether the first cost of the flagstaff and drum are or are not borne by the local authorities, the local authorities must undertake to bear all subsequent charges connected with the hoisting of the signal, and maintenance of the signal apparatus. The only subsequent expense that will be defrayed by the Meteorological Office, will be the charge for transmission of the notices of atmospherical disturbances.

(Signed) T. H. FARRER.

To this circular a few answers were received before the 31st

December, but the system proposed was not set in operation before the commencement of the new year.*

During the existence of the system of storm warnings as practised by Admiral FitzRoy, a plan was in operation by which the officers of Coastguard, and Receivers of Wreck, made reports to the Board of Trade of the weather which succeeded the hoisting of each signal. These returns were discussed at the Board of Trade, and they afforded materials for the investigation into the correctness of the storm warnings which was carried out by the Committee of Enquiry. The method followed is described in Section 30 of their report.

It is evident that as no opinion as to probable weather proceeds from the office under its present management, no report of the weather which succeeds the hoisting of a signal can afford a test of the correctness of the intelligence sent. This intelligence is simply the communication of an existing fact, of a storm or atmospherical disturbance, such as a great difference of atmospherical pressure in adjacent localities.

Again, if the reports had reference solely to the weather which succeeded the hoisting of the signal, they would give no means of ascertaining the number of times in which intelligence arrived at a port in time to be of practical service to the ships lying there, for the storm might have set in before the message was received.

The Committee, wishing to obtain information on this subject, and also to ascertain to what extent the gales which are felt on these coasts are reported to them by their own observers, have requested the Board of Trade to make application to the Comptroller-General of Coastguard, with the view of obtaining his co-operation in this service. The proposal was met by that officer with the utmost readiness, and a system has been organized by which the officers of coastguard will report to the Board of Trade every gale which is felt at their stations.

These returns will be discussed at the Meteorological Office, and it is hoped that this proceeding will assist in arriving at practical results for the future guidance of those charged with the duty of issuing the weather intelligence.

In order that the additional labour entailed by the service which is just described should not distract the attention of the staff of the office from their duties in the department of Ocean Meteorology to a greater extent than it was previously found necessary to do, the Committee have engaged another clerk, whose sole duties are to attend to the telegraphic intelligence and to the discussion of the coastguard returns.

Meanwhile the earnest attention of those charged with the preparation of the daily weather reports has been directed to the importance of methodizing their labours, so as, if possible, to deduce definite simple conclusions.

A daily weather map has been drawn ever since the date of

* April 1868. The first stations were placed on the list by letters of the Board of Trade dated Dec. 28, and before the end of March upwards of 60 stations were in receipt of intelligence of storms on the terms laid down in the circular.

the letter of June 8th, and it is expected that the systematic weather study thus commenced will be attended with useful results.

The Committee conclude this portion of their Report by giving a brief statement of the condition of affairs as regards Meteorological Telegraphy in this country and on the continent at the end of 1867. In this country the telegrams are received between the hours 10 and 11 a.m., and a Report is furnished for the second edition of the London morning papers. If the circumstances of the case require it, a telegram is sent to the Underwriter's Association, Liverpool, containing information as to the barometrical readings and the direction and force of the wind at certain stations. In the course of the day the complete Report, containing the afternoon telegrams, is supplied to the newspapers for publication in the issue of the following morning, and copies are forwarded by post to the corporation of Hull, and to other places.

Telegraphic intelligence of storms is also sent to Prof. Matteucci at Florence.*

In the month of July the office instituted enquiries as to the practice of other countries in this particular. They received replies from France, Holland, Italy, Austria, and Norway.

The question to which replies were requested were these:

1. Is telegraphic intelligence of weather transmitted to ports?
2. Is this of the nature of warning of expected storms?
3. Is such intelligence made public by the use of signals?
4. If so, what is the nature of the signals employed?

The abstract of the letters received in reply will be found in App. VI.

The results of this correspondence may be briefly stated as follows:

In France M. Le Verrier publishes the Daily Bulletin of the Observatoire Impérial containing reports from upwards of 60 stations situated in various parts of Europe. He also gives telegraphic information of existing weather to certain French ports and to foreign countries. In addition the Ministry of Marine receives its own reports, and sends to certain ports a telegraphic resumé of the state of the weather over France.

No signals are employed in France to make known the information received by telegraph.

In Holland, Prof. Buys Ballot, Director of the Royal Meteorological Institute at Utrecht employs an apparatus which is called an *Aeroclinoscope*, which is intended to indicate the difference of atmospherical pressure.

The investigations of Dr. Buys Ballot have led him to the conclusion that the direction of the wind which blows at any station

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December, but the system proposed was not set in operation before the commencement of the new year.*

During the existence of the system of storm warnings as practised by Admiral FitzRoy, a plan was in operation by which the officers of Coastguard, and Receivers of Wreck, made reports to the Board of Trade of the weather which succeeded the hoisting of each signal. These returns were discussed at the Board of Trade, and they afforded materials for the investigation into the correctness of the storm warnings which was carried out by the Committee of Enquiry. The method followed is described in Section 30 of their report.

It is evident that as no opinion as to probable weather proceeds from the office under its present management, no report of the weather which succeeds the hoisting of a signal can afford a test of the correctness of the intelligence sent. This intelligence is simply the communication of an existing fact, of a storm or atmospherical disturbance, such as a great difference of atmospherical pressure in adjacent localities.

Again, if the reports had reference solely to the weather which succeeded the hoisting of the signal, they would give no means of ascertaining the number of times in which intelligence arrived at a port in time to be of practical service to the ships lying there, for the storm might have set in before the message was received.

The Committee, wishing to obtain information on this subject, and also to ascertain to what extent the gales which are felt on these coasts are reported to them by their own observers, have requested the Board of Trade to make application to the Comptroller-General of Coastguard, with the view of obtaining his co-operation in this service. The proposal was met by that officer with the utmost readiness, and a system has been organized by which the officers of coastguard will report to the Board of Trade every gale which is felt at their stations.

These returns will be discussed at the Meteorological Office, and it is hoped that this proceeding will assist in arriving at practical results for the future guidance of those charged with the duty of issuing the weather intelligence.

In order that the additional labour entailed by the service which is just described should not distract the attention of the staff of the office from their duties in the department of Ocean Meteorology to a greater extent than it was previously found necessary to do, the Committee have engaged another clerk, whose sole duties are to attend to the telegraphic intelligence and to the discussion of the coastguard returns.

Meanwhile the earnest attention of those charged with the preparation of the daily weather reports has been directed to the importance of methodizing their labours, so as, if possible, to deduce definite simple conclusions.

A daily weather map has been drawn ever since the date of

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can be foretold by means of a comparison of the barometrical readings at adjacent stations. The apparatus is set each day so as to show the greatest barometrical difference observed that morning between any two of the four stations, Groningen, the Helder, Maestricht, and Flushing.

In Italy, Prof. Matteucci sends a daily resumé of weather, and a red flag is hoisted by day or a lamp by night when there is danger of a storm.

In Austria Prof. Jelinek sends a daily resumé of weather, and a drum is hoisted by day or a lamp by night when there is danger of a storm.

In Norway, Prof. Mohn sends a daily resumé of weather, but no signals are hoisted.

III.—Land Meteorology of the British Isles.

As has been stated above, the arrangements which were in progress for the establishment of observatories in these islands were suspended by the Committee until the date of passing the estimate for the office. Owing to the late period of the session at which this took place it has been impossible to set the system in regular operation before the close of the year. However, three of the observatories, viz., Kew, Stonyhurst, and Glasgow, were at work before December 31.

A full description of the instruments with which the observatories are supplied, will be found at p. 27.

The stations which are now in process of being established are seven in number.

Station.	Superintended by
Kew -	Kew Committee of British Association.
Falmouth -	Royal Cornwall Polytechnic Society.
Stonyhurst -	Council of Stonyhurst College.
Glasgow -	R. Grant LL.D., F.R.S., Professor of Practical Astronomy.
Aberdeen -	D. Thomson, M.A., Professor of Natural Philosphy.
Armagh -	Rev. T. Romney Robinson, D.D., F.R.S., Astronomer.
Valencia -	Rev. Thos. Kerr.

It will be seen that the situations of the stations have been selected with a view to their being as well distributed over the area of the British Isles as was compatible with the existence of an efficient local scientific superintendence. The Committee have as far as possible availed themselves of existing institutions of a similar character, but in the cases of Falmouth and Valencia there were no existing observatories to which they could attach themselves, so that the whole establishment had to be started *de novo*. At Valencia the Committee have had to undertake the entire management and expense of this distant but most important station.* A house has been taken and arrangements have been made to fit it up with the least possible delay.

* April 1868. Five observatories were in operation on the 31st March. A sixth, Armagh, was very nearly ready to commence, and the observatory at

EXPENDITURE.

Before concluding their Report the Committee would subjoin an account of the correspondence which passed with reference to the funds supplied by the Government for carrying out their operations.

The estimate framed by the "Committee of Enquiry" is found at page 40 of their report. It runs as follows :—

	£
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

In addition to an outlay of 2,500*l*., making together 12,950*l*., in addition to a sum not yet estimated for buildings at Kew, which was subsequently found to be 1,200*l*.

In their letter of August 30, 1866, App. II., the Board of Trade expressed their readiness "to adopt and support the course proposed by the above-mentioned Committee," and in a further letter dated December 5, 1866, the Royal Society were informed that it was "desirable that the estimates should be "prepared without delay," and that it was also "important "that no time should be lost in establishing the new system of "operations."

The Committee on the 21st January 1867, soon after commencing their labours, framed an estimate of their probable expenses for the year, and communicated it to the Board of Trade in the subjoined letter :—

SIR, Royal Society, January 21, 1867.

I HAVE the honour to forward an estimate prepared by the Committee for the expenses of the Meteorological Department during the year 1867–8.

As the present estimate must, until the Committee have had more experience into the working and requirements of the department, be considered in some measure an experimental one, it is probable that while some of the items provided for may exceed the sums assigned,

Valencia, being the seventh, had been fitted for the reception of the instruments. Besides these, Mr. Louis Crossley, the well-known meteorologist, has generously undertaken to fit up at his own expense an observatory at Halifax, in Yorkshire, and work it in connexion with the Meteorological Committee—an example which it is hoped may be followed by others.

others will fall short of them; but the committee will be prepared, at the close of the financial year, to render to the Board of Trade an account under the several heads of expenditure, and strictly to confine themselves within the sum total which the Treasury may grant.

The committee desire to express their sense of the responsibility they incur in the judicious management of these funds, and in the management of them, will keep in view the necessity of the strictest economy on their part which may be consistent with the efficient working of the department, for the advancement of science, and for the practical benefit of the public interests.

I have, &c.,

The Secretary,
Board of Trade.

(Signed) EDWARD SABINE,
Chairman of Meteorological Committee.

DRAFT OF ESTIMATES, METEOROLOGICAL DEPARTMENT, BOARD OF TRADE.

YEARLY EXPENSES.

Particulars.	Proposed Expenses for the Year 1867–8.		
	£	s.	d.
Salaries of Officers - - Director - - -	800	0	0
Salaries of Officers - - Secretary to Committee -	400	0	0
Salaries of Officers - - Marine Superintendent -	350	0	0
£143 each — Salaries of Seven Clerks - - - - -	1,000	0	0
Annual expense of eight observatories (including the central)	2,000	0	0
Purchase and repairs of instruments—Mercantile Marine -	300	0	0
Ditto ditto Admiralty - -	400	0	0
Verification of instruments - - - - -	50	0	0
Weather books - - - - - -	150	0	0
Travelling expenses - - - - -	300	0	0
Carriage of instruments to and from the ports - -	150	0	0
Agencies at ports for supplying instruments to ships -	200	0	0
Telegraphs - - - - - -	3,000	0	0
Office and contingencies - - - - -	800	0	0

	£			
Salaries - - -	2,550			
Expenses of observatories	2,000			
Telegraphs - -	3,000			
Books, instruments, &c. -	900		-	£9,900 0 0
Travelling expenses, carriage, agencies, and contingencies -	1,450			

TOTAL - - Nine thousand nine hundred pounds.

SPECIAL GRANT FOR EQUIPMENT, as proposed by the Government Committee in Parliamentary Return.

Particulars.	——		
	£	s.	d.
Instruments for eight observatories - - - -	1,700	0	0
Buildings and alterations at Kew - - - -	1,200	0	0
	£2,900	0	0

TOTAL - - Two thousand nine hundred pounds.

EDWARD SABINE,
Chairman of the Meteorological Committee.

It will be seen that the sum total, 9,900*l.* and 2,900*l.* = 12,800*l.*, proposed, falls below the amount originally named by the Committee of Inquiry by 150*l.*, in addition to the unknown sum stated to be requisite for buildings at Kew.

This estimate was forwarded by the Board of Trade to the Treasury on the 8th February 1867, with a general expression of approval, as the Committee learn from a letter which appears in a Return to the House of Commons (No. 240) ordered to be printed on the 30th April 1867.

The Civil Service estimates appeared in the month of March, and in them the sum proposed for the services formerly performed by the Meteorological Department of the Board of Trade was as follows:—

For Meteorological Observations and Experiments formerly under the Board of Trade to be conducted in future by the Royal Society -		£10,000
For Meteorological Services under the Admiralty		
Instruments - - -	£520	
Verification of Instruments - -	50	
	——	570
		£10,570

The reply of the Treasury to the letter of the Board of Trade bore date April 10, and some correspondence passed with reference to this subject between the Committee, the Board of Trade, and the Treasury.

From this it appeared that the Treasury not only declined to increase the amount proposed in the Civil Service Estimates, (excepting by the sum of 570*l.* "for Meteorological services under the Admiralty,") but stated that they "intended that the arrange-"ments to be made by the Committee should be curtailed "accordingly."

The Committee, on receipt of this communication, at once took measures to stay the arrangements which were in progress for the establishing of self-registering observatories, until such time as Parliament should have decided as to the vote. This branch of their operations was the only material feature of difference between the scheme proposed by them, and that originally carried out by the Meteorological Department of the Board of Trade. They further determined that the negotiations which had been originally set on foot to secure an observatory at Aberdeen and another in the extreme North of Scotland, should not be resumed during the current year, inasmuch as the funds at their disposal would not suffice for the establishment and maintenance of more than six such institutions; viz., Kew, Falmouth, Stonyhurst, Glasgow, Armagh, and Valencia.

It will be seen by their letter of January 23, 1867, p. 23, that they had formerly contemplated the establishment of eight such stations.

The vote, however, was not taken until August 9, and as more than five months of the financial year had then elapsed, the Committee were disposed to consider that the amount of 10,570*l.* would in all probability more than suffice for all the charges to be met before the 31st of March 1868.

Accordingly, when they received through the President of the Board of Trade a letter addressed to him in his capacity of Chancellor of the University of Aberdeen, by the secretary of that university, requesting that the claims of Aberdeen as a meteorological station should not be passed over, they relaxed their resolution respecting retrenchment, in this particular, and agreed to include Aberdeen in their arrangements.*

Summary.—The sum voted by Parliament to the Meteorological Committee for the year 1867 was 10,570*l.* The amount of this vote is considerably less than that named by the Committee of Enquiry, and by the Meteorological Committee itself in their communications with the Board of Trade. It will, however, be seen that although this sum has been spent, the operations of the Committee have not yet received their full developement; they have necessarily been, in the first instance, devoted to the improvement of the observations themselves, rather than to their utilisation. After allowance has been made, according to the estimate, for the issue of registers and instruments to ships, for the maintenance of daily telegraphic weather reports, and for the working of the self-recording observatories, there is a residue of a limited amount for the work of the central office. Accordingly at the present moment, there are only eight clerks to carry on this work, including the extraction and tabulation of an enormous number of observations scattered in log books or otherwise dispersed. The speed with which results can be obtained, especially in the branch of ocean meteorology, is directly dependent on the amount of clerk power. The force that can now be devoted to that branch is only two clerks a day, so that unless provision be made for the employment of additional clerks on this work, the arrears in this branch will be constantly increasing.

The daily telegraphic weather reports are adequately served, but as regards the future discussion of results in Branch III., no adequate provision for clerkship has as yet been made.

The Meteorological Committee, therefore, feel it their duty to prepare the Government for the probable contingency of their having to apply next year for a moderate increase of funds on the grounds of a present insufficient number of their clerks.

The audited accounts of the office for the financial year, ending March 30, 1868, will be found in App. I.

In Appendix VII. will be found a statement of the present staff of officials, and of their several occupations.

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* April 1868. The result has shown that they were scarcely justified in adopting this line of action, for the expenses of the year, including the liabilities outstanding on April 1, 1868, have exceeded the amount voted by the sum of 500*l.*

A Description of the Self-recording Instruments recently erected by the Meteorological Committee of the Royal Society in various Parts of the United Kingdom.

Preliminary.

It is not intended to enter here into an account of the origin and progress of self-recording instruments, nor would it be an easy matter in a case like the present, where each constructor may be imagined to have partly adopted and partly improved upon the labours of his predecessors, to give a historical account that would satisfy all.

The construction of the present instruments was put by the Meteorological Committee into the hands of Mr. Balfour Stewart, the director of their central meteorological observatory at Kew, and by permission of the Kew Committee of the British Association, Mr. Stewart obtained the co-operation of Mr. Beckley, mechanician at Kew, from whom he derived very great aid, and in conjunction with whom he arranged them. In these instruments several devices, due originally to Mr. Francis Ronalds (at one time Director of Kew Observatory), Mr. Charles Brooke, and Mr. John Welsh (late Director at Kew), have been adopted, along with such suggestions as occurred to Mr. Stewart and Mr. Beckley. The anemograph adopted is that devised by the Rev. Dr. Robinson, of Armagh, with certain mechanical modifications by Mr. Beckley.

The self-recording instruments as yet erected by the Meteorological Committee are three in number. There is—

1. The Thermograph, which records continuously the temperature of the air and that of evaporation.
2. The Barograph, which records continuously the pressure of the air.
3. The Anemograph, which records continuously the direction of the wind, and also the space which it passes over from moment to moment.

Principles of Construction of these Instruments.

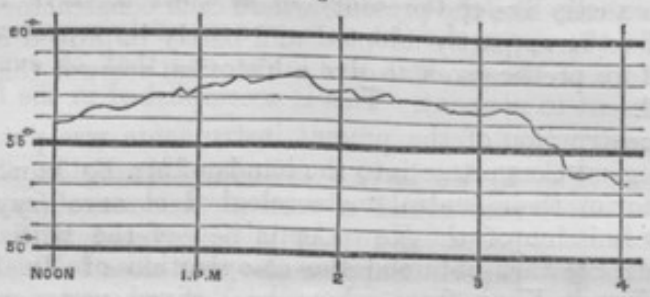
In order to obtain continuous records of any meteorological element, say, for instance, the temperature of the air, two things are obviously necessary:—

1. We ought to have the means of imprinting on a sheet of paper a mark denoting by its vertical distance above a fixed horizontal line on the paper the height of the mercurial column in the stem of our thermometer when the mark was impressed, or, in other words, the temperature of the air at that moment.
2. We ought to have a time-scale, so that by knowing the position of any mark with respect to left and right lines on the paper, we may know the exact moment at which the air had the temperature corresponding to the mark.

If now we have some means, by photography or otherwise, of marking our paper from moment to moment, each mark denoting by its vertical position the height of the mercurial column of our thermometer, and by its horizontal position the time at which this height was attained, we shall have the means of knowing what was the temperature of the air at any moment of time.

This will be seen clearly by looking at Fig. 1—

Fig. 1.



From which we see that the temperature at noon was 55°·8, while at 2 p.m. it was 57°·4. The possibility of producing an automatic record of any meteorological element is thus seen to resolve itself into that of imprinting continuously on paper a mark, denoting, by its vertical position the value of that element, and by its horizontal position the time corresponding to this value.

This mark may be imprinted either by photography or by mechanical means. When it denotes the top of the mercurial column of a thermometer or barometer it is necessary to use photography, but when it denotes the direction of the wind, or the distance which it travels over, a mechanical method of marking is employed, since abundant mechanical power may be derived from the motion of the wind.

Let us now proceed to consider the principles of construction of the instruments separately, beginning with the thermograph.

Principles of Construction of the Thermograph.

This instrument is designed to record continuously the temperature of the air, and that of evaporation, or, in other words, to record the indications of the dry and wet bulb thermometers.

Now, in the first place, as it is always the simultaneous readings of these two instruments that have to be compared together, it is highly desirable that the tracings of the two given by photography should be so arranged as to place the simultaneous indications of the two thermometers, the one exactly under the other, and near it, on the same sheet of paper; both indications will thus have the same time scale. By this arrangement, amongst other advantages, we obtain an excellent graphical representation of the changes which take place in the humidity of the air.

If we refer to the photolithographic facsimile of one of the Kew thermograph curves, Plate V., it will be seen that the depression of the wet bulb temperature below that of the dry, and hence the dryness of the air, is greater at noon than it is at midnight. The hygrometric peculiarities of any sudden change of temperature, such as that exhibited in this facsimile, can also by this means be very clearly perceived.

Thus, as far as temperature is concerned, the problem resolves itself into this:—To obtain on the same sheet of paper two traces, the one exactly under the other, so as both to have the same time scale, the upper one (let us say) accurately representing the temperature of the air, and the lower one that of evaporation from moment to moment. This is accomplished in the following manner:—

Suppose (Fig. 2) we have a cylinder turning at a uniform rate round a vertical axis once (say) in 48 hours, and that it be covered with sensitive paper. Suppose also that close to this cylinder we have a mercurial thermometer of rather wide bore, but having its column broken, a small speck of air separating the upper part from the lower part. It is evident that as the temperature increases the air speck will rise, and as it decreases the air speck will fall.

Fig. 2.

Suppose now that all light is shut off from the sensitive paper which wraps the cylinder, except what may pass through the air speck, and suppose also that there is a flame burning immediately behind this speck. Under these circumstances it is evident that we shall have, upon the part of the paper which is near the thermometer, a small dot of light corresponding in size to the air speck. It is also evident that the vertical position of this dot of light will denote the temperature of the thermometer, while its horizontal position with respect to left and right on the paper will be regulated by the motion of the cylinder, and if this motion be uniform the horizontal position of the dot will accurately denote the time, just as its vertical position will accurately denote the temperature.

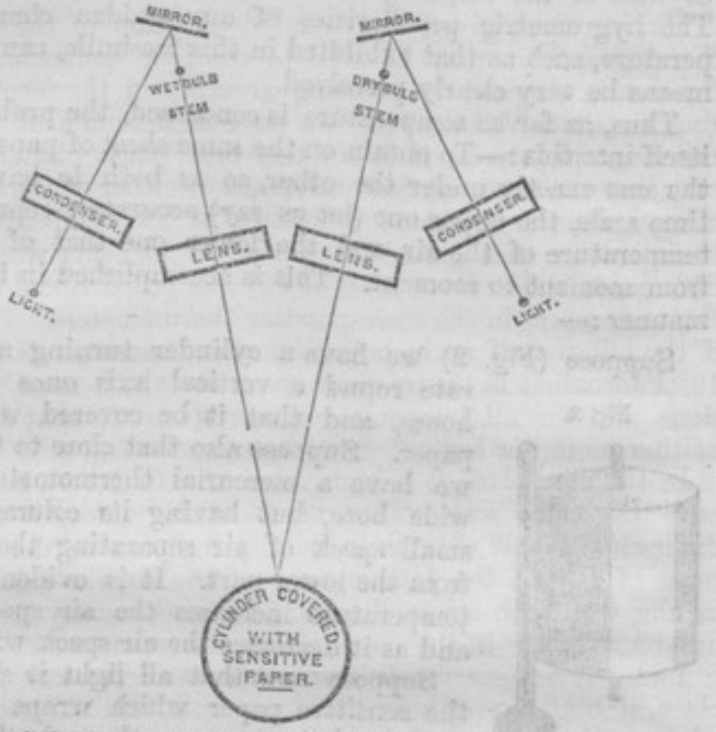
This precise arrangement has not, however, been pursued for several reasons; one of these is that we cannot well by this means have two dots of light, one denoting the temperature of the air and the other that of evaporation, the one vertically under the other on the same sensitive paper, so as to have the same time scale.

It is evident, however, that we may withdraw the thermometers to a considerable distance from the cylinder and from one another, and by means of suitably-placed lenses contrive to throw images of the illuminated air specks the one under the other on the sensitive paper.

It is this plan which has been adopted, and the arrangement

will be easily understood by referring to Fig. 3, in which we have a ground plan of the thermograph. It will be seen that

Fig. 3.



In this figure lights, condensers, mirrors, thermometer stems, lenses, and the cylinder are all supposed to stand vertically above the plane of the paper.

the light first of all passes through a condenser or bull's-eye, after which it falls upon a mirror placed so as to turn the beam towards the stem of the thermometer. The distance is so arranged that the light being in one focus of the condenser, the stem of the thermometer shall be at the other and more distant focus, so that an enlarged image of the light is thrown upon the stem. Virtually, therefore, as far as light is concerned, a very long flame may be supposed to be burning immediately behind the stem, the light being, however, allowed to pass through only at the air speck, the stem being similar to that shown in Figure 2. We have thus an air speck illuminated by a magnified flame of sufficient length to light it up throughout a very considerable range of temperature. Our next object is to throw an image of this illuminated air speck upon the sensitive paper which wraps the cylinder. This is done by means of a lens, by which the portrait, as it were, of the luminous air speck is impressed upon the paper; in fact, by a duplicate arrangement, the portraits of the two air specks belonging to the two thermometers are so impressed. Care must, however, be taken that the image of the speck of the wet bulb thermometer shall always be somewhat below that of the dry bulb for the same moment. This is accomplished by means of an adjustment regulating the relative vertical

height of the stems of the two thermometers, the air speck of the wet bulb having a different height from that of the dry bulb for the same temperature.

Temperature-Scale.

Having thus given a general description of the plan of the thermograph, it may be well to consider somewhat minutely the means adopted for securing accuracy in the results. Referring to Plate V. in which we have a facsimile of one of the thermograph traces, it is in the first place obviously necessary that the same vertical difference in either of the curves shall always denote the same difference in the temperature of the thermometer that gives that curve, or, in other words, vertical differences in the curves must always be proportional to temperature differences in the corresponding thermometers. For instance, if the fall of half an inch in the curve corresponds to a fall of 10° Fahrenheit in the temperature of the air, it must, on all occasions and for all temperatures, correspond to that amount, and neither more nor less.

In the next place, it is highly desirable that both curves should have the same scale value, or, in other words, if the vertical difference of half an inch in the dry bulb curve denotes a difference of 10° in the temperature of the air, the same difference in the wet bulb curve should denote as nearly as possible a difference of 10° in the temperature of evaporation.

Two advantages result from this arrangement. In the first place, if both curves have the same scale, and if on any occasion when both thermometers have the same temperature the wet bulb curve be set under the dry bulb, it will always remain under it, and the two curves will never cross. A good graphical representation of the hygrometric state of the air will thus be given by a glance at the two curves. In the next place, if both curves have as nearly as possible the same scale value, the same tabulating instrument may be used for both in order to convert their indications into numerical results.

In short the two requirements now stated are :—

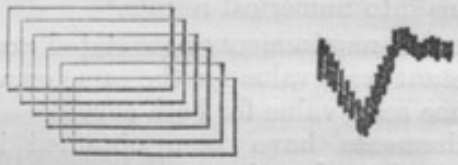
1. A constant scale value for the same curve.
2. The same scale value for both curves.

These requirements have been obtained in the following manner :—In the first place it was necessary to be assured that the bore of each thermometer was uniform throughout, so that for all heights the same space on the stem should denote the same number of degrees Fahrenheit. All the thermometers of the various thermographs had their accuracy in this respect ascertained at Kew. In the next place, it was necessary to have the means of selecting from a number of suitable thermometers a pair of very nearly the same scale value to serve as the two thermometers of the same thermograph. This has been done, and the thermometers have been paired in this manner, or rather, to speak accurately, three thermometers of nearly the same scale value have been thus selected for each instrument, as it was deemed essential that a third should be available in case of accident to either of the other two.

It has already been remarked that what we photograph on the sensitive paper is the image of an air speck which breaks the continuity of the mercurial column in each of the thermometers. Let us suppose that by the above means we have obtained excellent thermometers, nevertheless something more is necessary. We must, by means of suitable lenses, be enabled to throw upon a vertical sheet of sensitive paper, embracing our cylinder, well defined photographic images of the two air specks, and the lenses must be so arranged that the vertical distance travelled over from time to time by the air speck in the thermometer shall always bear a constant and definite proportion to the corresponding vertical distance travelled over by the image on the sensitive paper; thus if for one occasion the range of the air speck in the thermometer be found to be one half of the corresponding range of the image, the former must always be one half of the latter, and neither more or less.

These results have been obtained by a suitable optical combination in the lenses employed. With this object in view we have consulted Mr. Dallmeyer, the well-known maker of photographic lenses, by whom all the lenses of these instruments have been made.* But, in order to secure a good result, it is further necessary that the image of the air speck (and hence the air speck itself) be as narrow as possible, consistently with the amount of light at our disposal; for if the image of the air speck be very broad the various images in their varying positions would overlap one another, and thus produce a bad result. This result would be especially objectionable with respect to a clock arrangement to be presently described. The difference between a wide and a narrow air speck is clearly seen by the following figures, in one of which the breadth of the air speck is exaggerated in order to show the confusion produced by images superposed upon each other, while in the other we have an air speck of ordinary breadth.

Fig. 4.



Time-Scale.

Let us now imagine that by the methods described we have obtained a curve line of good definition and of constant scale value, it is further necessary to have an accurate time scale.

Accuracy in the time scale is obtained in the following manner:—In the first place, it is evident that, if the cylinder does not go round, regularly this will cause an error in the time scale, for the halfway point of the curve will no longer correspond in time to that moment which is halfway between the commencement and end of the observation. But even if the cylinder go regularly

* The other portions of the photographic self-recording instruments were made by Mr. P. Adie.

we have still to guard against any defect in our paper. For instance, the paper may bulge to some extent or fit loosely to the cylinder, or there may be an unequal stretching or contraction of the different parts of the paper, from hygrometric causes, after the image has been impressed upon it. Owing to these circumstances, it may easily happen that the midway point of the curve does not truly correspond to the midway moment of time. A method by which errors of this kind are much reduced has been practised for some time at the Royal Observatory, Greenwich. It consists in cutting off the light (for a few minutes each time) at certain known moments, say three or four times in the course of a day. Corresponding small blanks or gaps in the photographic impression are thus produced of which the exact moments are known, and the line between two consecutive gaps may be supposed to measure the intervening time with sufficient accuracy, for being comparatively short it is not likely to be unequally affected to an appreciable extent by bulging or any other cause.

In the instruments which we are now describing the light is cut off from the photographic paper for exactly four minutes every two hours. This is accomplished by means of a mechanical arrangement, connected with the instrumental clock, devised by Mr. Beckley. A screen is made to intercept the light exactly two minutes before every even hour, Greenwich mean time, as shown by the clock which drives the cylinder, and this screen is withdrawn exactly two minutes after the hour. Of course the success of this method depends upon the correctness of the instrumental clock. Now it has been ascertained at Kew that the thermograph clock, if started correctly by means of a chronometer, will never during the course of 48 hours, which is the duration of a curve, differ more than a few seconds from Greenwich mean time; it is therefore sufficiently accurate for our purpose. The action of the light stop will be clearly perceived by referring to the facsimile of the barograph curve Plate V.

Standards of Reference.

We have now described the method by which we have endeavoured to obtain good and accurate traces, both as regards temperature scale and time scale in our thermograph. It is not, however, enough to obtain lines which may be imagined to be accurate, but it is moreover necessary to institute some check by means of which we may measure the accuracy of these indications. In the case of the time scale this is done by a chronometer after the method we have described. Now just as we use a chronometer or standard timepiece to measure the accuracy of our time scale, so we must employ a standard thermometer to measure the accuracy of our temperature scale.

Accordingly for each thermograph there are two standard thermometers, having bulbs exactly similar in shape and size to those of the thermograph thermometers, with scales which can be easily read. One of these standards is used as a dry bulb, and is fixed near the dry bulb thermograph thermometer,

while the other is used as a wet bulb, and is fixed near the wet bulb thermograph thermometer. The following is the method of observing these standards :—

As often as possible, at the exact moment when the light is first cut off by the clock arrangement, that is to say, two minutes before some even hour, the observer reads the standard thermometer. We know by this means what ought to be the true reading of the curves at the moment when the light is cut off, and hence, by comparing the readings at this moment, as furnished by the curves, with those given by the standard thermometers, we obtain a measure of the accuracy of our instrument.

Method of Tabulation.

The indications of the thermograph, or *thermograms*, are converted into numbers in the following manner:—The tabulating instrument is a sheet of plate glass, engraved on its under side with a series of *vertical lines* each drawn from top to bottom, and the series extending from left to right, and of *horizontal lines* each drawn from left to right, and the series extending from the bottom to the top. The vertical spaces (48 in number) denote hours by the time scale of the thermograph, and the horizontal spaces degrees Fahrenheit by its temperature scale, every fifth line being more deeply etched than the others. These degrees extend, say from 0° to 100°, every fifth one being numbered, and this numbering repeated three or four times in the course of the 48 hours, so that the eye has never to look very far backward or forward for the number of a line. The glass scale is now placed above the curve, engraved side downwards, and is set by those readings of the standard thermometer nearest the beginning and end of the curve. The indications for each hour are then easily read off, and the final accuracy of the result thus obtained is judged of by comparison with the readings of the standards made at certain exact hours. We may state as an index of the amount of accuracy which has been thus obtained, that the mean difference between the tabulated Kew readings and the simultaneous readings of the standards at those hours at which they have been observed, was as follows for the month of November, the first month after the arrangements were complete :—

Mean difference between dry bulb standard and tabulated readings 0°·09, or less than a tenth of a degree.

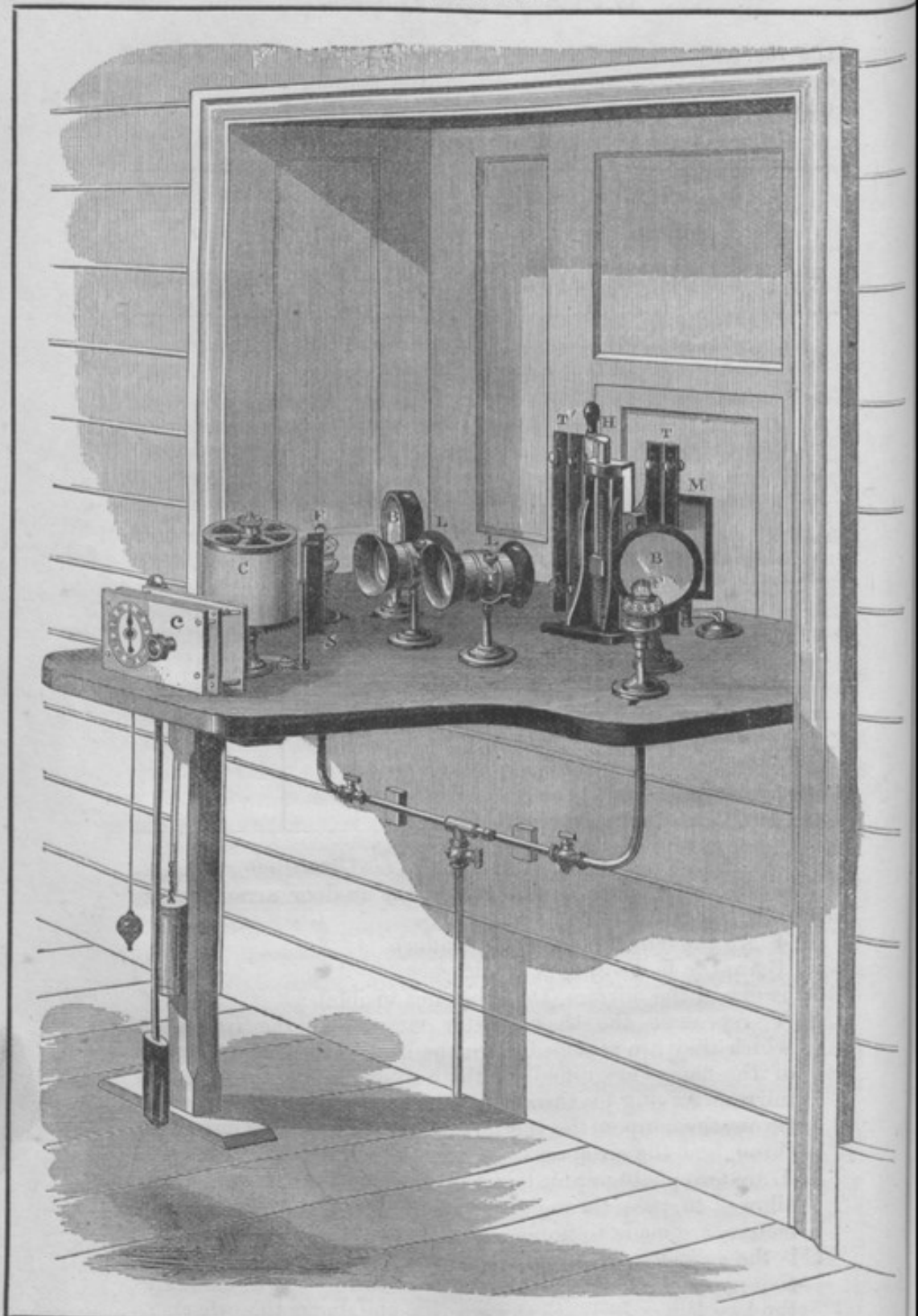
Mean difference between wet bulb standard and tabulated readings 0°·09, or less than a tenth of a degree.*

The following table exhibits the readings for every hour of

* The method of taking monthly mean differences between the simultaneous readings of the standard thermometer and of the corresponding thermograph curves has been adopted as an easy numerical way of ascertaining the accuracy of the results obtained at the various observatories. A similar method is practised as respects the barograph. In the anemograph there is no standard of reference, but when the monthly curves and tabulations arrive at Kew from the various observatories a certain proportion will be carefully remeasured, and a numerical standard of correctness will thus be obtained.

f. 63v

PLATE I.



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the *thermograms* which accompany this account (Plate V.), and records also those observations of the standard thermometers made during the period of time embraced by the curves.

TABLE I.

Date.	SATURDAY, MARCH 7.				SUNDAY, MARCH 8.			
	Dry Bulb.		Wet Bulb.		Dry Bulb.		Wet Bulb.	
Hour. G. M. T.	Tabulated readings.	Standard corrected.	Tabulated readings.	Standard corrected.	Tabulated readings.	Standard corrected.	Tabulated readings.	Standard corrected.
1 a.m.					48·7		47·3	
2					49·0		47·8	
3					49·5		47·6	
4					49·0		47·2	
5					48·4		47·0	
6					40·4		39·2	
7					36·9		35·9	
8					37·3		36·3	
9					39·2		37·5	
10	44·8	44·8	41·1	41·1	40·1	40·3	37·6	37·8
11	47·8		43·0		42·0		37·6	
Noon.	49·3	49·3	44·2	44·2	43·3		37·3	
1 p.m.	50·4		45·0		43·0		37·3	
2	48·7	48·9	44·5	44·5	44·0		37·5	
3	48·0		45·2					
4	47·1	47·0	45·5	45·3				
5	47·0		45·7					
6	47·4		46·3					
7	47·9		46·9					
8	47·8		47·1					
9	48·0		47·2					
10	48·5		47·2					
11	48·3		46·3					
Midnight	48·1		46·8					

In-door Arrangements of the Thermograph.

The sketch in Plate I. will enable the in-door arrangements of the thermograph to be understood:—

F, F are the flames (of gas or paraffin).

B, B are the bull's-eyes or condensers.

M is one of the mirrors (the other not visible).

T, T′ represent the thermometer stems and the frames to which they are attached. On the back of these stems images of the flames magnified by the bull's-eyes are thrown, the mirrors serving to turn the direction of the rays so as to throw them upon the thermometers. These rays only pass through at the air specks.

L, L are two photographic lenses upon which the rays, which are allowed to pass through the air specks of the two thermometers, are made to impinge.

C is the cylinder driven by clockwork and covered with sensitive paper, upon which the images of the air specks made by the two lenses L, L are thrown (the one under the other).

c is the clock.

S is the light stop driven by the clock. It cuts off the light for four minutes every two hours.

H is a handle which, working a screw, raises or lowers, as required, a frame containing the two thermometers. Thus in winter, when the temperature is low, it may be desirable to raise the frame in order to make the air speck central with the lens, for in this position the definition is best. In summer, for a similar reason, it may be desirable to lower the frame.

Out-of-door Arrangements of the Thermograph.

We have already alluded to the vertical part of the thermometer stems which contain the air specks, and which are necessarily within doors. At the bottom of this vertical part the stem is bent outwards and passes through the wall or boarding in a horizontal position, extending beyond the wall of the house for at least two feet before it is again bent vertically downwards near the bulb. The object of this arrangement is to have the bulb as far from the influence of the wall as possible.

In order to obviate this influence as much as possible, there is a thin outside boarding parallel with the wall, and allowing a current of air to pass freely between the wall and it; this boarding, which forms the back of the thermometer frame, may therefore be supposed to have as nearly as possible the temperature of the air.

The thermometer frame is of venetian or louvre boarding, forming an enclosure of about 4 feet square, which surrounds the thermometer on all sides to a little below the level of the bulbs. This boarding is very open, being only sufficiently close to keep out the rays of the sun and to protect the bulbs from the violence of the wind. These frames are always put at the north side of the observatory to which they are attached, care being taken that the situation has a free exposure, and that the bulbs are not nearer the ground than about 6 feet, and if possible not further from it than about 12 feet.

The sketch in Plate II. will enable the arrangement to be understood:—

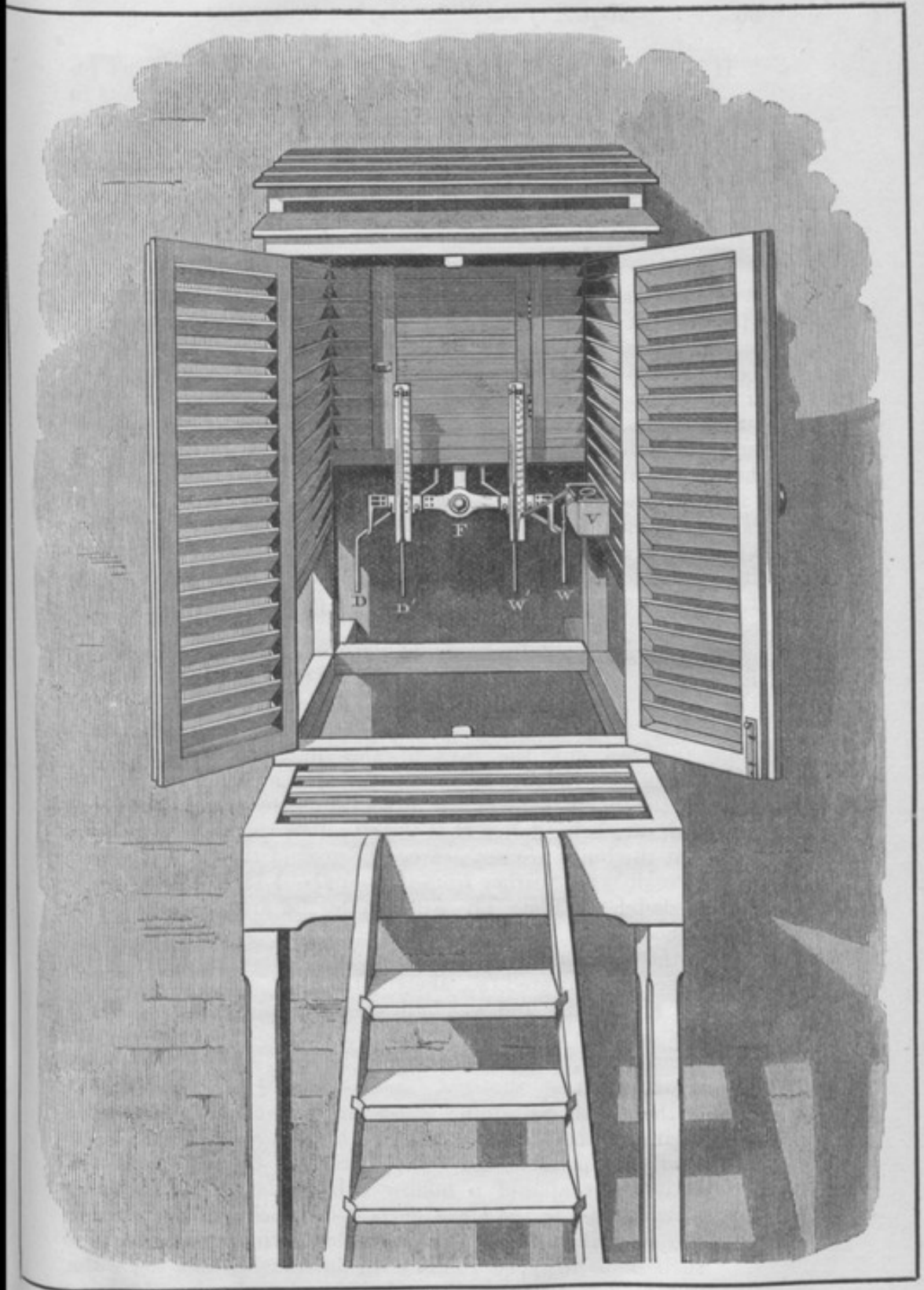
F is the frame carrying the thermometer, and capable of being raised and lowered (see sketch of in-door arrangement).

D, W are the dry and wet bulb thermograph thermometers.

D′, W′ are the dry and wet bulb standards of reference, used occasionally, when the light is cut off by the clock arrangement.

V is the vessel containing water for the wet bulb. In order to insure that the temperature of this water shall be as nearly as possible the same as that of the air, the vessel is in the shape of a hollow cube, a large surface being thus exposed to the air, a current of which goes up through the central hollow. The wet bulb thermometers have their bulbs wrapped round with fine muslin, and the water is conveyed to them through a bundle of threads lying in two grooves attached to the water vessel; the one groove carrying water to the wet bulb thermograph thermometer, the other to the wet bulb standard.

PLATE II.



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Influence of Local Peculiarities.

The description which we have now given renders it evident that the indications of the thermograph are as accurate as can be desired, when we compare these indications with simultaneous readings of wet and dry standard thermometers of the same size as those of the thermograph, and placed in the same frame. But it may be a point of discussion, not so much with reference to this particular thermograph as to all such instruments, how far their indications may be relied on as affording an accurate measure of the temperature of the air and of that of evaporation. In order to try this question, simultaneous comparisons have been made at Kew between the readings of two sets of dry and wet bulbs, one set being placed in a frame detached from the main building of the observatory, and the thermometers having very small bulbs; the other set being the wet and dry bulb standard thermometers of the thermograph frame. In the following table the result of this comparison for the month of February is given, from which it will be seen that the local peculiarity of either frame is comparatively small, and that the indications of the two agree very well together. The thermograph frame is called the west frame, the other being the east frame in this table.

TABLE II.

Date.	Time.	Dry Bulb Thermometer.		Difference.	Wet Bulb Thermometer.		Difference.
		East Frame.	West Frame.		East Frame.	West Frame.	
1868. Feb.		D.	D′.	D−D′.	W.	W′.	W−W′.
1	10 a.m.	51·9	51·7	+0·2	49·9	49·9	0·0
	2 p.m.	51·7	51·8	−0·1	44·5	43·3	+1·2?*
	10 p.m.	44·6	44·3	+0·3	41·3	41·3	0·0
2	10a.m.	44·8	44·4	+0·4	40·5	40·8	−0·3
3	10 a.m.	44·1	44·0	+0·1	39·1	39·25	−0·15
	Noon	43·9	43·8	+0·1	37·4	38·3	−0·9
	4 p.m.	42·1	42·3	−0·2	37·5	37·7	−0·2
	10 p.m.	36·6	36·7	−0·1	33·6	33·9	−0·3
4	10 a.m.	38·5	38·0	+0·5	35·7	35·6	+0·1
	Noon	45·1	44·8	+0·3	40·2	39·8	+0·4
	2 p.m.	47·1	46·8	+0·3	41·9	42·0	−0·1
	4 p.m.	47·5	47·2	+0·3	42·9	42·8	+0·1
	10 p.m.	45·5	45·3	+0·2	43·1	43·0	+0·1
5	10 a.m.	45·8	45·5	+0·3	41·4	41·4	0·0
	Noon	48·1	48·0	+0·1	42·5	42·6	−0·1
	2 p.m.	47·6	47·5	+0·1	42·4	42·5	−0·1
	10 p.m.	46·3	46·2	+0·1	42·9	42·9	0·0
6	10 a.m.	42·3	42·2	+0·1	40·6	40·5	+0·1
	Noon	46·4	46·4	0·0	41·3	41·7	−0·4
	10 p.m.	32·5	33·2	−0·7	32·2	32·7	−0·5

* Probably an error of one degree has here been made in reading the wet-bulb thermometer in the East frame

TABLE II.—*continued.*

Date.	Time.	Dry Bulb Thermometer.		Difference.	Wet Bulb Thermometer.		Difference.
		East Frame.	West Frame.		East Frame.	West Frame.	
1868. Feb.		D.	D′.	D−D′.	W.	W′.	W−W′.
7	10 a.m.	43·2	43·4	−0·2	42·8	43·0	−0·2
	Noon	46·2	46·4	−0·2	43·6	43·8	−0·2
	2 p.m.	45·9	46·3	−0·4	41·5	42·0	−0·5
	4 p.m.	44·1	44·5	−0·4	40·5	40·9	−0·4
	10 p.m.	43·0	43·2	−0·2	42·0	42·3	−0·3
8	10 a.m.	41·9	42·1	−0·2	39·2	39·3	−0·1
	Noon	43·1	43·6	−0·5	39·5	40·1	−0·6
	2 p.m.	39·3	39·2	+0·1	37·3	37·1	+0·2
	4 p.m.	40·4	40·5	−0·1	37·7	37·6	+0·1
	10 p.m.	34·9	35·0	−0·1	31·8	31·8	0·0
9	10 a.m.	32·7	32·9	−0·2	31·1	31·2	−0·1
	Noon	38·5	38·3	+0·2	34·1	34·4	−0·3
10	10 a.m.	44·5	44·1	+0·4	43·1	43·0	+0·1
	Noon	49·4	49·0	+0·4	46·1	46·2	−0·1
	2 p.m.	51·6	51·4	+0·2	47·3	47·3	0·0
	4 p.m.	49·8	49·6	+0·2	46·1	46·0	+0·1
	10 p.m.	42·6	42·8	−0·2	41·3	41·7	−0·4
11	10 a.m.	47·5	47·3	+0·2	45·1	45·1	0·0
	Noon	47·6	47·8	−0·2	44·3	44·5	−0·2
	2 p.m.	49·6	49·7	−0·1	44·7	45·0	−0·3
	4 p.m.	47·4	47·7	−0·3	41·0	41·3	−0·3
	10 p.m.	40·4	40·3	+0·1	37·7	37·6	+0·1
12	10 a.m.	36·3	36·1	+0·2	35·3	35·2	+0·1
	Noon	43·2	43·0	+0·2	39·7	40·0	−0·3
	2 p.m.	45·3	45·2	+0·1	40·9	41·0	−0·1
	4 p.m.	45·4	45·3	+0·1	40·9	41·0	−0·1
	10 p.m	40·7	40·9	−0·2	38·0	38·3	−0·3
13	10 a.m.	42·5	42·4	+0·1	40·9	41·0	−0·1
	Noon	44·7	44·6	+0·1	42·0	42·1	−0·1
	2 p.m.	46·7	46·6	+0·1	42·9	43·0	−0·1
	4 p.m.	47·3	47·1	+0·2	42·7	42·7	0·0
	10 p.m.	43·2	43·4	−0·2	41·7	42·0	−0·3
14	10 a.m.	44·8	44·8	0·0	42·6	42·6	0·0
	Noon	47·5	47·3	+0·2	43·7	44·0	−0·3
	2 p.m.	47·1	47·0	+0·1	42·5	42·5	0·0
	4 p.m.	46·1	46·1	0·0	41·5	41·75	−0·25
	10 p.m.	44·5	44·6	−0·1	41·1	41·4	−0·3
15	10 a.m.	44·5	44·7	−0·2	44·1	44·1	0·0
	Noon	45·3	45·4	−0·1	44·5	44·6	−0·1
	2 p.m.	43·4	43·5	−0·1	41·2	41·3	−0·1
	4 p.m.	44·5	44·8	−0·3	40·0	40·2	−0·2
	10 p.m.	36·4	36·7	−0·3	33·5	34·0	−0·5
16	10 a.m.	37·1	36·8	+0·3	34·7	34·4	+0·3
17	Noon	46·7	46·05	+0·65	39·9	39·6	+0·3
	2 p.m.	49·3	48·6	+0·7	40·5	40·6	−0·1
	4 p.m.	47·6	47·35	+0·25	39·5	39·85	−0·35
	10 p.m.	35·0	35·6	−0·6	34·1	34·5	−0·4

TABLE II.—*continued.*

Date.	Time.	Dry Bulb Thermometer.		Difference.	Wet Bulb Thermometer.		Difference.
		East Frame.	West Frame.		East Frame.	West Frame.	
1868. Feb.		D	D′	D–D′	W	W′	W–W′
18	10 a.m.	42·5	42·6	−0·1	42·3	42·2	+0·1
	Noon	45·8	45·9	−0·1	44·7	44·7	0·0
	2 p.m.	46·7	46·8	−0·1	45·9	45·9	0·0
	4 p.m.	47·1	47·2	−0·1	45·4	45·4	0·0
	10 p.m.	43·7	43·7	0·0	42·0	42·2	−0·2
19	10 a.m.	44·9	45·1	−0·2	42·6	42·6	0·0
	Noon	44·6	44·8	−0·2	43·9	43·9	0·0
	2 p.m.	45·5	45·7	−0·2	44·6	44·6	0·0
	4 p.m.	45·1	45·3	−0·2	42·9	43·0	−0·1
	10 p.m.	41·3	41·2	+0·1	38·5	38·6	−0·1
20	10 a.m.	38·2	37·9	+0·3	35·7	35·6	+0·1
	Noon	44·9	44·4	+0·5	38·3	38·6	−0·3
	2 p.m.	47·3	47·2	+0·1	41·5	41·5	0·0
	4 p.m.	46·5	46·5	0·0	41·2	41·0	+0·2
21	10 a.m.	49·9	49·7	+0·2	47·5	47·1	+0·4
	Noon	51·9	51·8	+0·1	46·3	46·5	−0·2
	2 p.m.	51·6	51·7	−0·1	45·5	45·8	−0·3
	4 p.m.	51·8	52·1	−0·3	45·3	45·7	−0·4
	10 p.m.	44·8	45·4	−0·6	41·9	42·5	−0·6
22	10 a.m.	49·1	49·0	+0·1	45·8	45·8	0·0
	Noon	47·8	47·8	0·0	43·1	43·6	−0·5
	10 p.m.	44·8	44·6	+0·2	38·9	39·0	−0·1
24	10 a.m.	49·8	49·5	+0·3	48·0	47·7	+0·3
	Noon	52·5	52·2	+0·3	49·6	49·5	+0·1
	2 p.m.	53·7	53·4	+0·3	50·3	50·2	+0·1
	10 p.m.	50·3	50·1	+0·2	48·9	48·9	0·0
25	10 a.m.	52·2	52·1	+0·1	48·7	48·8	−0·1
	2 p.m.	60·1	59·9	+0·2	52·2	52·2	0·0
	4 p.m.	59·0	59·0	0·0	50·3	50·7	−0·4
	10 p.m.	45·2	45·9	−0·7	44·1	44·5	−0·4
26	10 a.m.	48·8	49·0	−0·2	45·7	45·7	0·0
	Noon	49·6	50·1	−0·5	46·3	46·6	−0·3
	2 p.m.	52·7	52·8	−0·1	48·3	48·5	−0·2
	4 p.m.	52·2	52·6	−0·4	47·9	48·1	−0·2
	10 a.m.	47·8	48·0	−0·2	44·7	44·8	−0·1
27	10 a.m.	47·5	48·0	−0·5	45·2	45·5	−0·3
	Noon	48·6	48·8	−0·2	45·5	45·6	−0·1
	2 p.m.	49·4	49·6	−0·2	46·1	46·1	0·0
	4 p.m.	48·8	49·1	−0·3	45·9	46·2	−0·3
	10 p.m.	45·9	46·4	−0·5	44·1	44·4	−0·3
28	10 a.m.	49·8	49·1	−0·3	45·7	45·4	+0·3
	Noon	53·2	53·0	+0·2	47·5	47·7	−0·2
	2 p.m.	54·7	54·8	−0·1	49·2	49·4	−0·2
	4 p.m.	53·4	53·6	−0·2	48·0	48·2	−0·2
	10 p.m.	44·8	45·2	−0·4	42·9	43·2	−0·3
29	10 a.m.	48·9	49·1	−0·2	45·3	45·5	−0·2
	Noon	49·8	50·2	−0·4	45·9	46·0	−0·1
	2 p.m.	48·0	48·4	−0·4	45·1	45·4	−0·3
	4 p.m.	47·1	47·3	−0·2	45·2	45·6	−0·4
	10 p.m.	42·1	42·3	−0·2	40·9	41·0	−0·1

Principles of Construction of the Barograph.

This instrument is designed to record continuously the pressure of the air. It might at first sight appear enough for this purpose to measure the height of the barometric mercurial column after a manner similar to that by which the height of the thermometric column is measured in the thermograph. Such a process will not, however, exhibit accurately the pressure of the air. If the mercurial column could always be kept at the same temperature this process would be accurate, but since this column is always changing its temperature, and therefore its density, it becomes evident that the same height of mercurial column at different temperatures will not balance the same atmospheric pressure. Thus, mercury being denser at 32° Fahr. than at 60°, the height of column necessary to balance the same pressure will be somewhat shorter at 32° than at 60°. For this reason it is always the custom in reading a barometer to note at the same time the temperature of the mercury, and by means of a table of corrections to find what length of mercurial column at 32° Fahr. is equal in balancing power to the observed column at the observed temperature. In fine, the pressure of air is always supposed to be balanced by a column of mercury having the constant temperature of 32° Fahr.

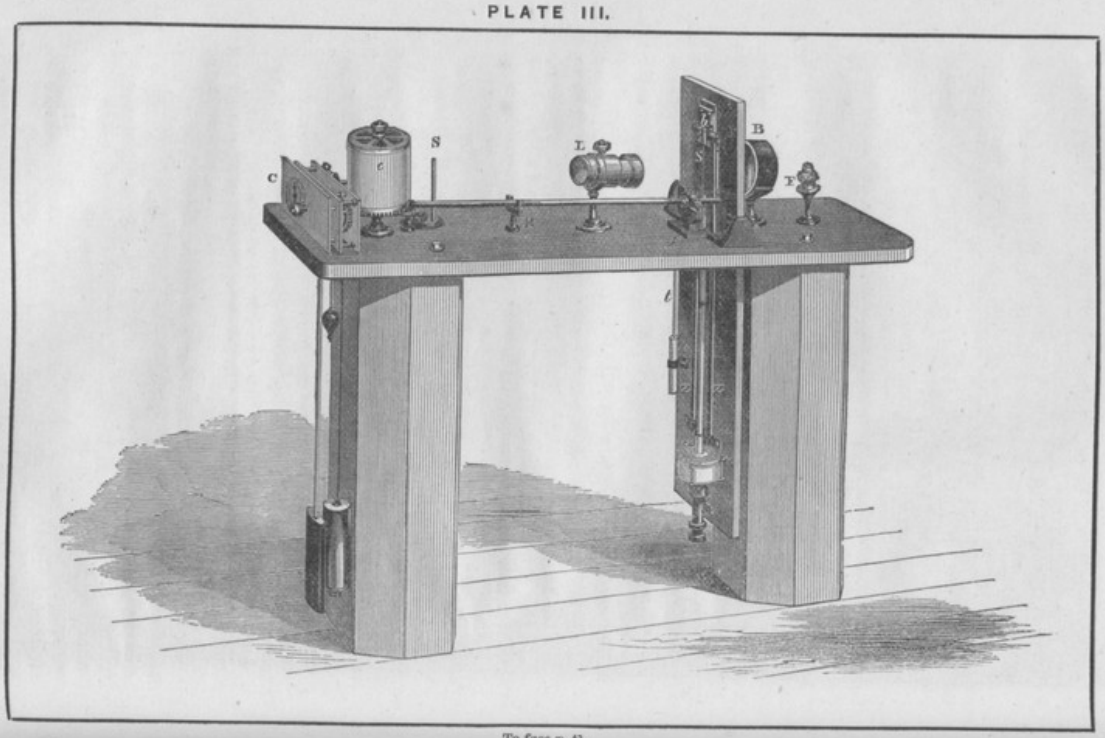
In the original barograph of Mr. Francis Ronalds, which may be regarded to some extent as the parent of these instruments, the compensation for temperature was made in the following manner:—Let us first suppose the absolute pressure of the air to remain constant, while the temperature of the mercurial column is increasing, and its density therefore diminishing. Under these circumstances the column of mercury necessary to balance the air will increase in height, or appear to rise. Now Mr. Ronalds had a temperature compensation so arranged that the whole tube containing the mercury was made to fall owing to an increase of temperature just as much as the column of mercury rose owing to the same cause. If this compensation could be accurately arranged, it is evident that the same height of the top of the mercurial column would for all temperatures correspond to the same pressure.

The objection to this arrangement is twofold.

In the first place, the barometer with its fittings being of a very considerable weight, any temperature arrangement which acts by moving this weight up and down may be suspected of not working smoothly and continuously, but of being subject to fits and starts.

In the next place, suppose that in an instrument of this construction it should ultimately be found that the temperature correction had not been made large enough, or made too large, there is no means of correcting, for this imperfection, the records that have already been obtained—these necessarily remain imperfect. In the present arrangement it has been endeavoured to obviate both these sources of inaccuracy, by a

PLATE III.



To face p. 41.

method which will be better understood after the other parts of the instrument have been described.

Of these parts, after what has already been said regarding the thermograph, a very short description will suffice.

Referring to the engraving of the barograph (Plate III.)—

F is the flame of gas or paraffin.

B is the bull's-eye or condenser, by means of which an enlarged image of the flame is thrown upon the void space above the mercury of the barometer *b*. The height of this barometer may be raised or lowered by means of a screw beneath the cistern; but it is desirable to avoid such an alteration if possible.

S is a slit which narrows the light allowed to pass through above the mercury. We have thus an illuminated slit, bounded above by the upper termination of the slit and below by the surface of the mercury of the barometer. Therefore, as the barometer falls this luminous slit will become longer, and as it rises it will become shorter.

L is a photographic lens, by means of which an image of this luminous slit is impressed upon sensitive paper surrounding the cylinder *c*.

C is the clock which drives the cylinder *c* once round in 48 hours, the time scale being precisely the same as that of the thermograph. This clock also drives

S, the stop which cuts off the light from the sensitive paper for four minutes every two hours.

Temperature Compensation.

Let us now proceed to describe the arrangement for temperature compensation.

Were there no such compensation, and nothing more than what we have described, the image thrown by the lens L upon the paper of the cylinder would be that of the illuminated slit. As this lens reverses things, the upper part of this illuminated slit, or that which represents the upper boundary of the slit S, would correspond to the lower extremity of the image on the cylinder, while the lower boundary of the illuminated slit, or that which is cut off by the mercury of the barometer, would be represented by the upper part of this image.

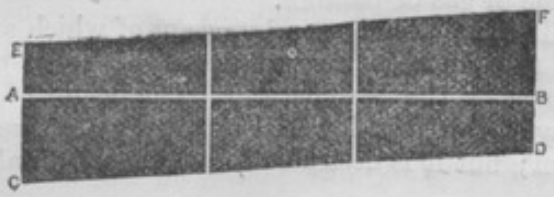
Now the upper boundary of the slit being fixed, while the surface of the mercury is variable, we should thus have traced by the action of light upon the paper, as the cylinder moves round, a blackened space, having below a level or straight and above a curved boundary, this curve being in fact the representation, given by the instrument, of the height of the mercury from moment to moment.

In order to explain the nature of the temperature correction, let us imagine that the true pressure of the air remains constant during a period of time, while, however, the temperature of the mercurial column continues to rise. This column will therefore become specifically lighter owing to its rise of temperature, and

it will require a greater length of it to balance the same atmospheric pressure—the mercury will therefore rise.

If CD (Fig. 5) be the slanting line denoting by its height that of the surface of mercury, then under the above circumstances CD

Fig. 5.



NOTE.—E F is the lowest part of the image as it is formed on the cylinder, but in the curve as it is read on the sensitive paper it forms the upper part.

will rise as in the figure, even although the true pressure of the air remains constant. If therefore we measure our ordinates from a horizontal straight line AB, DB will manifestly be less than CA. If, however, instead of measuring from the line AB we measure from a slanting line EF, which by some means is made to rise and fall with the temperature in precisely the same manner as CD rises or falls from the same cause, then we shall have a true result. Thus in the particular case we are describing (where the true pressure remains constant while the temperature changes) we have no longer a variable ordinate if we measure from EF as a base line, for CE is evidently equal to DF, and all the intermediate ordinates are also equal to one another.

The correction for temperature thus resolves itself into obtaining a curved or slanting base line which rises or falls from temperature to precisely the same extent as the mercurial column does from the same cause. This is effected by means of an arrangement of zinc rods (Z in the figure). These rods are fastened rigidly to a slate slab at their lower extremity, and at their upper end they are attached to a pointer P; this pointer therefore rises and falls with the temperature. Now P acts upon the smaller arm of a glass lever of which F* is the fulcrum, and of which the extremity of the long arm is quite close to the sensitive paper, where it carries a stop which thus cuts off the light and traces EF, the lower extremity of the image (as it appears on the cylinder). It is this moveable stop which gives us a slanting base line, and the length of the zinc rods and the position of the fulcrum are so arranged that the stop shall rise or fall from temperature as nearly as possible to the same degree as the other end of the image, which denotes the surface of the mercury, rises or falls from the same cause. It only remains to state that in the above figure the blank straight line AB is traced by means of a fixed thread of metal near the cylinder, which cuts off the light, and thereby gives us a line denoting the direction of motion of the cylinder.

* The fulcrum F has an adjustment by means of which it can be brought nearer to the pointer or further from it, if it should ultimately be found that the temperature compensation is not exact.

Standard of Reference.

It will now be desirable to describe the check that is kept upon the indications of the instrument so as to ascertain how it works. In the first place, we have the clock arrangement, similar in all respects to that of the thermograph, by means of which the light is cut off for four minutes every two hours (Greenwich mean time). Now let us suppose that, as often as possible, at the end of these four minutes the standard barometer is read: we have thus the true pressure of the atmosphere at certain moments of time corresponding to definite points of our barograph curve or *barogram*, and by comparing these with the readings of our barograph at these moments, we have a measure of the accuracy of our instrument.

Again, let us suppose that at these same moments we read the temperature of the mercury of our barograph column, which is ascertained by reading a thermometer plunged in mercury contained in a tube similar in bore to that of the barograph (*see* figure), we thus know the temperature of the barograph column, (which is also that of the zinc rods) at certain moments of time, corresponding to definite points of the curve. It will readily be seen that, by an arrangement of this kind, the line EF becomes in reality that of a thermograph which records continuously the temperature of the zinc rods, or what is as nearly as possible the same thing, that of the mercury of the barograph from moment to moment.

By treating this curve as a continuous record of the temperature of the mercury, we are thus independent of its accuracy as a temperature compensation to the barometer, for even if it were very inaccurate as a compensation, it would yet represent quite well the temperature of the mercury from moment to moment.

We have thus in fact two curves furnished by this instrument lying on opposite sides of the base line AB, one of these CD (referred to the base line AB) denoting the uncorrected height of the barograph column, and the other, EF, (referred to the same base line,) representing the temperature of this column from moment to moment. Now by means of these two curves we may, if we bestow sufficient pains, get an absolutely perfect correction applied to our observations as far as temperature is concerned.

While the method now described is one which will overcome all difficulties connected with temperature, if sufficient pains be taken, it yet involves a number of accurate measurements, and might therefore, perhaps, be considered too laborious.

This method has not been pursued by the meteorological committee as far as they have yet gone in the way of tabulation. Premising that the final method of tabulating from the barograph curves has not yet been determined on, it may nevertheless be desirable to relate here what progress in this respect has been made.

Method of Tabulation.

The first operation is to measure, by the aid of a simple tabulating instrument, carrying a scale with a vernier attached to it, and capable of being read to ·001 inch, the whole depth CE (Fig. 5) of the *barogram* for every hour G.M.T. If the temperature compensation is sufficiently accurate, these measurements (when converted into inches of pressure) should afford the true height of the barometer reduced to 32° for every hour. Now four or five times each day, while the light is cut off by the clock arrangement, the standard barometer is read. A comparison of these standard readings with the simultaneous measurements of the *barogram* will therefore enable us to determine two things: the first of these is the scale value of the instrument, or the value, in true inches of pressure, of a change of one inch in the depth, EC, of the curve, and the next is the reading of this depth corresponding to a definite height of the barometer.

Thus we find from the records of the Kew barograph, that on Jan. 2nd, 1868, we had the following relation between the barograph readings and the simultaneous readings of the standard barometer.

Reading of Barogram.	Corresponding to reading reduced of Standard Barometer.
Inches.	Inches.
1·201	30·249
1·241	30·222
1·305	30·182
1·285	30·197
1·272	30·204
Mean 1·261	30·211

Performing the same operation for each day of January, and dividing the daily means into two sets, one denoting high and the other low readings, we find as a result that 2·444 inches of scale reading corresponds to 29·455 inches reduced pressure of standard, while 1·317 inches of scale reading corresponds to 30·176 inches reduced pressure of standard.

From this we deduce that one inch of the barograph scale represents very nearly 0·640 inch of true pressure, and also that the true reading for the point marked 1·000 inch on the barograph scale is 30·379 inches.

We can now at once construct a table by the aid of which scale readings may be converted into true pressures.

Applying a scale of this kind to the readings for 2nd January, given above, we find that these represent in order the following pressures:—

	Inches.
	30·252
	30·227
	30·185
	30·197
	30·206
Mean	30·213

Now this mean is ·002 inch greater than the mean of the corresponding readings for that day of the standard, and this leads us to remark that for every day we may expect a residual difference of this kind, for even if the fittings of the barograph should be quite rigid, the hygrometrical condition of the curves when measured might vary so as to cause a small difference of this nature. Applying now to the converted barograph readings for Jan. 2nd a correction of —·002 inches, we shall find for these hours, when the standard was also read, the following result:—

Barograph reading converted, and residual correction applied.	Standard reading reduced to 32°.
Inches.	Inches.
30·250	30·249
30·225	30·222
30·183	30·182
30·195	30·197
30·204	30·204

Performing the same operation for each month, we have found that for the month of January the mean difference between the barograph readings, thus dealt with, and the simultaneous standard readings is 0·0027 in., while that for February is also 0·0027 in. This result is on the whole extremely good. It is possible, however, that a still better result may yet be obtained, and the labour of tabulation at the same time reduced.

In conclusion we give in Table III. the measurements for each hour of the *barogram* appended to this report (Pl. V.).

Table III.

Date	Saturday, March 7.						Sunday, March 8.					
Hour, G. M. T.	Recorded temperatures of Barograph corrected.	Recorded pressures of standard reduced to 32° and corrected.	Whole depth in inches of both curves = H.*	H reduced (uncorrected).	Residual correction to H.	Corrected pressure.	Recorded temperatures of Barograph corrected.	Recorded pressures of standard reduced to 32° and corrected.	Whole depth in inches of both curves = H.*	H reduced (uncorrected).	Residual correction to H.	Corrected pressure.
1 a.m.									2·761	29·252	−·001	29·251
2									2·856	29·193	− 1	29·192
3									2·974	29·116	− 1	29·115
4									3·084	29·046	− 1	29·045
5									3·213	28·964	− 1	28·963
6									3·151	29·003	− 1	29·002
7									3·127	29·019	− 1	29·018
8									3·050	29·068	− 1	29·067
9									2·993	29·104	− 1	29·103
10	52·6	29·772	1·951	29·772	−·002	29·770	52·0	29·158	2·919	29·152	− 1	29·151
11			1·992	29·745	− 2	29·743			2·882	29·176	− 1	29·175
Noon.	53·3	29·730	2·011	29·734	− 2	29·732			2·843	29·200	− 1	29·199
1 p.m.			2·070	29·695	− 2	29·693			2·798	29·229	− 1	29·228
2	53·0	29·674	2·099	29·677	− 2	29·675			2·766	29·248	− 1	29·247
3			2·146	29·647	− 2	29·645						
4	53·0	29·608	2·206	29·608	− 2	29·606						
5			2·291	29·553	− 2	29·551						
6			2·338	29·524	− 2	29·522						
7			2·385	29·493	− 2	29·491						
8			2·424	29·469	− 2	29·467						
9			2·479	29·434	− 2	29·432						
10			2·508	29·415	− 2	29·413						
11			2·569	29·376	− 2	29·374						
Midnight			2·648	29·324	− 2	29·322						

* See Figure 5.

PRINCIPLES OF CONSTRUCTION OF THE ANEMOGRAPH.

The anemograph adopted by the Meteorological Committee is that of Dr. Robinson, with certain mechanical modifications by Mr. Beckley.* A description of this instrument is given by Dr. Robinson in the Transactions of the Royal Irish Academy for June 10, 1850. The principle of its construction will be at once seen by referring to Plate IV. We have here four hemispherical cups which revolve in a horizontal plane and communicate their motion to a vertical axis, the whole being so arranged as to reduce the friction to as small an amount as possible.

Now, in whatever direction the wind blows, these cups will always be driven round with the convex side foremost, since the air presses with more effect into the cup than against its outside. Dr. Robinson, who in the paper mentioned above has investigated the instrument very completely, has been led both by theory and experiment to the following conclusions :—

(1.) The velocity with which the centres of the hemispherical cups are moved is in all cases as nearly as possible equal to one-third of that with which the wind blows horizontally, without any reference to the direction in which it blows :

(2.) This relation between the velocities is independent of the size of the instrument, that is to say, of the length of the arms and of the diameter of the cups.

The following are the dimensions of the instruments supplied to all the observatories of the Meteorological Committee, with the exception of that of Armagh :—

Distance of centre of cups from centre of axle - 24 inches.
Diameter of cups - - - - 9 „

At Armagh Dr. Robinson retains the instrument of his construction, of which the following are the dimensions :—

Distance of centre of cups from centre of axle - 23 inches.
Diameter of cups - - - - 12 „

The cups at Armagh are, therefore, somewhat larger than those at the other observatories, but this is of little consequence.

The following description refers to the instruments supplied by the Meteorological Committee, which differ somewhat in detail from Dr. Robinson's :—

Arrangement for Velocity.

The motion of the shaft A, which carries the cups and moves with them, is communicated vertically downwards to the box in the figure, where it is reduced in angular velocity by means of a train of wheels 7,000 times.

The sooner this reduction of motion is accomplished the better, as the friction consequent on a long axle moving rapidly is thus avoided. After being reduced in this proportion the motion is

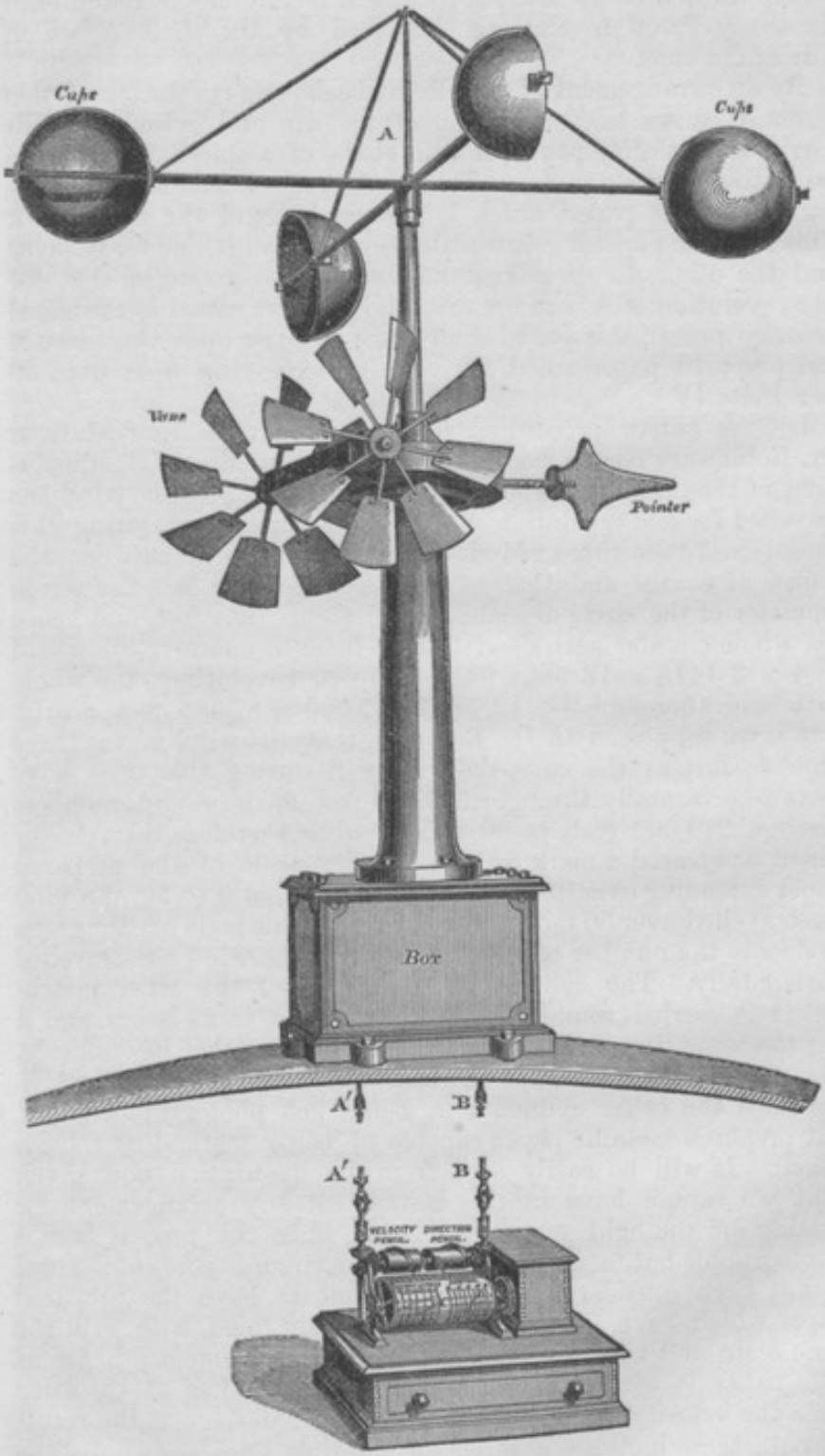
* The anemographs for the various observatories were made partly by Mr. Casella, and partly by Messrs. R. & J. Beck.

communicated to the shaft A′, which therefore moves round once for every 7,000 revolutions described by the shaft A which carries the cups.

By an arrangement of bevelled wheels, one revolution of this shaft A′ causes one revolution of a horizontal cylinder which carries the velocity pencil, in the shape of a spiral slip of brass projecting from its surface. This pencil presses on a sheet of prepared metallic paper which is wrapped round the cylinder C. This metallic paper has two scales engraved on it, one for velocity and the other for direction, and they are so arranged that for one revolution of A′ and hence of the cylinder carrying the spiral velocity pencil, this pencil shall trace a mark upon that part of the prepared paper ruled for velocity, extending from 0 to 50 (see Plate IV.).

Let us before proceeding further, endeavour to find from Dr. Robinson's results, combined with a knowledge of the dimensions of these instruments, what horizontal distance the wind has travelled for one revolution of A′. The cups have during this time gone 7,000 times round. Now the distance between the centre of a cup and that of the shaft being 2 feet, the whole diameter of the circle described by the cups is 4 feet, and hence the whole circular path described by them in one revolution will be $4 \times 3{\cdot}1416 = 12{\cdot}5664$ feet. In 7,000 revolutions the whole path will therefore be $12{\cdot}5664 \times 7{,}000 = 87{,}965$ feet nearly. But if we suppose with Dr. Robinson that the wind moves three times as fast as the cups, the wind will during this time have moved horizontally through 263,895 feet, or in round numbers through 264,000 feet, or 50 miles; while therefore the velocity pencil has traced a mark on the velocity scale of the prepared paper extending over its whole breadth, or from 0 to 50, the wind has travelled over 50 miles. The figures on this scale are thus seen to denote the number of miles over which the wind has travelled horizontally. The cylinder C like those of the other instruments is carried round by clockwork once in 24 hours, and it has the same time scale as the cylinder of the other instruments. The paper which envelops it differs, however, from that which envelops the other cylinders in being not photographic paper, but prepared metallic paper capable of being marked by a brass pencil. It will be easily seen from the description now given that we cannot have in this instrument any arrangement for cutting off the light every two hours, since the process is not photographic but mechanical. Under the circumstances of the case it has been considered most convenient to have the prepared paper which covers the cylinder previously ruled, both with the time scale and with the other scale of the instrument; hence as this paper is carried round by clockwork, and as at the same time the velocity pencil is in motion, we shall have as the result of both these motions a series of slanting lines drawn by the velocity pencil upon the prepared paper similar to those shown in the figure. Each of these lines will denote a space of 50 miles described by the wind, and it will be noticed in the figure

PLATE IV.



To face p. 48.

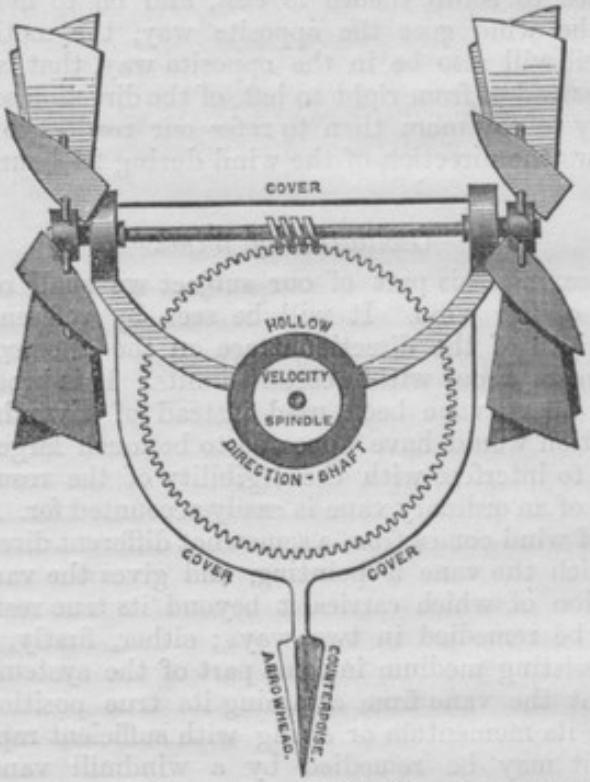
that when the spiral velocity pencil has marked 50 miles it leaves off at the left and commences again from 0 miles at the right. The appearance of the record traced in this manner in 24 hours will be seen by referring to a facsimile of one of the Kew *anemograms* (Plate VI.)

Arrangement for Direction.

The following is a brief description of that part of the instrument which records continuously the direction of the wind.

A reference to the following figure will show two windmill vanes having a common axle.

Fig. 6.



The joint axle of these two windmill vanes carries an endless screw, which gears into the teeth of a fixed toothed wheel, and the whole windmill arrangement is moveable, being delicately supported on friction rollers, so that this endless screw is at perfect liberty to travel along the periphery of the fixed toothed wheel, if the motion of the wind upon the fans inclines it to do so.

The whole apparatus being thus easily moveable, and the arrow head being placed as in the figure, it follows from the principle of windmill vanes, that the system will travel round the fixed wheel until the arrow head points to the direction in which the wind is blowing; when the system has taken this position the fans will be so placed with regard to the wind that there will be no longer any pressure tending to move them round.

This system has a hollow axle, shown in the figure, which hollow axle surrounds the central axle of the velocity spindle. This hollow axle will therefore go once round when the wind has completed one revolution, or it will move with any change of wind.

This hollow axle is connected with the shaft B (Plate IV.), so that one revolution of the hollow axle will cause one revolution of B, which will therefore move once round when the wind has moved once round. But B is connected with the spiral direction pencil in precisely the same way in which A′ was with the spiral velocity pencil. And this pencil will move over the whole breadth of the direction scale from the right to the left side when the wind has completed a whole revolution, moving from north to west, thence to south, thence to east, and on to north again; while, if the wind goes the opposite way, the motion of the spiral pencil will also be in the opposite way, that is, from left to right, instead of from right to left, of the direction scale. It is unnecessary to say more than to refer our readers to Plate VI., which shows the direction of the wind during 24 hours.

Oscillation of Wind.

Before leaving this part of our subject we shall refer to the oscillation of the wind. It will be seen by reference to the varying width of the direction trace on the *anemogram* that the wind veers about within certain limits. It is probable that, had an ordinary vane been used instead of a windmill vane, this oscillation would have appeared to be much larger, perhaps so large as to interfere with the legibility of the results. This peculiarity of an ordinary vane is easily accounted for. A momentary gust of wind comes from a somewhat different direction from that in which the vane is pointing, and gives the vane a blow, the reception of which carries it beyond its true resting point. This may be remedied in two ways; either, firstly, by interposing a resisting medium in some part of the system that does not prevent the vane from attaining its true position of rest, but checks its momentum or swing with sufficient rapidity; or, secondly, it may be remedied by a windmill vane such as has been employed in these instruments. The only objection to a windmill vane is that in order to move it, a certain amount of friction, however small this be, requires to be overcome, so that the final position taken up by the arrow head may not indicate precisely the direction of the wind, but only come so near this direction that the force tending to move the fan is not able to overcome the friction. This is no doubt true, but by judicious arrangements the friction may be greatly reduced, although perhaps it may not be rendered so small as in the case of an ordinary vane.

This friction may, however, be considered too small to interfere to any serious extent with the accuracy of the instrument in denoting the *direction* of the wind; but the case will be different if we should wish to measure the amount of *oscillation* of the

wind. Dr. Robinson is of opinion that it is a natural characteristic of certain winds to oscillate a great deal compared to others of precisely the same velocity, but when we come to measure oscillation with accuracy we encounter great difficulty. This difficulty lies not so much in comparing together two winds of the same or nearly the same velocity, but in comparing together a very strong and a very light wind, and assigning to each the true amount of oscillation. It is doubtful whether our present instrumental means would enable us to register this phenomenon with perfect accuracy unless we were to construct a very complicated apparatus for the purpose.

Friction Co-efficient.

It remains to make a few remarks regarding the effect of friction upon the record of velocity. Dr. Robinson has shown in the paper quoted above, how from knowing the smallest weight or pressure which must be applied horizontally at the centre of one of the cups of a particular instrument at rest in a calm, in order to set it in motion, we may tell at once how far friction is influential in apparently diminishing the wind's velocity in any of the records given by the instrument; and he has been good enough to calculate the friction corrections for the Kew instrument. These are as follows:—

TABLE IV.

Apparent velocity in miles per hour.	Correction (to be added to apparent velocity).	Apparent velocity in miles per hour.	Correction (to be added to apparent velocity).
Miles.	Miles.	Miles.	Miles.
Just moving.	1·55	10	0·18
0·1	1·48	11	0·16
0·2	1·42	12	0·15
0·3	1·37	13	0·14
0·4	1·31	14	0·13
0·5	1·26	15	0·12
0·6	1·21	16	0·11
0·7	1·16	17	0·11
0·8	1·12	18	0·10
0·9	1·07	19	
1·0	1·03	20	0·09
2	0·99	21	
3	0·54	22 to 24	0·08
4	0·43	25 to 28	0·07
5	0·36	29 to 33	0·06
6	0·30	34 to 41	0·05
7	0·26	42 to 50	0·04
8	0·23	51 to 64	0·03
9	0·20	75 to 100	0·02

It appears from this table that friction is influential chiefly in small velocities, and that in high velocities it may be neglected.

It would further appear from some experiments made at Kew, that the true friction co-efficient of any instrument that has just been made cannot be accurately fixed, for at first this friction is much larger than it ultimately becomes after the instrument has been at work for some time. The Kew instrument was driven artificially in the workshop in which it was made for a day or two, so that perhaps in this case we have ascertained the true friction; but in the case of the other instruments this preliminary trial has not been made, and their friction corrections have not yet been obtained; on the other hand, it is not possible to ascertain the friction correction of an instrument that is mounted without considerable trouble.

Pressure of Wind.

The instrument now described may be considered as giving with sufficient precision the direction of the wind at any moment, as well as the space travelled over by it from hour to hour. It does not, however, give us the pressure that the wind would exert upon a plate, say one foot square, directly opposed to it. The average pressure of the wind during one hour may no doubt be deduced from its average velocity for that hour by an appropriate formula; but it is very probable that there are in high gales sudden gusts of wind, lasting perhaps but a minute or two, or even less, of terrific force, but yet so transient as not to affect sensibly the hourly average velocity. These momentary gusts are hardly perceptible by this anemometer, the pressure plate being the appropriate method by which they may be recorded. Such gusts are worthy of being studied as local phenomena, sufficient to cause damage in the place of their occurrence, but their importance in enabling us to arrive at extended meteorological laws is probably very small. The space travelled over by the wind from hour to hour is universally allowed to be a result of much more general importance, but this is what we cannot easily get from a pressure instrument. In fact the pressure anemometer serves extremely well to determine the force of momentary gusts, but answers very badly in giving us the velocity; while, on the other hand, the cup anemometer gives us the velocity with great precision, but it does not enable us to determine the force of momentary gusts. As it appeared to the Meteorological Committee that the velocity of the wind was a point of far greater importance than a register of momentary pressures they have adopted Dr. Robinson's anemometer.

We now append in Table V. the measurements for each hour of the anemogram appended to this report, and in conclusion make a few remarks respecting the peculiarities of these curves.

TABLE V.

Date	SATURDAY, MARCH 7th.						SUNDAY, MARCH 8th.					
	Velocity of Wind in miles per hour.*			Direction of Wind.	Oscillation of Wind.		Velocity of Wind in miles per hour.*			Direction of Wind.	Oscillation of Wind.	
Hour, G.M.T.	Velocity uncorrected.	Approximate correction for friction.	Velocity corrected.	In numbers. East = 8 South = 16 West = 24 North = 32	In numbers. East = 8 South = 16 West = 24 North = 32		Velocity uncorrected.	Approximate correction for friction.	Velocity corrected.	In numbers. East = 8 South = 16 West = 24 North = 32	In numbers. East = 8 South = 16 West = 24 South = 32	
					From To	Extent.					From To	Extent.
1 a.m.							23	·1	23·1	20	18·5—21·5	3
2							21	·1	21·1	20	18·5—22	3·5
3							25·5	·1	25·6	21	19—22·5	3·5
4							28	·1	28·1	20·5	18·5—22·5	4
5							26	·1	26·1	20	19—21·5	2·5
6										Peculiar and sudden change.		
7							20	·1	20·1	28	27—31	4
8							15	·1	15·1	27·5	27—28	1
9							17	·1	17·1	27	26—27·5	1·5
10							19	·1	19·1	27·5	26·5—28·5	2
11	15	·1	15·1	24	22·5—25·5	3	19	·1	19·1	27	25—29	4
Noon	13	·1	13·1	23·5	21·5—25·5	4						
1 p.m.	15	·1	15·1	23	22—24·5	2·5						
2	16·5	·1	16·6	22·5	21—24	3						
3	14·5	·1	14·6	21	20—22·5	2·5						
4	13·5	·1	13·6	20	19—20·5	1·5						
5	15	·1	15·1	19	18·5—20	1·5						
6	14	·1	14·1	21	18·5—24	5·5						
7	13	·1	13·1	21	20—22	2						
8	14	·1	14·1	20·5	19—22	3						
9	15	·1	15·1	22	20·5—23	2·5						
10	13	·1	13·1	22·5	21—24	3						
11	13	·1	13·1	22	20·5—23	2·5						
Midnight	16	·1	16·1	20	Change.							

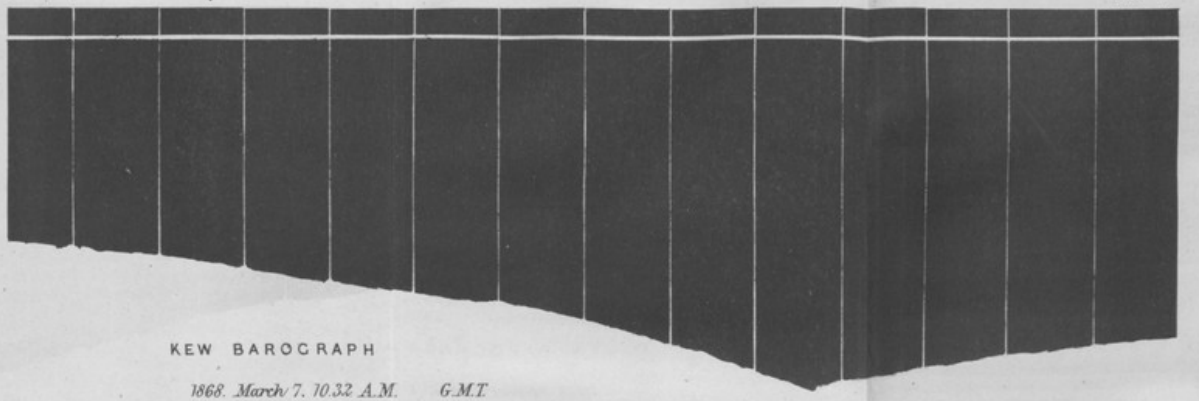
* Being the number of miles traversed by the wind from half an hour before to half an hour after the hour named.

It will be seen that about 5.30 a.m. of March 8th, there was a very sudden fall both in the temperature of the air and in that of evaporation.

It will also be noticed that the Barometer which had been rapidly falling previous to this instant, began then very suddenly to rise. The direction of the wind at the same moment changed from south-west to north-west, while the velocity of the wind, after the change, was less than it had been an hour or so previously.

Sudden and peculiar changes of weather of this kind have been remarked by Mr. Airy and others as of frequent occurrence with sudden change of wind.

Plate V.



KEW BAROGRAPH

1868. March 7. 10.32 A.M. G.M.T.

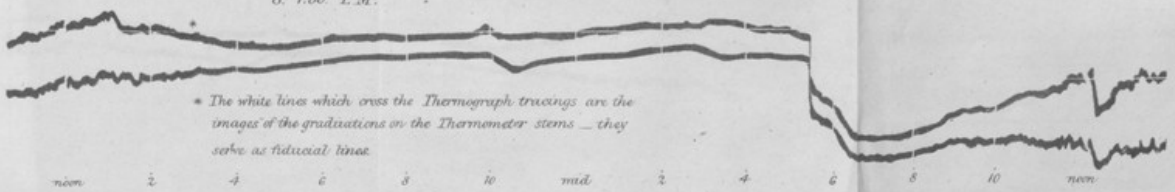
8. 1.58. P.M

noon 2 4 6 8 10 mid 2 4 6 8 10 noon

KEW THERMOGRAPH

1868 March 7. 10.38. A.M. G.M.T.

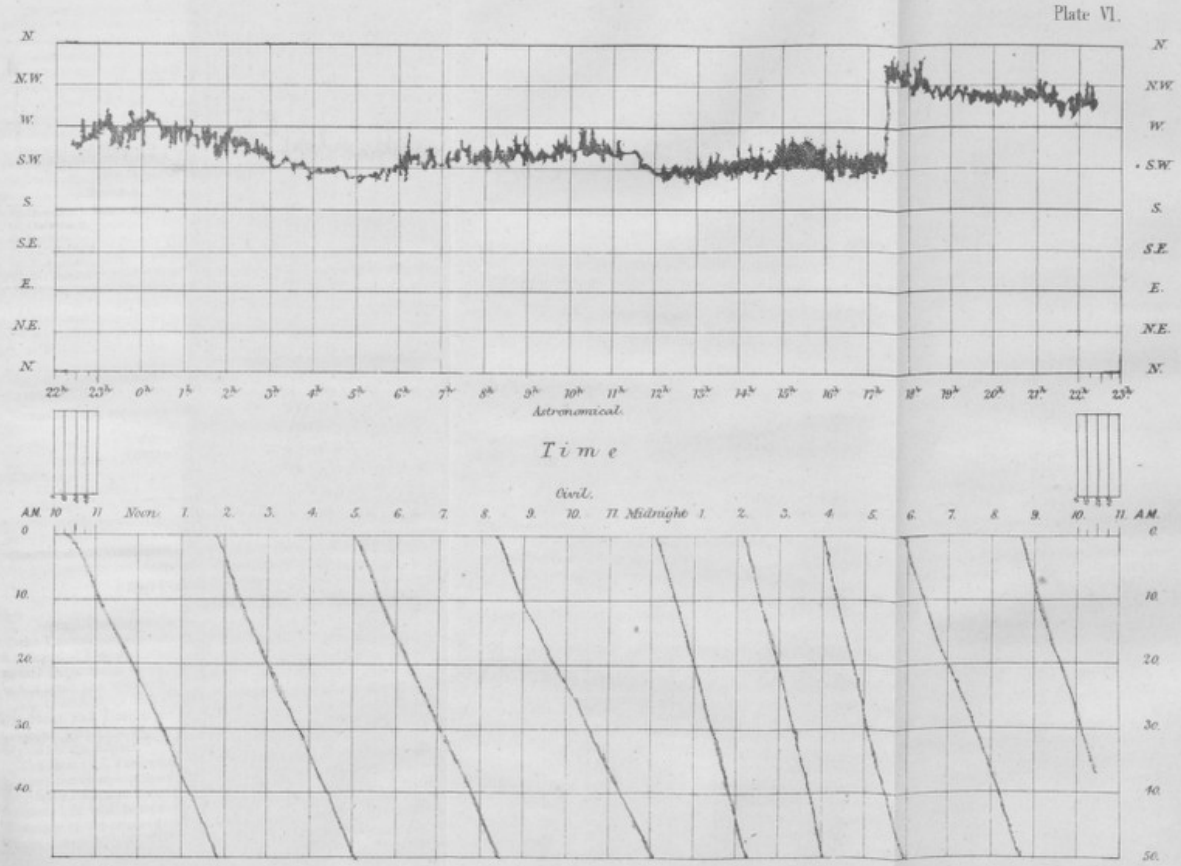
8. 1.58 P.M.



* *The white lines which cross the Thermograph tracings are the images of the graduations on the Thermometer stems — they serve as fiducial lines.*

noon 2 4 6 8 10 mid 2 4 6 8 10 noon

Plate VI.



ANEMOGRAPH CURVE.

Kew Observatory.

From March 7d 10h 22m A.M. to 8d 10h 22m A.M. 1868. G.M.T.

APPENDIX.

APPENDIX I.

METEOROLOGICAL OFFICE REVENUE and EXPENDITURE ACCOUNT for the year ended 31st March 1868.

Dr.	REVENUE.			EXPENDITURE.			Cr.
To Parliamentary Vote -	£10,570	0	0	By Salaries - -	£2,875	11	0
„ G. Dornbusch -	10	0	0	„ Expenses at Observatories - -	876	12	8
„ E. Pearson - -	4	5	0	„ Instruments - -	376	10	0
„ Earl of Seafield -	4	5	0	„ Do (Admiralty)	324	0	9
„ G. J. Swanston -	3	0	0	„ Travelling Expenses	166	4	11
„ W. W. Rundell -	1	1	3	„ Agencies at Ports -	49	18	10
				„ Telegraphy, &c. -	1,787	16	10
				„ Contingencies (Printing, &c.) - -	297	4	3
				„ Outfit of Observatories	3,826	8	0
				„ Balance in hand -	12	4	0
	£10,592	11	3		£10,592	11	3

Examined and compared with the vouchers and found correct.

(Signed) J. P. GASSIOT. }
(Signed) W. SPOTTISWOODE. } Auditors.

8 May 1868.

APPENDIX II.

CORRESPONDENCE relative to the TRANSFERENCE of the OFFICE to the present COMMITTEE.

Board of Trade to Royal Society.

Board of Trade, August 30, 1866.

SIR,

SOME time has now elapsed since the publication of the Report of the Committee appointed by the Royal Society, the Admiralty, and the Board of Trade to consider certain questions relating to the Meteorological Department of the Board of Trade, and it becomes necessary to decide upon the course to be pursued. The Board of Trade think it right, therefore, to bring the subject under the formal notice of the President and Council of the Royal Society, who have on former occasions given her Majesty's Government so much valuable help and advice on the subject.

The Board of Trade, as at present advised, are prepared to adopt and support the course proposed by the above-mentioned Committee; and they have reason to believe that the Board of Admiralty are of the same opinion. It will, however, be necessary to obtain the consent of the Treasury to the proposed expenditure, and before taking steps for that purpose, the Board of Trade will be glad to learn the views of the President and Council on the subject of the measures recommended by the Committee.

They will be glad to learn, in the first instance, upon the authority of the President and Council, whether those measures are well calculated to advance meteorological science in the most efficient way; and they will also be glad to learn whether, in the opinion of the President and Council, or of such competent persons as they may consult, the machinery and establishment suggested by the Committee is such as is likely to answer its purpose. Assuming these questions to be answered in the affirmative, the Board of Trade will be especially obliged if the President and Council can furnish or procure for them a detailed statement of the establishment which it will be necessary to provide at Kew, or in connexion with Kew, for the purpose of receiving and discussing meteorological observations; a similar statement with respect to local observations in the United Kingdom; and an estimate of the cost of both.

The Board of Trade will also be glad to learn the views of the President and Council with respect to the body under whose management and responsibility the establishments in question should be placed.

Upon learning the views of the President and Council on these points, the Board of Trade will take such steps as may then appear to be necessary for obtaining the opinion of the Treasury.

The Board of Trade regret that in consequence of unavoidable circumstances so much time should have been lost, and the more so as changes in the Meteorological Department render it desirable to arrive at a settlement as soon as possible.

I have, &c.

The President, Royal Society. (Signed) T. H. Farrer.

Royal Society to Board of Trade.

Royal Society, Burlington House,
October 27, 1866.

Sir,

I have to explain that the consideration of your letter of 30th August, addressed to the President, has been delayed by the absence of the President and many members of the council of the Royal Society during the recess. I am now directed to transmit to you the following reply:—

In your letter you state that "the Board of Trade, as at present advised, are prepared to adopt and support the course proposed by the Meteorological Committee" appointed by the Royal Society, the Admiralty, and the Board of Trade, but "before taking the steps for that purpose, the Board of Trade will be glad to learn the views of the President and Council on the subject of the measures recommended by the Committee," and you ask,—

1st, Whether those measures are well calculated to advance Meteorological Science in the most efficient way?

The President and Council consider that those measures are generally well calculated to advance Meteorological Science in a very efficient manner.

2ndly, Whether the machinery and establishment suggested by the committee are such as are likely to answer the desired purpose?

The machinery and establishment suggested by the committee are indicated in § 45, pp. 39 and 40 of the Report, and several important measures are therein proposed, each of which requires separate consideration.

a. The President and Council entirely concur in the opinion of the Committee, that "the collection of observations from captains of ships is a function which can probably be best performed through the medium of such agencies as a Government office can command."

b. The President and Council also concur with the Committee in the opinion that "the digesting and tabulating results of observations is 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." They believe that this "would be much better, as well as more economically, performed under the direction of a scientific body, furnished with requisite funds, than it will be if left to a government department." They would, however, limit the sea observations to those collected by British observers, and the land observations to those made within the British Isles, including those made at the lighthouses and coastguard stations. The President and Council assume, with the Committee, 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."

c. The President and Council, referring to the 4th paragraph in § 45, are of opinion that the reduction of a considerable amount of arrears of observations, both at sea and on land, will probably be desirable, and that it "may be placed in the same hands in which the future discussion of meteorological observations is placed."

d. In reference to the 5th paragraph of § 45, as to the issuing of storm warnings, the President and Council do not concur in the recommendation that the issue of storm warnings should be placed under the superintendence of the scientific body under whose direction the meteorological observations are discussed. At present these warnings are founded on rules mainly empirical. In a few years they may probably be much improved by deductions from the observations in land meteorology, which will by that time have been collected and studied. The empirical character may thus be expected to give way to one more strictly scientific, in which case the management of storm warnings might be fitly undertaken by a strictly scientific body.

It must not be forgotten that storm warnings did not originate in any recommendation from the Royal Society. If their present continuance be deemed of sufficient importance by the Government, it must be for them to consider the means of carrying them on.

e. The President and Council consider, with the committee, that the publication of results of meteorological observations at sea, referred to in the 6th paragraph, § 45, of the Report, is a function properly belonging to the Hydrographic Office of the Admiralty. It would seem desirable, therefore, that the Hydrographer should himself be a member of the superintending committee.

3rdly, You ask for a detailed statement of the establishment which will be necessary at Kew, for the purpose of receiving and discussing Meteorological Observations.

4thly, A similar statement with respect to local observations in the United Kingdom.

5thly, An estimate of the cost of both.

The President and Council have no reason to question the general sufficiency of the estimate contained in the Report, § 45, p. 40; but any detailed statement, either of the staff required or the amount of salaries to be paid, would be at present premature.

Finally, You desire to have the views of the President and Council with respect to the body under whose management and responsibility the establishments in question should be placed.

The President and Council consider that the department under whose care the observations, reductions, and tabulations are to be made should be under the direction and control of a Superintending Scientific Committee, who should have (subject to the approval of the Board of Trade) the nomination of all appointments, as well as the power of dismissal, of the several officials receiving salaries or remuneration.

The services of the members of this committee will be gratutious, but they would necessarily require the assistance of a competent paid secretary, whose salary will be included in the estimates requested.

Should the nomination of the Superintending Committee be entrusted to the President and Council, they would be prepared to recommend gentlemen competent to undertake the duties.

I remain, &c.,

(Signed) W. Sharpey, M.D.,
Secretary, R.S.

The Secretary, Board of Trade.

The Board of Trade then issued the following circular with reference to storm warnings :—

Circular.

Board of Trade, November 29, 1866.

The Board of Trade have had under consideration the report of a committee, appointed by the Royal Society, the Admiralty, and the Board of Trade, to inquire into the constitution and functions of the Meteorological Department, which recommended, as the most important step to be taken, the transfer of the management of the business of the department to a scientific body. The Board of Trade have also consulted the Royal Society upon the subject of this report, and the President and Council of the Royal Society concur generally in the measures recommended by the committee, and are prepared to undertake the duty proposed to them.

With regard to the issue of storm warnings, the President and Council of the Royal Society are of opinion that "at present these warnings are founded on rules mainly empirical," and therefore should not be issued under the superintendence of the scientific body to whom the discussion of meteorological observations will be committed. The President and Council think, however, that "in a few years they may probably be much improved by deductions from the observations in land meteorology, which will by that time have been collected and studied. And that the empirical character may thus be expected to give way to one more strictly scientific,—in which case the management of storm warnings might be fitly undertaken by a strictly scientific body."

Under these circumstances the Board of Trade are compelled to suspend, from the 7th day of December next, "Cautionary Storm Warnings," which have from time to time been issued by the Meteorological Department of the Board of Trade.

It is hoped that the warnings may be resumed by the new Meteorological Department at no distant time upon an improved basis.

In the mean time the daily "weather reports" will be received and published as heretofore. If at any port or place there is a desire to have these reports, or any part of them, communicated by telegraph on the morning on which they are received, they shall be so communicated on a request to that effect being sent to the Board of Trade, accompanied by an undertaking to pay the expense of the telegram from London to the port or place.

T. H. Farrer.

f. 81r

The subjoined correspondence passed before the end of the year 1866 :—

Board of Trade to Royal Society.

Board of Trade, December 5, 1866.

SIR,

I AM directed by the Board of Trade to enclose copies of letters addressed by this Board to the Boards of Treasury and Admiralty, on the subject of the proposed changes in the conduct of the business of the Meteorological Department of this Board. I also enclose copies of the replies received from those Boards, and I am to request that you will have the goodness to bring these papers to the notice of the Council of the Royal Society.

It will be seen from the correspondence that the Board of Trade, the Admiralty, and the Treasury have agreed to the original proposals submitted by the Board of Trade to the President and Council, subject to the modifications of those proposals contained in your letter of the 27th October 1866, and that the Treasury have authorised the preparation of Estimates upon the basis of those proposals.

I also enclose a copy of a circular concerning the storm warnings which, in consequence of the modifications of the original proposals of the Committee by the President and Council, the Board of Trade have found it necessary to issue.

As it is desirable, with a view to the coming Session, that the Estimates should be prepared without delay, and as it is also important that no time should be lost in establishing the new system of observations, I am to suggest for the consideration of the President and Council, that they should appoint the proposed committee with as little delay as possible, and that the committee should when appointed at once place themselves in communication with the Board of Trade.

I have, &c.

The President, Royal Society. (Signed) T. H. FARRER.

Royal Society to Board of Trade.

Royal Society, Burlington House,

December 15, 1866.

SIR,

I AM directed to inform you that your letter of the 5th instant, addressed to the President of the Royal Society, with copies of correspondence between the Board of Trade and the Admiralty and Treasury, was brought before the Council of the Royal Society at their last meeting ; and in answer thereto I am to send you the following copy of a minute approved by the President and the Council :—

"Resolved,—that a Standing Committee be appointed for the purpose of superintending the Meteorological Observations to be made for the Board of Trade in accordance with the foregoing letter.

"That the following gentlemen be nominated as members of this Committee :

"Lieut.-General Sabine,
"Mr. Gassiot,
"Dr. W. A. Miller,
"Mr. De la Rue,
} Members of the Kew Committee.

"Mr. Francis Galton,
"Mr. W. Spottiswoode,
} Officers of the British Association.

"The Hydrographer to the Admiralty.
"Colonel Smythe.

"That this Committee place themselves in communication with the Board of Trade.

"That in the event of a vacancy occurring in the Committee, the fact be communicated to the Council of the Royal Society in order that they may appoint a new member."

I remain, &c.
(Signed) W. SHARPEY,
Secretary, R.S.

T. H. Farrer, Esq.
&c. &c. &c.

Board of Trade to Royal Society.

SIR, Board of Trade, December 22, 1866.

I AM directed by the Board of Trade to acknowledge the receipt of your letter of the 15th inst., conveying a copy of a resolution, from which it appears that the President and Council of the Royal Society have resolved to appoint a standing committee for the purpose of superintending the meteorological observations undertaken by the Royal Society, and that this committee should place themselves in communication with the Board of Trade.

In reply I am to state that the Board of Trade are ready to consider the arrangements to be proposed by the committee so soon as they are communicated.

I have, &c.
(Signed) T. H. FARRER.

The Secretary, &c. &c. &c.
Royal Society.

APPENDIX III.

ARRANGEMENT OF DATA BOOK.

In addition to what has been said at p. 8 of the Report, a short explanation of the method of pagination may be thought advisable.

Each 10-degree square comprises 100 1-degree squares, and each opening of a data-book corresponds to one of these smaller divisions. Accordingly each data-book has 100 openings, which are numbered from 00 to 99.

The entry of an observation, at its proper opening, depends upon the unit figures of the degrees of latitude and longitude of the position in which it was made, *e.g.*, observations made in lat. 13° 44′ N. and long. 26° 15′ W. would be entered at opening 36 of the data-book for the proper month of square 10°—20° N. and 20°—30° W.

Four squares at the intersection of the equator and meridian of Greenwich are given on the opposite page, so as to show the adaptation of the system to north and south latitude and to east and west longitude.

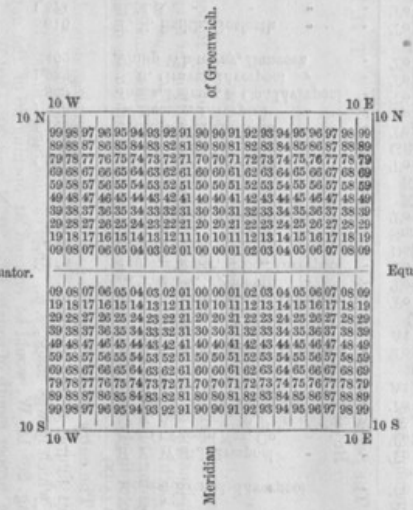
It will be seen from these that in each case the openings 00 and 99 correspond respectively to the lowest and highest latitude and longitude.

Also that all openings beginning with the same figure refer to the same parallel of latitude, while those ending with the same figure, refer to the same meridian.

Other numerical relations as to the positions of single squares will be easily perceived by inspection.

APPENDIX III.—Page of Data Book showing Mode of Extraction adopted in the Office.

No. of Log.	Year.	Day.	Hour.	Latitude.	Longitude.	Current in 24 hours.		Sea surface.		Variation.	Ship's head.	Wind.	Force.	Barometer.	Thermometer.		Clouds.		Clouds.			Weather.	Remarks.
						Direction.	Amount.	Temp.	Sp. gravity.						Dry.	Wet.	Lower.	Position.	Upper.	From.	Amount.		



APPENDIX IV.—A List of Documents received from Ships during the year 1867.

Captain's Name.	Ship.	Tons.	Owners.	Voyage.	Months of Register.
Forsyth, C. C.	Valorous	1,257	H.M.S.	At Simon's Bay, chiefly	4
Gales, I. C.	Quito	503	Messrs. Kendal, Liverpool	To Iquique, Junin, Arica, at these places, and to Liverpool.	12
Gilford, John*	Christabel	171	H. F. Watt, Liverpool	To and from Monte Video	5
Hicks, G. W.†	Indus	1,319	P. & O. Steam Nav. Co.	To and from Bombay	7
Jeffery, John	Kiltearn	599	W. R. Sandback, 10, Prince's Gate, W.	To, at, and from Demerara	5
Kelly, William	Alexandra	1,352	T. Brocklebank, Liverpool	To and from Calcutta	7
Millard, T. H.‡	James Longton	318	J. Longton, Liverpool	At Hong Kong, to Melbourne, Sydney, Adelaide, by Cape Good Hope to Liverpool.	7
Mossop, Clement	Candahar	1,418	T. & R. Brocklebank, Liverpool	To and from Calcutta	6
Parker, George	Liffey	2,654	H.M.S.	At Bermuda, to Portland, Lisbon, and Gibraltar.	2
Potts, T. C.	Aracan	789	T. & R. Brocklebank, Liverpool	To and from Calcutta	6
Rawle, Charles	Star of the North	662	A. Pardew, Plymouth	To and from Bombay	6
Reid, William	Andromeda	1,876	Jones, Palmer, & Co., Liverpool	To and from Calcutta	7
Richards, John (Master)	Constance	3,213	H.M.S.	Data for hurricane in West Indies	—
Shortland, P. F.	Hydra	818	H.M.S.	Surveying in Mediterranean	14
Slaughter, Peter	Spray of the Ocean	805	E. C. Friend, Liverpool	To Sydney, Shanghae, Rangoon, Hong Kong, Tahiti, Hong Kong, Penang, Hong Kong, Melbourne, by Cape Horn to London.	21
Smith, John	Sumatra	1,324	J. F. Jones, Liverpool	To Hong Kong, Callao, and Queenstown	15
Strange, J. N.	Mars	2,573	H.M.S.	Gibraltar to Malta	1
Studdert, Robert	Hotspur	1,142	T. E. Smith, Gosforth	To, at, and from Calcutta	10
Tate, William	Benefactress	1,276	G. Rennie, Liverpool	To and from Bombay	9
Thompson, William	Hypatia	869	Jones, Palmer, & Co., Liverpool	To Akyab, Lisbon, and Liverpool	9
Wherland, Frederick	Tudor	1,986	S. R. Graves, Liverpool	To New Zealand, Callao, Hamburg, & Mobile	11
Whiteway, Lewis	Dennis Brundrit	462	Philip Whiteway, Runcorn	To Chili, Melbourne, by Cape Horn, to Liverpool.	11
Wight, H. P.	Gosforth	810	T. E. Smith, Gosforth	To and from Madras	7
Wiseman, Sir W. S., Bart., C.B.	Curaçoa	1,571	H.M.S.	To Cape Good Hope, and to near Cape Leeuwin.	3
Wolfe, James	Orient	975	F. A. Clint, Liverpool	To and from Calcutta	7
Wood, A. D.	Oracle	1,134	J. W. Hamilton, St. John's, N. B.	To San Francisco, Honolulu, Hong Kong, Akyab, Singapore, Hong Kong, San Francisco, Honolulu, Baker's Island, Valparaiso, Callao, Queenstown.	14
Wood, Henry	Evangeline	965	F. A. Clint, Liverpool	To and from Calcutta	7

* Meteorological Register kept chiefly by the owner, H. F. Watt.
† Journal kept by Samuel Wyke Hocking, 2nd officer.

DOCUMENTS, amounting altogether to 41 in number, have been received during the year 1867 from the following places :—

Place.	Observer.	Nature of Observations.
Australia, interior	Mr. Kennedy	Journal kept during his expedition.
Do., western	Lightkeeper	Lighthouse Registers (2 stations).
Bangkok (Siam)	Dr. Campbell	Meteorological Register.
Bermuda	Dockyard Authorities	Anemometrical Records.
*Bucharest	-	Meteorological Registers kept at medical schools.
*Canada	-	Abstracts of monthly meteorological results from nine grammar school stations.
Carthagena	Consul	Monthly abstract showing average temperature and prevailing wind.
Falkland Islands	Lighthouse Keeper	Lighthouse Registers.
Fiji Islands	Consul	Monthly Registers.
Hamburg	Dr. Rümker	Daily Wind and Weather Reports.
*Helston	Mr. Moyle	Meteorological Results, Means, &c.
Holland	-	Extracts from Ships' Logs.
*Ivrea (Italy)	Dr. C. Gatta	Results of 30 years' observations of rain and temperature.
Messina	Consul	Daily barometer readings, with wind and weather Reports.
*Penzance	Mr. H. Richards	Review of weather of 1866, extracted from "Cornish Telegraph."
Scotland, West coast	Commander Chimmo, R.N.	Various Registers.
Somerset (Queensland)	T. J. Haran, surgeon, R.N.	Land Meteorological Registers furnished by office.

* These documents are printed.

APPENDIX V.

CORRESPONDENCE RELATIVE TO TELEGRAPHIC WEATHER INTELLIGENCE.

Board of Trade to Meteorological Committee.

Board of Trade, 31st May 1867.

SIR,

I AM directed by the Lords of the Committee of Privy Council for Trade to state that a large deputation has waited on the Duke of Richmond to urge that some warning should be given of apprehended danger from storms, and I am to ask whether it might not be possible for the Committee appointed by the Royal Society, upon such conditions and under such limitations as they may think necessary, to give effect to a desire which is strongly expressed by many competent and influential bodies and persons.

I am, &c.,

(Signed) T. H. FARRER.

Robert H. Scott, Esq.,
Director, Meteorological Office.

Meteorological Committee of the Royal Society to Board of Trade.

Meteorological Office, 2, Parliament Street,

SIR, London, S.W., 8th June 1867.

IN reply to your letter of the 31st ult., in which you ask "whether it might not be possible for the Committee appointed by the Royal Society" to give "some warning of apprehended danger from storms," I am directed by the Committee to state,—

1. Though they distinctly decline to prognosticate weather, or to transmit what have been called "storm warnings," they are collecting information which they confidently anticipate will enable them, sooner or later, to frame rules by which such prognostications can be made; and that one of the main objects which they propose to themselves is the advancement of meteorological science in this important practical direction.

2. That their observatories for continuous registration are not as yet in practical operation, nor can they be put into operation until the necessary funds have been voted by Parliament.

3. That the stations on the coasts from which reports are daily received by this office, and transmitted by it to the daily papers for publication, are in process of careful inspection, with a view to rendering the observations collected more trustworthy.

4. That, at an early period after commencing their labours, the Committee directed the following lithographed circular to be addressed to all parties applying to the office for information on the subject of storm warning :—

"SIR,

"I AM directed by the Meteorological Committee to acknowledge the receipt of . . . . and to inform you that this office is prepared to forward each day, by post, to any port which may require it, a copy of the daily weather report, the same as that furnished to the second edition of the London morning papers. This copy will be forwarded free of expense.

"Should the . . . at . . . . require regular or occasional telegraphic intelligence, you are requested to inform them that, on receipt of an application stating the precise nature and amount of information required, this office is prepared to furnish, without unnecessary delay, any telegraphic information which it may have received.

"In the case of telegraphic communication of this nature, half of the expense of the transmission is to be borne by the local authorities.

"I have, &c.,

. . . .

"By order of the Committee, Secretary of the Committee.

"Edward Sabine, Chairman."

5. With the view of collecting and distributing such information, the Committee included a sum of 3,000*l.* in their estimate, and they are willing to communicate information to any accessible place upon the terms laid down in their circular, and to an extent limited only by the sum placed at their disposal for the purpose.

The information conveyed by telegraph to each station would be of the following kind, one uniform signal being hoisted on the coast:—

"Storm from west at Penzance and south coast, hoist signal." Masters of coasters and others, on seeing the signal, might apply to know the nature of the information which had been received from the central office.

I have, &c.,

The Secretary, (Signed) ROBERT H. SCOTT,
Board of Trade. Director.

Board of Trade to Meteorological Committee.

Board of Trade, Whitehall,
11th July 1867.

SIR,

I AM directed by the Board of Trade to state, for the information of the Committee of the Royal Society, that they entirely approve of the proposal of the Committee that a portion of the cost of sending telegraphic information concerning storms should, as a general rule, be borne by the ports which desire such information.

At the same time the Board of Trade are of opinion that, in the case of poor fishing villages which are unable to find funds for the purpose, the Committee might properly send the information gratis; and I am to request that you will inform the Board of Trade whether, if the Board of Trade were to undertake to select and recommend places of this description to the Committee, the Committee would in those cases furnish the information without requiring part-payment.

I am, &c.,
(Signed) THOMAS GRAY.

R. H. Scott, Esq.,
Meteorological Committee.

Meteorological Committee to Board of Trade.

Meteorological Office,
15th July 1867.

SIR,

I HAVE the honour to acknowledge the receipt of your letter of the 11th instant (M. 5273).

I reply, I am directed by the Committee to inform you that they are prepared to transmit the telegraphic intelligence of weather, alluded to in their letter of the 8th June, gratis, to poor fishing villages, if the Board of Trade will undertake to give, from time to time, the names of any stations which are to be placed on the free list.

The Committee have in contemplation a scheme of signals for weather reports, and as soon as it, or any other scheme is adopted, they would suggest that the Board of Trade should present to each station a complete set of signal shapes and gear. In the opinion of this Committee, neither the Board of Trade nor this office should be responsible for any expense whatever connected with the maintenance of the gear or with the wages of the several persons charged with the management and hoisting of the signals.

The Board of Trade are aware that there are no funds at the disposal of this Committee which would be available for the preliminary outfit of the stations.

I have, &c.,
(Signed) ROBERT H. SCOTT,
Director.

Thomas Gray, Esq.,
Assistant-Secretary, Board of Trade.

Board of Trade to Meteorological Committee.

Board of Trade, Whitehall,
5th August 1867.

SIR,

I AM directed by the Board of Trade to acknowledge the receipt of your letter of the 15th ultimo, stating that the Committee of the Meteorological Department are prepared to send telegraphic intelligence of weather, gratis, to poor fishing villages to be named by this Board, and suggesting in connection with a scheme for weather reports in contemplation by the Committee, that the Board of Trade should present to each station a complete set of signal shapes and gear.

In reply, I am to state, for the information of the Committee, that the Board of Trade are willing to hand over to the Committee the old signals, gear, &c., supplied under the direction of Admiral FitzRoy, but that they have no funds at their disposal for the purchase of new signals.

I am to add that the Board of Trade agree with the opinion of the Committee, that neither this Board nor the Meteorological Department should be responsible for any expense whatever connected with the maintenance of the gear or with the wages of the persons charged with the management and hoisting of the signals.

I am, &c.,

(Signed) C. Cecil Trevor.

Robt. H. Scott, Esq.,
Meteorological Department.

Board of Trade to Meteorological Committee.

Board of Trade, Whitehall,
30th October 1867.

Sir,

I am directed by the Board of Trade to transmit to you, to be laid before the Meteorological Committee, the accompanying copy of a letter* sent to the Duke of Richmond by Sir J. D. Elphinstone, upon the subject of the resumption, during the forthcoming winter, of the system of Storm Warnings.

In so doing, I am to state that the Board of Trade would be glad to learn whether the Meteorological Committee can supply them with any further information than that already received upon the subject, and in particular, whether the Committee are prepared to issue cautionary notices, and if so, of what description, on what basis, and on what terms.

I am, &c.,

R. H. Scott, Esq., (Signed) T. H. Farrer.
Meteorological Office.

Meteorological Committee to Board of Trade.

Meteorological Office,
7th November 1867.

Sir,

I am directed by the Committee to inform you, in reply to your letter (No. M. 7726), of the 30th ultimo :—

1. That a system of weather telegraphy has been approved by them. The specimen signals will be tested, for a short time, at one or more of our chief ports before being issued to the public. They consist of a semaphore, similar in principle to a railway-signal post.

2. The nature of the information to be thereby conveyed is stated in my letter to the Board of Trade of the † 8th of June, to which they beg leave to recall the attention of the Board of Trade.

3. The basis on which such notices would be issued would be the study of the daily weather reports, as, in consequence of the lateness of the period at which the Estimate was sanctioned by the House of Commons, it has not been possible to have any of the self-registering observatories proposed by the Committee set at work. The normal observatory at Kew is in active operation, and it is hoped that more than one of the other observatories will be in action before the 1st of January.

4. The terms on which the notices are to be issued have been already determined between the Board of Trade and this Committee to the following effect :—

The messages shall be sent free, and a complete set of signals presented to such stations as may be named by the Board of Trade as

* Not printed.

† p. 64.

"poor fishing villages." This shall be done to an extent limited only by the funds at the disposal of the Committee for the purpose.

All other stations are to purchase the signals, and pay half the cost of transmission of the messages.

All stations, without exception, are to defray all expenses connected with the maintenance of the gear, and the wages of the several persons charged with the management and hoisting of the signals.

The Committee would suggest that the entire cost of transmission of the messages to all stations might be defrayed by this office.

Until the new system of signals in preparation by the Committee is complete, they propose to employ the drum as a cautionary signal to indicate the existence of a gale. This arrangement could be commenced with very little delay.

I have, &c.,

T. H. Farrer, Esq., (Signed) Robert H. Scott,
Secretary, Board of Trade. Director.

Board of Trade to Meteorological Committee.

Sir, Board of Trade, Whitehall, 13 November 1867.

I am directed by the Board of Trade to acknowledge the receipt of your letter of the 7th instant, detailing the various arrangements made by the Meteorological Committee for the future issue of notices concerning storms.

In reply, I am to request that you will state to the Meteorological Committee, with reference to the concluding paragraph of your letter, that the Board of Trade fully concur in the employment of the drum, as there proposed; and that they think arrangements for using it should be made with the least possible delay.

They would also be glad to learn how soon the hoisting of the drums can be effected, and also what notices it is proposed to issue upon the subject.

As regards the cost and transmission of messages, I am to state that the Board of Trade fully concur in the proposals of the Meteorological Committee.

I am, &c.,

R. H. Scott, Esq., (Signed) T. H. Farrer.
Meteorological Office.

Meteorological Committee to Board of Trade.

Meteorological Office, 2, Parliament Street,
Sir, London, S.W., 19th November 1867.

I have the honour to acknowledge the receipt of your letter (M. 8,028) relative to the issue of notices concerning storms.

I am directed by the Committee to inform you, that they are prepared to issue such notices as soon as the necessary arrangements shall have been made for hoisting the drums.

The signal shapes are, in most instances, at present in charge of the respective officers of Coast Guard, in pursuance of circular 5,620 W., issued in December 1866.

The Board of Trade, by letter (M. 5,426), dated 5th August 1867, have transferred the whole of the apparatus, &c., which belonged to them, to the Committee; and I have therefore to suggest that the coast guard be desired to deal with this apparatus in compliance with such requests as may from time to time be addressed to them by this office.

The Committee would request that the Board of Trade would send to such ports and fishing stations as they consider expedient, a circular stating that the Meteorological Office is prepared to transmit, free of cost, immediate intelligence of all storms of whose existence it may have

received information, to all parts of the coast accessible by telegraph, which appear liable to be exposed to their violence; this intelligence to be made public by the use of the drum.

Such a signal would be simply of a warning nature, and, without conveying the impression that the storm would necessarily strike the port where it was hoisted, would imply that extra caution in navigation was requisite.

The Committee are prepared to present a staff and drum to the authorities at every station which will undertake to bear all expenses connected with the care, hoisting, and repair of the signals, and they will transmit the messages, free of cost, to the persons charged by the local authorities with their reception, according to the arrangements already sanctioned by the Board of Trade.

Lastly they would request that the Board of Trade would set in action some mode of testing the agreement of the warnings with the winds actually experienced, similar to the former practice of the Wreck Department of the Board.

The Committee are only awaiting the reply of the Board to set this arrangement in operation.

I have, &c.

(Signed) ROBERT H. SCOTT, Director.

T. H. Farrer, Esq.,
Secretary, Board of Trade.

Board of Trade to Meteorological Office.

Board of Trade, Whitehall,
22d November 1867.

I AM directed by the Board of Trade to acknowledge the receipt of your letter of the 19th instant, stating that the Meteorological Committee are prepared to issue notices concerning storms, when the requisite arrangements shall have been made for the hoisting of the drums upon the coast.

In accordance with the first request of the Committee, I am to state that a letter has been this day sent to the Controller General of Coast Guard requesting him to issue instructions at once to the various officers of Coast Guard to deal with the signal shapes and apparatus now in their custody as they may be required to do, from time to time, by the Meteorological Committee.

A list of the various ports and fishing stations to which storm warnings were despatched by the late Admiral FitzRoy is herein enclosed.* A copy of a proposed circular for transmission to the ports and stations in question, announcing the new arrangements for notices concerning atmospheric disturbances, and the local publication of them by the drums, is also enclosed.

With regard to the concluding paragraph of your letter, I am state that the Board of Trade will gladly take steps for instituting a check on the warnings in their Wreck Department, as was previously done in Admiral FitzRoy's lifetime. The forms previously employed may probably suffice for this purpose, but the Board of Trade will gladly adopt any suggestions the Meteorological Committee may make for rendering the check as effective as possible.

I am, &c.

(Signed) T. H. FARRER.

R. H. Scott, Esq.,
Meteorological Office.

* This enclosure is not printed herewith.

The following circular, being that referred to in the foregoing letter, was issued on the 30th of November:—

TELEGRAPHIC WEATHER INFORMATION.

I AM directed by the Board of Trade to acquaint you that they have been informed by the Meteorological Committee appointed by the Royal Society, that that committee are now prepared to issue, free of cost, to ports and fishing stations which are accessible by telegraph, notice of serious atmospherical disturbances on the coasts or in the vicinity of the British Islands.

The conditions on which these notices will be issued are as follows, viz.:—

They will be forwarded, in each case, as soon as information of the atmospherical disturbance shall have been received at the Meteorological Office; and the ports or fishing stations to which they are to be sent will be determined by the Board of Trade. When the list of places to which notices may be sent has been determined by the Board of Trade, it will rest with the Meteorological Committee, in each case of atmospheric disturbance, to send notices to all or any of those places, as the circumstances of the particular case may appear to the Meteorological Office to be advisable.

When a telegraphic notice of atmospherical disturbance is received at one of the places named on the Board of Trade list, its receipt is to be made public by hoisting one of the late Admiral FitzRoy's drums, and the drum is to remain hoisted for 36 hours after the receipt of the telegraph message containing the notice. One telegraph notice implies that the drum is to remain hoisted for 36 hours, and no longer. Should the Meteorological Committee think it necessary that a drum should remain hoisted for more than 36 hours, in any case, they will send messages to that effect, and continue them from day to day, so long as it appears desirable, or until the storm shall have abated.

If the authorities at any port or fishing station wish to receive intelligence of atmospherical disturbances, and will undertake to hoist the drum, subject to the conditions named, and subject to such regulations or directions as may from time to time be issued by the Meteorological Office, an application should be addressed to the Secretary to the Meteorological Committee, 2, Parliament Street, Westminster, S.W., in order that the necessary steps may be taken to place the name of the station on the Board of Trade list, and to provide the flagstaff and drum.

It is to be understood that where the place or station can pay for a flagstaff and drum, they will be expected to do so, if a staff and drum are not already provided, and that where it is made to appear to the Board of Trade that no staff and drum are provided, and that the place is too poor to bear the expense, then the cost will be defrayed by the Meteorological Office, with the sanction of the Board of Trade.

But in all cases, whether the first cost of the flagstaff and drum are or are not borne by the local authorities, the local authorities must undertake to bear all subsequent charges connected with the hoisting of the signal, and maintenance of the signal apparatus. The only subsequent expense that will be defrayed by the Meteorological Office, will be the charge for transmission of the notices of atmospherical disturbances.

(Signed) T. H. FARRER.

The form on which the reports of weather are made by the officers of coast guard is here subjoined.

f. 86v

Wr. 37.
(late 25.)
Issued by the Board of Trade, January 1868.

Inspecting Officer's Division or Receiver's District _____

REPORT by Inspecting Officer of Coast Guard or Receiver of Wreck of the DIRECTION and FORCE of the WIND and of the State of the Weather during the Time that the Wind blows with the Force of 8 or upwards, whether the Drum is up or not.

PARTICULARS OF PLACE AND DATE OF REPORT.

Place.	Date.		
	Year.	Month.	Day.
1.	2.	3.	4.

STATE OF WEATHER.

To be recorded as soon as the Wind reaches the force of 8, and as far as practicable, once every Six Hours as long as its force does not fall below 8.

Date and hour of Observations.	Direction of the wind. (Here state the true direction of the wind, not the magnetic.)	Force of the Wind. (Here state the force, according to the notation on the back hereof.)	State of the Weather. (Here state briefly the state of the weather, *e.g.*, "blue sky," "fog," "mist," "rain," "snow" "lightning," "hail," &c. &c.)	REMARKS. 1. Whenever the "Drum" is hoisted, the fact should be noted in this column, with the date and hour of hoisting and lowering it. 2. If the greatest violence of the wind occurs at a time not stated in Column 5, 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.
5.	6.	7.	8.	9.
—— o'clock ——M. First observation.				
—— o'clock ——M. Second observation.				
—— o'clock ——M. Third observation.				
—— o'clock ——M. Fourth observation.				
—— o'clock ——M. Fifth observation.				
—— o'clock ——M. Sixth observation.				
—— o'clock ——M. Seventh observation.				
—— o'clock ——M. Eighth observation.				
—— o'clock ——M. Ninth observation.				
—— o'clock ——M. Tenth observation.				
—— o'clock ——M. Eleventh observation.				
—— o'clock ——M. Twelfth observation.				

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 six-hourly observations, the particulars should be entered in addition to the usual observations.

(Signature and Title of Officer forwarding this Report.

DIRECTIONS.

WHENEVER the wind begins to blow with force 8 or upwards the fact is to be noted in Columns 5, 6, 7, and 8 of this form as the "First Observation;" and the direction and force of the wind and state of the weather are to be noted herein every six hours during the time that the wind remains at force 8 or above it. It is to be distinctly understood that the entries in this form are to be commenced only when the wind reaches Force 8, that they are to be discontinued as soon as the wind falls below Force 8, and that they are to be made whether Admiral FitzRoy's drum is hoisted or not.

The value of this Form will depend on the readiness and accuracy with which it is kept and forwarded to the Board of Trade.

The Officers who make these Returns are not required to possess any scientific knowledge or attainments, but are expected to exercise ordinary care. The sailor's habit of observing the weather and sky, coupled with common sense and tolerable accuracy, will ensure that these Reports are what they are intended to be.

They should be sent to the Board of Trade at the earliest moment after the wind falls below Force 8, *and they need* not *be enclosed in an envelope when sent to the Board of Trade. A supply can at any time be got from the Receiver of Wreck for the district.*

FIGURES to denote the FORCE of the WIND.

0. Calm.		
1. Light Air	Just sufficient to give steerage way	
2. Light Breeze	With which a ship with all sail set and clean full would go in smooth water	1 to 2 knots.
3. Gentle Breeze		3 to 4 „
4. Moderate Breeze		5 to 6 „
5. Fresh Breeze	In which she could just carry in chase, full and by	Royals, &c.
6. Strong Breeze		Single reefs and T. G. sails.
7. Moderate Gale		Double reefs and jib, &c.
8. Fresh Gale		Triple reefs, &c.
9. Strong Gale		Close reefs and courses.
10. Whole Gale	In which she could just bear close-reefed main topsail and reefed foresail.	
11. Storm	Under storm staysail.	
12. Hurricane	Bare poles.	

APPENDIX VI.

PRACTICE of other COUNTRIES in 1867, with reference to TELEGRAPHIC WEATHER INTELLIGENCE.

In the course of July 1867, letters were addressed to various foreign Governments, requesting them to furnish replies to the following questions:—

1. Is telegraphic intelligence of existing weather transmitted to ports?
2. Is this of the nature of warning of expected storms?
3. Is such intelligence made public by means of signals?
4. If so, what is the nature of the signals employed?

Replies were received from France, Holland, Austria, Italy, and Norway.

An abstract of these letters is here subjoined:

Ministère de la Marine
Paris, le 25 Juillet 1867.

ABSTRACT.

Captain E. de Rostaing writes :—"There are in France two distinct meteorological services. The Imperial Observatory of Paris (of which M. Le Verrier is the director) receives each morning the state of the weather at 60 stations in Europe, about 20 of which are in France itself. The reports from the latter stations are chiefly furnished by officers of the navy at the ports. All the telegrams arrive in Paris at about 10 o'clock, and copies are forwarded to the Imperial Observatory and to the Ministry of Marine. M. Le Verrier sends a report of the state of the weather at a certain number of stations to 70 seaports of France.

"The Ministry of Marine receives meteorological telegrams from 10 French seaports, and sends immediately a résumé to about 20 of the principal seaports, and also to Jersey."

The meteorological reports received at the Imperial Observatory of Paris have been, for several years, published by M. Le Verrier in his "Bulletin International," accompanied with a résumé of the weather over Europe.

(Copy.)

Royal Meteorological Institute,
Utrecht, 12th August 1867.

SIR,

IN reply to your letter of the 24th July, and the 7th August, I have the honour to inform you that,

1. Every day's existing weather is transmitted to Ports at 8h. a.m. and 6h. p.m.

2. When storms are expected, intelligence also is given.

3. Intelligence of the weather in our country is made public by the use of signals. The state of the weather in England and France is written on a black board which is placed by the signal post at the Pilot Office.

4. The nature of the signal employed is the aeroclinoscope, an instrument (with a moveable arm) which indicates the difference of the pressure of the air over this country, and the direction in which the greatest difference exists.

It is a fact that the wind will always blow almost perpendicular to the direction of the arm, and from the left side when we look from the highest to the lowest station.

The force of the wind depends upon the difference of the pressure.

If we take four places—easterly winds will blow when the places to the northward have a high reading of the barometer, and on the contrary the wind will come from a westerly direction when the barometer reads higher at the places situated to the southward.

Every day at 8h. a.m. and 6h. p.m. the aeroclinoscope is placed in the proper direction by intelligence sent by telegraph. When storms are expected, or the intelligence from England and France "gives" storms, a cone is hoisted by day-time and lanterns are shown by night close to the aeroclinoscope. These signals (cone and lanterns) are only temporary, until the seamen at the ports understand the aeroclinoscope. We endeavour, sir, that the public should no longer call these signals "storm signals." The aeroclinoscope is only a new instrument, more perfect than our barometer, which shows the difference of the pressure of the air, and whereby we can follow the undulations of the atmosphere in the environs.

(Signed) J. E. CORNELISSEN,
Director of the Naval Department.

Robert H. Scott, Esq., Meteorological Office.

"Ministero della Marina,

"CHER MONSIEUR, Florence, 28 Juillet 1867.

"JE reçois tous les jours à 11 heures à-peu-près les dépêches météorologiques de 23 ou 24 stations de mer, qui me donnent baromètre, thermomètre, vent, état du ciel et de la mer, et la variation dans les dernières 24 heures. A 2 heures je réçois la dépêche résumée de Paris et de Vienne. Toutes ces données sont traduites dans un prospectus et dans un carte d'Italie, où l'on signe la variation de la pression et de la température et le vent. Alors, ordinairement, moi-même (ou M. Donati), je fais un résumé de l'état de l' atmosphère en Italie et puis le résumé de celui de l'Europe. J'ajoute la variation de la matinée de Florence et autres observatoires voisins, s'il en vaut la peine. Si la tempête est annoncée de Paris, ou de vous, je donne une dépêche circulaire immédiate aux ports de mer. Autrement on donne à 4 heures à toutes les stations le résumé. A la fin je mets ordinairement 4 mots ou 5 : "saison variable" ; "beau temps" ; "le courant équatorial avance" ; "le courant polaire vient avec le beau temps." Et voilà tout. Dans les temps ordinaires les chefs de stations, qui sont des Capitaines de Port, publient la dépêche du Bureau Central en manuscrit, ou imprimée, ou dans un journal du soir.

"Si on annonce une tempête on lève un drapeau sur un mat dans le port de mer. Et si la tempête est prévue par la station par une baisse très grande de son baromètre, elle lève son drapeau sans attendre le Bureau de Florence.

"Voici à-peu-près le peu qu'on fait et qui ne vaut pas beaucoup, mais qui est, je crois, tout ce qu'on peut faire de sage et de prudent."

"C. MATTEUCCI.

"Mr. Robert H. Scott, Meteorological Office."

"K. K. Central Anstalt für Meteorologie,

"Vienna, 31 July 1867.

"Two telegrams are transmitted to Trieste and Pola (and from thence to other parts). The first is a telegram from the Central Office at Vienna, and contains a sketch of the actual weather at 7h. a.m. in the Austrian empire, and states especially whether the barometer and thermometer stand *above* or *below* the normal value for the day in question, whether the barometer has risen or fallen ; whether it is colder or warmer. Also the state of the wind, clouds, &c., is briefly communicated. You will find in the newspaper extracts which I send to you monthly, such résumés each day.

"Secondly, a telegram from the Paris Observatory, which contains more particularly the course of the isobaric lines, is telegraphed from Vienna to Trieste and Pola.

"The first telegram arrives at Trieste about noon, the second from 4h. to 5h. in the afternoon.

"The first telegram contains *no* storm-warnings, at least not yet. I intend to investigate the observations received by telegraph with reference to the rules given by Dr. Buys Ballot, and if the results prove to be sufficiently satisfactory, I shall commence the transmission of warning telegrams.

"The telegrams from the Paris Observatory contain storm warnings in exceptional cases. I am not aware how far they agree with the actual conditions of the weather. The difficulty sometimes arises that the Paris telegrams reach Trieste very late, and frequently after the atmospherical changes have occurred ; and further that in the northern portion of the Adriatic Sea, the prevalent direction of the wind is *East*,

and the 'Bora' storms which are very frequent, blow from North to East. These storms are not accompanied by any notable fall of the barometrical column.

"Only storms, not the daily state of the weather, are made known by means of signals. These signals are hoisted at 10 points of the Adriatic Coast (Journal of the Austrian Meteor. Soc., Vol. I. pp. 363, 366).

"Direction is not denoted by the signal, only the fact that a storm is expected. By day the signal consists of a Drum made of wicker-work and painted black. It is 3 feet high by 3 feet wide, and is hoisted on a mast about 20 feet high.

"By night the signal consists of 4 lanthorns (showing a white light) placed at the corners of a square framework, each side being 3 feet in length.

"(Signed) C. JELINEK."

"Det Norske Meteorologiske Institut,
"Christiania, 5th August 1867.

"From the beginning of 1861 Meteorological observations, including barometer, thermometer, humidity, wind and weather, made at 8 a.m., in the winter months, at 7 a.m. in the summer months, are every morning transmitted by telegraphs to the ports, and published by copies being put up in a convenient place. The Stations of Observation are the following :—Christiansund, Aalesund, Skudesnes, Mandal, Sandösund, and Dovre.

"The ports that receive the telegrams pay a small annual sum to the telegraph office.

"The reductions of the observations are made at the place of observation itself.

"Warnings of expected storms are never given; the knowledge of the laws of the storms in our regions being yet too incomplete. No storm warning signals have ever been erected in Norway.

"(Signed) H. MOHN."

APPENDIX VII.

LIST of PERSONS in the EMPLOYMENT of the METEOROLOGICAL COMMITTEE on Dec. 31st, 1867, with their occupations :—

NAME.	DUTIES.
Robert H. Scott	Director of the Office.
Capt. H. Toynbee	Marine Superintendent.
W. Salmon, R. N.	Preparation of Weather Reports. Reduction of Logs.
Jas. S. Harding, Junr.	Correspondence — Accounts — Registry of Documents.
R. Strachan	Care and management of the instruments, and correspondence therewith connected.
F. Gaster	Discussion of Returns from Land Observatories.
C. Harding	Preparation of Weather Reports—Reduction of Logs.
Jas. S. Harding, Senr.	Registry of Documents and assistance in Accounts, &c.

R. H. Curtis	-	Preparation of Weather Reports—Reduction of Logs.
G. White	-	Discussion of Weather Reports and Coast Guard Returns.

Balfour Stewart	-	Secretary to the Committee—Director of Normal (Kew) Observatory.
Rev. Thos. Kerr	-	Director of Valencia Observatory.

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For Her Majesty's Stationery Office.

REPORT

OF THE

METEOROLOGICAL COMMITTEE OF THE ROYAL SOCIETY,

For the Year ending 31st December 1874.

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

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

1875.

[C.-1307.] *Price 6d.*

CONTENTS.

PREFACE.

THE Meteorological Committee consists of Fellows of the Royal Society who have been nominated by its President and Council, at the request of the Board of Trade, for the purpose of superintending the Meteorological duties formerly undertaken by a Government Department, under the charge of Admiral FitzRoy.

The Committee are credited with a sum of £10,000, voted annually in the Estimates, for the administration of which they are wholly responsible.

The services of the Committee are *entirely gratuitous*.

The Meetings of the Committee are held regularly once a fortnight, or oftener when necessary, when every subject on which action has to be taken by their executive officers receives their careful consideration.

MEMBERS OF THE COMMITTEE:—

GENERAL SIR E. SABINE, R.A., K.C.B., *Chairman*.
Mr. DE LA RUE.
Captain F. J. O. EVANS, C.B., Hydrographer to the Admiralty.
Mr. FRANCIS GALTON.
Mr. GASSIOT.
Rear-Admiral G. H. RICHARDS, C.B.
The EARL of ROSSE.
Major-General W. J. SMYTHE, R.A.
Major-General R. STRACHEY, R.E., C.S.I.
Sir CHARLES WHEATSTONE.

May, 1875.

REPORT

For the year ending December 31st, 1874.

Introductory.

THE administration of the Office in this, the eighth year of its management by the Committee, has been unchanged from that existing at the date of the last Report, the executive officers being Mr. Robert H. Scott, as Director, and Captain Henry Toynbee, as Marine Superintendent.

Among the principal points of interest in the proceedings of the year has been the assemblage at the Office, in the month of September, of a private International Conference on Maritime Meteorology, to discuss the questions deemed advisable for the further prosecution of that inquiry. The report of that Conference has now been published, and a summary of the resolutions adopted will be found in Part II.

An agreement has been entered into with the Meteorological Society (of London), by which that body, in consideration of a certain annual allowance, furnishes the Office with copies of the observations taken at some of their stations. The particulars of this arrangement will be found at p. 26.

Mr. Scott was examined before the Royal Commission on Scientific Instruction, &c., in the month of May, and his evidence, which may be expected to appear shortly, gives copious details on the history and management of the Office.

Inasmuch, however, as even the scientific portion of the public seem to be hardly familiarly acquainted with the subject, it seems to the Committee advisable, in the present Report, to review at some length the operations of their Office in the three departments into which it is subdivided, and to compare them with the development of the same branches of the science in other countries. These three departments are as follows:

I. Ocean Meteorology.
II. Weather Telegraphy.
III. Land Meteorology of the British Islands.

I.—OCEAN METEOROLOGY.

The systematic prosecution of enquiries relating to the Meteorology of the Ocean may be said to have been first placed on a sound basis by Mr. Marsden, Secretary to the Admiralty, who at the end of last century (in 1784) proposed to divide the surface

Origin of the science of Ocean Meteorology.

of the sea into a certain number of squares, and to consider the observations geographically, dealing with those taken in each square by themselves, instead of treating each voyage by itself, and publishing, *e. g.*, mean results for each month, without regard to any change in the ship's position during the month.

It is needless to say that it was Maury who set the example of an extensive sphere of operations in the course above indicated, but his charts, copious as was the amount of information embraced by them, were unavoidably defective as regards minute accuracy, owing to the fact that at the time he commenced his operations, now about 30 years ago, the instrumental appliances for the registration of the phenomena were very poor as compared with those now in use.

The Meteorological Department of the Board of Trade, from its first establishment under Admiral FitzRoy in 1855, laid the greatest stress on the importance of the selection of observers and the supply of first-class instruments, duly tested before issue, and the Committee have been guided by the same principles, attaching weight to the *quality*, as contrasted with the *quantity*, of the records to be obtained.

In order that nothing should be wanting on the part of the newly-founded Office to secure the accuracy of the instruments employed, almost the first action of the Board of Trade in 1855 was to invite the Kew Committee of the British Association to devise improvements in the instrumental appliances for Marine observations, and the most important outcome of their deliberations was the recommendation of the Kew pattern Marine Barometer, the principle of which has been universally adopted as that best suited for use at sea.

Issue of instruments.

The Office possesses a large stock of these and other instruments, and its practice as to the collection of observations is to supply on loan to captains a set of instruments properly verified at Kew, which are returned to the Office for recomparison with standards as soon as the voyage is over. The loan is granted on condition of observations being taken with the instruments, and entered in a log supplied for the purpose, which is sent into the Office when filled. The instruments supplied to a ship consist of—

1 Marine barometer (Kew pattern),
6 Thermometers with a thermometer screen,
4 Hydrometers,

and in exceptional cases an azimuth compass is added.

Observations made with instruments which have not been supplied or authentically verified by the Office, are not employed in the investigations. Aneroid readings are never used.

Supply to the Royal Navy.

The foregoing remarks apply to the Merchant Service. As regards the Royal Navy, H.M. ships are supplied with Meteorological instruments under an arrangement with the Admiralty, and the Meteorological observations are returned to that Department in the form adopted in the Naval Service. It is voluntary

whether the Meteorological log of this Office is kept in addition: some valuable logs are, nevertheless, from time to time received from H.M. ships.

Agencies.

In addition to the supply of instruments direct from the Office in London, a stock is kept at some of the more important seaports, *e.g.*, at Liverpool, Glasgow and Aberdeen, the Agents in charge of them receiving a fee for each case of issue and return, and a further fee for each observer obtained through him who furnishes first-class observations. The names of all applicants for instruments are submitted to Captain Toynbee for approval prior to the supply.

As soon as a log is received at the Office it is examined and classified according to its quality, and an acknowledgment is immediately made to the captain sending it; and at the same time if explanations on any points arising out of the inspection of the log are found to be requisite, he is requested to furnish the information while the circumstances are still fresh in his memory. Replies received from the captain are at once noted in the log for future reference when the observations are discussed.

Presentation of Pilot Charts.

To each observer who has obtained the mark "excellent" a copy of the Atlantic Pilot Charts, or of the Wind and Weather Charts of the Atlantic, Pacific, and Indian Oceans, published by the Admiralty, is presented. Observers who have already received these charts, and who may continue to observe for the Office, have the special thanks of the Committee for each register which has received the mark of "excellent." They also receive such publications of the Office as are likely to be of interest to them.

The names which have been added during the financial year to the list given in last year's Report are as follows:—

Presentation of Admiralty Charts.

Captain's name.	Ship.
Becket, Alexander - - -	"City of Perth."
Comley, William Guise, R.N.R. -	S.S. "Hong Kong."
Dobson, Charles Meadows - -	S.S. "Beta."
Freeman, Thomas W. - - -	S.S. "Wisconsin."
Longley, Herbert - - -	S.S. "Yorkshire."
Maples, Charles - - -	"Genii."
Owen, John - - - -	"W. G. Russell."
Smith, William Charles - -	"Kingdom of Saxony."
*Jackson, Robert, R.N. - - -	H.M.S. "Glasgow."
Jones, Theodore Morton, R.N. - -	Do.
Nares, George Strong, R.N. - -	H.M.S. "Challenger."
*Tizard, T. H., R.N. - - -	Do.

The Committee do not feel themselves at liberty to present Admiralty Charts to officers in the Royal Navy; they receive the letters of thanks.

In Appendix II. will be found a list of the observers whose logs have been classed as "excellent," since the beginning of the year 1869. Some of the gentlemen mentioned in the list have been regular observers for the Office for many years.

* Navigating Lieutenant.

Localities whence observations are being derived.

The geographical distribution of the vessels in which observations were being taken at the close of the year 1874 was as follows:—

Voyages.	Ships.
To Baffin's Bay or Greenland	3
„ East Coast, North America	10
On East Coast, North America	4
To West Coast, North America	4
„ West Indies	4
„ East Coast, South America	2
„ West Coast, South America	7
„ East Coast, Africa	1
„ Australia and New Zealand	17
„ India, viâ the Cape	16
„ India, viâ Suez	3
In Indian Seas	1
To China Seas, viâ Suez	3
„ Mediterranean Ports	1
„ Home Ports	2
„ Archangel	1
	79

The Committee regret that the number of observers who are co-operating with them remains small when compared with the strength of the Mercantile Navy, as will be seen from the figures just quoted: but the duty of observing regularly and frequently entails a considerable degree of responsibility on anyone who undertakes it, and if the captain is not supported by a good staff of officers it is simply impossible that the log should be properly filled.

Collection of observations.

Circulars have been issued to the various shipping offices, &c. in connexion with the Board of Trade, and it is hoped that by constantly keeping before the eyes of captains the objects and aims of the Office the services of such among them as have a real interest in the science will be secured for the Office.

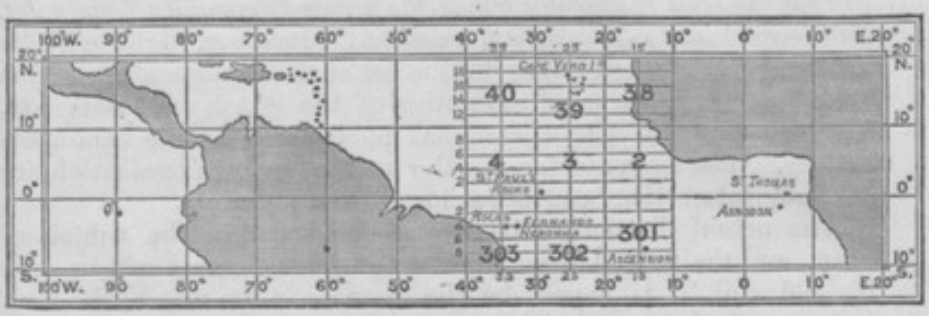
The method employed by the Royal Meteorological Institute of the Netherlands, the only other office extensively engaged in this branch of Science, in the collection of observations, is to appoint in each seaport a committee of shipowners, the members of which use their personal influence in inducing captains to become observers. It is stated that the results of this system are satisfactory.

Progress of discussions, Equatorial region of the Atlantic.

As regards the progress of the discussions carried on by the staff, it was mentioned in the last report that the treatment of the materials for the entire district of nine ten-degree squares, Nos. 38–40, 2–4, and 301–303, extending from 20° N. to 10° S., and 10°–40° W., as shown in the subjoined chart, was expected to be completed by the end of the year 1874.

This has been the case, and the results are now in process of publication in the form of monthly charts, but not to the same degree of minuteness as the charts already published for Square III., which contain the information sifted into two-degree squares. The charts now in course of publication are subdivided into areas of

5° of longitude by 2° of latitude as shown in the diagram, and each chart contains the data of three ten-degree squares. Equatorial region of the Atlantic.



It will be seen that the island of Ascension falls within the area now under treatment, and accordingly the detailed observations made at that island in the years 1863–5, by Lieutenant Rokeby, R.M., are being discussed, and the results will be embodied in the forthcoming publication. Observations at Ascension.

For the two years into which these observations extend we have the wind direction and velocity recorded continuously by a self-registering anemometer, and almost hourly observations, by eye, of pressure, temperature, and other meteorological phenomena. It is consequently considered that a thorough investigation should be made of the observations which have cost so much time and care in collecting, and are rendered the more interesting from the fact of the island being situated in the heart of the S.E. Trade wind, the wind being there S.Ely. almost without exception throughout the year. By referring the winds to 32 points of the compass it is believed that the discussion will exhibit a diurnal and annual march of the direction and velocity of the S.E. Trade.

It is hoped that the results to be deduced will form a valuable addition to the information obtained from observations made on board ships traversing this part of the ocean, and will also add to our knowledge of the extent and regularity of the ordinary fluctuations in the tropics.

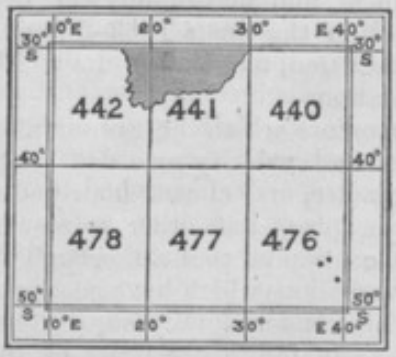
The material available for that part of the Atlantic between the parallels of 20° N. and 10° S., which lies east and west of the nine squares which are being discussed, is so scanty that its discussion would not be likely to lead to any practical results; this will easily be conceived from the fact that 59 per cent. of the entire information in the office for the whole district was concentrated in the central Square III.

The Committee have therefore decided to turn their attention to another region in order to subject it to a process of examination similar to that which has been bestowed on the belt of the Atlantic Doldrums, and they have had little hesitation in selecting the south point of Africa, where the tracks of all vessels trading by long sea to India and China, and those outward bound to Australia, lie within narrow limits of latitude. The district will therefore afford a copious store of observations, and their discussion may be expected to yield results of great importance to navigation, and of interest South point of Africa.

South point of Africa.

to science. In the first place it is hoped that in that proverbially stormy part of the sea it may be finally ascertained *which track affords the most favourable winds, the greatest immunity from gales, and consequently the easiest passage.* Moreover, light will be thrown on the irregularities in the sea surface temperature which have long since attracted the notice of the Dutch meteorologists, and on which M. Cornelissen has published valuable communications. The currents too, in the region under examination are specially interesting, and as yet insufficiently known.

The actual district to be treated is shown in the subjoined chart, and the degree of minuteness to which the area will be subdivided will, it is hoped, be the same as in the case of the nine squares of the equatorial region of calms and rains already mentioned.



Relative value of old and new materials.

The Committee would here observe that it has been often remarked that their chief attention should be directed to the utilization of the more recent materials, and that the store of old logs should be considered as of more secondary importance. Such an opinion as this is affected by a serious misconception of the mode of dealing with the subject of Ocean Meteorology enforced by the nature of the materials at hand for discussion.

It cannot be too well understood that it is not possible to produce mean results of any value from recent logs. Observations taken at sea are not like records obtained from land stations. The ship is constantly changing her position, so that it is only from the comparison of a number of observations made in different ships at or near the same spot and at the same seasons in successive years that we can ever hope to obtain materials for the calculation of mean values.

Synoptic charts of Atlantic.

The chief inquiry the solution of which can be attempted by the use of recent observations alone, is the construction of synoptic charts of weather, but for this purpose a large number of observations taken at the same period and in the same district are requisite. It is hardly needful to say that these conditions cannot easily be fulfilled, as say 100 ships observing on any one day between the parallels of 40° and 60° in the North Atlantic would be the very least which might be expected to afford anything approaching to a complete representation of the conditions of

weather prevailing over that portion of the earth's surface at the time.

Storms of August 1873 in Atlantic.

In the last Report it was mentioned that invitations had been issued to British shipowners to lend to the Office any logs of ships in the Atlantic during the month of August 1873, in order to aid in tracing the history of the hurricane which swept the Eastern seaboard of the United States and wrought great damage on the coasts of Nova Scotia at that time.

280 logs have been received in compliance with the invitation, and Captain Toynbee has commenced the examination and discussion of the material on a principle similar to that already employed by him in the case of the "City of Boston" gale.*

It may be hoped that, as apparently more material is available for the present investigation than has existed in the case of any previous inquiry of a similar nature, additional light may be thrown by it on the real facts of wind motion in cyclones—a subject which even at the present day is the theme of discussion,—and thereby the knowledge may be enlarged, on which are based the rules for avoiding such storms altogether, or for dealing with them when encountered.

Conference on Maritime Meteorology.

In the last Report it was mentioned that a sub-committee consisting of five members had been appointed by the Vienna Meteorological Congress to arrange for the assemblage of a Conference to reconsider the decisions of the Brussels Maritime Conference in 1853. These gentlemen decided that the Conference should be of a private character. The meeting in question took place in London from August 31 to September 3, at the Meteorological Office. As regards its results, it is remarkable to find that although the first promoters of the Conference had urged as the principal ground for its being convened that the regulations for filling the log adopted at Brussels had been too stringent, the members, when assembled, passed by a large majority rules hardly differing in any important particular from those emanating from the Brussels meeting; the only deviations, in fact, being a demand for increased information, viz., the entry of "Course and Distance by Log every four hours," in order to facilitate a closer approximation to the true position of the ship from time to time than was previously possible, and a request that the wind should be given for the actual time of observation, and not estimated for a certain number of hours previously.

In fact, the Committee cannot but feel that the practical experience of the Office carried on under their superintendence was highly honoured by the fact that the draft Log and the Instructions for Observers, prepared by their own Marine Superintendent, Captain Toynbee, were, by the resolution of the Conference, appended to the Report of its proceedings. It should here be remarked that the Log and Instructions just referred to are almost *identical* with the modified form of the Brussels Log

* "A Discussion of the Meteorology of that part of the Atlantic lying north of 30° N. for the eleven days ending February 8, 1870," by Captain H. Toynbee. Official No. 13. London: Stanford.

Conference on Maritime Meteorology.

adopted by Admiral FitzRoy at the first institution of the Meteorological Department; in fact, the Office may almost say that its practice has been unaltered from the first, and is now handed on for general adoption.

In Part II. will be found the several Resolutions adopted at the Meeting.

It may be hoped that the tendency of this Conference will be towards the more extensive prosecution of studies bearing on Ocean Meteorology, inasmuch as the institutions whose attention is specially devoted to the subject at present are very few in number. In fact, with the exception of the Royal Meteorological Institute of the Netherlands, the United States Naval Observatory, the Deutsche Seewarte, and the Meteorological Office, it can hardly be said that original investigations bearing on this branch of science have been published of late years by any office in any country, although the Hydrographical Department of our Admiralty and the Dépôt des Cartes et Plans of the French Navy have both furnished several most important contributions to our knowledge of Ocean Meteorology.

Appendix IV. contains a list of the contents of the publications issued by the Office during the year, in continuation of that given in the Report for 1873, p. 45.

Stock of instruments.

In Appendix V. will be found a list of all the instruments supplied to ships in the Royal Navy during the year, with a statement of the entire stock and distribution of instruments standing on the books to the account of the Admiralty on the 31st December 1874. This latter statement is prepared from the latest returns furnished by the storekeepers at the respective dockyards, &c.

Appendix VI. gives similar information with regard to the Board of Trade instruments.

II. Weather Telegraphy.

Condition of stations.

There has not been any change of importance in this department of the Office during the year, and the service has on the whole been performed with satisfactory regularity, unless on such occasions as that of October 21, when the communication along many telegraph lines was interrupted by the violence of the storm.

It is, however, much to be regretted that the condition of the cable to the Shetlands has hardly been permanently improved since the date of the last Report. Connexion was certainly re-established in the beginning of August, and the wire worked satisfactorily until the end of the year, but after that time the service speedily became less regular, and ceased altogether on the 23rd of January 1875.

The stations were, as usual, inspected during the year, with five exceptions, Cambridge, Oxford, St. Ann's Head, Sumburgh Head, and Yarmouth. A list of the stations with the observer's names will be found at Appendix VII.

Inasmuch as there appears to be an impression among some meteorologists that the observations made at telegraphic reporting

stations ought to be available for climatological inquiries, it may perhaps not be amiss to explain what such stations are, as a general rule, capable of affording, and what reasons exist for their deficiencies in certain respects, as compared with ordinary observing stations. Difficulties of organization of reporting stations.

In the first place the choice of a station is necessarily determined by the existence of telegraphic communication, and this implies in most cases that the reporting stations are situated in towns. It is hardly necessary to say that under such circumstances the observations of temperature, rain, and wind are of minor value as compared with those obtainable under more favourable conditions of exposure, inasmuch as in many towns it is absolutely out of the question for men, in the position of telegraphic reporters, to obtain the use of a very open space for the erection of their thermometer screen or rain gauge within a reasonable distance of their residence or reporting office.

To take a single instance where a satisfactory exposure has been obtained, viz., Leith; the thermometer screen and rain gauge are erected on the Links at a considerable distance from the telegraph office, so that much labour is entailed on the reporter as compared with that falling upon an observer who can have his thermometers in his own garden.*

In view of considerations like these it will at once be admitted that it is needless to publish mean results for other elements than barometrical pressure and rainfall for ordinary telegraphic stations. The accuracy of barometrical observations does not depend on the exposure; and as regards the rainfall, local differences in measurement are so great that absolute accuracy may be considered unattainable, and the figures furnished by gauges erected in the best conveniently attainable situations are sufficiently accurate for practical purposes, as indicating the approximate amount of fall in the districts in which the respective stations are situated.

There is yet another reason for the somewhat exceptional nature of telegraphic reports, the duty of reporting demands constant attendance and punctuality, and it therefore cannot be discharged by anyone whose avocations interfere with these requirements.

In many outlying stations the choice of observers is exceedingly limited, and it is impossible to find the same class of observers as would be looked for in establishing a station for climatological purposes; but for several of the stations, *e.g.*, at the observatories of Oxford, Cambridge, and Bidston, and at Plymouth, the services of very high class observers have been secured.

In fact the exceptional character of telegraphic reporting stations is recognized by every one who has ever had the slightest experience in their management.

On the whole the Committee may point to the fact that their system of telegraphic observation, defective though it admittedly is, when compared with the strict requirements of the science, is

* The Committee are very glad to say that permission has at last (June 1875) been obtained from the proper authorities to have the thermometers and rain gauge at North Shields transferred from the Post Office premises to Dockwray Square, which affords very good conditions of exposure.

Errors in telegraphic reports.

allowed to be the most complete in Europe as regards the character of its observers, the control exerted over them by inspection and correspondence, the outfit of its stations, and the care taken to introduce improvements, *e.g.*, in thermometric exposure whenever the possibility is offered, to ensure accuracy in the published reports, and to correct errors when detected. The last-named task is the most difficult of fulfilment of any, for it is only in the case of barometrical readings and to a slight extent as regards temperature, that an approach to accuracy in the publication of observations received by telegraph is attainable. In the case of the barometer the differences of reading between adjacent stations are usually so small, and follow such regular laws that a comparison of the reports reveals the existence of even slight errors. Serious mistakes in temperature are also detected by the same means, but as regards the other elements, especially the rainfall, and at times even the wind, slight discrepancies between the reports from the same line of coast are to be expected under ordinary circumstances, owing to the differences of local conditions of exposure, &c., so that it is impossible at first sight to say whether such discordances are simply due to telegraphic errors or to real differences in the phenomena observed.

Manuscript reports.

The system of the receipt of monthly sheets from the stations, containing the copy of the observations actually taken, enables the Office to exert a considerable check on the accuracy of transmission of the reports, and care is taken that any *mean* results published by the Office, *e.g.*, of rainfall, shall be compiled from such manuscript reports, as telegraphic reports are untrustworthy as authority for minute calculations, owing to the fact that such messages, transmitted in cipher, afford little internal evidence of their correctness or the contrary.

In fact, inasmuch as weather telegraphy must be carried on by means of the ordinary telegraphic staff, it is hopeless to expect such accuracy in transmission of the reports as is requisite if the data are to form the basis for precise calculations day by day. We have also the difficulty to encounter, at least at present, that as soon as a serious storm occurs the communication along the lines is very uncertain, if it be not entirely interrupted by the breakage of wires.

In the face of facts such as these, all who have had practical experience of weather telegraphy have long since admitted that such stations are to be placed under a totally different category from those which furnish the information for climatological inquiry.

We may now contrast the service of this country in regard of weather telegraphy with those at present existing elsewhere in Europe, excluding from our view the magnificent organization of the United States, whose signal service spends for its own share not far from the total expenditure of the collective governments of Europe on the same object.*

* The cost of the signal service U.S.A. is upwards of 50,000*l.*, and this does not include any salaries.

Cost of improvements in service.

Weather telegraphy depends for its success almost entirely on the amount of money which can be devoted to it; if the information is to be improved in quantity, in frequency of reception, or in quality, whether this last implies a higher class of observations or increased accuracy in transmission, the cost is at once raised, as these conditions imply a more extensive use of the telegraph and longer hours of attendance in the office and at the stations.

British organization.

The Office receives, or would receive, were the Continental telegraphic communications and that with the Shetlands perfect, 51 reports every morning, and 9 every afternoon, except on Sundays. The observations are taken on Sundays as on other days, but are not received at the Meteorological Office until Monday morning, when the report for Sunday is made out. The stations are situated along the entire coast of the Continent, from Christiansund, in lat. 63° N., to Corunna, in lat. 43°, with four stations on the coast of the Baltic, and one at Cape Sicié in the Mediterranean.

Stations on the west coast.

The system is unfortunately most defective along our own western coasts, owing to the imperfections of telegraphic communication in those thinly-peopled and mountainous districts. The only stations along the line in question are Valencia, Greencastle on Lough Foyle, Ardrossan, and Stornoway. The Committee are not without hopes that they may be able to carry out the idea, proposed in their last Report, of establishing a station at Mullaghmore, a low lying point on the south side of Donegal Bay, not far from Sligo.

Reports from stations over the Atlantic.

The possibility of deriving benefit, as regards the probable weather of these islands, from constant reports from America has frequently been inserted in the newspapers and in scientific journals, but the experience of the Office, which for four years received daily reports free of charge from Heart's Content by the liberality of the Anglo-American Telegraph Company, is not favourable to the idea of incurring expense for such a service. Not only was little benefit derived from such isolated and unsupported reports, but the subsequent study of the weather recorded in ship's logs has shown that atmospheric disturbances, though they may cross the Atlantic occasionally from shore to shore, in most instances undergo such changes in their progress, that the fact of the severity of a storm on the coast of America is no gauge of its probable character when it arrives on our shores.

The Committee need only refer to their last Report for the reasons which are there given for the comparative inutility to us of reports from stations even so near as the Azores, and although it must be granted that Newfoundland lies more in the track of storms crossing the Atlantic than the group of islands named, yet the experience of those who have paid most attention to Atlantic weather appears to show that the area of origin of most of our storms lies some distance to the eastward even of Newfoundland.

The information received from the Continent is obtained by way of exchange, for which arrangements exist with France, Holland, Hamburg, Denmark, Norway, and Sweden.

Interchange of information with the continent.

In France the Office interchanges information with two distinct organizations, the Ministère de la Marine and the Observatory.

From the former it receives daily reports from six stations, Cape Grisnez, St. Mathieu (Brest), Grognon (L'Orient), Isle d'Aix (Rochefort), Biarritz, and Cape Sicié (Toulon), and supplies in return a daily summary of the weather over the area covered by the British system of reports, and in addition warnings whenever requisite, which are hoisted along the French coast from Dunkerque to Nantes.

From the Observatory it receives reports from Paris, Charleville, Lyons, Brussels, and Corunna, and sends in return copies of the daily reports received from Valencia, Greencastle, Thurso, Scarborough, Yarmouth, and Scilly, and from Greencastle a Sunday report in addition.

From Holland it receives daily reports from the Helder, and sends occasional warnings in return, as will be explained farther on.

From the Scandinavian systems and Hamburg the Office receives reports from Christiansund, Skudesnaes, and Oxö (near Christiansand), in Norway, from Skagen and Fanö in Denmark, from Haparanda, Hernosand, Stockholm, and Wisby in Sweden, and from Cuxhaven, and supplies in return daily reports from Yarmouth, Valencia, and Thurso (the last twice daily), which are sent from these islands to Christiania, and Copenhagen, and distributed from the latter place to Stockholm and Hamburg, and also cautionary telegrams of a similar character to those sent to Utrecht.

Any cost incurred in transmission of these telegrams over the British lines falls on the Office; but, as regards the French telegrams, their transmission is free over the French wires; while in the case of the messages crossing the North Sea, a free transit has been most liberally granted by the Great Northern Telegraph Co.

Preparation of Daily Weather Report.

The daily observations are taken at 8 a.m., Greenwich time, and most of the telegrams arrive in London about 9 o'clock, when the Intelligence Department of the Post Office extracts from them the portions required for its wind and weather reports. They are then at once transmitted to the Office by the private wire. About two hours are required for their reduction, discussion, and the preparation of the Daily Weather Report, copies of which are ready by about 11 a.m., and are at once supplied for the afternoon issue of several of the London papers. A wind chart for the day is also drawn for the "Shipping Gazette." A brief telegraphic resumé of the weather is despatched to the Marine Ministry in Paris, and if necessary, telegraphic intelligence of storms or of atmospherical disturbance is sent to our own coasts and to foreign countries. Later in the day the foreign telegrams, and subsequently the afternoon reports, come in. The Daily Weather Charts are drawn by noon, and forwarded to the lithographers to be printed. The copies for postal distribution are received at the Office at about 3.30 p.m. The total number of copies issued every day is about 530.

Royal College of Surgeons of England.
Lincoln's Inn Fields.
London. W.C.2.

Telephone.
4699 HOLBORN.

day of 19

With Sir Arthur Keith's Compliments

The list of institutions and persons who receive the Charts free will be found at Appendix VIII.

In the last Report it was mentioned that the Committee were in hopes of being able to furnish Weather Charts for issue in the daily papers. These hopes have at last been carried into fulfilment, and from the 1st of April 1875 a chart of the subjoined character has appeared in the "Times." Weather charts in newspapers.

The following description of the process of production of these charts, which appeared in "Nature" of April 15, may not be without interest:

EXPLANATION.

In the above Chart the dotted lines are "isobars" or lines of equal barometrical pressure, the values for the lines being given at the end in figures, thus, "30·4." The shade temperature is given in figures for several places on the coast, and the weather prevailing at 8 a.m. is recorded in words. The arrows fly *with* the wind, the force of which is shown by barbs and feathers, thus, ⟶ = light, ⟶ = fresh to strong, ⟶ = a gale, and ⟶ = a violent gale. ⊙ signifies calm. The state of the sea is given in capitals.

"The method of preparation of the chart seems simple enough at present, but it has been the fruit of much thought, as the problem of producing, in the space of an hour, a stereotype fit for use in a Walter machine has not been solved without many and troublesome experiments.

"In the first place a material had to be provided which would admit of being engraved rapidly without burr or chipping, and would without further preparation serve as a mould for type metal. Secondly, drill pantagraphs had to be adapted to engrave the lines, and to be furnished with a gauge so as to vary their depth at pleasure.

"The actual process is as follows:—The outline of the land is kept standing, and the composition is run in a mould bearing this outline on one face. The block, which is now an outline chart of the British Islands, is then placed under the pantagraph drill, which reduces the original drawing, furnished from the Meteorological Office, to one fourth. The isobaric curves and wind arrows are put on direct from the drawing, the figures and words by means of templates, in order to ensure uniformity in the type.

"The instant the block is engraved it is ready to be stereotyped, and

Weather charts in newspapers.

then it is a simple matter to adapt it in the usual manner to the cylinder of the machine.

"The initiative in this new method of weather illustration is due to Mr. Francis Galton, and the practical details have been carried out by Messrs. Shanks and Johnson, of the Patent Type Founding Company.

"It is hardly necessary to allude to the value of such charts as these as a means of leading the public to gain some idea of the laws which govern our weather changes. As soon as they appear in our afternoon papers, we may hope for a more intelligent comprehension of the difficulties which beset any attempt to foretell the weather of these islands for the space of even 24 hours.

"We may safely say that with these charts we have not seen the end of weather illustration, which was set on foot more than four years ago by Sir W. Mitchell in the "Shipping Gazette," and has been continued daily; but whatever improvements may hereafter be introduced in the process, it must be remembered that the credit of breaking the egg is due to the gentleman we have named."

Continental organizations.

It may now be interesting to give a brief review of what is being done in other European countries in the way of Weather Telegraphy.

France.

France takes the lead both as regards the seniority of its arrangements, which date from nearly 20 years past, and the extent of its international exchanges.

Its reports are published daily in the Bulletin International, which has appeared regularly since 1858, and contains a weather chart for the whole of Europe; but if anything were wanted to prove the truth of what has been stated above,—of the entire dependence of the service on the perfection of telegraphic arrangements,—it is to be found in an examination of the daily charts of the Bulletin International at a time of continued atmospherical disturbance, when for days in succession the reports from distant stations are entirely absent, and the chart consequently blank, at a time when full information would be of most interest and importance. It is to be hoped that Weather Telegraphy will not always be liable to fail at the most critical times.

Scandinavia.

The next extensive system is that of the three Scandinavian countries, which publish their reports conjointly in the Bulletin Météorologique du Nord, issued at Copenhagen.

Russia, too, has a telegraphic organization of considerable magnitude, and issues a lithographic bulletin, as do also Austria and Spain, while the other countries of Europe for the most part content themselves with the dissemination of their weather observations by the agency of the public press.

International telegraphic code.

The Committee are glad to say that the hopes mentioned in the last Report of the adoption of an international telegraphic code for Europe have been fulfilled by the resolution of the Permanent Committee of the Vienna Congress recommending such a step.

The code proposed has been introduced in most European countries, being only subject to such modifications as are requisite to adopt it to the foreign and English scales, as will be seen from the scheme given at p. 39, Part II. The code adopted differs but

slightly from that which has been hitherto in use in the British isles, with the exception that the use of mixed letters and figures in the groups has been discarded, in order to return to the exclusive employment of figures, as in the code originally devised by Admiral FitzRoy.

Telegraphic weather intelligence.

The intelligence of storms which is sent out from the Office varies in character, according to the requirements of the place which receives it. In Appendix IX. will be found a list of the stations which are furnished with signals, in accordance with circular 717 of the Board of Trade, issued in February 1874. These stations were, at the end of December, 130 in number, situated, 64 in England, 15 in Wales, 32 in Scotland, 13 in Ireland, 3 in the Isle of Man, and 3 in the Channel Islands. Lamps for night use are supplied to a few of the stations. All the stations have been established under, and are in accordance with, the terms laid down in the circular, excepting the Royal dockyards, which are of course under Admiralty management. The messages sent consist of an order to hoist the signal, accompanied by a brief explanation of the reasons why it is to be hoisted. The message is posted up for the information of the public as soon as it is received. It continues in force for 48 hours, *and no longer*, from the time of its issue from London, unless modified by a subsequent telegram, which is frequently sent, either when the danger is known to have passed over, or when there are signs of the approach of another storm.

In addition to the foregoing, a telegram consisting of reports of the atmospherical pressure and the wind at the most important stations, is sent daily to the Underwriters' Rooms, Liverpool, the entire expense of the transmission being borne by that association.

All intelligence sent to the coasts is also forwarded to Lloyd's Rooms, where it is at once posted up for the information of the members.

Warnings to foreign countries.

The intelligence of storms which is supplied to foreign countries is of a two-fold character.

To the Ministère de la Marine at Paris warnings are issued in the same form as to our own coasts, but these are only destined for the portion of the French coast which lies within a reasonable distance of our own shores.

The Committee, when the arrangement in question was originally set in action, stipulated that their warnings were not to extend farther to the southward than Nantes, and accordingly for the purposes of these telegrams the coast of France is divided into two districts. North from Dunkerque to Cap la Hague, and West from Cap La Hague to Nantes.

To the Meteorological establishments of the other countries which exchange information with the Office no direct warnings of storms are issued unless in rare instances, but a regular service of cautionary telegrams is in action by which the London Office transmits to Utrecht and Copenhagen, and to Christiania when

necessary, a telegram containing the most important barometrical readings and wind observations, whenever the total amount of barometer difference over the area covered by the network of the British system amounts to 0·7 in. In speaking of this area, the extreme stations are disregarded, such as those on the Baltic, Christiansund, Cap Sicié in the Mediterranean, and Corunna, inasmuch as in winter it would be a rare occurrence for a difference of 0·7 in. not to be apparent over an area embracing so large a portion of Europe.

These warning telegrams are regularly transmitted from Copenhagen to Stockholm and Hamburg, but whenever the conditions of weather appear urgent, a special telegram is sent from London to the latter town.

Comparison of warnings with weather in 1874.

The comparison has been instituted between the warnings issued and the weather experienced on our coasts, as was the case in the four previous years. The method of testing the warnings is as follows: The intelligence issued is compared with the weather experienced on the coasts, as recorded by the various continously self-recording anemometers, by the telegraphic reporters, and by the several gentlemen who have volunteered to observe for the Office, and whose names will be found at p. 27.

The coasts were subdivided into nine districts, as will be seen in the subjoined table. Two large tracts of coast are entirely omitted. The west of Ireland from the Shannon to Malin Head, and the west of Scotland from the Mull of Cantyre to Cape Wrath. No warnings were issued to any place within the limits indicated, except to Galway, and the amount of information as to weather received from the coasts in question is as yet very scanty.

It should be remembered that in analysing the reports, "all "observations of the wind in which the force exceeded 7 (a "'moderate gale') or the velocity exceeded 40 miles an hour, "have been quoted as instances of the occurrence of a gale; but "it has not been considered that the signal was hoisted late or "was hauled down too soon, unless the force of 9 (a 'strong "gale') or the velocity of 50 miles an hour was reached prior to "the issue of the order to hoist, or subsequent to the issue of the "order to lower."

In the summaries all cases in which the signal has been shown to be late by one single report of force 9, or of the velocity of 50 miles an hour, have been specially noted in the remarks and marked with a *p*.

All telegrams which have been late, owing to the intervention of a Sunday, or owing to telegraphic errors, are marked with an *s*.

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RETURN of the Result of the Comparison between the Warnings issued and the Weather experienced in 1874.

Coasts.	Total No. of Orders to hoist and repetitions.	Warnings justified by subsequent Gales, Force 8 and upwards.	Warnings justified by subsequent strong Winds, Forces 6 and 7.	Warnings not justified by subsequent Weather.	Warnings late, Force 9 reached at two Stations before issue.	Warnings partially late, Force 9 reached at one Station before issue.	Warnings late, owing to Sundays, or Telegraphic Errors.	Storms for which no Warning was issued.
Ireland, South -	37	17	6	6	4	4	—	Apr. 13[a], Sept. 22, Oct. 21.
„ East -	43	19	15	8	—	1	—	Jan. 18[a], Sept. 22, Oct. 21.
Scotland, East -	35	15	9	10	—	1	—	Jan. 11[a], Jan. 18[a], Jan. 26[a], Apr. 16, Aug. 6, Oct. 21, Dec. 8, Dec. 11.
„ West (Clyde)	42	15	21	5	—	1	—	Jan. 18[a], Mar. 27, Oct. 21.
England, North-west	41	25	7	6	1	1	1	Oct. 21.
„ West -	37	19	12	5	—	—	1	Oct. 21.
„ South -	36	17	14	4	—	1	—	Oct. 21, Nov. 29.
								Sept 21[p], at entrance of channel.
								Dec. 11[p], in eastern portion of channel.
England, South-east -	19	5	11	3	—	—	—	Oct. 21, Nov. 29.
„ East -	27	12	9	5	—	1	—	Jan. 18[a], Oct. 21, Nov. 29.
Totals - -	317	144	104	52	5	10	2	
Per-centages -	—	45·4	32·8	16·4	1·6	3·2	0·6	

If these figures be compared with those for the previous years in which the system has been checked, we arrive at the following result in per-centages:

—	Warnings justified			Warnings not justified by subsequent Weather
	By subsequent Gales.	By subsequent strong Winds.	Total.	
1870	46·7	21·7	**68·4**	22·4
1871	46	17·7	**63·7**	22·0
1872	61	19·5	**80·5**	11·9
1873	45·2	34·0	**79·2**	16·8
1874	45·4	32·8	**78·2**	16·4

It will be seen that the results for the years 1873–4 are nearly identical with each other, and a closer investigation into the reason of the excess in the figures in the first column for the year 1872, has shown that it was attributable to the fact that in the comparison for that year the occurrence of force 7, called in Beaufort's scale a "moderate gale," was considered as entitling the result of the warning to be entered in the first column, instead of force 8, a "fresh gale," as assumed in the other years in which force 7 was reckoned among the "strong winds."

The correctness of this explanation of the discrepancy is confirmed by the fact that the per-centage of "total warnings justified" remains almost identical in the last three years.

Success of warnings.

It must always be remembered that as the Office has necessarily to issue its warnings on the first signs of the approach of a storm, and before its character and course have fully declared themselves, in several cases it has only winds of forces 6 and 7 to show as justifications of its cautionary telegrams. The warnings may therefore be considered as right in principle, though hardly necessary for large ships, as distinguished from smaller craft.

As in former years, instances of serious failure of the warnings to give timely notice of storms have not been absent in the year 1874. The storm of October 21, almost the most serious of the year, came on so rapidly during the night-time, subsequent to the receipt of the afternoon reports of the previous day, that no warnings could be issued by the Office. It does not seem that the funds at present at the disposal of the Committee will enable the Office to give timely warning of such gales as that in question, as for that purpose much more frequent telegrams—in fact an almost constant service on the coast and at the Office—would be required, and such an arrangement would involve a *materially* increased expenditure, as the present organization of the postal services would not allow of any use of the wires to outlying stations during the night hours.

The experience gained of the restoration of the use of the cones as signals of the probable direction of the wind in an apprehended storm, has been on the whole satisfactory; the only failures having been in the case of a few storms which were expected to commence to blow from the south-eastward at our northern stations, but set in from the north-east, "backing" to north, owing to the fact that the centre of the storm took a more southern course than had been anticipated by the Office.

"Probabilities."

As indicated in the last Report, tentative forecasts of weather ("probabilities") have been prepared daily in the Office by direction of the Committee for more than a year. The results of a comparison of these with the weather experienced has led to the conviction that, while they have turned out perfectly correct in a large majority of instances for the south-east of England, the district for which it is, of course, easiest to draw them in London, their *daily* publication would not be of great utility, inasmuch as it is only occasionally that the conditions are so marked that a definite forecast suitable for publication in the daily press could be issued 18 hours in advance.

This result is only what may be expected when we consider the exceptional position of the United Kingdom as regards its weather. An extension of the telegraphic system, if attainable, would be indispensable; but, as already explained, this extension would be one hundredfold more valuable to the westward, whence we can hardly hope to obtain it, than to the south-eastward and eastward, whence additional information is of course to be had from the Continent. It has frequently been asserted that information from central Europe and Russia would enable us to form a correct judgment of our own chances of weather, but as yet no proofs have been produced of this statement, and the experience of the Office

distinctly controverts any such idea in the present condition of weather knowledge.

Hoffmeyer's charts.

The Committee have hailed with great pleasure the publication, at his own expense, by Captain Hoffmeyer, Director of the Danish Meteorological Institute, of his Synoptic Charts of Europe and the North Atlantic (in so far as the land observations made in the Danish Colonies and in Newfoundland afford information), and they sincerely hope that the public appreciation of the work, as evidenced by the list of subscribers, may be such as will enable him to continue an undertaking of such value for the purposes of international weather study.

Synchronous observations.

It was stated in the last Report that the Office had entered cordially into the proposal made at the Vienna Congress in 1873, by Brigadier-General Myer, in relation to the organization of a system of really synchronous observations at 0h. 43m. p.m. Greenwich mean time.

Early proposals for synchronous observations.

It may here be observed that this was not the first occasion on which the importance of such observations for the purposes of weather study has been urged on meteorologists. In the very first Report of the Meteorological Department (for 1857), Admiral FitzRoy dwelt on the necessity for such simultaneous observations in times of atmospherical disturbance; but some years prior to that date, Professor Buys Ballot, in a paper in Volume IV. of the Ergänzungs-Bände to Poggendorff's Annalen had insisted on the value of synchronous operations for the science.

The invitation to British observers to join in the work was at once responded to, and upwards of 60 observers resident in the United Kingdom joined in the work, while the Army Medical Department has from some of its foreign stations supplied most valuable contributions to the stock of materials.

The list of those who have co-operated in the scheme will be found at Appendix X.

Fishery barometers.

The number of Fishery Barometers issued on loan to small ports and fishing stations has been increased by nine, and there are now 129 stations on our coasts supplied by the Office with barometers for public use. They are situated, 49 in England, 5 in Wales, 44 in Scotland, 29 in Ireland, and 2 in the Isle of Man. See Appendix XI.

III.—Land Meteorology of the British Isles.

The observatories have continued in regular working order throughout the year, and were all inspected as usual by Mr. Scott.

Quarterly Weather Report.

The publication of the Quarterly Weather Report has been continued, and the part for the first quarter of 1874 is in the press. The rate of issue of the successive quarterly numbers is ruled entirely by the progress of the work of reproducing the curves by means of Galton's and Wagner's pantagraphs, in which process it is impossible to ensure the requisite accuracy of execution if the operations be hurried. The resignation of Mr. F. Steventon,

who left the Office in the course of the year to undertake the post of Assistant at the Mauritius observatory, produced a vacancy in the staff trained to the use of the pantagraph, and considerable loss of time was incurred in the necessary education of his successor.

Redetermination of instrument scales.

Another very serious cause of retardation of the work of the pantagraph room at the close of the year has been the necessity of re-determining carefully the scales originally supplied for the thermographs, as explained in Part II. This has involved a long series of comparisons and calculations, which could not have been effected until the lapse of a series of years had enabled the Office to accumulate a large number of thermograms covering an extensive range of temperature, and affording the opportunity of repeated measurements of the same reading on different curves.

Special character of the published curves.

It must be remembered that the plates of the Quarterly Weather Report are absolutely unique, nothing at all approaching them for minuteness in the way of a continuous record having ever been attempted; and as to accuracy, the greatest care is taken to render the impressions from the copper plates accordant with the tabulations from the original photographic curves, to the extent of half a degree for the thermometer, and one hundredth of an inch for the barometer.

Some idea of the difference between the character of this and all previous publications of meteorological results may be gathered from the consideration that, while the continuous curves were originally destined to allow meteorologists to obtain from them the observations corresponding to any epoch of time required for any special investigation, within the limits of accuracy which have just been quoted, they of course provide the means of testing the correctness of most of the statements contained in the text of the Report. *In no other publication of a similar nature in any country is there a direct and immediate gauge afforded of the precision of almost every numerical statement.* The cost of this process of publication is very great, and it entirely excludes the possibility of attempting the detailed discussion of the observations at the different observatories, as long as the pecuniary resources at the disposal of the Committee are not increased.

Publication of hourly tabulations.

The preparation of lithographed copies of the hourly tabulations, as indicated in the last Report, has been carried out for the year 1874, but the number of subscribers towards the expense of copying the figures has not exceeded 15! The Committee have, however, distributed copies *gratis* to important libraries and scientific societies at home and abroad. They have also resolved to continue the preparation of similar sheets for the year 1875, adding to the information already given, the hourly values of vapour tension at the observatories for 1875.

In the last Report a summary of the resolutions of the Vienna Congress was given, and among them some of the most important were those relating to international meteorology.

It will be remembered that at that meeting a Permanent Committee was appointed to see to the carrying out of the Resolutions

of the Congress, and among the proposals of that committee, contained in its report, which has recently appeared, was the suggestion of forms for the publication of observations of an international character from a limited number of stations in each country, in order to facilitate climatological inquiries. Anyone who has ever attempted to extract information from the various meteorological publications in existence hitherto, must at once have been struck by their total want of accordance as to either the information conveyed or the form in which it is presented in the several countries. Not only were the hours of observation different (and uniformity in this respect, however desirable, is apparently at present admitted to be utterly unattainable), but the actual phenomena which were the subjects of observation were not the same in many instances. International publication of results.

The Vienna Congress therefore undertook the task of attempting to call into existence a real international publication, and the members deemed it advisable, as a first step, to propose that at least it should be recommended to publish the observations and mean results, on definite forms, and on the same size of paper, so that the returns for different countries could be bound up together.

Each country was to be invited to contribute its quota to the common stock of information, by publishing actual observations from a number of stations proportional to its territorial area.

The carrying out of this course of action fell to the Permanent Committee, who have devised the forms which are published in its Report and given in Part II. of this Report (p. 43) and have proposed the following inferior limit for the number of stations among the several European governments.

Norway - - -	10	Germany - - -	12
Sweden - - -	10	France - - -	12
Denmark with Iceland and Faroe - - -	6	Austria and Hungary -	15
Great Britain and Ireland -	15	Turkey - - -	10
Russia in Europe - -	50	Switzerland - - -	5
„ Asia - -	100	Italy - - -	12
Netherlands - - -	2	Spain, Portugal and Azores -	12
Belgium - - -	2	Greece - - -	3

It remains open for the directors of the individual systems not only to select the stations which are best suited for the purpose, but also to increase at pleasure the minimum number above given.

It is naturally of importance that these 15 stations, which fall to our share over and above the seven observatories in connexion with the Office, should be distributed pretty uniformly over these islands; and accordingly the opportunity seemed to be offered, by this proposed international publication, for instituting satisfactory relations of co-operation between the office and the several independent organizations of observers in the United Kingdom, in order that the information to be published should be as fairly representative of our climate as possible.

In the month of November an invitation was issued to the Meteorological Society (of London) to supply to the Office

Arrangements with the Meteorological Society.

certain returns from several of its newly-established stations. The proposal was at once favourably received, as might have been foreseen from the satisfactory character of the preliminary negotiations for conjoint action mentioned in the last Report, and the terms of agreement were speedily settled. The most important of these are as follows:—

Verified copies of detailed observations at 9 a.m. and 9 p.m. are to be supplied monthly from at least five stations in consideration of a minimum payment of 25*l.* per annum, and from any further number of stations agreed upon at 5*l.* per annum per station.

Verified copies of mean monthly values to be supplied from certain other of the society's stations, not exceeding 20, at the rate of 2*l.* 10*s.* per annum per station.

Proposals to Scottish Meteorological Society.

A similar invitation was issued to the Scottish Meteorological Society, but up to the end of June 1875 it cannot be said to have led to a satisfactory result, as the council of that body, while professing their readiness to co-operate in any work of an international character, are unwilling to enter into such an arrangement as that which has been so cordially accepted by the London Society.

Inasmuch as a new "lustrum" of five years will commence with January 1, 1876, it is hoped that the arrangements for international publication in Europe will be in regular operation by that period, even though, for our part, some districts of the United Kingdom may be but poorly represented, but the Committee have resolved to make a commencement of this publication even for the years 1873 and 1874.

For the former of these they are publishing *in extenso* the observations from Parsonstown (observer Ralph Copeland Ph. D.), inasmuch as in the comparative absence of all information bearing on the meteorology of the interior of Ireland, it is thought that good observations from a station in the centre of the island would always be acceptable to meteorologists.

Stations for which results are being published.

1873.

The stations for which mean results are being published for 1873 are, in addition to Parsonstown:

Sandwick Manse -	Observer	Rev. C. Clouston, LL.D.
Seaham Harbour - -	„	G. H. Aird.
Durham Observatory -	„	J. J. Plummer, M.A.
Hull - - -	„	Rev. W. P. Mackay, D.D.
Dublin - - -	„	J. W. Moore, M.D.

1874.

For the year 1874 the Parsonstown observations will again be published in full, the observer, however, being J. Dreyer from August, Dr. Copeland having left the observatory; while the list of stations appearing in the table of mean results will be augmented by three:

Leicester Museum - -	Observer, W. J. Harrison.
Oscott, St. Mary's College, Warwickshire	Rev. S. Whitty.
Chigwell Row, Essex - - -	J. Campbell, M.D., R.N.

In the other stations the only change has been that Mr. Plummer, at Durham, was succeeded by Mr. G. Goldney in the course of the year.

Arrangements for publication for 1875.

With the year 1875 the arrangements with the Meteorological Society above noticed came into operation, and for that year the following is the list of stations which have commenced observing for the Meteorological Office, for the most part on the 1st of January, and whose returns will be published, either in full, or as monthly summaries of mean results at the end of the year.

Names of Stations.	Observers.	Remarks.
England.		
Chatham	Qr.-Master Sergt. Conroy.	
Chigwell Row	J. Campbell, R.N.	
Durham	G. A. Goldney.	
Giggleswick	Rev. G. Style, M.A.	
Hastings	A. E. Murray, F.M.S.	
Hull	Rev. W. P. Mackay, D.D.	
Leicester	W. J. Harrison.	
Norwich	J. Quinton, junr.	
A Oscott	Rev. S. Whitty.	
Seaham	G. H. Aird.	
Scotland.		
A Sumburgh Head (Shetlands).	W. Lawrence	The instruments are about to be removed to Fair Isle.
Glenalmond (Perthshire)	Rev. W. P. Robinson, M.A.	
Ireland.		
Dublin	J. W. Moore, M.D.	
A Markree Castle (Sligo)	W. Doberck, Ph. D., for Col. Cooper, F.R.A.S.	
A Parsonstown (Birr Castle)	J. Dreyer, M.A., for the Earl of Rosse, F.R.S.	

The stations marked A in the preceding list are those for which it is intended to publish the observations *in extenso* on Form A (see App. II. p. 43).

The following is the list of stations in connexion with the Meteorological Society whence returns are received for publication A, in full, or B, as monthly summaries, in pursuance of the arrangements already mentioned.

Stations, A.

Aysgarth, Yorkshire	Rev. F. W. Stow.
Buxton, Derbyshire	E. J. Sykes.
Calcethorpe, Lincolnshire	D. G. Briggs.
Carmarthen	G. J. Hearder, M.D.
Dartmoor Prison	R. E. Power, L.R.C.P.
Strathfield Turgiss, Hants	Rev. C. H. Griffith.

Stations, B.

Audley End, Essex	Mr. J. Bryan.
Bath	C. S. Barter, M.B.
Cheadle	J. C. Philips.
Crowborough Beacon	C. L. Prince, M.D.
Hillington, Norfolk	Rev. H. Ffolkes.
Marlborough	Rev. T. A. Preston.

Volunteer observers.

Returns of various degrees of completeness are received from the following observers, in addition to the monthly copies of the observations taken at all the telegraphic stations.

Names of Stations.	Observers.
England.	
Acrise, Kent	G. C. Woollet.
Barnstaple, Devonshire	T. Mackrell.
Brighton, Sussex	F. E. Sawyer, F.M.S.
Chiswick (Royal Horticultural Society), Middlesex	G. H. Fiesser.
Cooper's Hill (Indian Civil Engineering College)	H. McLeod, F.C.S.
Helston, Cornwall	M. P. Moyle, M.D.
Killingholme, Lincolnshire	Rev. J. Byron.
Rugby, Warwickshire	J. M. Wilson, F.R.A.S.
Saffron Walden, Essex	J. G. Bellingham.
Sheffield, Yorkshire	W. F. Cooper, F.M.S.
Shipston-on-Stour, Worcestershire	Finlay Dun.
Silloth, Cumberland	Rev. F. Redford, F.R.S.E.
Winchester, Hants	Rev. G. Richardson.
Scotland.	
Annanhill	W. H. Dunlop.
Ireland.	
Dromore (Coleraine)	Mrs. Torrens.
Dungloe (Templecrone Rectory)	Rev. A. Delap.
Ennis (county Clare)	J. Hill, C.E.

Registrar General's Reports.

The Committee have received an intimation from the Local Government Board to the effect that the Registrar General does not at present contemplate calling on them to supply information for the various Meteorological Tables published in his Reports.

In the last Report it was stated that Mr. Scott was engaged in the preparation of a set of "Instructions in the Use of Meteorological Instruments." The work is now completed and will be published in the course of the year 1875.

Sea temperature observations.

The arrangements alluded to in the last Report, between the Office and the Trinity House and Commissioners of Irish Lights respectively, have been concluded satisfactorily, and on the 1st of January observations of sea temperature were commenced at the following stations:—

England.	
Fern Islands	Lighthouse.
Dudgeon	Lightship.
Leman and Ower	,,
Galloper	,,
South Sand Head	,,
Owers	,,
Seven Stones	,,
Morecambe Bay	Lightship.
Bahama Bank	,,
Ireland.	
Kish	Lightship
Arklow, South	,,
Coning Beg	,,
Daunt's Rock	,,

Time will show to what extent observations made under such conditions as are available at lightships will serve for investigations into the intricate problem of determining the changes of sea temperature round our coasts.

LIBRARY.

Appendix XII. contains a list of the donations made to the library during the year. Most of these have been received in return for the publications of the Office. In addition a few volumes have been purchased.

In consequence of the constant reference which is made to the Office for information on meteorological questions, it has been endeavoured to collect a small library containing the standard works on meteorology, and the subjects allied to that science. The Committee are glad to say that they have already succeeded in obtaining many important works.

The library at present consists of nearly 2,000 volumes, and above 2,000 pamphlets, exclusive of charts and MS. records of observations. The pamphlets are bound in convenient volumes for reference. The books, &c. are lent to the staff of the Office, under the usual regulations.

EXPENDITURE.

The disbursements during the year ended 31st March 1875 have exceeded those of the preceding year by the amount of 1,689*l.* 9*s.* 3*d.* The following table shows the general distribution of the expenditure under the several heads of service :— General abstract.

———	1873-74.	1874-75.	Increase.	Decrease.
	£ *s.* *d.*	£ *s.* *d.*	£ *s.* *d.*	£ *s.* *d.*
Office salaries, &c. -	1,275 12 3	1,314 19 0	39 6 9	—
„ rent, attendance, and contingencies -	817 3 1	798 19 8	- - -	18 3 5
Observatories - -	3,506 6 3	3,799 7 10	293 1 7	—
Telegraphy - -	2,184 9 4	3,387 17 8	1,203 8 4	—
Ocean Meteorology -	2,212 10 4	2,384 6 4	171 16 0	—
Totals £	9,996 1 3	11,685 10 6	1,707 12 8	18 3 5

Net increase, 1,689*l.* 9*s.* 3*d.*

This abstract does not give a complete representation of the financial state of the Office. This will be better seen by referring to the statements in Appendix I.

The increase under the head of *Observatories* is entirely due to transactions on account of our colonial Meteorological establishments, the directors of which have greatly availed themselves of

the assistance of the Office in purchasing self-recording instruments. The cost incurred on this account is of course repaid by the recipients, the Office deriving no profit from the transactions.

The greatest increase falls under *Telegraphy*. It will be seen, on referring to the last Report, that a large amount due under this head was outstanding on the 31st March 1874; this has now been paid off. Another cause of increase has been the outfit of all storm-signal stations with new apparatus. And, further, a comparison of the statements of warnings issued this year and last (Reports, 1873, p. 16, and 1874, p. 21), shows that there has been a greater amount of activity in this branch during the current year.

Under *Ocean Meteorology* the increase is partly due to special expenses of the Marine Staff, and partly to purchases of instruments for foreign and colonial establishments.

On the left-hand side of Appendix I. will be found a statement of the amount received for such commissions, from which, as above explained, the Office derives no profit whatever, the work being undertaken for the sake of furthering the cause of Meteorological Science in general.

Available balance.

Finally, the statements in Appendix I. show that the amount standing to the credit of the Committee on March 31 was 1,826*l.* 15*s.* 5*d.* and that, after deducting liabilities, &c., the estimated *available* balance was 1,053*l.* 1*s.* 5*d.* against 1,165*l.* 12*s.* 8*d.* last year. These figures show that the expenditure of the year has exceeded the actual income by about 112*l.* The parliamentary grant is wholly expended in the Meteorological service of the country, and, indeed, owing to the increased impulse given to the science, the greatest care is necessary in the management of the finances, to keep the expenses within the limits of the amount voted to the Office.

SUMMARY.

The Committee subjoin the usual summary of the operations of the Office during the year.

Mr. Scott, the director, attended the meeting of the Permanent Committee of the Vienna Congress, which was held at Utrecht in September, and the report of that Committee has been published in English.

Mr. Scott was also examined at considerable length before the Royal Commission on Scientific Instruction, &c,. and his evidence will shortly be published in the Report of that Commission.

I. *Ocean Meteorology.*—The number of barometers afloat in the Merchant Service on the 1st January 1875 was 83, as compared with 82 in the preceding year. In addition, all the ships in commission in the Royal Navy have, as usual, received all their meteorological instruments from the Office.

Fifty-three gentlemen have sent in logs which have received the mark of "Excellent."

The Monthly Charts for Square III. in the Atlantic have been published, and the Monthly Charts for the entire region of the Atlantic from 10° W. to 40° W., and from 20° N. to 10° S., are in a very advanced state and will be published within the year 1875.

It has been decided to take up the region lying about the south points of Africa, as the next district for examination. This extends from 10° E. to 40° E., and from 30° S. to 50° S.

The logs of 280 ships, which were in the Atlantic Ocean at the time of the storms of August 1873, have been received at the Office, and their discussion has been taken in hands.

The International Maritime Conference alluded to in the last Report was held in London at the Meteorological Office early in September. A copy of the resolutions adopted at that conference will be found at p. 34.

The cost of this department has been 2,384*l.* 6*s.* 4*d.*

II. *Weather Telegraphy.*—There has been no change of importance in this department during the year, but the greatest care has been taken to improve the condition of the stations and the character of the reports wherever possible.

Information is regularly interchanged with all the adjacent continental nations excepting Belgium, and warnings of storms are issued to the coasts of Norway, Denmark, Germany, Holland, and France.

Storm warning signals are hoisted at 64 stations in England, 15 in Wales, 32 in Scotland, 13 in Ireland, 3 in the Isle of Man, and 3 in the Cannel Islands.

The results of total success of the warnings have been 78·2 per cent. as compared with 79·2 in 1873 and 80·5 in 1872.

The Daily Weather Charts have been issued to the number of above 500 copies, and the arrangements for the publication of charts in the newspapers have been completed. (The publication in the "Times" commenced April 1st, 1875.)

The number of observers co-operating in the scheme of Synchronous Observations at 0h. 43m. p.m. has exceeded 60.

An international code for Meteorological telegraphy has been devised by the Permanent Committee of the Vienna Congress, and adopted by the Office and by several European nations The number of stations supplied with Fishery barometers is 129, situated 49 in England, 5 in Wales, 44 in Scotland, 29 in Ireland, and 2 in the Isle of Man.

The cost of this department has been 3,387*l.* 17*s.* 8*d.*, but this has included the payment of a sum of over 750*l.* due to the Post Office at the date of the close of accounts for 1873–4.

III. *Land Meteorology of the British Islands.*—The publication of the Quarterly Weather Report and the issue of the lithographed copies of the hourly tabulations has been continued. and for the year 1875 the hourly values of vapour tension will be added.

It has been found necessary to devise a new method of tabulating the thermograms, and the scales of the thermometers at the observatories have been redetermined at the Office, and new tabulating instruments engraved where necessary.

It has been resolved to commence the publication of returns from stations auxiliary to the Seven Observatories, on a plan suggested by the Permanent Committee of the Vienna Congress.

Arrangements have been concluded with the Meteorological Society (of London) by which that society supplies copies of returns from certain of its stations for publication by the Office, in consideration of the payment of a certain sum of money.

The cost of this department has been 3,799*l.* 7*s.* 10*d.*

Office.—The expenses of management in salaries and wages have been 1,314*l.* 19*s.* 0*d.*

The other charges incident on the Office for rent, furniture, postage, &c. have amounted to 808*l.* 19*s.* 8*d.*

PART II.

(1.) The International Maritime Conference.

The Conference consisted of 25 members, belonging respectively to every maritime country of consequence in Europe, except Sweden and Turkey. India and China were also represented. The following is the list of the gentlemen who attended :—

Austria - -	R. Müller, Director of the Imperial Royal Hydrographic Office at Pola.
Belgium -	F. van Rysselberghe, Navigation School, Ostend.
Bengal - -	H. F. Blanford, Secretary Meteorological Committee, Calcutta.
China - -	J. D. Campbell, Inspectorate General of Maritime Customs, London.
Denmark -	Capt. N. Hoffmeyer, Director of the Royal Danish Meteorological Institute at Copenhagen.
France - -	A. De la Marche, Ministry of Marine, Paris.
	C. Sainte Claire Deville, Inspector of French Meteorological Stations, Paris.
Germany -	W. H. von Freeden, Director of the "Deutsche Seewarte" at Hamburg.
	H. A. Meyer, Commissioner for investigating the German Seas, Kiel.
	G. Neumayer, Hydrographer, Berlin.
	Capt. Stempel, Imperial Navy .
Great Britain -	R. J. Mann, M.D., President of the Meteorological Society, London.
	Rear-Admiral M. F. Nolloth (Representative of the Admiralty).
	R. H. Scott, F.R.S., Director of the Meteorological Office, London.
	Capt. H. Toynbee, Marine Superintendent, Meteorological Office (Representative of the Board of Trade).
Holland -	Prof. Buys Ballot, Director of the Royal Meteorological Institute of the Netherlands, Utrecht.
	Capt. J. E. Cornelissen, Marine Superintendent, &c.
Italy - -	Capt. N. Canevaro, Naval Attaché to the Royal Italian Legation, London.
Norway -	H. Mohn, Director of the Royal Norwegian Meteorological Institute at Christiania.
Portugal -	J. C. de Brito Capello, Director of Nautical and Meteorological Observations; Observatory of the Polytechnic School, Lisbon.
Russia - -	A. Moritz, Director of the Observatory at Tiflis.
	Capt. M. Rikatcheff, Central Physical Observatory, St. Petersburg.
Spain - -	Capt. J. N. Montojo, Spanish Navy.
	„ C. Pujazon, Director of the Marine Observatory, San Fernando.

Professor Buys Ballot was elected President, and Captain Hoffmeyer and Mr. Scott secretaries. The Conference met on the 31st August, and it at once subdivided itself into two sub-committees, dealing with the various questions connected with 1, "Obser-

vations," and 2, "Discussions." Each sub-committee held four sittings, and at the closing meeting of the Conference the several resolutions framed by the sub-committees were adopted, in most cases unanimously.

The Conference completed its labours on the afternoon of the 2nd September and on Thursday (3rd), by kind permission of the Astronomer Royal, the members went to Greenwich in the morning, where they were conducted over the Magnetical and Meteorological Department by Mr. Glaisher. In the afternoon they spent some hours at Kew Observatory, where they were received by Mr. Jeffery, and in the evening the whole party were entertained at dinner, at the Star and Garter.

On the 4th several members availed themselves of the great courtesy of the War Office, and repaired to Woolwich, where they were conducted over the Arsenal by Colonel Field and other officers connected with that Department. Finally, on September 5th they inspected the Meteorological Office, where the meetings of the Conference had been held, and paid special attention to the arrangements there existing for reproducing the records of the photographic and other instruments.

The following are the resolutions adopted by the Conference:—

Maritime Conference.

Resolved—"That there should be but one form of Meteorological Register for the Navies and Merchant Services, and that those who cannot fill the log should keep part of it."

1.—Observations.

Columns 1 to 6.*—*Date and Position of the Observations.*

Questions.	Resolutions.
Is it your opinion that a fresh column should be added, headed "Course and distance by the log in every watch of four hours?"	That an additional column should be given in the log for "Course and distance." That the course should be expressed in degrees, and not in points. That the question of hours, 4-hourly periods, as proposed by Captain Toynbee, should be adopted.

Columns 7 and 8.—*Currents.*

	That observations on the "direction and rate" of currents be transferred to the column for Remarks.

Column 9.—*Magnetic Variation.*

Is it desirable to give an additional column for the "Direction of ship's head"?	That an additional column be given in the log for the direction of the ship's head, and the amount of heel to port or starboard. That the total compass-error and not variation only be given. That the Conference expresses its opinion that the lettering on the English compass should be adopted by all nations for meteorological purposes.

* The numbers of the columns refer to the Brussels abstract log.

Columns 10 and 11.—*Wind Direction and Force.*

Questions.	Resolutions.
Is it possible to employ an anemometer at sea, so as to give trustworthy results?	That a decided answer to this question cannot at present be given, but it is desirable that various anemometers should be tested by special ships, and a special form of four extra columns should be prepared for the purpose of recording such observations.
Can the use of the Beaufort scale be made universal?	That the use of the Beaufort scale should be continued, with the addition of the amount of sail which Beaufort's ship would have carried had she been rigged with double topsails. Also that the direction and force of the wind should be recorded at the *time* of observation, and not estimated for a certain number of previous hours. Also, that they should be recorded every two hours.

Columns 12 and 13.—*Barometer.*

To what degree of minuteness is it necessary to observe this instrument?	To one-hundreth of an inch at sea, or its equivalent in the metric scale.

Columns 14 and 15.—*Thermometers, Dry Bulb and Wet Bulb.*

Should these observations be required from all ships?	That wet and dry bulb observations are desirable, and should be obtained whenever possible.

Column 16.—*Forms and Direction of Clouds.*

Is this column sufficient, or should any notice be taken of more than one stratum of clouds?	That the upper and lower clouds should be recorded in separate columns, and that the direction from which *upper* clouds come should be recorded when possible.

Column 17.—*Proportion of Sky Clear.*

Is it not advisable to substitute for this heading "Proportion of sky clouded"?	That it is preferable to give the proportion of sky clouded instead of the entry "proportion of sky clear," as recommended by the Brussels Conference.

Column 18.—*Hours of Rain, Fog, Snow, &c.*

Is it desirable to retain this heading, or to substitute for it and No. 23, a column headed "Weather by Beaufort Notation"?	That it is desirable to retain this heading, but that the use of Beaufort's Notation may be continued by those accustomed to it.

Column 19.—*State of the Sea.*

Should this be given according to a numerical scale?	That a numerical scale (0 – 9) be adopted, and that an extra column should be given to the observation. The direction of the sea swell, or the different swells, to be given in the original column.

Columns 20 to 22.—*Temperature of Sea Surface, Specific Gravity, Temperature at Depths.*

Is it desirable to retain these columns, or can the observations when taken be inserted in the column for "Remarks"?	That the first two columns should be retained. That sea temperatures at depths should not be required from all ships, and should be recorded in the "Remarks."

Column 23.—*Weather.*

Vide the resolution on Column 18.

Column 24.—*Remarks.*

Questions.	Resolutions.
	That the "Remarks" as asked for by the Brussels Conference should be adopted, with the exception of the observations of temperature with coloured bulbs at sea.

II.—Instruments.

What patterns of instruments should be employed for any observations which may require them?	That the question of the precise pattern of instruments is not of very great importance, so long as they satisfy the tests applied at the several central Institutions, and are compared with standard instruments; but it is recommended that they shall be of a pattern as easy as possible for reading.
Is there any reasonable possibility of introducing the metric and centigrade systems for general use at sea?	The recommendation respecting the use of the metric and centigrade systems as expressed at the Vienna congress was approved, and it was recommended that a table of conversion should be entered in each log to enable Captains to compare barometers which have different scales.

III.—Instructions.

Is it possible to devise a general form of Instructions to ensure uniformity in regard of methods of observation and registration?	That the Instructions should be suited to the log now proposed by the Conference, but modified to meet the various requirements of different nations.

The Conference requested that Capt. Toynbee's proposed form of log should be lithographed and the English "Instructions" printed for circulation amongst its members.

IV.—Observers.

What control should be exercised over the Observers as to their instruments and registers?	That it is necessary that all instruments should be compared with standard instruments, either at the central or the filial institutions (if such exist), before and after the voyage; and that the corrections and date, &c., of the comparison should be entered in the log.
Is it desirable that all instruments employed should be the property of the central establishment, and *lent* to the observers?	That it is desirable that the instruments should be the property of the central office. That it is necessary that a careful examination should be made into the quality of the observations recorded, and that the attention of the observers should be specially directed to any errors which may have been detected.

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V.—Co-operation of the Royal Navy.

Questions.	Resolutions.
To what extent can ships of war assist in forwarding the ends of meteorological inquiry?	The Royal Navy can furnish more complete observations than are possible on board merchant ships, as, *e.g.*, Deep-sea soundings and temperatures. Observations in unfrequented parts of the sea. Special experiments. It is most desirable that the duty of observing should be intrusted to some responsible Officer. It is therefore resolved that the Authorities of the Navies shall be requested to continue to give such assistance to the prosecution of meteorological science as circumstances shall permit.

A Report was handed in which had been drawn up by a number of the members who were in the Naval Services of some of the countries represented, and it was decided that the following resolutions which it contained should be adopted in lieu of those given above:—

1. "It is very important that the organisation of meteorological inquiry, as regards the Navies of all countries, should be arranged in accordance with the principles and stipulations laid down by the Conference for Marine Meteorology generally; and it is further important that the results of all observations made on board ships of war in any country should be rendered accessible for discussion by the central station for maritime meteorology in that country, without prejudice to any subsequent publication by the respective Naval Authorities.

2. "The Conference, while admitting that the introduction of measures calculated to improve the condition of meteorological inquiries in the Navy must be left to the Authorities of the respective Navies, is nevertheless of opinion that all care should be taken to secure uniformity as to mode of observation, and especially to provide for the comparison of all instruments used with the respective standard instruments of the Central Institutes.

3. "The Conference considers it to be its duty to request that those entrusted with the management of scientific affairs on board men of war will lend their strenuous support in securing from the Naval Authorities in each country such regulations as will place meteorological inquiry on board such ships in as favourable a position as may be deemed consistent with the execution of the ordinary duties of the Service, and will also induce the commanders to render to such inquiries all the assistance and furtherance in their power. The Conference, knowing that such regulations must be framed according to the requirements of each country, expresses, nevertheless, its opinion that, inasmuch as meteorological observations require considerable experience, they should be entrusted to experienced officers on board suitable vessels.

4. "Although the Conference is of opinion that, as far as the general scope of meteorological inquiry goes, the same form of register should be supplied to merchant ships as to men of war, it declares it will be most desirable that, besides the regular observations, a more extended scale for scientific inquiry should be adopted on board ships of war, as in such cases there is a large number of suitable officers, as well as more means for carrying on the service. As examples of observations which are of importance for the development of Maritime Meteorology, over and above the regulations embodied in the scientific instructions given to Naval expeditions for the special purpose of the advancement of science, the following suggestions may be enumerated:—

(*a.*) "Possibility of carrying out accurate observations on the velocity of the wind by anemometers at sea.

(*b.*) "Possibility of employing rain-gauges satisfactorily at sea.

(*c.*) "Observations with Regnault's and other hygrometers, and experiments on the best mode of observing wet and dry thermometers, and the best position to place them in on board ship.

(*d.*) "Currents at the surface and at depths to be observed with great minuteness, with the special object of defining their limits.

(*e.*) "The comparison of various instruments, among which are expressly mentioned that of aneroids with mercurial barometers. It is further deemed very desirable that frequent comparisons should be instituted between the instruments used at sea and meteorological stations on shore in various countries.

(*f.*) "Deep-sea soundings and temperatures, with specimens of water.

(*g.*) "The collecting of information on Ocean Meteorology at outlying stations.

(*h.*) "The furnishing of synchronous observations at 0h. 43m. G. M. T., in accordance with the suggestion and request of the United States Signal Office."

VI.—Discussion.

Questions.	Resolutions.
Can general suggestions be thrown out as to the most profitable mode of discussing the observations?	That it is desirable that every Institution should publish the observations and results in such a manner that every foreign institute can incorporate them with its own observations and results in the easiest way possible; that is, by preserving the number of observations, together with any means derived from them, for single square degrees. That it is further desirable that, whatever charts be published, the results for single square degrees should be published in a tabular form. That it seems desirable for the use of the sailor that each chart should have reference to only one element, or, at least, only to elements closely related to each other.

VII.—Subjects of Inquiry.

To what extent can a division of labour, as regards subjects of inquiry, be carried out in a spirit of fairness to the collecting and discussing establishments respectively?	That the division of labour, as regards investigations, can only be carried out by mutual agreement between the several institutions; and each institution should announce to other institutions what investigations it proposes to undertake. It is very desirable that such divisions of labour should be effected.

VIII.—Sailing Directions.

In how far are purely practical investigations, such as the preparation of sailing directions, admissible for a scientific institution?	That the sailor wants the result of experience alone, and he must receive assurance that his observations have been turned to use. When these results of experience have been given, the theorist may point out the reason why certain routes are the best.

It was resolved, that Capt. Toynbee's remarks on the programme should be printed in full, with extracts from the remarks of other gentlemen, should they contain important suggestions.

(2.) International Code for Weather Telegraphy.

The following system has been proposed by the Permanent Committee of the Vienna Congress for general adoption (*vide* their Report p. 13).*

The messages consist of six groups of five figures each, which are as follows:—

1°	2°	3°
B B B W W	S S H T T (Eng.)	B B B W W
	S H T T T (Cont.)	

4°	5°	6°
S S H T T (Eng.)	T′ T′ R R R (Eng.)	M M m m Sea
S H T T T (Cont.)	T′ T′ T′ R R (Cont.)	

* Data refer to the previous evening.

Decimal points are always disregarded, and in the case of the barometer the first figure is also omitted, as this must, under ordinary circumstances, be 7 for continental stations (millimetres), or either 2 or 3 for British stations (inches). Thus:—

763·5 mm. is telegraphed as - 635
29·34 in. „ „ - - 934
30·03 „ „ „ - - 003

and for Temperature:—

25°·3C „ „ - - 253

B=Air pressure at sea level and 32° F. and to 0·1 mm. or 0·01 in.

T=Dry bulb thermometer to 0°·1C or 1°·0 F.

T′=Wet bulb thermometer to 0°·1 C, or 1°·0 F. For temperatures below 0°, 50° C are to be added. In other words, with Temperatures below 0° C, no sign (+ or —) is to be used, but the reading is to be increased by 50. So, *e.g.* for — 5°·3 C, 553 would be telegraphed.

M.=Max.
m.=min. } Temperature, to 1°·0 C, or 1°·0 F.

W=Wind direction (*true*, not magnetic) referred to 16 of the 32 points, being only the even numbers:

N = 32, E = 8, S = 16, W = 24.

S=Wind-force (Beaufort scale). For the continent, when the force exceeds 9, this figure will be recorded in the proper group, and at the end of the telegram the force should be repeated in words.

R=Rain to 1mm. or 0·01 in. In the Norwegian Telegrams in winter 99 means "Fall during the night" without its being measured.

Sea=Sea disturbance 0—9.

0=dead calm.	4=moderate.	7=high.
1=very smooth.	5=rather rough.	8=very high.
2=smooth.	6=rough.	9=tremendous.
3=slight.		

* "Report of the Permanent Committee of the first International Meteorological Congress at Vienna." Published by authority of the Meteorological Committee, London. Potter and Stanford. 1875. Price 1*s.* 6*d.*

H=Hydrometeors or weather, as follows :

0	State of sky	Quite clear.	5	Rain.
1		¼ clouded.	6	Snow.
2		½ ,,	7	Dust-haze (Höhenrauch.)
3		¾ ,,	8	Fog.
4		Overcast.	9	Thunderstorm.

The occurrence of Hail, Sheet Lightning, Aurora, &c., should be added in words at the end of the telegram.

Instead of the Maximum the Temperature at 2 p.m. can be given.

If there is no Minimum thermometer at a station, and the sea disturbance is not observed, the sixth group is omitted.

The data for pressure, temperature, wind direction and force, are in the British Isles for 6 p.m. and 8 a.m. ; for the Continent for 9 p.m. and 7 a.m. in general.

(3.) Forms for Publication of Observations from Stations of the Second Order.

The Permanent Committee have recommended the forms given on pp. 43–46 for general adoption.

If the language of the country is other than German, French, or English, the headings of the columns are to be given in one of these languages, in addition to the special language of the country.

In these monthly tables the maxima and minima of pressure and temperature are to be given by Egyptian figures.

In the relative humidity, perfect saturation can either be given by three figures (100) or, by omitting the figure (1), by giving only the two figures (00).

In the column "Remarks," it is desirable, in order to indicate the duration or the epoch of hydrometeors, &c., to employ symbols which are generally intelligible, and accordingly to add to the respective symbols for hydrometeors either the hour of the beginning and end, in which the forenoon hours are marked *a* (a.m.) and the afternoon hours *p* (p.m.). ● 10 a — 4 p would therefore indicate "rain from 10 a.m. to 4 p.m., civil time."

Or where this is not possible, to give by means of additional figures, 1, 2, or 3, whether the hydrometeor in question had occurred at or before the 1st, 2nd, or 3rd period of observation. ≋3 would indicate "fog at or before the 3rd period of observation" about 9h. or 10h. in the evening; ≋1·3 would mean "fog at the time of or before the first and last periods of "observation, *i.e.*, morning and evening."

As to the further order or arrangement of the individual monthly tables of this form in the annual volumes of the Central Offices, the majority of the Committee thinks that at present it should be left to the editors of these books whether they will, as has been hitherto generally the case, print the tables for each station for the same month one after another, in which case monthly parts may be issued; or whether they, as will be the case in future in Norway, Sweden, Denmark, Austria, Russia, and Saxony, will only give complete yearly volumes, in which the 12 monthly tables for one station, arranged in pairs one under another (4 months to one opening), should follow immediately one after another.

In accordance with the wish of several Directors of Central Institutes, the Committee thinks it desirable to give an *inferior limit* for the number of stations of the Second Order, which are at least necessary for the study of the general phenomena of weather in each country, and observations from which should be published *in extenso* in the method above given.

Country.	No.
Norway - - - - -	10
Sweden - - - - -	10
Denmark, with Iceland and Faroe -	6
Great Britain and Ireland - -	15
Russia in Europe - - -	50
Russia in Asia - - - -	100
Netherlands - - - -	2
Belgium - - - - -	2
Germany - - - - -	12
France - - - - -	12
Austria and Hungary - - -	15
Turkey - - - - -	10
Switzerland - - - -	5
Italy - - - - -	12
Spain, Portugal (and Azores) - -	12
Greece - - - - -	3

It remains open for the directors of the individual systems not only to select the stations which are best suited for the purpose, but also to increase at pleasure the minimum number above given.

For the publication of monthly and yearly resumés for all stations of the second order, the Committee proposes the form which has been devised by Dr. Jelinek, pp. 44, 45.

For want of room the 16 wind directions are reduced to eight. This reduction is to be made in the same way as that from 32 directions to 16, according to the resolution of the Congress on the 11th September 1873.

The definition of clear and cloudy days is :—

"Clear" when the mean cloud - - < 2
"Cloudy" " " - - > 8

The number of days with aurora, with the maximum temperature under or equal to 32° (days without thaw), and with the minimum of temperature under or equal to 32° (days of frost), further the giving of the mean force of the wind, &c. may, when there is room, either be included in these tables, or even given specially with other remarks in the Appendix to the yearly volume.

These tables are to be given apart from the former ones in the yearly volume.

As for the means of daily humidity and pressure it seems desirable to arrange the calculation so that they shall accord as nearly as possible with true daily means.

With regard to the form of publications of *other* meteorological observations of each country the Committee thinks that it should leave the most perfect freedom to the Directors.

Plan for Publication of the Monthly and Yearly Results for Stations of the Second Order

AND

Plan for the Publication of Actual Observations.

In case the text of the Publication is in any other language than French, German, or English, the headings of the different columns are to be given in one of these languages in addition to their original language.

The hours 7, 1, 9 have been given in the Forms; for these, any other combination of hours, accepted by the Vienna Congress may be substituted.

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Months.	Mean Pressure.	Air Temperature.										Tension of Vapour.				Relative Humidity.			
		7.	1.	9.	Mean.	Means of		Absolute Min. and Max.				7.	1.	9.	Mean.	7.	1.	9.	Mean.
						Min.	Max.	Min.	Date.	Max.	Date.								
Station ______ . λ = . φ = . H = .																			
January																			
February																			
March																			
April																			
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Year																			

λ = The longitude of the station. φ = The latitude of the station. H = Height above mean sea level.

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ht = . *hr* = . ______________ Station.

Months.	Amount of Cloud.				Rainfall.			Weather. No. of Days of							Wind. No. of Observations of								
	7.	1.	9.	Mean.	Total.	Max.	Date.	Rain.	Snow.	Hail.	Thunder Storms.	Clear Sky.	Overcast.	Gales.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
January -																							
February -																							
March -																							
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Year -																							

ht = . *hr* = . ______________ Station.

Months.	7.	1.	9.	Mean.	Total.	Max.	Date.	Rain.	Snow.	Hail.	Thunder Storms.	Clear Sky.	Overcast.	Gales.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
January -																							
February -																							
March -																							
April -																							
May -																							
June -																							
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October -																							
November -																							
December -																							
Year -																							

ht = . *hr* = . ______________ Station.

Months.	7.	1.	9.	Mean.	Total.	Max.	Date.	Rain.	Snow.	Hail.	Thunder Storms.	Clear Sky.	Overcast.	Gales.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
January -																							
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December -																							
Year -																							

ht = . *hr* = . ______________ Station.

Months.	7.	1.	9.	Mean.	Total.	Max.	Date.	Rain.	Snow.	Hail.	Thunder Storms.	Clear Sky.	Overcast.	Gales.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
January -																							
February -																							
March -																							
April -																							
May -																							
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July -																							
August -																							
September -																							
October -																							
November -																							
December -																							
Year -																							

ht = Height of the Therms. above the ground in feet. *hr* = Height of the Raingauge above the ground in feet.

Station_____ 187___. Long._____

Height above M.S.L._____ ft. Month _____ Lat._____ N.

Day.	Barometer.			Air Temperature.					Tension of Vapour.			Relative Humidity.			Wind. Direction and Force.			Amount of Cloud.			Rain-fall.	Remarks.
	7	1	9	7	1	9	Max.	Min.	7	1	9	7	1	9	7	1	9	7	1	9	—	
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2																						
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29																						
30																						
31																						
Mean																						

Station_____ 187___. Long._____

Height above M.S.L._____ ft. Month _____ Lat._____ N.

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2																						
3																						
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5																						
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31																						
Mean																						

(4.) Improvements in the Method of Tabulation of Thermograms.

The only important modification of procedure in connection with the automatic instruments has been as regards the tabulation of the thermograms, the method now followed being on a totally different principle from that described in the Report for 1867, p. 34, where it is said that the glass scale "is set by the readings "of the standard thermometer which are nearest the beginning "and ending of the curve." This rule was altered in the Report for 1868, p. 38, to read as follows:—"The tabulating instrument "should be set from the observation hours where there is little "thermometric fluctuation." Experience has, however, shown that even when the latter method of tabulation has been employed the curve readings at times would not agree with the intermediate standard readings within the limits of accuracy required.

This was evidently, in the main, due to what is termed "bagging," or in other words to the curvature of the assumed base line of the photograph, a defect which has from the first been detected in the barograms, inasmuch as a base line for their tabulation is mechanically produced by the photographic process.

In the regulations for the thermograph, Report 1868, p. 65 (9), the possible existence of this cause of error in the thermograms was recognized, but no principles for its detection were laid down, nor indeed was any simple method of doing so at that time possible, for the white lines on the photographs, called in the Report for 1867 "fiducial lines," are not sufficiently constant in their appearance to serve for that purpose.

After some time the Committee, owing to the experience gained in the reproduction of the curves for publication, where they are necessarily referred to a straight line, decided to have their instruments altered by piercing the metallic framework of the thermometer so as to allow of the production of a photographic trace at a definite temperature, which should at the same time afford a fiducial line for setting the tabulating scale and allow of the easy detection of any divergence from horizontality in its own course.

It has also been rendered possible by the comparison of an extensive range of readings of the curves and also of the distance apart of the several white lines on the thermograms above mentioned, obtained by measuring their distances from the new fiducial lines, to determine within what limits the pairs of thermometers originally supplied had "very nearly the same scale value," so as to be measurable by the same tabulating scale.

The result has shown that in more than one instance the scales of the thermometers had not been at first determined with the requisite accuracy, and it became necessary to furnish new ones.

The whole of the work connected with the measurements referred to has been carried out in the Office, and the new glass scales required have been engraved in the Office by the use of Wagner's pantagraph.

APPENDIX.

APPENDIX I.

METEOROLOGICAL OFFICE: ACCOUNT of RECEIPTS and PAYMENTS for the year ending 31st March 1875.

RECEIPTS.				PAYMENTS.					
Balance from year 1873–4		£2,290 12 2		OFFICE:					
Parliamentary Vote		10,000 0 0		Salary of Director	800 0 0				
Commissions for Instruments	725 1 7			„ Two Clerks	339 15 0				
Subscriptions for D.W. Charts	297 2 11			Office-keeper and Messenger	175 4 0				
Subscriptions to Hourly Obsns.	14 0 0						£1,314	19	0
Subscriptions for Danish synoptic charts	17 1 6			Rent of Office	534 12 0				
Subscriptions for M.S. Weather Reports	15 0 0			Fuel and gas	41 18 5				
Supply of Meteorological data, &c.	23 16 11			Furniture and fittings, &c.	26 12 3				
		1,092 2 11					603	2	8
Interest on deposit account		129 10 10		Postage	79 18 4				
				Printing and books	21 14 7				
				Attendance, and other Contingencies	94 4 1				
							195	17	0
				LAND METEOROLOGY:					
				Expenses at Observatories	2,644 3 11				
				New instruments (colonies, &c.)	391 12 9				
				Computations	763 11 2				
							3,799	7	10
				Telegraphy	2,139 8 9				
				Inspections, issue of D.W. Charts, &c.	583 2 3				
				Computations	665 6 8				
							3,387	17	8
				OCEAN METEOROLOGY:					
				Marine Superintendent	450 0 0				
				Supply and Return of Instruments, &c.:					
				Admiralty	265 15 0				
				Mercantile Marine	575 4 11				
				Computations and Care of Instruments	1,093 6 5				
							2,384	6	4
							11,685	10	6
				Cash in hand	60 12 7				
				Advance to Valencia Observatory	50 0 0				
				Bank of England account	545 10 8				
				London and Westminster Bank	1,170 12 2				
							1,826	15	5
		£13,512 5 11					£13,512	5	11

Examined and compared with the vouchers and found correct.

June 4, 1875. (Signed) W. J. SMYTHE, Major-General, WARREN DE LA RUE, } Auditors.

BALANCE SHEET, 31st March 1875.

To sundry creditors	1,015 10 0			By cash (as above)	1,826 15 5	
„ probable net surplus	1,053 1 5			„ sundry debtors	241 16 0	
		2,068 11 5				2,068 11 5

APPENDIX II.

LIST of CAPTAINS (and Officers) who have received from the Committee a Copy of the Admiralty Charts, to 31st March 1875 (*see* Report, p. 7). The figures opposite to each show the number of Special Letters of Thanks written to each Observer in acknowledgment of "Excellent" Registers *subsequently* returned to the Office.

Captain's Name.	Letters of Thanks.	Ship.
Almond, Thomas Michael, F.R.A.S.	1	"Decapolis."
Angel, John Fry - -	—	"Twilight."
Balderston, Richard James -	—	"Rajmahal."
Banner, Frederick William -	3	"Lady of the Lake," and "Kenilworth."
Barwood, William Richford -	1	"Fugitive."
Becket, Alexander - -	—	"City of Perth."
Blake, Edwin John - -	4	"Gilbert Thompson," "Gitana," and "Sydney Dacres."
Bouchette, Francis Baines -	1	S.S. "European."
Brooks, Samuel - - -	2	S.S. "City of Brooklyn."
Brown, Robert - - -	1	S.S. "Moravian."
Bruce, John - - -	3	"City of Adelaide," and S.S. "Australian."
*Bythesea, John (V. C.), R.N. -	2	H.M.S. "Phœbe."
Campbell, Archibald - -	4	S.S. "Britannia," and S.S. "Europa."
Capper, Edward Hall - -	1	"Palm Tree."
Carruthers, Forrest Priest -	2	"Minero."
Comley, William Guise, R.N.R. -	1	S.S. "Hong Kong."
Davidson, Charles - -	—	"Perseverance."
Dobson, Charles Meadows -	—	S.S. "Beta."
Donkin, Thomas, R.N.R.- -	2	"Inverness."
Ellery, William - - -	3	"Bowfell."
Fernie, Alexander Durwood -	—	"Sir John Lawrence."
Finlay, James - - -	2	"Duncairn."
Freeman, Thomas W. - -	1	S.S. "Wisconsin."
Fry, Alfred - - -	1	"Foam."
Gaye, Gerrard - - -	2	"Eliza Shaw."
*Goodenough, James G., R.N. -	1	H.M.S. "Pearl."
*†Hosken, Henry, R.N. - -	—	Do.
Grange, James - - -	—	S.S. "Acantha."
Gray, David - - -	1	S.S. "Eclipse."
Gray, John - - -	1	S.S. "Mazinthien" and S.S. "Hope."
Gray, John McDonald - -	4	"Speranza."
Greenwood, William - -	4	S.S. "Scotia" and "Assaye."
Grigs, George, R.N.R. - -	2	S.S. "Helvetia," and S.S. "France."
Harris, David - - -	1	S.S. "Medway."
Hassell, Thomas Edward -	2	"Mervyn."

* Pilot charts not presented. † Navigating Lieutenant.

Names of Officers, deceased, *in italics*.

Captain's Name.	Letters of Thanks.	Ship.
Hayes, James	5	S.S. "Ptolemy" and S.S. "Camoens."
Hayward, George Olive	2	S.S. "Durley."
Heggum, Edward Carl V.	6	"Czar."
Henderson, Henry	5	"Hope," and S.S. "Cleveland."
‡Hodding, Samuel White	—	"Indus."
Holdich, John Peach, R.N.R.	1	"Agra."
*Hopkins, John O., R.N.	—	H.M.S. "Liverpool."
Huster, David	4	S.S. "Alpha" and S.S. "Delta."
*§Jackson, Robert	1	H.M.S. "Glasgow."
Johnson, Charles, R.N.R.	1	"St. Lawrence."
Jones, Arthur Arundel	2	"Victoria Nyanza," and "Chevychase."
Jones, George Henry	4	S.S. "Nile," and S.S. "Niger."
*Jones, Theodore Morton	1	H.M.S. "Glasgow."
Kennedy, Charles William	2	S.S. "Scotia," and S.S. "Baltic."
Kennedy, James Branch, R.N.R.	—	S.S. "Blue Cross."
Kerr, Alexander	1	"Ardgowan."
Kerr, Thomas Coulter, R.N.R.	1	"Durham."
Lecky, Squire Thornton Stratford, R.N.R., F.R.G.S.	2	S.S. "Uruguay" and S.S. "Halley."
Leportier, Theodore	1	"Kate."
Lewis, John Thomas, R.N.R.	1	S.S. "Scotia," and S.S. "Chaldea."
Lindsay, Henry Kay	1	"Valparaiso."
Longley Herbert	—	S.S. "Yorkshire."
Lunham, Robert Dowe	4	S.S. "Berar," S.S. "Durley" and "Charles Howard."
**MacDonald, John*	—	S.S. "Europa."
McKechnie, Duncan Ferguson	3	"Cottica."
Mackellar, D. E.	—	Observations at Rapa Island.
Mackie, Thomas	—	S.S. "Mazinthien."
Maddison, John, R.N.R.	—	"Anglesey."
Manning, Henry	—	S.S. "Kangaroo."
Maples, Charles	—	"Genii."
Martyn, John Artis	10	S.S. "Siberia" and S.S. "Samaria."
*Mayne, Richard C., R.N., C.B.	1	H.M.S. "Nassau."
†Menzies, Charles James	1	S.S. "Austrian" and S.S. "Sarmatian."
Moore, Thomas	—	"W. E. Gladstone."
Morton, John D'Arcy	—	"Henry Bath."
Mossop, Clement	2	"Candahar."
Mouland, John Elsey	1	S.S. "Batavia."
Murphy, Michael	—	S.S. "Tarifa."
*Nares, George Strong	1	H.M.S. "Challenger."
Newton James William	—	S.S. "Grenadier."
Owen, John	—	"W. G. Russell."
†Paterson, James Forrest	2	S.S. "Moravian."
Pearson, Charles William	6	"S.S. "Strathclyde."
*Perry, John L., R.N.	2	H.M.S. "Orontes."
‡*Petch, John A. R., R.N.	2	H.M.S. "Phœbe."
Petrie, Peter Conrad	1	S.S. "Patagonia."
Potts, Thomas Crosby	4	"Tenasserim."

* Pilot Charts not presented.
‡ Second Officer.
† Chief Officer.
§ Navigating Lieutenant.

Names of Officers, deceased, *in italics*.

Captain's Name.	Letters of Thanks.	Ship.
Price, James John - -	5	"Sorata."
Rawle, Charles, R.N.R. - -	1	"Star of the North."
Raymond, Charles Tenzer -	3	"British India" and "British Consul."
Reid, Carson William - -	1	"Lord Strathnairn."
Renaut, Charles Henry - -	3	"Celaeno" and "Glenlora."
†Scott, Fergus - - -	—	S.S. "Hotspur."
†Scott, George Alexander Brown -	—	S.S. "Nestorian."
*Sharp, William H., Staff Com., R.N.	—	H.M.S. "Liverpool."
*Shortland, P. F., R.N. - -	—	H.M.S. "Hydra."
Simpson, Alexander - -	4	"Traveller."
Smith, David, F.R.A.S. - -	—	"Wiltshire."
Smith, William Charles - -	—	"Kingdom of Saxony."
Smith, William Henry, R.N.R. -	5	S.S. "Hibernian," S.S. "Peruvian," and S.S. "Scandinavian."
Stanhope, John - - -	—	"Decision."
Steele, John - - -	1	S.S. "Erl King."
Stephen, John George - -	1	S.S. "Moravian" and S.S. "St. Patrick."
Stuart, George Rennie - -	2	"Otago."
Stuart, William Henry - -	4	"Richmond."
Sutherland, James Taylor -	1	"Maggie" and "Glenesk."
Symington, William - -	6	"Northfleet," "Flying Venus," and S.S. "Hong Kong."
*Tandy, Dashwood G., R.N. -	1	H.M.S. "Nassau."
Tilmouth, Robert J. C. - -	—	"Peeress."
Townsend, William Henry -	—	"Valentine and Helene."
Trench, Chas. E. Le Poer -	1	"Newcastle."
Tucker, John Worth - -	—	"John Temperley."
Tully, Thomas - - -	1	"Baroda."
*‡Vine, William W., R.N. - -	2	H.M.S. "Orontes."
Vowell, Michael - - -	1	"Kelso" and "Undine."
Wadham, Thomas Littleford -	2	"Vere."
Walker, John Burnett - -	—	S.S. "Erik."
Watkins, Thomas - -	—	"Emulation."
Watson, William - -	11	S.S. "Palmyra" and S.S. "Parthia."
Wherland, Frederick, R.N.R. -	4	"Galatea."
Wight, Henry Potts - -	2	"Gosforth."
Wilcox, Henry George, R.N.R. -	—	"St. Lawrence."
Williams, James Agnew - -	—	S.S. "Wisconsin."
Wylie, James - - -	1	S.S. "Austrian" and S.S. "Sarmatian."

In addition the Committee have presented barometers to two gentlemen who have formerly kept registers for the office, but have now retired from the sea, viz., to Capt. A. D. Wood in 1867, and to Capt. Isaac Gales in 1870. A set of instruments was also presented to Capt. Alfred Fry in 1868.

* Pilot Charts not presented. † Chief Officer.
‡ Navigating Lieutenant.
Names of officers deceased, *in italics*.

APPENDIX III.—Ships supplied and Documents returned during the year 1874.

The number of ships supplied with standard instruments and meteorological registers during the year 1874 was 78. This number does not include ships in the Royal Navy, all of which are supplied with instruments by the Meteorological office, but in which the keeping of a special meteorological register is optional.

The number of meteorological registers and documents received during the year 1874, and registered in the office, amounted altogether to 198, of which 103 were returned from ships, and 95 from land stations, generally outside the British Isles.

List of Documents received from Land Stations.

Place.	Observer.	No. of Documents.	Nature of Observations.
Abaco (Bahamas) - - -	Lightkeeper - - -	1	"Lighthouse" Register, July – December, 1874.
Angra do Heroismo (Azores) -	- - - - -	12	One observation daily. November 1873 to October 1874.
Belize - - - - -	S. Cockburn - - -	1	11 : January to June 1874, and monthly means (Aneroid barometer).
Bermuda - - - - -	Dockyard Authorities - -	12	Anemometrical Records, November 1873 to October 1874, and accounts collected by Gen. Lefroy relating to hurricanes of August 19 – 24, 1873.
Cape Pembroke (Falklands) -	Lightkeeper - - -	1	"Lighthouse" Register July – December 1873.
Cay Sul (Bahamas) - - -	Lightkeeper - - -	1	"Lighthouse" Register, March 1873 to February 8, 1874.
China Sea - - -	Capt. T. Donkin - -	1	Typhoon, September 1873.
Durham - - - - -	J. J. Plummer, M.A. - -	1	Summary of meteorological results for 1873.

LIST of DOCUMENTS—*continued.*

Place.	Observer.	No. of Documents.	Nature of Observations.
Funchal (Madeira)		12	One observation daily, from November 1873 to October 1874.
Gibraltar	Serjeant J. Brewster	12	Two observations daily and monthly means, December 1873 to November 1874.
Heligoland	Lightkeeper	6	Eight observations daily, from December 1873 to May 1874.
Mogador (Morocco)	French Consul	3	Three observations daily, from January 1872 to August 1874. (Aneroid barometer and French measures.)
Patras (Greece)	Rev. H. A. Boys	15	One observation daily, August 1873 to October 1874.
Punta Arenas (Patagonia)	Capt. R. C. Mayne, R.N.	1	Mean barometer 1854 – 1860; Mean thermometer 1854 – 1865.
St. John's (Newfoundland)	J. Delany	12	Three observations daily, December 1873 to November 1874.
St. Thomas	F. H. Jahncke	1	Charts and documents relating to Cyclones in West Indies from 18th – 26th August and 26th September to 9th October 1873.
Selkirk (Manitoba)	Wm. R. Flett	1	One observation daily, September to December 1873.
Sombrero	Lightkeeper	1	"Lighthouse" Register from November 1873 to April 1874.
Woosung (China)	C. D. Braysher	1	One observation daily during 1873.
		95	

List of Documents received from Ships.

Captain's Name.	Ship.	Tons.	Owners.	Voyage.	Months of Register.
Adams, J. T.	Soukar	1,304	Savill & Temple, London	Towards Canterbury, N.Z.	2
Almond, T. M.	Decapolis	632	T. B. Walker, London	Brisbane	6
Balderston, R. J.	Rajmahal	1,302	T. Brocklebank, Liverpool	Calcutta	7
Becket, Alexander	City of Perth	1,189	G. Smith & Sons, Glasgow	Melbourne	7
Bennett, E. C.	Medea	1,066	J. H. Carmichael, Greenock	Calcutta, Surinam, and home	7
[1] Bird, G. E., R.N.R.	S.S. Kafir	613	Union Steamship Co.	To Natal	1
Bond, Edward	Indiana	300	T. Seed, Fleetwood, Lancaster	Amoor river, Siberia	3
Brett, E. E.	Strathearn	246	Harrison & Co., Liverpool	Old Calabar (W. C. A.)	1
" "	Ardgillas	410	" "	West Coast of Africa	3
Brown, A. J.	Vere	396	Anderson & Co., London	Jamaica	3
Bruce, John	South Australian	1,040	Devitt & Moore, London	Adelaide	5
Carruthers, George	Minero	478	C. C. Lewis, Brentwood, Essex	Chili	6
Comley, W.G., R.N.R.	S.S. Hong Kong	1,221	E. H. Watts, London	China, viâ Suez	4
Crombie, W. A.	Prince of Wales	182	Aberdeen Lime Co.	Archangel, two voyages	3
Cruickshank, William	Richard Wright	1,353	J. Nevins, St. John's, N.B.	Bombay, Calcutta, and home	9
Cunningham, Andrew	Surrey	1,089	G. Marshall, London	To Sydney, Calcutta, Demerara, and home from St. Vincent.	9
Dobson, C. M.	S.S. Beta	1,014	Smith, Hill, & Co. Hull	Constantinople, Odessa, and back to Altona	2
Donkin, Thomas	Inverness	725	J. & R. Grant, London	To Sydney, Hong Kong, and Foochow	7
Douglas, Charles	Malabar	1,219	H. Green, Blackwall	Melbourne	6
Eales, James	Sir Robert Sale	704	J. D. J. Teigh, London	To Calcutta	9
Ellery, William	Bowfell	1,002	T. & R. Brocklebank, Liverpool	Calcutta, thence to Adelaide, Mauritius, and Bombay.	8
Faithful, Henry	Haddon Hall	1,416	R. Alexander, Liverpool	Sydney	4
Freeman, T. W.	S.S. Wisconsin	3,700	Liverpool and Gt. Western Steam Co., Lim., Liverpool.	New York, five voyages	4
" "	"	"	" "	" "	4

LIST of DOCUMENTS, &c.—*continued.*

Captain's Name.	Ship.	Tons.	Owners.	Voyage.	Months of Register.
Gaudin, James	Lady Lampson	412	Hudson's Bay Co.	Vancouver Island	8
Gaye, Gerrard	Eliza Shaw	696	C. Shaw, London	Yokohama, New York, and home	9
Gedge, W.S., R.N.R.	Celœno	702	Rhoades & Sons, London	Wellington	7
[2] Goodenough, J.G., R.N.	Pearl	2,187	H.M.S.	New Zealand and Australia	4
[3] " " "	"	"	"	At Australian Stations	4
Gray, David	S.S. Eclipse	435	J. Arbuthnot, Peterhead	Greenland, Spitzbergen, and home	6
Gray, John	S.S. Hope	452	R. Kidd, Peterhead	Greenland	6
Gray, J. McDonald	Speranza	455	W. Nicholson, Sunderland	Valparaiso	6
Greenwood, William	Gareloch	1,177	P. Kintoul, Glasgow	Calcutta, Moulmein, and home	8
Gun, A. F.	Golden Fleece	1,257	Carmichael & Co., Greenock	Calcutta, Demerara, and New York	7
Harland, Charles	Nelly	407	J. C. Brooks, Newfoundland	Wellington, U. S.	3
Hassell, T. E.	Mervyn	288	R. J. & W. Poole King, Bristol	On West Coast of Africa	7
" "	"	"	" " "	From West Coast of Africa	3
Hayes, James	S.S. Camoens	1,053	Brazil and R. Plate S. L. Co.	Trading on South-east Coast of America	2
Heggum, E. C. V.	Rozelle	1,286	R. Cuthbert, Greenock	Calcutta, New York, and home	7
Hilliard, A. J.	S.S. Dacia	1,470	India Rubber Telegraph Co.	Marseilles	3
" "	"	"	" "	West Indies	9
Holdich, J. P., R.N.R.	Agra	821	Bilborough & Parsons, Liverpool	To Canterbury (N. Z.), Newcastle, San Francisco, and home.	11
[4] Horne, James	John Allan	734	J. H. Allen, London	Negapatam, Cocoanada, Marseilles, and home.	8
Johnson, Chas., R.N.R.	St. Lawrence	1,094	J. Lawrence, London	Madras	6
Jones, G. H.	S.S. Niger	1,125	C. M. Norwood, London	Odessa, two voyages	4
[5] Jones, T. M., R.N.	Glasgow	3,037	H.M.S.	From Seychelles to Trincomalee, Colombo, and Aden.	4
[6]					
[7] " "	"	"	"	On East India Stations	4
" "	"	"	"	From Trincomalee to Mauritius, Johanna, and Zanzibar.	4

LIST of DOCUMENTS, &c.—*continued.*

Captain's Name.	Ship.	Tons.	Owners.	Voyage.	Months of Register.
[8] Kennedy, J.B., R.N.R.	S.S. Baltic	2,209	Ismay, Imrie, & Co. Liverpool	New York, six voyages	4
Kerr, Alexander	Ardgowan	1,283	G. Adam, Greenock	Calcutta, Bombay, and home	8
Leet, J. R., R.N., acting Captain.	Princess Charlotte	4,122	H.M.S.	Off Hong Kong	15 days.
Longley, Henry	S.S. Yorkshire	1,771	W. H. Tindall, London	China, Japan, Calcutta, and home, viâ Suez.	5
Lunham, R. D.	S.S. Charles Howard	1,021	J. Ryde, London	Buenos Ayres	2
" "	"	"	" "	" "	3
McEwen, J. P.	Sherbro	351	H.M. Col. Steamer	To, at, and from West Coast of Africa	12
McKechnie, D. F.	Cottica	319	A. Pearson, Glasgow	Two voyages to, and one from Surinam	4
" "	"	"	" "	Surinam	4
[9] Manning, E.	S.S. Kafir	613	Union Steamship Co.	Voyage to Natal	1
Maples, Charles	Genii	975	MacIntyre & Co., Liverpool	Rio Janeiro, Bassein, and home	9
Martyn, J. A.	S.S. Java	2,696	J. Burns, Glasgow	New York, six voyages	4
" "	"	"	" "	" five "	4
[10] Maxwell, W. F.	Gulnare		H. M. hired ship	On Coast of Newfoundland and Labrador	5
Mayne, R. C., R.N.	Nassau	877	H.M.S.	Magellan Strait to Rio, 1st May 1869	—
Miller, A. J.	Tiger	1,028	De Wolf & Co., Liverpool	Newfoundland	3
Mouland, J. E.	S.S. Batavia	2,553	J. Burns, Glasgow	Boston, four voyages; Boston and New York, one.	4
Murray, Alexander	Perseverance	170	W. Baxter, Aberdeen	Cumberland Gulf	13
[11] Nares, G. S., R.N.	Challenger	2,306	H.M.S.	Bermuda to Halifax, Azores, Bahia, Cape of Good Hope, and Kerguelen Island.	11
Newton, J. W.	S.S. Grenadier	737	Tyne Steam Shipping Co., Newcastle-on-Tyne.	Trading between Newcastle and London	5
Owen, John	W. G. Russell	1,248	J. Thomas, Liverpool	Monte Video, Callas, and home	7

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LIST of DOCUMENTS, &c.—*continued.*

Captain's Name.	Ship.	Tons.	Owners.	Voyage.	Months of Register.
[12] Parish, Comr., J.E., R.N.	Princess Charlotte -	4,122	H.M.S. - - - -	Off Hong Kong - - -	4
[13] ,, ,, -	,, -	,,	,, - - - -	,, - - -	4
Pearson, C. W. -	S.S. Strathelyde -	1,951	Burrell & McLaren, Glasgow -	Bombay, viâ Suez - - -	3
,, ,, -	,, ,, -	,,	,, ,, ,, -	,, ,, - - -	2
Phillips, E. - -	Sea Chief - -	1,083	G. Smith, Hampstead, Middlesex -	To Aden and home from Madras -	9
Potts, T. C. - -	Tenasserim - -	1,419	T. & R. Brocklebank, Liverpool -	Calcutta - - - -	7
Prehn, C. C. - -	Eleanor - -	428	J. J. Holdsworth, Minories -	Bassorah (viâ Suez), Algoa Bay, and home	8
Price, J. J. - -	Sorata - -	332	C. C. Dawson, London - -	Jamaica - - - -	3
,, ,, - -	,, - -	,,	,, ,, - -	,, - - - -	3
Raymond, C. T. -	British Consul - -	1,266	British Shipowners Co. - -	San Francisco - - -	10
Renaut, C. H. -	Glenlora - -	764	Saville & Temple, London -	Wellington, N. Z. - - -	7
Shaw, Gilbert -	S.S. Alpha - -	653	W. Cunard, Halifax - -	From Halifax to St. Thomas and back, viâ Bermuda. } 4 voyages	3
,, ,, - -	,, - -	,,	,, ,, - -	,, ,, 2 ,,	35 days.
,, ,, - -	S.S. Beta - -	1,014	Smith, Hill, & Co., Hull - -	,, ,, 3 ,,	2
,, ,, - -	S.S. Delta - -	644	W. Cunard, Halifax - -	,, ,, 1 ,,	18 days.
,, ,, - -	,, - -	,,	,, ,, - -	,, ,, 2 ,,	1
Simpson, Alexander -	Traveller - -	195	Alex. Simpson - - -	Ivigtut thence to Stettin, Ivigtut, and home.	6
[14] Smith, — - -	Worcester - - - -		Training Ship - - -	Off Greenhithe - - - -	4
Smith, Alexander -	Hannah and Mary -	365	J. M. Rankin, Sutherland -	Singapore - - - -	9
Smith, W. C. -	Kingdom of Saxony -	538	A. Gosman, London - -	Madras - - - -	8
[15] Smith, W. H., R.N.R.	S.S. Peruvian - -	1,432	Allan, Brothers, Glasgow -	Halifax, one voyage; Baltimore, viâ Halifax, four voyages; Quebec, one voyage; Portland, one voyage.	6
[16] ,, ,, ,, -	S.S. Scandinavian -	1,811	,, ,, -	Quebec, four voyages; Portland, viâ Halifax, one voyage	4
,, ,, ,, -	,, -	,,	,, ,, -	Portland, three voyages; Quebec, one voyage.	4

LIST OF DOCUMENTS, &c.—*continued.*

Captain's Name.	Ship.	Tons.	Owners.	Voyage.	Months of Register.
Stuart, W. H.	Richmond	183	Board of Trade	At Bahamas	17
Symington, William	S.S. Hong Kong	1,881	E. H. Watts, London	China, viâ Suez, one voyage	5
" "	S.S. Hankow	2,331	" "	Bombay, viâ Suez	3
Thomson, J. M.	St. Vincent	891	Devitt & Moore, London	Peru	6
Thomson, S. J.	Chevy Chase	678	J. Ravenscroft, Liverpool	West Coast of South America	7
Trench, C. Le Poer	Newcastle	1,137	H. Green, Blackwall	Sydney, San Francisco, and home	9
Tully, Thomas	Baroda	1,364	T. Brocklebank, Liverpool	Calcutta	7
Unknown	Falcon			In China Seas	—
Wadham, T. L.	Vere	396	J. Anderson, London	Jamaica	3
Watson, William	S.S. Parthia	3,167	J. Burns, Glasgow	New York, two voyages; Boston, two voyages.	4
" "	" "	"	" "	Boston, two voyages; New York, two voyages.	4
" "	" "	"	" "	" " "	3
[17] Wharton, W. J. L., R.N.	Shearwater	913	H.M.S.	Between Cape of Good Hope and Rodriguez Island.	16 days.
Wherland, Fredk., R.N.R.	Galatea	1,447	Norwood & Co., Liverpool	Melbourne, San Francisco, and home	10

In cases distinguished by marginal numbers the Meteorological Registers were kept chiefly by officers, as follows:—

[1] [9] Kept by R. Ladd, 2nd Officer.
[2] [3] Kept by H. Hoskin, Navigating Lieutenant.
[4] Assisted by A. A. Boyle.
[5] [6] [7] Assisted by R. Jackson, Navigating Lieutenant.
[8] Assisted by St. George Armstrong Williams, 2nd Officer.
[10] Kept by Dr. T. J. Sunning.
[11] Kept by T. H. Tizard, Navigating Lieutenant and A. Havergal, Navigating Sub-Lieutenant.
[12] [13] Kept by T. W. Webster, Navigating Lieutenant.
[14] Kept by boys under superintendence of Rev. W. T. Read, M.A.
[15] [16] Assisted by J. Riddich.
[17] Extract from log.

APPENDIX No. IV.

CONTENTS of the PRINCIPAL PUBLICATIONS issued.

Continued from Report for 1874.

Official No.

19. QUARTERLY WEATHER REPORT for 1873. 4to.

This contains the usual continuous traces of the self-recording Instruments at the seven British and Irish Observatories, with a chronicle of the weather. It also contains tables showing the Monthly Rainfall at 48 stations, and the following Appendices:—I. Mean Monthly Results from the continuous Records, and Five-day Means of the same, in both English and French measures. II. Diagram of the Rainfall of London District, being a discussion by Mr. G. Dines, for the 60 years 1813–72. III. Returns from certain stations in the United Kingdom, furnished by volunteer observers, on the forms proposed by the Permanent Committee of the Vienna Congress.

20. CHARTS of METEOROLOGICAL DATA for SQUARE 3, Lat. 0–10° N., Long. 20–30° W.; and REMARKS to accompany the MONTHLY CHARTS. 1874. Folio and Quarto.

The Charts show the best routes across the Equator for each month. About 75,000 Observations were discussed in this Investigation, and the Remarks extend to 319 pp. 4to., and contain, in addition to the Data given on the Charts, Extracts relating to Currents, Clouds, Sea Temperature, Specific Gravity, Wind, Weather, Natural History, &c. In an Appendix is given a Discussion of Four-hourly Means of Barometer and Air and Sea Temperature, for each month and for the year, in the Northern and Southern Halves of the Square, and from these have been calculated the Constants in the Periodical Expression for the Diurnal Variations, and therefrom the most probable Values for each hour of the day, &c. &c.

21. REPORT of the PROCEEDINGS of the METEOROLOGICAL CONGRESS at VIENNA. 1874. 8vo., pp. 97.

This Congress was held at Vienna in the year 1873, and was attended by 32 delegates from various countries. The Report contains Protocols and Appendices referring to the various meetings. The matters treated by the Congress were subdivided into—1° Instrumental. 2° Reduction of Observations. 3° Weather Telegrams. 4° Maritime Meteorology. 5° Organisation. 6° Publication of Observations, &c. The Supplement contains several valuable contributions, among which may specially be mentioned Papers on Determination of Air Temperature; on a Simple Wind Gauge; on Exposure of Thermometers; Observations of Humidity, &c.

23. REPORT of the PROCEEDINGS of the CONFERENCE for MARITIME METEOROLOGY. 1875. 8vo., pp. 61.

This Conference was held in London in 1874, and was attended by 24 gentlemen representing every maritime country of importance except the United States and Sweden. The Report contains a series of Resolutions drawn up for the purpose of obtaining uniformity in Observations made at Sea, and proposed new Instructions for the Guidance of English Captains and Observers. It also contains contributions from several gentlemen unable to attend the Conference.

24. INSTRUCTIONS in the USE of METEOROLOGICAL INSTRUMENTS. In the press.

APPENDIX VII.

LIST of STATIONS reporting Meteorological Observations by Telegraph to the Office, with the Observers.

Sumburgh Head -	W. Lawrence - - - -	Schoolmaster.
Stornoway - -	J. Smith - - - -	Gardener.
*Thurso - - -	J. Trotter - - - -	——
Wick - - -	J. Sinclair - - - -	Watchmaker.
Nairn - - -	W. D. Penny - - - -	Schoolmaster.
Aberdeen - -	J. McCormack - - -	Telegraph Clerk.
Leith - - -	J. Turnbull - - - -	Do.
Shields - - -	J. Irvine - - - -	Do.
*Scarborough - -	F. Shaw, F.M.S. - - -	Do.
York - -	C. Wakefield - - - -	Curator of Museum.
Nottingham - -	E. J. Lowe, F.R.S. - - -	Highfield Ho. Observatory
Ardrossan - -	W. McNeil - - - -	Telegraph Clerk.
*Greencastle(Moville)	J. McGladery - - - -	Do.
Donaghadee - -	J. MacGowan, jr. - - -	Do.
Kingstown - -	G. Mitchell - - - -	Keeper of Sailor's Home.
*Holyhead - -	J. Tilston - - - -	Do.
Liverpool - -	J. Hartnup, junr. - - -	Bidston Observatory.
*Valencia - -	E. O'Sullivan - - -	Telegraph Clerk.
Roche's Point - -	W. Kennedy - - - -	Do.
Pembroke - -	J. C. Walker - - - -	Do.
Portishead - -	W. Sandford - - - -	Station master.
*Scilly - - -	W. Thomas - - - -	Signalman.
Plymouth - -	J. Merrifield, LL.D., F.R.A.S.	Teacher of Navigation.
Hurst Castle - -	R. T. Jobbins - - -	Telegraph Clerk.
Dover - - -	J. Costello - - - -	Telegraph Clerk.
*London - -	F. Gaster, F.M.S. - - -	——
Oxford - - -	J. Lucas - - - -	Radcliffe Observatory.
Cambridge - -	H. Todd - - - -	Observatory.
Yarmouth - -	G. T. Watson - - -	Secretary, Sailor's Home.

Summary:

England and Wales - -	- 16
Scotland - - -	- 8
Ireland - - -	- 5

Those marked with an asterisk, report twice daily. The office also receives daily reports from 22 places on the Continent.

APPENDIX VIII.

LIST of PERSONS, PLACES, &c. to which the Daily Weather Report has been supplied, free of cost, to 31st December.

Newspapers :

Daily News.
Echo.
Express.
Globe.
Hour.
Lloyds' Shipping List.
Mark Lane Express.
Mechanics' Magazine.
Morning Advertiser.
Observer.
Pall Mall Gazette.
Shipping and Mercantile Gazette (with special daily chart).
Standard (Morning and Evening).
Times (1st and 2nd editions).

For Exhibition at following Seaports :

Banff.
Barrow-in-Furness.
Belfast.
Blackpool.
Boscastle.
Bournemouth.
Broughty Ferry.
Buckie.
Budehaven.
Carnarvon.
Cowes.
Cromer.
Cullercoats.
Deptford Yard.
Dover.
Exeter (2 copies).
Falmouth.
Great Grimsby.
Hastings.
Hayle.
Holyhead.
Hull.
Kingstown.
Lancaster.
Nairn.
Newquay.
Plymouth.
„ G. W. Docks.
Port Dinorwic.
Porthcawl.
Portland.
St. Ann's Head.
Scarboro'.
Silloth.
Teignmouth.
Thurso.
Ventnor.
Weston-super-Mare.
Wick.
Yarmouth.

In exchange for Observations, &c. :

Aird, G. H., Seaham.
Barnes, R. H.
Barnstaple Meteorological Committee.
Cambridge Observatory.
Clouston, Rev. C., Sandwick, Orkney.

In exchange for Observations, &c.—cont.:

Cooper, Col., F.R.A.S., Markree, nr. Sligo.
Cooper, W. F., F.M.S., Sheffield.
Crossley, L. J., Halifax.
Curtis, Prof. A. H., Galway.
Durham University Observatory.
Fernley Observatory, Southport.
Greenwich Observatory.
Griffith, Rev. C., F.M.S., Strathfield Turgiss.
Hills, Staff Comr., Liverpool.
Hoskins, Dr. S. E., F.R.S., Guernsey.
Jersey, Submarine Telegraph Company.
Jobbins, R. T., Hurst Castle.
Jones, G. J., Lymington.
Kingston, G. T., M.A., Toronto.
Liverpool Observatory.
Lowe, E. J., F.R.S., Nottingham.
Mackay, Rev. W. P., D.D., Hull.
Malleson, Rev. F., Broughton-in-Furness.
Miller, S. H., F.R.A.S., Wisbech.
Moore, Dr. J. W., Dublin.
Morris, E. E., Bedford.
Moyle, M. P., F.R.C.S., Helston.
Murray, A. E., F.M.S., Hastings.
Northumberland, Duke of, Alnwick.
Pim, Captain, Bedford, R.N., M.P., Editor of "The Navy."
Prince, C. L., F.R.A.S., Tunbridge Wells.
Quinton, J. Jr., Norwich.
Radcliffe Observatory, Oxford.
Richards, W. H., Penzance.
Rosse, Earl of, F.R.S., Parsonstown.
Royal Horticultural Society.
Royal Indian C.E. College, Staines.
Rugby Natural History Society.
Sawyer, F. E., F.M.S., Brighton.
Stewart, Dr. Balfour, F.R.S., Manchester.
Stow, Rev. F. W., F.M.S., Aysgarth, Yorkshire.
Sutherland, A., Carrickfergus.
Style, Rev. G. J., Giggleswick, near Settle.
Walker, J. C., St. Ann's Head.
Whitehouse, W. O., F.M.S., Hampstead.
Whitty, Rev. S., Oscott.
Woollett, C., Acrise.
Yorkshire Philosophical Society.

Government Offices, Societies, &c.:

The Queen.
The Principal Government Offices: 50 copies.
"Achilles," H.M.S., Portland.
Association of Underwriters, Liverpool.
Do. Lloyd's.
"Britannia," H.M.S., Dartmouth.
British Museum.
Calcutta, Meteorological Committee.
Devonport Dockyard, 3 copies.
" Commander-in-Chief.
Greenwich, R.N. College.

Government Offices, Societies, &c.—cont. :

Ireland, Lord Lieutenant.
„ Geological Survey.
Meteorological Society, London.
Patent Office.
Portsmouth, Commander-in-Chief.
Reuter's Telegram Company.
Royal Artillery Institution.
Royal Military Academy.
Royal Society.
Royal United Service Institution.
Scottish Meteorological Society.
Sheerness Dockyard.
" Squirrel " H.M.S., Devonport.
Staff College.
United Service Institution.

Foreign Places :

Christiania, Meteorological Institute.
Constantinople, Imperial Meteorological Observatory.
Copenhagen, Meteorological Institute.
Emden, Dr. Prestel.
Hamburg, German Ocean Observatory.
Lisbon, Observatory.
Madrid, Royal Observatory.
Paris, Meteorological Observatory, Montsouris.
„ Meteorological Society.
„ Ministry of Marine.
„ Observatory.
„ M. Harold Tarry.
Rome, Ministry of Agriculture.
St. Petersburg, Central Physical Observatory.
Stockholm, Meteorological Institute.
Upsala, University Observatory.
Utrecht, Royal Meteorological Institute.
Vienna, Imperial Meteorological Institute.
Washington, Smithsonian Institution.
„ United States Naval Observatory.
„ Chief Signal Officer, War Office.

APPENDIX IX.

Telegraphic Weather Intelligence.

The following stations, having been approved by the Board of Trade, are supplied with telegraphic information of storms free of expense, and " drum " and " cone " signal shapes have been furnished to most of them, all further expenses attendant on the maintenance and repair of

the apparatus being borne locally. The stations are situated, 79 in England and Wales, 32 in Scotland, 13 in Ireland, 3 in the Isle of Man, and 3 in the Channel Islands.

NORTH.	WEST.	SOUTH.	EAST.
Scotland. East Coast.	England, N.W.	England, S.W.	England, E.
Kirkwall.	Silloth.	Ilfracombe.	Tynemouth.
Inverness.	Maryport.	Barnstaple.	S. Shields.
Nairn.	Workington.	Port Isaac.	Sunderland.
Burghead.	Whitehaven.	Boscastle.	Middlesborough.
Lossiemouth.	Ramsey.	Newquay.	Redcar.
Buckie.	Douglas.	Hayle.	Whitby.
Portsoy.	Castletown.	Pendennis.	Filey.
Banff.	Barrow.	Scilly.	Withernsea.
Fraserburgh.	Morecambe.	Penzance.	Hull.
Peterhead.	Fleetwood.	Falmouth.	Goole.
Aberdeen.	Blackpool.	Plymouth, four stations.	Grimsby.
Stonehaven.	Lytham.	Teignmouth.	Boston.
Montrose.	Runcorn.	Exeter.	Sutton Bridge.
Broughty Ferry.	Southport.	Exmouth.	Lynn.
St. Andrews.	Liverpool.		Cromer.
Dundee.	Queensferry.	England, S.	
Anstruther.	Hawarden.		England, S.E.
St. Monance.	Mostyn.	Guernsey.	
Burntisland.		St. Helier, Jersey.	Yarmouth.
Alloa.	England, W.	Gorey, Jersey.	Southwold.
Grangemouth.		Weymouth.	Ipswich.
Bo'ness.	Bangor	Poole.	Harwich.
Granton.	Port Penrhyn.	Cowes.	Chatham.
Leith.	Holyhead.	Ventnor.	Sheerness.
Fisherrow.	Carnarvon.	Portsmouth.	Faversham.
Dunbar.	Port Dinorwic.	Littlehampton.	
Eyemouth.	Aberystwith.	Brighton.	
	Milford.	Newhaven.	
	Pembrey.	Hastings.	
	Llanelly.	Rye.	
	Swansea.	Dover.	
	Briton Ferry.		
	Porthcawl.		
	Penarth.		
	Cardiff.		
	Newport.		
	Weston-super-Mare.		
Firth of Clyde.	Burnham.		
Glasgow.			
Greenock.	Ireland, E.		
Rothesay.	Belfast.		
Campbeltown.	Howth.		
Girvan.	Kingstown.		
	Ireland, S. and W.		
	New Ross.		
	Dunmore, East.		
	Dungarvan.		
	Youghal.		
	Queenstown.		
	Passage.		
	Cork.		
	Tralee.		
	Limerick.		
	Galway.		

Circular No. 717.

TELEGRAPHIC WEATHER INTELLIGENCE.

Board of Trade, February 14th, 1874.

THE Board of Trade have been informed by the Meteorological Committee that they are now prepared to re-introduce the use of Admiral FitzRoy's signals (cones and drum) with slightly modified significations, and that the change will take effect on and after 15th March 1874.

The signals to be used will consist of:—

1°. Cone, point downwards for Southerly gales; S.E. round by S. to N.W.

2°. Cone, point upwards for Northerly gales; N.W. round by N. to S.E.

3°. Drum, *with cone*, to indicate the probable approach of a *very heavy gale* from the direction indicated by the cone.

The drum will not be used without the cone.

The signals are to be kept hoisted *during the daylight only*, until 48 hours have elapsed from the time *the telegram was despatched*, unless countermanded. At night, lanterns may be used wherever the local authorities deem it desirable to do so, as pointed out in the explanatory pamphlet* sent herewith, copies of which are supplied for gratuitous distribution.

It will be seen from the pamphlet in question that the meaning of the signals is that an atmospherical disturbance exists (which will be explained in the telegram), and will probably, but not *necessarily*, cause a gale at the place warned, *from the direction* indicated by the signal.

The Meteorological Office will supply the canvas shapes and lanterns to such places as require them, on loan, but in all cases the local authorities must undertake the charges incidental to the hoisting of the signal, such as flagstaff and gear, oil, &c., and also to the keeping of the apparatus in repair, painting, &c., as directed by the Circular No. 278, dated 30th November 1867.

THOMAS GRAY.

APPENDIX X.

LIST of STATIONS from which DAILY SYNCHRONOUS OBSERVATIONS (at 0h. 45m. p.m. G. M. T.) have been received.

Stations.	Observers.	Remarks.
	ENGLAND AND WALES.	
Barnstaple - -	W. Knill, for T. Mackrell -	Ceased 31st May, 1874.
Battersea, St. John's Col.	Rev. J. Faunthorpe -	„ 15th June, 1874.
Bradford - -	J. McLandsborough	—
Bywell - - -	J. Dawson - -	Ceased 31st July, 1874.

* The "explanatory pamphlet" referred to is a circular entitled "Telegraphic Weather Intelligence," printed in large type on four pages, so as to be posted up on a board.

Stations.	Observers.	Remarks.
Cambridge - -	H. Todd.	—
Cardington - -	J. McLaren.	—
Carlisle - - -	J. Beil, for J. Cartmell.	—
Chatham, School of Military Engineering -	Quarter-master Sergeant Conroy - -	Commenced in Oct. 1874.
Dartmoor - -	R. E. Power, F.R.C.S.	
Dover - - -	J. Costello.	—
Durham Observatory -	J. Plummer, M.A.	—
Eccles - - -	T. Mackereth.	—
Falmouth Observatory -	The Staff.	—
Gloucester County Asylum	E. Toller.	—
Greenwich Observatory -	The Staff, for Sir G.B.Airy	—
Guernsey - -	Dr. Hoskins, F.R.S.	—
Halifax, Moorside -	L. J. Crossley.	—
Helston - - -	Dr. Moyle.	—
Holyhead - -	J. Tilston.	—
Jersey (St. Helier) -	A. P. Amy.	—
Kew Observatory -	The Staff.	—
Lampeter - -	E. James - -	Ceased at end of Jan. 1874.
Leicester (Museum) -	W. J. Harrison.	—
Liverpool Observatory (Bidston).	J. Hartnup, Jun.	—
Llandudno - -	J. Nicol, M.D.	
Marlborough College -	Rev. T. A. Preston, M.A.	Ceased 15th Dec., 1874.
Nottingham - -	E. J. Lowe, F.R.S.	—
Osborne - - -	J. R. Mann - -	Ceased 31st Jan. 1875.
Oscott (St. Mary's Col.)	Rev. S. Whitty.	—
Oxford, Radcliffe Obs. -	J. Lucas, for Rev. R. Main, F.R.S.	—
Plymouth - -	J. Merrifield, L.L.D., F.R.A.S.	—
Portishead - -	W. Sandford - -	Ceased 31st December 1874.
Pwllheli (Cochy foel) -	W. Jones -	Ceased 31st Jan., 1874.
Scarborough - -	F. Shaw, F.M.S.	—
Sheffield - - -	W. F. Cooper, F.M.S.	—
Shields (North) - -	J. Irvine.	—
Sidmouth - -	J. Ingleby Mackenzie -	Ceased 31st May, 1874.
Silloth - - -	Rev. F. Redford, M.A., F.R.S.E.	—
Somerleyton - -	Rev. J. Steward, M.A.	—
St. Ann's Head (Milford Haven) - -	J. C. Walker.	—
Stonyhurst Observatory -	The Staff.	—
Strathfield Turgiss -	Rev. C. H. Griffith, M.A.	—
Streatley - - -	Rev. J. Slatter.	—
Taunton - - -	Rev. W. Tuckwell -	Ceased 30th April, 1874.
Truro (Royal Institution)	W. Newcombe.	—
Wisbeach - -	S. H. Miller, F.M.S. -	Ceased 31st Jan., 1875.
Worthing - -	W. J. Harris, F.M.S.	—
Yarmouth (Norfolk) -	G. T. Watson.	—
York (Museum) - -	C. Wakefield - -	Ceased 30th Sept., 1874.
	SCOTLAND.	
Aberdeen Observatory -	W. Boswell.	—
Annanhill - -	W. H. Dunlop - -	Ceased 16th Jan., 1875.
Ardrossan - -	W. McNeil.	—
Glasgow Observatory -	J. Gray.	—
Nairn - - -	W. D. Penny.	—
Orkneys, Sandwick -	Rev. C. Clouston, L.L.D.	—
Stornoway -	J. Smith.	—
Sumburgh Head - -	W. Lawrence.	—
Thurso - - -	J. Trotter.	—
Wick - - -	J. Sinclair - -	Ceased 15th March, 1874.

Stations.	Observers.	Remarks.
IRELAND.		
Armagh Observatory -	S. Call for Dr. Robinson.	—
Banbridge - -	J. Smyth, M.A., C.E. -	Ceased 31st August, 1874.
Donaghadee - -	J. McGowan.	—
Dublin - - -	J. W. Moore, M.D.	Ceased 31st Dec., 1874.
Galway, Queen's College-	B. G. Clare, for Professor Curtis.	—
Kingstown - -	G. Mitchell.	—
Markree Castle - -	R. Smith (for Col. Cooper)	Ceased 31st Jan., 1874.
Moville - - -	J. McGladery - -	„ 31st Oct., 1874.
Parsonstown - -	R. Copeland and J. Dreyer for Lord Rosse.	—
Roche's Point - -	W. Kennedy.	—
Valencia Observatory -	The Staff.	—
BRITISH COLONIES, POSSESSIONS, &c.		
Barbadoes* - -	T. H. Hunt, A.H.C.† -	Commenced July 1874. Barometer broken at end of Sept. 1874. No observations since.
Bermuda - - -	Sergeant J. Freeman, A.H.C. - -	Commenced July 1874. Barometer broken *very* soon after. No observations since.
Cape of Good Hope -	Sergt. D. E. Hunt, A.H.C.	Commenced July 1874.
Colombo - -	Sergeant. W. F. Hopkins, A.H.C. - -	„ August, 1874.
Gibraltar - -	S. Sergeant J. Brewster, A.H.C. - -	„ May 16th, 1874.
Halifax, N.S. - -	Corporal J. Thompson., A.H.C. - -	„ June 1st., 1874.
Malta - - -	Priv. E. Dowling, A.H.C.	„ „
Nassau (Bahamas) -	Surgeon-Maj. J. Jamieson, M.D. - - -	„ August, 1874.
Natal - - -	Priv. G. Salmon, A.H.C. -	„ October 1, 1874.
Scutari, British Cemetery	Serg. W. H. Lyne, R.E. -	„ March 1, 1874.
Sierra Leone - -	Surgeon A. Johnston.	—

SUMMARY.

—	No. which commenced.	No. ceased, to May 1875.
England and Wales -	49	12
Scotland - - -	10	2
Ireland - - -	11	4
Colonies and British Possessions - -	11	0*
Total -	81	18

* It is hoped that when the barometers at Barbadoes and Bermuda are repaired, the returns will again be sent in.

† A.H.C.—Army Hospital Corps.

APPENDIX XI.

Fishery Barometers.

List of Places supplied with Fishery Barometers.

Those supplied during the years 1867–74 are distinguished by an asterisk.

Shetland Isles.—Sandsair, Lerwick.

Orkney Isles.—Burray. Kirkwall.*

Scotland, east coast.—Stroma, Staxigoe, Wick, Sarclet, Lybster, Dunbeath,* Portmahomack, Cromarty, Avoch, Nairn, Burghead, Portessie, Port Knockie, Portsoy,* Whitehills, Gardenstown, Rosehearty, Pitullie, Inverallochy,* Findon, Portlethen, Stonehaven,* Arbroath, Broughty Ferry, St. Andrews, Crail, Cellardyke, St. Monance,* Burntisland, Newhaven.

England, east coast.—Berwick, Beadnell, North Shields, South Shields, West Hartlepool, Staithes, Scarborough, Filey, Flamborough, Bridlington Quay, Withernsea, Hull, Lynn, Wells, Gorleston, Harwich,* Brightlingsea,* Wivenhoe,* Margate, Deal, Kingsdown, Dover.

England, south coast.—Bognor,* Portsea, St. Helens and Ventnor*(2) (Isle of Wight), Gorey (Jersey), Poole, Weymouth, Portland, Budleigh-Salterton, Cawsand, Mevagissey, Gorranhaven, Devoran, Penryn, Falmouth, Newlyn, Mousehole.

England, south-west coast.—St. Ives, Hayle, Port Isaac, Boscastle,* Fremington, Burnham, Highbridge.

Wales.—Briton Ferry,* Swansea, Angle,* Milford, Abersoch.*

England, north-west coast.—Fleetwood, Morecambe, Maryport.

Isle of Man.—Port St. Mary,* Peel.

Scotland, south-west coast.—Port Patrick,* Stranraer.

Ireland, east coast.—Cushendall,* Belfast, Bangor, Strangford, Ardglass, Carlingford,* Greenore,* Dundalk, Malahide,* Howth, Kingstown, (2).

Ireland, south coast.—Dungarvan, Kinsale,* Crookhaven.*

Ireland, west coast.—Valencia, Dingle, Tralee, Ballina,* Tribane,* Killybegs,* Teelin,* Burton Port, Bunbeg.

Ireland, north coast.—Dunfanaghy, Rathmullen, Buncrana,* Greencastle,* Portrush.*

Scotland, west coast.—Campbeltown,* Portree (Isle of Skye) Plockton.

Hebrides, Stornoway, Cromore, Babyle, Obb, Ness.

Summary of Instruments on Service.

England and Wales - - - - -	57
Scotland - - - - - -	44
Ireland - - - - - -	28
	129

APPENDIX XII.

Donations received during the Year 1874.

Presented by Societies, Institutions, &c.

Algiers - -	Observatoire National -	Panorama Météorologique du Climat d'Alger. Observations météorologiques (33 tables and one diagram), Jan. 1872. Perturbation Atmosphérique (seven tables and one diagram), 15 – 17 March 1873. Rainfall observations, 1862 – 74. Rain and evaporation, 1859 – 67. Résumé des observations météorologiques, 1873, July – November. By M. Bulard.
Berlin - -	K. Hydrographisches Bureau.	Hydrographische Mittheilungen. II. Jahrgang. Nos. 1–25.
	" "	Nachrichten für Seefahrer, V. Jahrgang. Nos. 1–51.
	" "	Bericht über Wetter-Telegraphie und Sturm-Warnungen. Die Grundlagen der gaussischen Theorie und die Erscheinungen des Erdmagnetismus im Jahre, 1829, von A. Erman and H. Petersen. By Dr. G. Neumayer.
	K. Statistisches Bureau -	Preussische Statistik XXVII. (Monthly means of Pressure, Temperature, &c. for 1872.) By H. W. Dove, F.R.S.
Birmingham -	Free Libraries -	Catalogue of books. History of the Birmingham free libraries.
Bombay - -	Colaba Observatory -	Report for year ending 30th June 1874. By. C. Chambers, F.R.S.
Brussels -	Observatoire Royal -	Annales, Tome XXII.
	" -	Observations des Phénomènes Périodiques, 1872. Annales Météorologiques, 1872 – 3. L'Aurore Boréale du 4 Fevrier 1874. By MM. A. & E. Quetelet.
Calcutta - -	Meteorological Office -	Meteorological Report for 1873.
	" -	Abstract of Observations, Oct. 1873 to Aug. 1874.
	" -	Weekly Report of Rainfall, Decr. 1873 to Octr. 1874.
	" -	Telegraphic Reports, Decr. 1873 to Octr. 1874.
	" -	The Winds of Northern India. On the Climate of Bengal. By H. F. Blanford.
	Surveyor General's Office	Abstracts of the Results of Hourly Observations, Oct. 1873 to Sept. 1874. By Col. Thuillier, F.R.S.
Carlsruhe -	Meteorologische Central-Station.	Beobachtungen der badischen Stationen, Oct. 1873 to Sept. 1874. Berichte, 1872–73. By Dr. F. Sohncke.

Christiania -	Norske Meteorologiske Institut.	Meteorologiske Jagttagelser i Norge, 1873, pp. 121–156.
	" " -	Meteorologisk Aarbog, 1873, pp. 1–8.
	" " -	Praktisk Veiledning til Benyttelser af de Met. Telegrammer. Bidrag til ost-Ishavets Klimatologie og Meteorologie. Luftens Temperatur i og undenfor Christiania, &c. Om visse Virkninger af Stromme paa Vandets og Luftens Temperatur. Alberts Expedition til Spids-bergen (Novr. and Decr. 1873.) By Professor H. Mohn, and by the University.
Colombo (Ceylon).	Surveyor General's Office	Monthly Results of Meteorological Observations, Novr. 1873 to Septr. 1874. Rainfall returns, 1870 to 1873. Results, 1870 to 1873. By Lt.-Col. A. B. Fyers, R.E.
Copenhagen -	Danske Meteorologiske Institut.	Observations at Danish Stations, pp. 85–108.
	" "	Bulletin Météorologique du Nord, for 1874. Weather charts from 1st Feb. 1874. By Capt. N. Hoffmeyer.
	K. Danske Videnskabernes Selskab.	Forhandlinger, Nos. 1 – 3, 1873 and No. 1, 1874.
	" "	Tables Météorologiques 1866 – 73, by Prof. C. Holten. By Prof. J. Steenstrup.
Cracow - -	K. K. Sternwarte - -	Meteorologische Beobachtungen, November 1873 to October 1874.
	" - -	Materyaly do Klimatografii Galicyi. Rok, 1873. By Dr. F. Karlinski.
Dublin - -	Inspector of Irish Fisheries	Reports, 1871–2.
Edinburgh -	Royal Society - -	Proceedings, Session 1872–3.
	Scottish Meteorological Society.	Journal, Nos. 36–42.
Falmouth -	R. Cornwall Polytechnic Society.	Report for 1873.
Fiume - -	I. R. Academia di Marina	Meteorological Observations, Oct. 1873 to August 1874.
	" "	Results 1873.
Frankfort o M.	Physikalisches Verein -	Jahresbericht, 1853–73. By Dr. J. Wallich.
Geneva - -	Bibliothèque Universelle	Archives des Sciences, Vols. XLIX.—LI.
	Société Géographique -	Le Globe, Vol. XII., Nos. 4–6.
Greenwich -	Royal Observatory - -	Report of the Astronomer Royal to the Board of Visitors, 1874.
	" -	Weekly Returns to Registrar-General, Vol. XXXV.
	" -	Daily Weather Reports for the year. By Sir G. B. Airy, K.C.B., F.R.S.
Gorizia -	- - - - -	Osservazioni delle Statione Meteorologica, July 1873 to April 1874, except January and February.
Hamburg -	Deutsche Seewarte - -	Jahresbericht, 1873. "Hansa" for 1874. Wetterbericht for 1874.
	" " - -	Deutsche Nordpolarfahrt, Pt. IV.
	" " - -	Die Zweite deutsche Nordpolarfahrt in den Jahren, 1869–70. Vols. I. and II. By W. H. v. Freeden, and Captain C. Koldewey.

Havana - -	R. Colegio de Belen -	Observaciones magneticas y meteorologicas, 1872 By R. P. A. Viñes.
Helsingfors -	Société des Sciences de Finlande.	Klimatologiska Jakttagelser i Finland, Vols I. and II.
	" "	Forhandlingar, Vols. XIV – XVI.
	" "	Observations Magnétiques, Vols. I.–IV.
	" "	Observations Météorologiques, Vols. I. – IV.
	" "	By M. L. Lindelöf.
Hobarton -	R. Society of Tasmania -	Monthly Notices of Papers and Proceedings, 1870 and 1872. By F. Abbott, F.R.A.S.
Hong Kong -	Government Civil Hospital	Meteorological Observations made at Victoria, Oct. 1873 to Sept. 1874.
	Harbour Office - -	Meteorological Observations taken at Praya West and Victoria Peak, Oct. 1873 to May 1874.
	" - -	China Coast Meteorological Register, Dec. 1873 to Nov. 1874.
Kew - -	Observatory - - -	Report of the Kew Committee, November 1873 to October 1874.
Kiel - -	Ministerial Commission zur Untersuchung der deutschen Meere.	Untersuchungen über physikalische Verhältnisse des westlichen Theiles der Ostsee. Tafeln zur Berechnung der Beobachtungen an den Küsten. Ergebnisse der Beobachtungsstationen an den deutschen Küsten. 1873. Jan. – Decr. 1874. Jan. – Feby. By Drs. Meyer and Karsten.
Kremsmünster-	Sternwarte - - -	Resultate aus den im Jahre 1870 angestellten meteor. Beobachtungen. By Dr. A. Reslhuber.
Lahore - -	Meteorological Department for the Punjab.	Meteorological Report for 1873. By Dr. A. Neil.
Leipzig -	Sternwarte - -	Übersicht der Resultate aus den meteor. Beobachtungen angestellt auf den K. sächsischen Stationen. September 1873 to September 1874. Meteorologische Beobachtungen angestellt auf der Leipziger Universitäts Sternwarte, 1873. By Dr. C. Bruhns.
London - -	Admiralty - - -	Tide Tables for 1875.
	" - - -	Nautical Almanac, 1873–7.
	" - - -	Catalogue of Charts, &c.
	" - - -	Hydrographic Notices of H.M.S. "Challenger" &c.
	" - - -	Index to Nautical Magazine, 1832–70. By the Hydrographer.
	Army Medical Department.	Report for the year 1872.
	Board of Trade - -	Report of Wrecks, Casualties, &c. Jan.–June, 1873.
	British Association - -	Report for 1873.
	Colonial Office - -	Returns from various Colonies and Settlements.
	India Office - - -	Returns from various Observers in India.
	" - - -	Report of the Great Trigonometrical Survey of India, 1872–3. By Col. J. T. Walker, R.E., F.R.S.

London - -	India Office - - -	Catalogue of Maps, &c. of India and other parts of Asia.
	London Institution - -	Journal, Vol. IV., Nos. 23–24.
	Medical Department of the Navy.	Reports, 1872–3.
	Meteorological Society -	Quarterly Journal, Vol. II., Parts 9–12.
	Royal Astronomical Society	Monthly Notices, Vol. XXXIV., Nos. 3–9. Vol. XXXV., No. 1.
	Royal Geographical Society	Proceedings, Vol. XVIII., Nos. 1–5.
	„ -	Journal, Vol. XLIII.
	Royal Horticultural Society	Journal, Vol. IV., Nos. 14–15.
	Royal Institution of Great Britain.	Proceedings, Vol. VII., Nos. 59–61.
	Royal National Lifeboat Institution.	Journal, Nos. 91–4.
	Royal Society - -	Proceedings, Vol. XXII., Nos. 149–155. „ XXIII., No. 126.
	Royal United Service Institution.	Journal, Vol. XVII., No. 75 and App. „ XVIII., Nos. 76–78.
	„ - - -	Lectures addressed to Officers of Volunteer Corps.
	Society of Arts - -	Journal, Vol. XXII., Nos. 1,104–1,153.
	Standards' Department -	Report, 1873–4, &c.
	Trinity House - -	Report on Fog Signals.
Lyons - -	Commission Météorologique.	Reports, 1871–2. By M. E. Lafon.
Madrid - -	R. Observatorio - -	Daily Weather Reports 1874. By Sr. Aguilar.
Manchester -	Literary and Philosophical Society.	Proceedings, Vols. VIII.–X. Vol. XIII. Nos. 6–12. „ XIV. „ 1–5.
	„ - - -	Index to Vol. XII. Memoirs, Vol. IV.
	The Owens College -	Essays and Addresses by Professors and Lecturers.
Mauritius -	Meteorological Society -	On a Periodicity of Cyclones and Rainfall in connexion with the Sunspot Periodicity. By C. Meldrum, M.A.
Melbourne -	Flagstaff Observatory -	Monthly Record of Results of Observations in Meteorology, Terrestrial Magnetism, &c., June 1873 to July 1874.
	„ - - -	Results of Observations, 1872, Vol. I. By R. J. Ellery, F.R.S.
Milan - -	R. Observatorio - -	Osservazioni astronomiche e fisiche sulla grande cometa del 1862. Osservazioni di stelle cadenti durante l'anno, 1872. By Sr. G. V. Schiaparelli.
Modena - -	„ -	Sulle variazioni non periodiche della pressione atmosferica. I venti impetuosi. Di una cronaca fiumalbini. Le variazioni del vento. By Prof. D. Ragona.
Moncalieri -	Osservatorio del R. Collegio Carlo Alberto.	Bullettino Meteorologico: Vol. VII., Nos. 5–6. „ VIII., Nos. 8–12. „ IX., Nos. 1–3.
	„ „ -	Osservazioni meteor. fatte nelle stationi presso le Alpi Italiane, December 1873 to November 1874. By Sr. F. Denza.
Montpellier -	Comité Météorologique de l'ouest Méditerranéen.	Bulletin du Département de l'Hérault.

Munich - -	K. Sternwarte - -	Meteorologische und magnetische Beobachtungen, July to December, 1873.
	" -	Beilage, Nos. 17–18. By Dr. J. v. Lamont, Director.
Naples - -	Specola Reale - -	Osservazioni meteoriche, November 1873 to October 1874. By Sr. Brioschi.
New York -	Central Park Observatory	Abstract of Registers from S.R. Instruments, April to November, 1874. By Prof. D. Draper.
	State Library - -	Report, 1872–3. Subject Index, 1872. Meteorology, 1850–63. Annual Report of Trustees, 1873.
Oxford - -	Radcliffe Observatory	Results of Meteorological Observations, 1871.
	" - - -	Mean monthly values of the pressure and air temperatures, &c., 1828–52.
		Report for 1874. By Rev. R. Main, F.R.S.
Palermo - -	R. Osservatorio - -	Bullettino Meteorologico:— Vol. IX., Nos. 7–12. Vol. X., Nos. 1–4. By Sr. G. Cacciatore.
Paris - -	Académie des Sciences -	Comptes-Rendus Hebdomadaires, Vol. LXXVIII. " LXXIX., Nos. 1–23.
	Association Scientifique de France.	Bulletin Hebdomadaire, Nos. 324–374.
	Dépôt des Cartes et Plans	Annales Hydrographiques: Part 4 of 1873. Parts 1 and 2 of for 1874.
	" -	Récherches sur les chronomètres, cah. 8 et 9.
	" -	Phares des Côtes. By Captain A. Le Gras.
	Ministère de la Marine, &c.	Revue Maritime et Coloniale. Vols. XL.–XLIII.
	Observatoire de Paris -	Atlas Météorologique, 1869–71.
	" " -	Bulletin International, 1874. By U. J. Le Verrier.
	Observatoire Météorologique de Montsouris.	Bulletin Mensuel, Nos. 24–35.
	" " -	Annuaire Météorologique, 1874. By M. Marié-Davy.
	Service Hydrométrique, (Seine.)	Résumé des Observations Centralisées, 1869–72.
	" " -	Observations sur les Cours d'Eau et de la Pluie, 1872.
	" " -	Observations pluviométriques, 1869–71.
	" "	Feuilles, 1–7, &c. By M. E. Belgrand.
Perpignan -	Commission Météorologique des Pyrénées Orientales.	Bulletin Météorologique, 1873.
Pesth -	K. Ung. Anstalt für Meteorologie, &c.	Jahrbücher, 1872, II. Bd. By Dr. G. Schenzl.
Philadelphia -	Franklin Institute - -	Journal, Vols. XLVII. and XLVIII.
	American Phil. Society -	Proceedings, Vol. XII., No. 89. " XIII. " XIV., No. 92.

Pola - -	K.K. Hydrographisches Amt.	Meteorologische Beobachtungen, December 1873 to November 1874.
	" "	Resultate, 1864–73. By Lieut. Pick.
	" " -	Mittheilungen aus dem Gebiete des Seewesens. Vol. I., No. 12. Vol. II., Nos. 1–11. By M. R. Müller, Director.
Porto Rico -	Department of Public Works.	Meteorological Observations, October 1873 to April 1874.
Prague - -	K.K. Sternwarte - -	Magnetische and Meteorologische Beobachtungen, 1872–3. Jan. – July, 1874. By. Dr. C. Hornstein.
Rome -	Ministero d' Agricoltura, &c.	Meteorologia Italiana,— 1873, pp. 141–274. 1874, pp. 1–120.
	" "	Bollettino Decadico— 1873–4, pp. 1–144.
	" "	Riassunto delle Osservazioni fatte nel settenio, 1866–72.
	" "	Bullettino Meteorologico— Vol. XII., No. 12. Vol. XIII., Nos. 1–11.
	Osservatorio del Collegio Romano.	Studii intorno ai diametri solari, &c. Studio delle burrasche del clima di Roma, by G. Lais. By Padre A. Secchi.
Roorkee - -	Meteorological Department of N.W. Provinces of India.	Report for 1873. By Murray Thompson, M.D.
St. Petersburg	Central Physical Observatory.	Annalen, 1872. Bulletins, 1874. Simultane Witterungs Beobachtungen, Jan. – Aug., 1874. Sturmbahnen für Europa in den Jahren, 1872–4. Über die Bestimmung des Luftdrucks. Über einen einfachen Verdünstungs-messer für Sommer und Winter. Die magnetische Declination in St. Petersburg. By J. Mielberg.
	" "	Repertorium für Meteorologie, Bd. III. Bestimmung der Anemometer Constanten. By F. Dohrandt.
	" "	Über die Abhängigkeit des klimatischen Charakters der Winde von ihrem Ursprunge. By Dr. W. Köppen. By Dr. H. Wild.
San Fernando -	Observatorio de Marina -	Annales, 1872–73. By Don C. Pujazon.
Singapore -	Convict Jail Hospital -	Meteorological Observations, November 1873 to August 1874. By H. L. Randell, M.D.
Stockholm -	Meteorologiska Central-Anstalten.	Väderleks—Bulletin, July–Sept. 1874. By Dr. R. Rubenson.
	Observatoire - - -	Ableitung der Declinationen aus den am Verticalkreise der Polkowaer Sternwarte in den Jahren 1842–49, angestellten Beobachtungen, and 7 excerpt papers. By Prof. H. Gyldén.
Stonyhurst -	Observatory - - -	Results of Magnetical and Meteorological Observations for 1873. By the Rev. S. J. Perry, S.J., F.R.S.

Stuttgart -	Polytechnische Schule -	Witterungsbericht für 1872. Mittlere Bewölkung zu Stuttgart, 1826–70. Übersicht über die Witterungsverhältnisse Württembergs; Aug 1873 – Apr. 1874, and year 1873. By Dr. H. Schoder.
Tiflis - -	Phys. Observatorium -	Inhaltsverzeichniss zum Bibliotheks-Katalog. By H. Kiefer.
	" "	J. B. Biots. Tafeln zur Berechnung barometrischer Höhenmessungen. By H. Kiefer. By Dr. H. Moritz.
Toronto - -	Education Office - -	Journal of Education, Vol. XXVII.
	" -	Annual Report of Schools, 1872. By the Rev. E. Ryerson, D.D.
	Magnetical Observatory -	Monthly Meteorological Register, May to December 1871 and 1873.
	" -	General Meteorological Register, 1873.
	" -	Report of Meteorological Office, 1873. By G. T. Kingston, M.A.
Trieste - -	R. Accademia di Commercio e Nautica.	Osservazioni Meteorologiche, November 1873 to October 1874.
	" "	Results for 1873. By Prof. V. Farolfi.
Turin - -	R. Osservatorio Astronomico.	Bollettino Meteorologico ed Astronomico, 1872.
	" "	Determinazionie del diametro solare. By G. Mazzola.
	" "	Effemeridi del sole, &c. By G. Mazzola. By Sr. A. Dorna.
Upsala - -	Observatoire - - -	Bulletin Météorologique Mensuel: Vol. V., Nos. 11–13. Vol. VI., Nos. 1–5. By. M. G. Svanberg.
Utrecht - -	K. Nederlandsch Meteor. Institut.	Jaarboek, 1870 and 1873.
	" "	Différences des Écarts Barométriques simultanés en Néerlande, &c. December 1865 to November 1873.
	" "	Gemiddelde Barometerstand en Stormen rond Afrika's Zuidpunt.
	" "	Sur la signification du Congrès Météor. de Vienne pour l'avenir de la Météorologie.
	" "	Telegraphic Reports for 1874. By Dr. Buys Ballot and Captn. J. E. Cornelissen.
Vienna -	Commission für die Adria	III. Bericht, 1870–72. By Dr. H. Lorenz.
	K. K. Central Anstalt für Meteorologie, &c.	Beobachtungen, December 1873 to October 1874.
	" " -	Jahrbücher, 1871–2.
	" " -	Telegraphische Witterungsberichte, 1874.
	" " -	Rapport sur les Travaux du Congrès International des Météorologistes (1873). By Dr. C. Jelinek.
	Oesterreichische Gesellschaft für Meteorologie.	Zeitschrift, Bd. IX. By Dr. J. Hann.

Washington -	Hydrographic Office -	N.W. and W. Coasts of Spain and coast of Portugal; Madeira; the Salvages and the Canary Islands; the Azores, or Western Islands; the West Coast of Africa, Vol. I. Coast of Brazil, Vol. I. By Lieut. Comr. Gorringe.
	" -	The Navigation of the Atlantic Ocean; Tables for finding the distance of an object by two bearings; Fourth Supplement to Papers on the Gulf Stream. By Commodore R. H. Wyman, U.S.N.
	Smithsonian Institution -	Report for 1871–2. Miscellaneous Collection, Vols. IX. and X.; Contributions to Knowledge, Vols. XVII. and XVIII.; The Constants of Nature, Part I. By F. W. Clarke, S.B., U.S.
	" " -	Geological Survey of Montana, Idaho, Wyoming, and Utah, 1872. By F. V. Hayden.
	" " -	Problems of Rotary Motion. By Major Barnard, LL.D.
	" " -	The Transatlantic Longitude. By B. A. Gould.
	" " -	Converging series expressing the ratio between the diameter and circumference of a circle. By W. Ferrel.
	" " -	Instructions for Observations of Thunderstorms. Directions for constructing Lightning Rods. Temperature Chart of the United States. By Prof J. Henry.
	U. S. Geological Survey -	List of elevations in that portion of the U. S. west of the Mississippi River By H. F. Gannett.
	" " -	Meteorological observations during 1872, in Utah, Idaho, and Montana. By H. F. Gannett. By F. V. Hayden.
	U. S. Naval Observatory -	Astronomical and Meteorological Observations, 1871. Meteorological Observations, 1872–3. Report on the difference of Longitude between Washington and Detroit, Michigan, &c. By J. R. Eastman. By Admiral Davis, U.S.N.
	War Office - - -	Monthly Weather Review, December 1873 to October 1874. Daily Weather Charts and Reports, December 1873 to October 1874. Instruction to Observer Sergeants. Report for 1873. Meteorological Record, January to September, 1874. By Brigadier-Gen. A. J. Myer, U.S.A.
Wellington, N.Z.	Observatory - - -	Meteorological Observations at various Stations, 1873.
	" - - -	Meteorological Observations at Wellington, January to August, 1873. By J. Hector, M.D., F.R.S.
Zürich -	Meteor. Central Anstalt der schweizerischen naturforschenden Gesellschaft.	Meteorologische Beobachtungen, Aug. 1873 to Oct. 1874. Ueber den täglichen Gang der Temperatur in Bern. By A. Weilenmann. By Dr. R. Wolf.

Presented by the Authors.

Allison, F., M.A. - -	Synopsis of Climatological Statistics, Canada, December 1873–August 1874. Meteorological Abstract for 1874. General Meteorological Register for 1873.
Ansart A. - -	Essai sur la Mécanique des Vents et des Courants.
Barnard Major, L.L.D. -	See Washington.
Baumhauer, E. H. v. -	Sur un Météorographe universel destiné aux Observatoires solitaires.
Belavenetz, Capt. R.I.N. -	Russian Nautical Magazine, Nos. 10–12 for 1873, Nos. 1–8 for 1874.
Boguslawski, G. v. -	Beitrag zur Witterungskunde von Stettin. Übersicht der Witterungsverhältnisse zu Stettin in den einzelnen Monaten der Jahre 1867–8.
Capello, Sr. - -	Conference for Maritime Meteorology.
Carl, Dr. Ph. - -	Repertorium für Physik. Vol. IX., No. 6., Vol. X. Nos. 1–5.
Chambers, F. - -	The diurnal variations of the wind and barometric presure at Bombay.
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Clarke, F. W. - -	See Washington.
Cora, Guido - -	Cosmos. Vol. 1. No. 6 ; Vol. II., Nos. 1–5.
Croll, J. - - -	On the physical cause of ocean currents (2 papers).
Cundall, H, J. - -	Abstract of Meterological register at Charlottetown, P. Edward's Id., 1873.
Delany, J. - -	General Meteorological Register for St. John's, Newfoundland, 1873.
De La Rue, W., D.C.L. -	On a piece of apparatus for carrying out M. Janssen's method of time photographic observations of the transit of Venus.
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Donovan, N. - -	Description of a comparable Hygrometer.
Dohrandt, F. - -	See St. Petersburg.
Dunlop, W. H. - -	Results of Meteorological Observations at Annanhill N.B., December 1873 to November 1874. Summary for 1873.
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Edlund, E. - -	Bidrag till kannedommen om Sveriges Klimat.
Erman, A. - -	See Berlin.
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Galloway, W. - -	Experiments with safety lamps.
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Gloesener, E. - -	Papers on M. van Rysselberghe's Meteorograph.
Gorringe, Lt. Comr. -	See Washington.
Gould, D. A. - -	„ „
Gray D. & J. - -	Report on new whaling grounds in the Southern seas.
Harris, W. J., F.M.S. -	Results of Observations at Worthing, 1873.
Herchel, Prof., A.S. -	Observations of shooting stars in 1869–71., with charts, by Capt. G. L. Tupman R.M.
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Lais, G. - -	„ Rome.
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Mazzola, G. - -	See Turin.
Meldrum, C. - -	On a periodicity of Cyclones and Rainfall, in connexion with the sun-spot periodicity.
Mielberg J. - -	See St. Petersburg.
Miller, S. H., F.R.A.S. -	The Fenland Meteorological Circular and Weather Report, February to December 1874.
Moyle, M. P., F.R.C.S. -	Summary of observations at Helston, 1873.
Mühry, Dr. A. - -	Die äquatoriale Ascensions—strömung. Die Temperatur—differenz als Ursache der latitudinalen oceanischen Circulation. Zur Lehre von den Meeresströmungen.
Neil, A., M.R.C.S. -	Meteorology of the Punjab for 1873.
Parkinson, R. - -	Wetterstudien zur Benützung der täglichen Witterungsberichte von N. Hoffmeyer. (Translation).
Perry, Rev. S. J., F.R.S. -	Magnetic Survey of Belgium, in 1871. See also Stonyhurst.
Petermann, Dr. A. -	Mittheilungen, Vol. XX., Nos. 1–11 ; Ergänzungsheft, Nos. 35–38.
Petersen, H. - -	See Berlin.
Pick, Lt. - - -	See Pola.
Plantamour, A. - -	Résumé météorologique de l'année 1873, pour Genève et le Grand St. Bernard.
Poëy, A. - - -	Rapports entre les taches solaires, les tremblements de terre aux Antilles et au Mexique, et les éruptions vulcaniques sur tout le globe.
Preston, Rev. T. A., F.M.S.	Half-yearly Report of the Marlboro' College Natural History Society, for the half-year ending Christmas 1873.
Prettner, Dr. J. - -	Meteorologische Beobachtungen zu Klagenfurt, December 1873 to November 1874.
Prince, C. L., F.R.A.S. -	Summary of Meteorological Register kept at Crowborough Beacon, Tunbridge Wells, 1873.
Quinton, J. jr. - -	Summary of the Norwich Meteorological Register, 1873.
Rawson, Govr. R. W., C.B.	Monthly Returns of Rainfall and Meteorological Observations in Barbados, November 1873 to October 1874. Map of Daily Rainfall, November 1873 to October 1874. Report on the Rainfall of Barbados, 1847–71.
Rikatcheff, Capt. M., R.I.N.	La marche diurne de la Température à St. Pétersbourg.
Rundell, W. W. - -	On the diurnal inequalities of the Barometer and Thermometer.
Scarpellini, Mme. V. -	Bullettino delle osservazioni ozonometriche meteoriche fatte in Roma ; 1873, September and December ; 1874, March and April.
Stewart, Dr. B. F.R.S. -	Preliminary experiments on a magnetized copper wire.
Symons, G. J., F.M.S. -	Monthly Meteorological Magazine for 1874. British Rainfall for 1873.
Tarry, H. - - -	Programme d'Instructions aux navigateurs.
Taylor, R. - -	Weather in the Isle of Wight, 1873.
Tebbutt, J., F.R.A.S. -	Meteorological Observations at Windsor, New South Wales, 1867–70.
Thomson, Sir W. F.R.S. -	Directions for the adjustment and use of the Quadrant Electrometer, by W. Leitch.
Toynbee, Capt. H., F.R.A.S.	Occultations of Stars and Solar Eclipses, by F. C. Penrose, M.A.
Vernon, G. V., F.R.A.S. -	Mean Monthly Barometric readings at Old Trafford, Manchester, 1849–72.
Walker, Col., R.E., F.R.S.	See London (India Office).
Weilenmann, A. - -	See Zürich.
Zurcher, F. - -	Voyage Scientifique autour du monde de la Corvette Anglaise " Challenger," by C. Martins.

APPENDIX XIII.

LIST of PERSONS in the EMPLOYMENT of the METEOROLOGICAL COMMITTEE on December 31st, 1874, with their Occupations and Amount of Salary.

Name.	Duties.	Salary	
		Yearly.	Weekly.
		£ s. d.	£ s. d.
Office.			
Robert H. Scott	Director of the office	800 0 0	—
J. S. Harding, jun.	Correspondence, Accounts, Library	230 0 0	—
J. S. Harding, sen.	Copying, accounts of stores, registry of documents, &c.	—	1 18 6
T. D. Bell		—	1 8 0
Land Meteorology (*Observatories*).			
R. H. Curtis	Reproduction of observatory curves by pantagraphs, and preparation for publication.	150 0 0	—
A. J. Rigby		—	1 18 6
C. H. Thompson		—	1 3 0
C. Stodart		—	2 2 0
J. A. Curtis	Discussion of returns, and computations.	100 0 0	—
H. N. Cobley		—	1 0 0
R. Sargeant		—	1 0 0
Land Meteorology (*Telegraphy*).			
F. Gaster	Preparation of weather reports and computations.	170 0 0	—
W. L. Dallas		92 0 0	—
F. Brodie		78 0 0	—
G. G. Francis		—	1 8 0
H. Chivers		—	0 12 0
Ocean Meteorology.			
Capt. H. Toynbee	Marine Superintendent	400 0 0	—
R. Strachan	Care of instruments and reduction of meteorological returns.	240 0 0	—
C. Harding	Discussion of data and computations.	160 0 0	—
*W. G. James		100 0 0	—
T. E. Allen		100 0 0	—
J. W. McVeagh		—	1 3 0
*V. Sandiford		—	1 3 0
Commissionaire	Messenger	—	1 1 0
Rev. Thos. Kerr	Director of Valencia Observatory	250 0 0	—

* Resigned since the 31st December, and the names of H. Harries and H. F. Green added instead.

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LIST OF PUBLICATIONS, &c. issued under the Authority of the Meteorological Committee.

OFFICIAL.

No. 1. Report for 1867. Presented to Parliament. 1*s.*

2. Instructions for Meteorological Telegraphy. New Edit. (1875.) 6*d.*

3. Fishery Barometer Manual. 6*d.*

4. Charts of Surface Temperature, South Atlantic Ocean. 2*s.*6*d.*

5. Report for 1868. Presented to Parliament. 5*d.*

6. Report for 1869. Presented to Parliament. 10*d.*

7. Quarterly Weather Report 1869.—Parts I. to IV. Price 5*s.* each.

8. Barometer Manual. 1*s.*

9. Quarterly Weather Report, 1870.—Parts I. to IV. Price 5*s.* each.

10. Report for 1870. Presented to Parliament. 10*d.*

11. Contributions to our Knowledge of the Meteorology of Cape Horn and the West Coast of South America. Price 2*s.* 6*d.*

12. Currents and Surface Temperature of the North Atlantic Ocean, from the Equator to Lat. 40° N., for each month of the year, with a General Current Chart. Price 2*s.* 6*d.*

13. A Discussion of the Meteorology of the Part of the Atlantic lying North of 30° N. for the Eleven Days ending 8th February 1870. Price, with Book of Charts, 5*s.*

14. Quarterly Weather Report 1871. — Parts I. to IV. Price 5*s.* each.

15. Report for 1871. Presented to Parliament. 10*d.*

16. Quarterly Weather Report 1872. — Parts I. to IV. Price 5*s.* each.

17. Report for 1872. Presented to Parliament. 1*s.*

18. Contributions to our Knowledge of the Meteorology of the Antarctic Regions. Price 2*s.*

19. Quarterly Weather Report, 1873.—Parts I. to IV. Price 5*s.* each.

20. Charts of Meteorological Data for Square 3. Lat. 0° – 10° N. Long. 20° – 30° W., and Remarks to accompany the Monthly Charts. Showing the Best Routes across the Equator for each Month. 20*s.*

21. Report of the Proceedings of the Meteorological Congress at Vienna. 1*s.*

22. Report for 1873. Presented to Parliament. Price 4*d.*

23. Report of the Proceedings of the Conference on Maritime Meteorology held in London, 1874. Price 2*s.*

24. Instructions in the Use of Meteorological Instruments. Price 1*s.* 6*d.*

25. Quarterly Weather Report for 1874.—Part I.—January to March. Price 5*s.*

26. Report for 1874. Presented to Parliament. Price 6*d.*

LIST OF PUBLICATIONS, &c.—*continued.*

NON-OFFICIAL.

No. 1. Report to the Committee on the Connexion between Strong Winds and Barometrical Differences.—By Robert H. Scott, Director of the Office. 6*d.*

2. Report to the Committee on the Meteorology of the North Atlantic.—By Captain H. Toynbee, Marine Superintendent. 1*s.*

3. Report to the Committee on the Use of Isobaric Curves.—By Captain H. Toynbee, Marine Superintendent. 1*s.*

4. Routes for Steamers from Aden to the Straits of Sunda and back. Translated from a Paper issued by the Royal Meteorological Institute of the Netherlands. Price 6*d.*

5. On the Winds, &c. of the North Atlantic along the Tracks of Steamers from the Channel to New York. Translated from a Paper issued by the Deutsche Seewarte, Hamburg. Price 6*d.*

6. Report of the Proceedings of the Meteorological Conference at Leipzig. Price 1*s.*

7. Notes on the Form of Cyclones in the Southern Indian Ocean.—By C. Meldrum, Esq., M.A., F.R.A.S. Price 6*d.*

8. Report on Weather Telegraphy and Storm Warnings. Presented to the Meteorological Congress at Vienna. Price 6*d.*

9. Report of the Permanent Committee of the Vienna Congress for 1874. Price 1*s.* 6*d.*

Sold by POTTER, 31, Poultry, and STANFORD, Charing Cross.
The Annual Reports may be obtained of all Parliamentary Booksellers.

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Printers to the Queen's most Excellent Majesty.
For Her Majesty's Stationery Office.

EIGHTH REPORT

OF THE

ROYAL COMMISSION

ON

SCIENTIFIC INSTRUCTION AND THE ADVANCEMENT OF SCIENCE.

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

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

1875.

[C.—1298.] *Price 7d.*

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ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION AND THE ADVANCEMENT OF SCIENCE.

VICTORIA R.

VICTORIA, by the Grace of God of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith, To Our Right Trusty and Right Entirely Beloved Cousin William Duke of Devonshire, Knight of Our Most Noble Order of the Garter,—Our Right Trusty and Entirely Beloved Cousin Henry Charles Keith Marquess of Lansdowne,—Our Trusty and Wellbeloved Sir John Lubbock, Baronet,—Our Trusty and Wellbeloved Sir James Phillips Kay-Shuttleworth, Baronet,—Our Trusty and Wellbeloved Bernhard Samuelson, Esquire,—Our Trusty and Wellbeloved William Sharpey, Esquire, Doctor of Medicine,—Our Trusty and Wellbeloved Thomas Henry Huxley, Esquire, Professor of Natural History in the Royal School of Mines,—Our Trusty and Wellbeloved William Allen Miller, Esquire, Doctor of Medicine, Professor of Chemistry in Kings College, London,—and Our Trusty and Wellbeloved George Gabriel Stokes, Esquire, Master of Arts, Lucasian Professor of Mathematics in the University of Cambridge, Greeting:

Whereas We have deemed it expedient for divers good causes and considerations that a Commission should forthwith issue to make Inquiry with regard to Scientific Instruction and the Advancement of Science and to Inquire what aid thereto is derived from Grants voted by Parliament or from Endowments belonging to the several Universities in Great Britain and Ireland and the Colleges thereof and whether such aid could be rendered in a manner more effectual for the purpose.

Now Know Ye that We reposing great Trust and Confidence in your Ability and Discretion have nominated constituted and appointed and do by these Presents nominate constitute and appoint you the said William, Duke of Devonshire—Henry Charles Keith, Marquess of Lansdowne—Sir John Lubbock—Sir James Phillips Kay-Shuttleworth—Bernhard Samuelson—William Sharpey—Thomas Henry Huxley—William Allen Miller—and George Gabriel Stokes—to be Our Commissioners for the purposes of the said Inquiry.

And for the better enabling you to carry Our Royal Intentions into effect We do by these Presents authorize and empower you or any three or more of you to call before you or any three or more of you such persons as you may judge necessary by whom you may be the better informed of the matters herein submitted for your consideration and also to call for and examine all such Books Documents Papers or Records as you shall judge likely to afford you the fullest information on the subject of this Our Commission and to Inquire of and concerning the Premises by all other lawful ways and means whatsoever.

And Our further Will and Pleasure is that you or any three or more of you do Report to Us under your Hands and Seals (with as little delay as may be consistent with a due discharge of the Duties hereby imposed upon you) your opinion on the several matters herein submitted for your consideration, with power to certify unto Us from time to time your several proceedings in respect of any of the matters aforesaid, if it may seem expedient for you so to do.

And We do further Will and Command and by these Presents ordain that this Our Commission shall continue in full force and virtue and that you Our said Commissioners or any three or more of you shall and may from time to time proceed in the

execution thereof and of every matter and thing therein contained although the same be not continued from time to time by adjournment.

And for your assistance in the execution of these Presents We do hereby authorize and empower you to appoint a Secretary to this Our Commission to attend you whose services and assistance we require you to use from time to time as occasion may require.

Given at Our Court at Saint James's, the Eighteenth day of May 1870, in the Thirty-third year of Our Reign.

By Her Majesty's Command,

H. A. BRUCE.

ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION AND THE ADVANCEMENT OF SCIENCE.

VICTORIA R.

VICTORIA, by the Grace of God of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith, To Our Trusty and Well-beloved Henry John Stephen Smith, Esquire, Master of Arts, Savilian Professor of Geometry in Our University of Oxford, Greeting:

Whereas We did by Warrant, under Our Royal Sign Manual, bearing date the Eighteenth Day of May, One Thousand Eight Hundred and Seventy, appoint Our Right Trusty and Right Entirely Beloved Cousin, William, Duke of Devonshire, Knight of Our Most Noble Order of the Garter, Our Right Trusty and Entirely Beloved Cousin, Henry Charles Keith, Marquess of Lansdowne, together with the several Gentlemen therein named, to be Our Commissioners to make Inquiry with regard to Scientific Instruction and the Advancement of Science, and to inquire what aid thereto is derived from Grants voted by Parliament, or from Endowments belonging to the several Universities in Great Britain and Ireland, and the Colleges thereof, and whether such aid could be rendered in a manner more effectual for the purpose: And whereas since the issue of the said Warrant William Allen Miller, Doctor of Medicine, one of the Commissioners thereby appointed, hath deceased:

Now Know Ye, that We, reposing great Trust and Confidence in Your Zeal, Discretion, and Integrity, have authorized and appointed, and do by these Presents authorize and appoint you the said Henry John Stephen Smith to be a Commissioner for the purpose aforesaid, in addition to, and together with, the Commissioners now acting under the above-mentioned Royal Warrant.

Given at Our Court at Saint James's the First Day of December 1870, in the Thirty-Fourth Year of Our Reign.

By Her Majesty's Command,
H. A. BRUCE.

Professor Henry John Stephen Smith, M.A.,
To be a Commissioner for inquiring into
Scientific Instruction and the Advancement of Science.

EIGHTH REPORT.

TO THE QUEEN'S MOST EXCELLENT MAJESTY.

MAY IT PLEASE YOUR MAJESTY,

WE, the Commissioners appointed by Your Majesty to make Inquiry with regard to Scientific Instruction and the Advancement of Science, humbly beg leave to present to Your Majesty, in conclusion of the Inquiry entrusted to us, the following Report on the Advancement of Science and on the Relations of Government to Science.

In the course of our Investigations into the Proceedings and Management of the Universities, Colleges, Museums, and other Institutions, which exist wholly or in part for Scientific Purposes, considerations bearing on the Relations of the Government to Science, and on the Advancement of Scientific Research, necessarily came under our notice to a certain extent; they were, consequently, referred to in an incidental manner in the Reports already submitted to Your Majesty, which, however, were mainly concerned with Scientific Instruction. The present Report will address itself directly to the Relations of Government to Science, and to the Advancement of Scientific Research; and our Inquiry divides itself into the following branches:—

(1.) The Scientific Work carried on by Departments of the Government.
(2.) The Assistance at present given by the State towards the promotion of Scientific Research.
(3.) The Assistance which it is desirable the State should give towards that object.
(4.) The Central Organization which is best calculated to enable the Government to determine its action in all questions affecting Science.

I.—The Scientific Work carried on by Departments of the Government.

The principal branches of Scientific Work conducted by Officers of the Imperial Government, and the Departments by which they are administered, are as follows:—

Topographical Survey [Treasury (Office of Works)].
Hydrographical Survey [Admiralty].
Geological Survey [Privy Council].
Astronomical Observations:
  Greenwich and the Cape of Good Hope [Admiralty].
  Edinburgh [Treasury (Office of Works)].
Meteorological Observations:
  Greenwich [Admiralty].
  Edinburgh [Treasury (Office of Works)].
  The Meteorological Office.

[The Meteorological Office is not administered by any Public Department, but is directed by a Committee, which, although appointed by the Royal Society, is independent of that body.]

Botany.—Royal Gardens, Kew; Botanic Garden, Edinburgh; Botanic Gardens, Dublin [Treasury (Office of Works)].
The Chemical Department of the War Office.
The Standards Department of the Board of Trade.

Analogous work is carried on in some of the Colonies and Foreign Possessions by Departments of their respective Governments.

In one case, that of the Royal Observatory, Greenwich, the work is examined into and reported on to the Admiralty by a Board of Visitors composed of men of Science.

Some branches of the work dealt with, from the accident of their origin and from other causes, are less entirely devoted to the direct necessities of the State than others; whilst it will be seen that there are certain lines of investigation of no less importance to the State than those for which provision has already been made, which the State has not as yet undertaken.

The Imperial Investigations enumerated, with the exception of the very special work of

the Chemical Department of the War Office and the Standards Department of the Board of Trade, generally extend over large areas or long periods of time, and consequently are of such a nature that the State could not safely intrust them to the action of Individuals or Societies, even if these were willing to undertake them.

When Scientific questions arise on which the Departments are not supposed to possess the requisite theoretical or practical information, Special Committees are appointed or the advice of individuals presumed to be specially qualified is obtained, either directly or through the Royal, the Geographical, or some other Learned Society.

The following is a Statement showing the annual charges borne by Imperial Funds, at the present time, to defray the expenses of such of these various investigations as appear separately in the Estimates for the year 1874–75.

Appendix I.

	£
Topographical Survey - - - - (excluding Military pay of men employed).	132,000
Hydrographical Survey - - - -	121,055
Geological Survey - - - - -	22,920
Astronomy - - - - - -	9,703
Meteorology - - - - -	12,082
Botany, including the maintenance of Botanical Gardens as places of Public Recreation - - -	21,470
Standards Department of the Board of Trade - -	2,063

In addition to these recurring charges, sums are voted from time to time for various Expeditions and for Experiments incidental to the Services of the various Departments, such as the Investigations concerning the Causes and Processes of Disease carried on under the Direction of the Lords of the Privy Council, and the various Experimental Researches carried on for the Army and Navy.

We have not considered it necessary to take Evidence regarding the detailed work of the Public Departments, but have thought it sufficient to collect the general opinion of those who are connected with, or well-informed concerning, the Scientific Work carried on by those Departments.

In the case of the Meteorological Office, however, both on account of its recent establishment and the circumstance that it is not directly responsible to any Public Department, we have felt it our duty to take Evidence at some length, both as regards its Scientific and Financial Administration.

Evidence as to the Insufficiency of the present Organization.

The Evidence which we have taken as to the sufficiency or insufficiency of the work done for the Advancement of Science, including that of the Government Departments, is very copious. A large portion of it is contained in the volumes already published, and it will have been seen that there is a general concurrence of opinion, that, even in the interests of the Departments themselves, more ought to be done by the Government in the way of Investigation, particularly in respect of those Sciences the Practical Application of which has been developed, or the scope of which has been enlarged by Discovery, within recent years.

These opinions are entertained alike by persons engaged in Scientific Work under the various Departments of the Government, and by Scientific Men having no official connexion with the State.

The following are extracts from the Evidence on this branch of the subject.

Sir Henry Rawlinson, a member of the Indian Council, states that in that Council
Qu. 12,564. they perpetually have references before them which they are unable to deal with. He adds :

Qu. 12,565. * * * "We have, for instance, Sir William Baker upon the Council, and General Strachey and Colonel Strange both attached to the Office; yet, notwithstanding their valuable aid, there are many subjects referred to us with which we are quite incompetent to deal."

He then refers to the following subjects among others :—The Manufacture of Iron and Steel in India; the Efflorescence of Soda on Irrigated Land; the Fermentation of Beer, "which "may involve a loss of 200,000*l.* or 300,000*l.* a year to the British Government;" the question of Drought arising from the Destruction of Forests; the Construction of Harbours and of other Hydraulic Works; the Founding of Brass Guns; Tidal Observations; the Publication of Works on the Flora and Fauna of India; Geological and Trigonometrical Surveys; Sea Dredging; and Observatories.

He points out that many of these questions are practical and economical, but that still there is a scientific element in almost all of them, and he adds—

"References on all these subjects are constantly coming home, and we have no means of answering them in our own body, while it is very unsatisfactory to be obliged to send out for gratuitous information. We do sometimes, it is true, apply to individuals and sometimes to societies, but in very many cases, I am afraid, the questions are shelved, because there is no competent and authoritative body to refer to." Qu. 12,565.

Captain Douglas Galton, of the Office of Your Majesty's Works and Public Buildings, thinks that, as a rule:

* * * * "Our statesmen do not appreciate properly the value of scientific advice or scientific inquiry, and that they are very much fonder of experiments made upon a large scale with no defined system, than they are of experiments which have been brought out as the result of a carefully studied previous inquiry. I think that an enormous amount of money was wasted in the case of the inquiry into armour plates, both for ships and forts. In that case the Government appointed a partly scientific committee, but it was mixed up with other persons who were not scientific; and instead of commencing a series of experiments upon a small and clearly defined scale, from which they could have drawn conclusions for making their larger experiments, they began by firing at any plates that were offered to them which had no relation one to another, either in their relations to the guns or to the form of backing, or in any other way, and consequently it was difficult to draw useful calculations from them." Qu. 12,966.

Mr. Froude, who was a prominent member of the late Committee on Naval Designs, and who is now devoting his whole time without remuneration to the investigation of the proper forms of ships of war, states that if, at an earlier time, a laboratory had existed, and proper experiments had been made, enormous sums would have been saved which have been expended in the actual construction of ships, or, as he terms it, in "experiments on the scale of 12 inches to a foot;" and that definite results would have been arrived at with less loss of time.

"I think any experiment almost on the sailing or rolling properties of a big ship, when tried in a big ship to begin with, is a waste of money. The cost of construction of a big ship as an instrument of investigation is enormous; and if it is tried with a view to the application of a new principle, there must be the risk that the experiment will be to some extent wasted. Being an experiment, the very fact that it is an experiment implies that it may not turn out as it is expected, and a failure in so costly a piece of apparatus as a new complete ship is inevitably a very costly failure. So far as it is possible to arrive at a proper understanding of such subjects by small-scale trials, it is of the utmost importance, economically, that that method should be adopted, and I think that that has not been sufficiently adopted." Qu. 11,344.

It will be seen from the Evidence of General Strachey, which we quote in a subsequent part of this Report, that he also disapproves of the mode in which Government is at present advised on questions of Science, especially on the ground of the absence of scientific training in the political and official classes of this country.

Sir Wm. Thomson has given us the following Evidence:

* * * "With a vast amount of mechanical work which is necessarily undertaken by the Government and which is continually in hand, questions involving scientific difficulties of a novel character frequently occur; questions requiring accurate knowledge of scientific truth hitherto undeveloped are occurring every day. In both respects the Government is at present insufficiently advised, and the result is undoubtedly that mechanical works are sometimes not done as well as they might be done, that great mistakes are sometimes made; and, again, a very serious and perhaps even a more serious evil of the present system, in which there is not sufficient scientific advice for the Government, is the undertaking of works which ought never to be undertaken." Qu. 10,675.

"Are you able to point out any instances which you have in your mind of mistakes which you think have occurred from the want of good advice on the part of the Government?—One great mistake undoubtedly was the construction of the "Captain," and I believe that a permanent scientific council advising the Government would have made it impossible to commit such a mistake. They would, in the very beginning, have relieved the Government from all that pressure of ignorant public opinion which the Government could not possibly, in the present state of things, withstand." Qu. 10,676.

The present system of Special Committees is objected to by Sir William Thomson, and by other competent Witnesses.

Sir William Thomson thinks "that a single body would be better than a number of small Committees for advising the Government on the great variety of questions which from time to time would be likely to arise." Qu. 10,677.

Admiral Richards, late Hydrographer of the Admiralty, is of opinion that:

"The members of such committees must be selected more or less to fulfil certain political conditions, and that, as a rule, they would come new to the subject that they were going to consider, and I do not believe that the Commission which sat on the Naval Designs the other day was a very successful one. I do not know that any great advantages have arisen or are likely to arise from it." Qu. 11,589.

Mr. Froude, in reply to the remark: "You do not consider Committees of that kind "to be a very satisfactory way of proceeding?" thus states his objection to the present system:

"I do not think so, because they have to find out the dream and the interpretation both, which is always a difficulty. They have to feel their way to a *locus standi*, which would already be possessed by a Council habitually operating with reference to the subject." Qu. 11,293.

Additional examples of these defects are given, not only by these Witnesses, but also by others, whom we shall quote in that part of our Report which deals with the proposed remedies.

Evidence as to the Insufficiency of the present Appliances for Investigation

Our attention has been especially directed to the want of Laboratories for the use of the officials charged with Scientific Investigations urgently required for the economical management of the Public Departments.

Qu. 11,923. Mr. Anderson, the Superintendent of Machinery at Woolwich, who has been responsible for the expenditure of "very nearly 3,000,000*l.* of public money," points out that there are no means at the disposal of State servants to enable them to investigate questions on which large expenditure depends. With special regard to his own Department, he states:

Qu. 11,929. Qu. 11,950. "There is a very great deal which I should like to see taken in hand systematically. * * * * There is much that we are in the dark about; we are groping in the dark in almost everything at present."

* * * * "Although we know a very great deal with regard to iron, cast, wrought, and in the condition

Qu. 11,930. of steel, there is yet very much which we do not know, and I am persuaded that if we could with certainty treat ordinary cast iron in the way that we sometimes do, nearly by chance, we would do away with three-fourths, or a very large proportion of the wrought iron which is now used in this country, and we should use cast iron. A great deal of the cast iron of commerce is not much above five tons per square inch in tenacity, but we can, by trying, get it up to 15 tons, although some of the reasons that determine that high character are obscure and it is very difficult to see what they are. I should like that the subject of cast iron should be thoroughly exhausted, and at the same time I should like to see the physical properties of iron thoroughly exhausted." * * * *

He next refers to another question of great importance to almost all the Public Departments:

Qu. 11,931. * * * "There is another very important subject which I might mention to the Commission. Some 20 years ago we were using 10 or 12 pounds of coal per horse-power per hour, and the majority of engines still require six pounds, but by the improvements that have taken place we are now down to two pounds. There is a little engine at work now in the London district which is working at $1\frac{3}{4}$ pounds. There is a great gulf yet between getting steam-engines that will work at $1\frac{3}{4}$ pounds per horse-power per hour, and the point where we are now; I mean getting that done practically; but I believe that if the right man, or two men, were told off to thoroughly investigate this subject, and not to stop working until they had brought it to a practical shape, we could in 10 years from this time get down to one pound per horse-power per hour. I see that there are very many leakages or loss in steam-engines in the very best way that we make them at present. The knowledge that was gained by Joule's experiments a few years ago seems to me to have been of immense value. Those experiments that he carried out for himself were the sort of thing which I think the Government should have done for the sake of the country. He did more to make engineers thoroughly dissatisfied with their present knowledge with regard to what they can do with steam than anything which had been done before. I believe that what Mr. Joule did will do more for this country than even what James Watt did. The part that James Watt took was very great, and the world gives him full credit for it, but the world is scarcely willing to give credit to Joule for what he will do; but he has made all engineers dissatisfied. They know that the best steam engine is not doing one-sixth of the work which it ought to do and can do. That is a sad state of matters to be in when we know that we are so far wrong, but yet no one will go to the trouble of going to the end of the question so as to improve the steam engine as it might be done; in fact, it will cost a great deal of trouble and a great deal of expense, I have no doubt."

Qu. 11,933. With regard to the question whether it is "desirable that the Government should establish any Laboratories for carrying on those investigations," he thus stated his opinion:

"I should like to see a grand laboratory fitted with everything that would go towards the investigation of such matters, and at the same time a testing apparatus for getting at the physical facts as well. To get up the proper plant would be very expensive, but still I should like the nation to have it, so that any public department could go to this same laboratory and ask them for assistance to investigate any doubtful point. * * * * In the Government service everybody who gets any work to do worth mentioning is overpowered with work—either they get too much or too little to do—and the investigator should not be bothered with such miscellaneous work. For example, take my own case, I may have 50 subjects in a day many times. Yesterday I had well on to 50 subjects to take up, and go into them all as well as I could, and I did not get over my work to write the paper which now lies before your Grace until 9 o'clock last night. A man is not in a position to pursue investigations when he is overworked in that way."

Mr. Anderson's Evidence finds a parallel in that given by Mr. E. J. Reed, M.P., late Chief Constructor of the Navy.

Qu. 12,706. "I think that there are many branches of science remaining undeveloped at present, the development of which would be of great advantage to the country. I base that opinion partly upon the experience which I acquired at the Admiralty, in which I continually found that great and important questions were undeveloped for the want of organisation and of the means of developing them."

Qu. 12,707. * * * "Mr. Froude in his evidence before this Commission stated that he had in hand a series of experiments for the Admiralty, having for their primary object the determination of the relations between form, speed, and resistance in ships, and, as he justly observed, this inquiry collaterally raises some other questions; but there is one subject related to that which Mr. Froude has under consideration, but which has not been developed at all yet, and it is one upon which very important financial questions hang; I refer to the dependence of the form of ships upon the weight of the materials composing their hulls. It will be obvious to the Commission that if you are going to build a ship for high speed of the thinnest steel, you can afford to prolong the ends of the vessel at either end, and give them extreme fineness in a manner and to a degree which would be preposterous, and I may even say monstrous, in the case of a ship which had to be built with very thickly-armoured sides. In this country the earlier ironclads were made of a form involving very long and fine lines, in fact a form analogous to that of mercantile steamships, and the consequence was that although in the 'Minotaur' type of ship armour and backing equivalent only to that used in the first instance in the

'Warrior' was employed, yet we got a ship 400 feet long, costing nearly half a million sterling. The impropriety of that course impressed itself upon my mind, and I believe it was more for that reason than for any other that I ventured to propose to the Admiralty a great change in that respect, and placed before them the design for the 'Bellerophon' as an example of a vessel which should be as fast as those long ships, and more effectually armoured, and much more handy, carrying at least as efficient an armament, and yet should cost about 100,000*l.* less. That policy was sanctioned by his Grace the Duke of Somerset; the 'Bellerophon' was built, and I believe long before she was finished the principle obtained so much favour that the idea of building another of the extremely long vessels never entered anybody's mind, and it was stated by the late First Lord of the Admiralty, Mr. Childers, in Parliament, officially, that by adopting that modification of form at least a million sterling had been saved to the county in the course of a very short time. But I wish to impress upon the Commission, if I may be allowed to do so, that that economy resulted from a mere tentative and limited application of a scientific principle, which has never been developed, and which the organisation of the Admiraly furnishes no means for developing. I indicated the nature of this investigation in a paper laid before the Royal Society some two or three years ago, but as the solution of it involves high mathematics on the one hand, and elaborate experimental investigations upon the other, it has never been taken up and dealt with in any sufficient way."

"A second illustration which I should like to give is this: the present condition of the marine steam-engine and boiler is very unsatisfactory. It is unsatisfactory to such an extent that I believe if the manufacture of iron and steel were improved with reference to its use in the construction of engines and boilers, and if improved material were applied by improved methods, a saving of one half of the present weight would be attained, and when I say one half I know that I am speaking greatly within the limits which some persons who have thought very much about this question would be prepared to express. Of course, if that be so, if we are carrying about in our mercantile and other steamships twice the weight which is essential for the production of the power, that is so much taken off either from the further power and speed which might be obtained, or from the freightage and commercial value of the vessel. I may mention that in the manufacture of shafts, for instance, of the marine engine and of stern posts, and other large forgings for ships, the method of production is comparatively rude, and it very much needs development. I for one feel the necessity of great improvement in these respects, because I know that at the present moment the successful production of those enormous forgings rests a great deal more upon the skill of a workman than upon the application of any science whatever to them. So much has the subject been neglected, that, at this moment, I have the responsibility of seeing some very large forgings indeed made for certain ships, and the most effectual manner in which I can give effect to my responsibility is that of selecting the very best working smith that I can find, and putting him into the manufactory where those things are being made, for him to do the best that his experience enables him to do, in order to see them properly constructed. I believe that if a regular independent scientific investigation were applied to a manufacture of that nature, enormous advantage would at once result." Qu. 12,708.

The Standards Department of the Board of Trade is another Department requiring advice in varied scientific subjects. The Warden of the Standards (Mr. Chisholm) states:

"There is no scientific authority to which I am entitled to appeal. It happens at the present time that I have the advantage of appealing to my former colleagues in the Standards Commission, to the Astronomer Royal and to Professor Miller, and I get a great deal of assistance from them in that way, especially from Professor Miller. In fact I could hardly have executed the scientific duties of my department without having assistance of that kind, but such aid has been obtained merely in consequence of my relations with them as a colleague. I am in no wise authorised to call upon them or upon any other scientific authority for information or assistance. I may here particularly refer to one subject which is mentioned in my paper, the preparation of new standard trial plates for coin. I actually required scientific information upon that point, and I could only apply to the Astronomer Royal, but his time was taken up so much that after some time he declined interfering in the matter, so that I have been obliged to act in the matter without having any scientific authority to aid me, although it is a very responsible duty cast upon me by law." Qu. 11,666.

Sir William Thomson, in reference to the subject of Standards, says:

"The conservancy of weights and measures is a subject involving questions of the most extreme scientific nicety. Faraday made statements showing how completely unknown at present are the properties of matter upon which we depend for a permanent standard of length. One of the very first objects that should be undertaken in connexion with the conservancy of the standards of weight and length is secular experiments, on the dimensions of metals and solids of other classes under various conditions of stress, temperature, and atmosphere. Those would involve scientific experiments of an extremely difficult character, and also operations extending from year to year. There ought to be just now a set of experimental specimens of solids laid up which should be examined every year, or every 10 years, or every 50 years, or every 100 years, the times when observations are to be made from age to age being regulated by the experience of the previous observations. It would be necessary to begin observing every month, then when constancy is attained within the degrees of observable minuteness to observe every year, then every 10 years, then perhaps every 50 years, and then it might be sufficient to look at them every 500 years, and examine whether this copper standard and that brass standard have retained precisely the same length. This would not be a very difficult or expensive thing to institute in such a way as eventually to obtain good results, but it would be an operation of a secular character, which could only be carried out by the Government." Qu. 10,678.

Dr. Frankland thus refers to the various requirements of Government involving Chemical Investigations:

* * * "The State requires many important investigations to be carried on. Such investigations are being continually conducted in buildings often very ill-adapted for the purpose, and which are fitted up for the purpose at a great cost. The laboratory of the Rivers Commission, for instance, which we have occupied for four years, was constructed in a house in Victoria Street; a rent of 200*l.* a year is paid for it, and it is literally nothing more than a moderate sized room, and two smaller ones, very ill-adapted for the purpose. Consequently, this laboratory is not so efficient as a building erected for the express purpose of conducting such investigations would be." * * * * Qu. 11,065.

In the Evidence which we have taken with regard to Astronomical Physics and Meteorology, the expressions of opinion as to the insufficiency of the means of investigation are so interspersed with suggestions as to the remedies to be applied, that we think it more convenient to refer more particularly to these subjects in the Third Part of this Report.

II.—The Assistance given by the State towards the Promotion of Scientific Research.

Fourth Report.

It may be convenient, for the purposes of this Report, to consider the Assistance given by the State towards Scientific Research as being either Permanent or Occasional.

Our great National Museums (upon which we have already reported) come under the first of these descriptions, and it will have been seen that for the purposes of the Student of the Biological and Geological Sciences, Collections are provided on an extensive scale, so that the Student of these branches of Science has advantages similar to those provided for the Student of Art or Literature.

On the other hand, the Student of the Physical Sciences has no such facilities; there are, at the best, for some of these branches of study, Collections of Instruments of a very inadequate kind, and relating for the most part to Applied as distinguished from Theoretical Science.

We have also reported to Your Majesty that the National Collections, so far as they illustrate the Biological and Geological Sciences, are rendered easily accessible to the Students of those Sciences. But the few instruments illustrative of Physical Science in any National Collection are so placed that they can scarcely be used even in the study of the History of Science. Moreover, as a mere collection of instruments, however complete, without working laboratories, is of little use to the Student of the Experimental Sciences, and as there are no Public Laboratories available for the Researches of Private Investigators, it may be said that in many branches of Experimental Science the State affords no permanent material aid to such Investigators.

Assistance of a Permanent Description is also afforded to certain Learned Societies, by providing them with apartments free of rent, or with annual grants of money in lieu of such accommodation: the sum of 500*l.* granted annually to the Royal Geographical Society under certain conditions is an instance of such a grant.

We may regard as a Permanent Aid to Science the grant of 1,000*l.* for Researches carried on by Private Individuals, which is annually voted by Parliament, and administered by a Committee of the Royal Society.

This Grant has rendered such great services to Science, that we desire to give the following Outline of its History.

The first proposal for such a grant was contained in a letter (dated October 24th, 1849) from Earl Russell (then Lord John Russell) to the then President of the Royal Society (the Earl of Rosse), and was to the following effect:

App. XI. vol. II. p. 41.

"As there are from time to time scientific discoveries and researches which cost money and assistance the students of science can often but ill afford, I am induced to consult your Lordship, as President of the Royal Society, on the following suggestion:—

"I propose that at the close of the year the President and Council should point out to the First Lord of the Treasury a limited number of persons to whom the grant of a reward, or of a sum to defray the cost of experiments, might be of essential service. The whole sum which I could recommend the Crown to grant in the present year is 1,000*l.*, nor can I be certain that my successor would follow the same course; but I should wish to learn whether, in your Lordship's opinion and that of your colleagues, the cause of science would be promoted by such grants."

Lord Rosse, in his reply to the proposal made by Lord John Russell, expressed his personal opinion that the judicious employment of grants in the way proposed "would very materially promote the Advancement of Science;" and of the two alternatives, namely, expending the 1,000*l.* in rewards or appropriating it to the payment of the expenses of experiments, he preferred the latter, indicating his reasons as follows:

App. XI vol. II. p. 41.

"There are often details to be worked out before it is possible to employ usefully newly discovered principles. In many of the sciences reductions are required before observations can be made use of. Both in Science and Art facts technically called constants are the materials of discovery; to determine them accurately is of great importance. Now in all these cases, and in many others, the work to be done is laborious and expensive, and as it adds but little comparatively to the fame of the individual, it especially requires encouragement."

On this correspondence being communicated to the Council of the Royal Society, a Committee was appointed "to consider and report respecting the application of the "proposed grant." This Committee agreed to the following Recommendations:

"First and chiefly—That the grant be awarded in aid of private individual scientific investigation.

"Secondly. In aid of the calculation and scientific reduction of masses of accumulated observations.

"Thirdly. In aid of astronomical, meteorological, and other observations, which might be assisted by the purchase and employment of new instruments.

"Fourthly, and, subordinately to the purposes above named, in aid of such other scientific objects as may from time to time appear to be of sufficient interest, although not coming under any of the foregoing heads."

It was further added—

"That a Committee be appointed, consisting of the whole Council for the time being, ex officio, together with an equal number of Fellows of the Society, chosen by the Council amongst the members most conversant with the business of the Royal Society, or with one or more of the leading departments of Science, or officially connected with the principal scientific bodies of the kingdom; such additional members to be named for a period of three years, subject to the annual revision of the Council, and provision being made for filling up the vacancy occasioned by such additional member becoming a member of Council during his term of service on the said Committee, should such occur." App. XI. vol. II. pp. 41, 42.

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With regard to this Government Grant, Sir Edward Sabine, in his Evidence, says:

* * * "I suppose that the 1,000*l.* in one year was designed as an experiment to try the matter in the first instance. I always understood that Lord Russell contemplated that the sum would be augmented if the plan were found to work well." Qu. 11,135.

Neither the amount of the Grant, nor the conditions of its administration, have been varied from the time of its commencement. For full details as to its application in successive years, we refer to the Statement presented by Sir E. Sabine, and printed in the Appendix to Vol. II., at pp. *41* to *47*. In a later part of this Report, we shall refer to the proposals which have been made to us for increasing the amount and usefulness of the Grant.

The most important instances of the Occasional Assistance given by the State, are Expeditions for Special Researches, and Outfits of Ships, and Apparatus and Grants of Money for such Researches. These contributions are of great value, but they do not appear to be granted or refused on any sufficiently well defined principle.

III.—The Assistance which it is desirable the State should give towards Scientific Research.

We have received strong Evidence that it is the interest and within the proper function of the State to give efficient aid to the Advancement of Knowledge, even in those cases where such knowledge is not directly required for State purposes, and, we may remark, that some of the most decided expressions of opinion to this effect are those of Statesmen, whose views, owing to their official experience and their intimate knowledge of the exigencies of Parliamentary Government, are entitled to great weight on points involving increased grants of public money.

The Evidence of Lord Salisbury is emphatic:

Qu. 13,555. "Do you hold that the State may legitimately interfere in giving aid to the advancement of science?—I certainly do. It is a very orthodox doctrine to hold, and one which could be supported if necessary by quotations out of Adam Smith, the essence of the doctrine being, that the State is perfectly justified in stimulating that kind of industry which will not find its reward from the preference of individuals, but which is useful to the community at large."

Qu. 13,556. "The State has already, to a considerable extent, recognized, has it not, that duty; and there are a considerable number of scientific institutions supported more or less by the State?—No doubt the State, in the money that it gives, and has given in past times, to the best Universities, has recognized that duty."

Qu. 13,557. "There are the Observatory at Greenwich, the British Museum, and Kew Gardens; you would consider those as instances in which the State aids the promotion of science?—They would be all instances in point; and I do not apprehend that as to the abstract doctrine itself there has ever been any serious contest." * * *

Lord Derby's Evidence in favour of State Aid to Science is all the more weighty from the limitations by which he guards it:

Qu. 13,513. "I think there has been a very general consent amongst a large number of men of science who have been examined before this Commission that in the present state of science there are many branches as to which there is no probability of their being advanced to the degree to which they are capable of being advanced by private effort, and without the assistance of State funds in some shape; what is your Lordship's opinion upon that subject? —I am, as a general rule, very strongly in favour of private effort, and very decidedly against the application of State funds to any purpose that can be accomplished without them; but I think that if there is any exception to that which I venture to call a sound and wholesome rule, it is in the case of scientific research, because the results are not immediate, they are not popular in their character, and they bring absolutely no pecuniary advantage to the person engaged in working them out. A great mathematical or a great astronomical discovery is a benefit to the whole community, and in a certain sense to mankind in general; but it is productive of absolutely no benefit, in a pecuniary point of view, to the person who has given his labour to it.'

Sir Stafford Northcote thus states his opinion on the point:

Qu. 13,623. * * * "The State should do what it can both to promote scientific education and also to assist in the prosecution of scientific experiments and inquiries when they can be best prosecuted by the aid of the State."

On the proposition that it is the duty of the State to encourage Original Research, we might multiply our extracts from the Evidence indefinitely. Dr. Frankland, Sir W. Thomson, Dr. Joule, Mr. Gore, Dr. Carpenter, Professor A. W. Williamson, Mr. Reed, Sir E. Sabine, Dr. Siemens, Dr. Sclater, Mr. Farrer, Admiral Richards, and numerous others, show that the Aid of Government to Scientific Research has been beneficial, so far as it has gone, but that it has been insufficient and should be increased.

We have selected the Evidence of Dr. Frankland and Sir W. Thomson from amongst that given by men of Science.

Dr. Frankland's Evidence is to the following effect:

Qu. 5883. "Setting aside the interests of science, what would be your expectation under equal circumstances otherwise, in reference to two countries, in one of which scientific research was neglected, whilst in the other it was pursued with considerable vigour, with regard to the progress of the arts and of manufactures?"

"In my opinion there could not be any doubt but that the nation which neglected science must suffer in the end, because although it could buy scientific inventions from the other country, yet still it would always be behind, as it were, in the market; it would have to follow the lead of the other country, which I imagine would be a commercial disadvantage."

Qu. 5884. "Might it not also be the case that the appreciation of the commercial value of scientific inventions would be very much more uncertain in the one country than in the other?"

"Yes. It is also much more difficult to establish manufactures upon new inventions in a country which neglects science, because you cannot have either workpeople or managers competent to conduct those processes which depend upon scientific principles."

Qu. 5885. "People might pay large sums for what was worthless, and neglect that which was of great value?"

"They might."

Qu. 10,736. Sir W. Thomson emphatically asserts that, in his opinion, it is of the most immediate consequence to the honour and welfare of the country that men should be enabled to

live on Scientific Research, and that a definite and secured position should be given to Scientific Workers.

In another part of his Evidence he states:

* * * * "There are many investigations which can only be done by the nation as a whole; and viewing the Government in one sense as acting for the nation, as it were a committee of the whole nation, there are very many investigations not merely of importance with reference to promoting the material prosperity of the nation, but valuable to the nation as promoting scientific discoveries, in which the whole nation takes a pleasure, and from which the whole nation derives as great benefit as anything material can possibly produce. Investigations for which a large expenditure of money is necessary, and which must be continued through long periods of years, cannot be undertaken by private individuals. Generally speaking, I believe that if the Government is well advised in respect to science, it will be for the good of the nation that the Government should make it part of its functions to promote experimental investigations in science." Qu. 2,693.

As representing the opinions of public servants occupying high official positions in Government Departments, we may refer to the Evidence of Admiral Richards, late Hydrographer of the Admiralty, and to that of Mr. Farrer, Secretary to the Board of Trade, the latter of whom, in answer to the question—"Have you formed any opinion "as to whether further grants ought to be given by the Government for Scientific Research?" says: Qu. 12,642.

"I can only give an opinion which is of very little value; but I think there can be no doubt whatever that there are numerous subjects, and always will be numerous subjects, in which private observers are unable to do what is wanted. For the older sciences you have had observatories established at the Government expense, for astronomy, and now, recently, for meteorology; and those cannot be the only sciences to which assistance ought to be given on the same principle."

Evidence relating to the Establishment of Laboratories.

We proceed to give extracts from the Evidence placed before us in reference to the need of Laboratories for conducting alike Chemical, Physical, Metallurgical, and Physiological Inquiries, both for Departmental Work, and for the Researches of Private Individuals. Where the Evidence is of a general character, and includes proposals regarding Observatories also, we give it here, although we shall deal with the special question of Physical Observatories separately.

Amongst the witnesses who are in favour of the erection of new Laboratories for Research is Colonel Strange, whose view of the National Requirements in these respects is thus given:—

"Will you be so good as to enumerate the institutions which you think should be under the State?—(1,) an observatory for physics of astronomy; (2,) an observatory for terrestrial physics, namely, meteorology, magnetism, &c.; (3,) a physical laboratory; (4,) an extension of the Standards Office: (5,) a metallurgical laboratory; (6), a chemical laboratory; (7,) an extension of collections of natural history, and an able staff of naturalists; (8,) a physiological laboratory; (9,) a museum of machines, scientific instruments, &c. I believe that under one or other of these and existing institutions every requisite investigation will range itself. I have not stopped to inquire whether one or another is more or less important. My aim in the spirit of my postulate No. 2 has been *completeness*. It may be necessary for a manufacturer to prosecute only such particular investigations as promise direct and speedy profit. A great nation must not act in that commercial spirit. All the operations of nature are so intimately interwoven, that it is impossible to say beforehand that a given line of research apparently unproductive may not throw light in unsuspected directions, and so lead to untold and undreamt of treasures." * * * * Qu. 10,441.

Sir W. Thomson's Evidence is as follows:—

"Are you of opinion that any national institutions supported by the Government are required for the advancement of science?—I think that there ought to be institutions for pure research supported by the Government, and not connected with the Universities. The only suitable place at present for such institutions would be London, or the neighbourhood of London; in that situation, I believe, very great things could be done by institutions for pure research, at which work of a very great immediate money value would be produced at an extremely moderate cost, and I believe that discoveries redounding to the honour, and credit, and pleasure of this country would infallibly be made." Qu. 10,696.

"Are you able to give any idea as to how many such institutions would be required?—There should be five. One at present exists, namely, the Royal Observatory at Greenwich. Another in my opinion is very much wanted, an observatory for astronomical physics, then again a physical laboratory, and a laboratory for chemical research, and a physiological laboratory are necessary." * * * * * Qu. 10,697.

"Would such a physical laboratory differ in any essential respects from a physical laboratory attached to an University?—Yes; it would be adapted solely for research, with no provision for pupils except what may be called apprentices, or pupils for research; no provision for teaching the mere elements of manipulation, but provision for researches directly adapted to increase knowledge, and for making pattern researches for the sake of training research pupils who had already gained experience and proved ability in institutions of instruction." Qu. 10,703.

"Would you leave the researches to be carried on at such a laboratory mainly to the discretion of the person who had charge of it, or would you place it in any degree under the control of the council of which you have been speaking?—I would leave it to the discretion of the person who has charge of it." * * * Qu. 10,704.

Qu. 10,705. "And that the Government should also be able to command investigation on the advice of the council?—Yes."

Qu. 10,706. "Of course the director would report?—Yes, the director would report on everything, both researches undertaken at his own instigation, and investigations undertaken for the council, or for the Government."

Qu. 10,707. "And your view of what should be done in the chemical and physiological laboratories would, I presume, be something of the same nature?—Yes, something of the same kind, *mutatis mutandis*."

Qu. 10,709. "With respect to the apparatus, and the annual supply of apparatus, it is probable, is it not, that the physical laboratories would be the most costly?—Yes, the most costly in apparatus."

Qu. 10,710. "Some very fine instruments of a costly kind are now required in physiological inquiries, and large pieces of apparatus are sometimes employed, such as the respiration apparatus at Munich, which was put up on the recommendation of Professor Pettenkofer?—Yes, it would be in my opinion necessary not to limit to a fixed endowment the expenditure of any one of those institutions, but to let it be determined (if I may use the expression once more) by natural selection; applications for money to be made to the council to be duly weighed, and the council to apply to the Treasury. That would be much more economical than giving a fixed sum which, being to be spent, might be spent without due regard to economy, or which, on the other hand, might prove to be insufficient for valuable researches, causing the institution thereby to be crippled and to lose efficiency.'

Qu. 10,711. "You would not think it indispensable, would you, that such institutions, if the Government thought fit to establish them, should be in the heart of London, or in any very central situation?—No; it would be much better that they should be in the country in positions conveniently accessible to London. For a physical laboratory quietness of the ground is of immense importance. It would be impossible to make a great deal of the most important scientific investigations in a physical laboratory within 100 yards of any of the great thoroughfares of London, and a much greater distance than 100 yards is quite necessary for many such investigations."

Qu. 10,712. "You would not institute any regular provision for teaching in those laboratories?—No."

Qu. 10,713. "But you would allow young men or students who wished to carry out original research to avail themselves of them under the direction of the persons who were in charge of them?—Yes, under the direction, and to some degree under the instruction of the persons in charge; but the instruction should be limited to methods for advancing science. The director of such an institution must not be occupied with lecturing in any other institution, or with lecturing at all. He ought indeed to be prohibited from lecturing, except one or two occasional lectures in the course of a year."

Qu. 10,714. "You think that the object for which you recommend the establishment of those laboratories could not be accomplished by any other means—not by investigations carried on in other laboratories in the country?—Certainly not by any other means."

Dr. Frankland thus refers to the double function which such Laboratories might perform, and states his view in reference to their management:—

Qu. 11,064. "Can you make any suggestions as to stimulating original research in this country?— * * * We have in this country a considerable body of investigators who are not engaged in teaching at all, and I think that this is a peculiarly hopeful feature of our case. It shows that the English have not only a taste for research, but that they have a natural talent for it. We have numerous men like Mr. Gassiot, Sir W. Grove, Dr. De La Rue, Mr. Spottiswoode, Mr. Huggins, Mr. Duppa, Mr. Buckton, Mr. Joule, Mr. Lockyer, Mr. Perkin, Mr. Schunck, Colonel Yorke, and others whom I could name, who are not in any way engaged in teaching, and never have been, but who have made important original researches, and have spent a good deal of their time in the working out of new discoveries. Now that method of stimulating research, which I have mentioned in my former examination, would not of course apply to them. Men of this class are really peculiar to England, for I have never known any such instance in Germany or in France, of men altogether disconnected with teaching taking up research in the way it is done in England. I think that for such men the establishment of national institutions such as those which are recommended by Colonel Strange would be peculiarly useful. In fact, I have heard several of these gentlemen express strong opinions as to the great advantage it would be to them if they could go to some institution of that kind to conduct research, where expensive instruments, which are often required for their experiments, were provided for a number of such investigators, and where appropriate rooms for carrying on these researches could be had. It is exceedingly difficult to carry on chemical research in one's own house, because of the want of proper contrivances for dealing with corrosive gases and vapours; and hence appropriate buildings ought to be provided for carrying on such investigations. I think, therefore, that it would afford a great stimulus to research of this kind if such institutions were provided, and furnished with such instruments as would be generally useful in research, leaving the more special instruments and materials adapted to the particular researches themselves, to be provided by each operator. * * * I have reason to believe that no inconsiderable number of men, more especially of those educated in some of the science schools, would undertake researches if such facilities were afforded them."

Qu. 11,065. "Would you consider the chief use of such institutions as laboratories to be to enable private inquirers to carry on their researches, or would you propose that any investigations should be carried on there on behalf of the State?—I think that both things might be provided for. The State requires many important investigations to be carried on. * * * That might well form one part of the objects of such a building, but I should think that so far as abstract research, of which we are more especially speaking now, is concerned, the other portion of those objects, namely, the encouragement of original investigation in the case of amateurs would be more important, because the investigations made for the Government are essentially practical investigations; they are not usually of that character which lead to discoveries or to the advancement of science."

Qu. 11,066. "Would you place those laboratories under a permanent official?—They must of necessity be under the direct and constant superintendence of some one thoroughly conversant with the operations going on in them; and, so far as the conducting of the separate original researches is concerned, I think that it would be very desirable that the admission into such institutions should be granted through some such body as the Research Fund Committee, for instance, of the Council of the Royal Society, or some body of that kind, who would make intelligent and impartial inquiry into the qualifications of the men applying for accommodation."

Qu. 11,067. "You would not throw upon the director the sole responsibility of deciding who should be admitted and who should not?—I think that would not be desirable."

Qu. 11,068. "And I understood you to say that you would not think it desirable that the Government should direct any specific original research to be carried on, except with reference to some practical purpose?—Except with regard to subjects about which the Government wished for information, I think it is much better for each

man to devise his own research; he takes much more interest in it, and is much more likely to pursue it with vigour than if it is prescribed for him."

"And do you think it would be requisite that those institutions should be on a large scale?—I think that they ought to be on a fairly large scale even to begin with, because it is always a costly process to rebuild such institutions; and I am inclined to think that they would be rapidly filled. A tolerably large institution of that kind would probably in a very few years be filled with workers." Qu. 11,069.

"You would not recommend, in the first instance, at least, more than the establishment of one for each department of science?—I think not more than that." Qu. 11,070.

"And should it be in London?—Yes, I suppose they must be commenced here, but eventually it would be desirable that the important centres in the provinces should also be furnished with such places." Qu. 11,071.

"Colonel Strange recommended the establishment of four laboratories; should you be disposed to agree with him in that view?—Yes, I think that those would be necessary; perhaps the least essential of them would be the metallurgical one, but certainly the others would be quite essential." Qu. 11,072.

"Could that be combined with the chemical laboratory?—I think the metallurgical one, in the first instance, might be combined with the chemical laboratory, as the processes are similar. There would be the chemical laboratory, the physical laboratory, the physico-astronomical, as we may term it, and the biological. It would be necessary, in connexion with the physico-astronomical observatory, to have the means of performing various chemical experiments and making physical observations. Of course the chemical operations would be quite subsidiary to the cosmical observations there." Qu. 11,073.

Mr. De La Rue expresses himself as follows:—

"Are you of opinion that any new institutions in the way of laboratories should be established by the State?—I hold it to be so important that Chemistry should be extensively cultivated in England, that I would strongly advocate that there should be a State laboratory. That State laboratory should undertake all the chemical work which the Government might require, but at the same time, according to the views which I hold, it ought to be such an establishment as could afford facilities to men who have completed their scientific education, and who might be desirous of continuing original investigations, in which space for working and instruments should be afforded them, and, moreover, if men were not in a position of fortune to continue their researches, in some cases materials and even money might be granted to them on the recommendation of the council. I may state that of my own knowledge I know that chemical science at present is not progressing in England in a satisfactory manner, that we do not make so many original researches as our continental neighbours, particularly the Germans, do. In Germany very great patronage is given to science, magnificent laboratories have been built, and the students, who, after they are sufficiently advanced, are encouraged to make original investigations, contribute at present most largely to scientific Chemistry." Qu. 13,054.

"Do you think that the establishment of those Government laboratories would be likely to give rise to complaints from any existing institutions?—I think not, if those Government establishments were not educational establishments. There would be a natural jealousy on the part of educational establishments if the Government were to undertake to educate students without charge; but what I contemplate is merely that facilities should be given to men who have already been educated, and not to interfere at all with the functions of educational establishments." Qu. 13,063.

* * "I think that some good might be done by aiding educational establishments; but I believe that the more advantageous course would be for the State to afford facilities in the laboratory which it might require for other purposes." Qu. 13,105.

"Do you think that any other laboratories would be needed?—I attach the greatest importance to a chemical laboratory, because I believe that Chemistry is destined to play a very important part in the advancement of the arts in all civilised countries, but there also ought to be a physical laboratory, very much on the same footing as the chemical laboratory, and in which facilities should be afforded for conducting physical investigations." Qu, 13,057.

"You would give admission to those laboratories on the same principle as to the chemical laboratories?—Yes, to men who could show that they were qualified to make a beneficial use of them." Qu. 13,058.

"You think that any investigations required by the State should also be conducted there?—Yes, they should be conducted in either the chemical or physical laboratory, according to the nature of the investigations. For example, there were a great number of investigations carried on at Woolwich relating to the strength of different alloys whose chemical composition was determined by analysis. Such investigations would be very well conducted in the chemical laboratories." Qu. 13,059.

"Would you transfer the work now done at Woolwich to such a laboratory?—Part of the work, but I would except such special work as could be better done at each of the Government establishments. Special investigations would fall within the duties of the central government laboratory. The testing of the purity of the products to be used in the department, and routine work, would be better conducted in those establishments." Qu. 13,077.

"With respect to the other purpose of the laboratory, do you think that there would be a sufficient number of independent inquirers to occupy an establishment like that?—I think that there would be a great number of men who would be very glad to avail themselves of such opportunities as a laboratory of that kind would afford, and their doing so would not add materially to the cost of the establishment." Qu. 13,078.

Mr. Gore also recommends the establishment of Laboratories:—

"Are there any measures that you can suggest to the Commission which you wish to see adopted in order more effectually to promote this object than is the case at present?—I propose that national laboratories should be established, in which abstract scientific investigation alone should be carried on. I propose that in those laboratories scientific investigators should be wholly employed upon abstract original investigation, and be paid for their labour and be supplied with the necessary means in their respective sciences, leaving each investigator to choose his special subjects of research." Qu. 10,782.

"Perhaps you could explain to the Commission rather more fully what should be the general character of those laboratories?—For making original scientific investigations in the subjects of chemical physics and chemistry. I speak only within the subjects with which I am familiar." Qu. 10,784.

"Do you refer, in this recommendation, to the establishment of a physical laboratory?—If you mean by a physical laboratory one in which the sciences of heat, light, electricity, and magnetism would be investigated, I should mean a physical laboratory." Qu. 10,785.

"And you think that that ought to be distinct from a laboratory for chemical physics and chemistry?—Yes, I think distinct from the laboratory for chemistry only." Qu. 10,786.

Qu. 10,787. "I understand you to recommend that this should be a Government institution supported entirely by Government funds?—Yes, I do recommend that."

We next proceed to refer to the Evidence in which other views are expressed. It will be seen that it is rather in favour of the utilization and extension of existing, than of the establishment of new Laboratories. We shall confine ourselves to extracts from the Evidence of Dr. A. W. Williamson, Dr. Siemens, Dr. Burdon Sanderson, and Lord Salisbury.

Dr. A. W. Williamson—

Qu. 12,696. "A good deal of evidence has been offered to the Commission in favour of establishing and maintaining laboratories of research at the expense of the State, in order to give opportunities to original inquirers to carry on investigations. Have you formed any opinion of the expediency of such arrangements?—I think that to establish a laboratory for research only would be beginning at the club end, and would be decidedly inadvisable. I think that the main thing for research is to give to schools, and especially to the higher schools, proper facilities for it, and to develope them greatly. At the same time, it is quite possible that, in exceptional cases, research might with advantage be carried on in separate places; but I should always view with regret, as a waste of resources, the separation of that higher work of research from the more humble work of teaching, which naturally belongs to it. They help one another, and I think that each would lose from being separated from the other; still, in some cases, it might possibly be advisable."

Dr. Siemens—

Qu. 11,804. "What is your opinion as to the establishment of laboratories at the Government expense?—I would recommend the establishment of observatories but not of laboratories, for the same reason, that in laboratories unconnected with teaching, as have been proposed, using the public conveniences, and public money, there would be a necessity for results which would lead to a certain extent to something approaching charlatanism in the enunciation of those results; and, moreover, I consider that it might lead to disappointment in many, who would believe that they had an equal right with others to take advantage of such establishments."

Qu. 11,805. "Do you consider that laboratories are required in greater numbers, and better equipped than they are at present?—I think so, decidedly."

Qu. 11,806. "But still you would not remedy that defect by establishing Government laboratories?—Not by establishing Government laboratories, but by granting Government aid towards the establishment of laboratories, and chiefly by the endowment of chairs."

Qu. 11,807. "Do you think that laboratories should chiefly exist in connexion with universities or other teaching institutions?—I think so, because we should always look to the coming generation, upon which the future depends chiefly; and a well appointed academical laboratory presents great opportunities for a student, under a great leader, to attain to eminence himself."

Qu. 11,820. "With reference to national physical laboratories, it has been suggested to the Commission by several witnesses that such laboratories might be of use, not so much for the researches to be carried on officially in them, but as giving opportunities to private individuals for carrying on researches in them; has it occurred to you whether, in that point of view, they might be useful or not?—They might be useful in certain cases; but if the Government takes in hand such a thing, there must always be favouritism. It would be impossible to grant such facilities to all applicants, and it would be very difficult for the Government to use such discrimination. Any university or society could do so by granting facilities to men who had given promises of success by reading papers, or by fully explaining their objects in view; but for the Government to use such discretion would be impracticable, I think."

Qu. 11,821. "Then you think that there should be such laboratories that should be available to persons who could not afford, for instance, to have a physical laboratory of their own, but you do not think that such laboratories should be under the control of the Government, or should be Government institutions?—They should be exceptional cases altogether. If, in any existing laboratory, whether Government or otherwise, an instrument existed necessary for certain research, I think that facilities might be given occasionally to an applicant, but I am of opinion that it would not be desirable to establish what might be termed a national workshop of science."

Qu. 11,822. "Is there any such institution in Germany as a physical or other laboratory (apart from astronomical observatories), independent of an university or an educational establishment?—I believe not. There are laboratories connected with Polytechnic or Mining schools, but still they are connected with teaching."

Qu. 11,823. "Has any difficulty been found in affording facilities in those laboratories to original inquirers who may not belong to the school?—It would not be difficult for any one to get access, for instance, to the laboratory of an University. If he entered his name, he would be allowed to go into the laboratory, and, under certain restrictions, imposed by the Professor, carry on his researches."

Qu. 11,824. "Are those laboratories, as established in Germany in connection with the universities and other educational institutions, quite sufficient for all the wants of science and of original investigation in science?—Whether more might be done by increasing their number I am not prepared to say, but still there seems to be no expressed want for additional laboratories."

Qu. 11,825. "At any rate you would not propose to establish laboratories on a different footing?—No."

Dr. Burdon Sanderson—

Qu. 12,302. "Will you proceed to state in what way you consider that money might be applied for the promotion of physiology?—I consider that it might be available for three purposes; namely, for the improvement of laboratories, for the providing of instruments and materials for research, and for the remuneration of workers. I will speak first of the spending of money upon the improvement of laboratories. I do not myself see at the present moment that we are in a position to require the expenditure of large sums of money upon the building of large laboratories, for this reason, that if such laboratories were built we should not have workers to work in them; at present we have not men to work in the laboratories that we actually possess. We have men of a certain class, but we have not men of that trained class which we require. I am of opinion that a physiological laboratory to be of any use at all must be in connexion with the great schools of medicine. A physiological laboratory at a distance from such schools would fail for want of people to work in it. Physiology will never flourish, therefore, excepting in connexion with the two arts which are dependent upon it. Just as vegetable physiology will flourish best in connexion with agriculture, so also animal physiology will flourish best in connexion with medicine. I think that grants might be very advan-

tageously given for the improvement of the laboratories now existing. Of course, in the administration of such grants, one would go upon the principle 'to him that hath shall be given;' that is to say, wherever a good laboratory exists, or wherever men are to be found to work a laboratory, and where there are likely to be students to work in it, money should be given to carry out improvements. I would further notice that in physiological researches, the expenditure for materials is usually much greater than for instruments, and consequently money is more wanted for current than initial expenses; for this reason large sums ought not to be expended in the purchase of collections of costly instruments, for if such sums were spent they would probably not be used. It is much better to provide money to assist to meet those heavy expenses which are required for material. To show this it would merely be necessary to refer to some of the physiological researches which are now being carried out, in which a great expenditure is required for material, but no tremendous expense for instruments. Of course I do not mean to say that it is not necessary to spend money on instruments, but any expenditure on a large scale for this object would be very likely wasted. On the whole I believe that money can be more economically spent in sums paid for work done than in any other way, *i.e.*, either in the way of periodical payment to men of acknowledged competency, for the purpose of carrying out inquiries of long duration, or in the form of separate grants for special researches, or in the form of grants for skilled assistants. * * * * Of course in Germany men who do this work are not paid, and it is very necessary to bear this in mind, but the difference there is that such men have something to look forward to. There are in Germany numerous teaching appointments to which a man can look forward with the certainty that if he works industriously for a certain time, he is sure to get an appointment of some kind afterwards, which will enable him to take the position of a professor. This state of things does not exist in England, and therefore it is more necessary in England to encourage the younger men to engage in research by pecuniary aids than it is in Germany."

Lord Salisbury—

"In speaking of the establishment of laboratories by the State, your Lordship appeared to me rather to refer to chemical laboratories; but it has not escaped your attention, I am sure, that the cost of physical apparatus is so very great as to put physical inquiries really out of the reach of a very large number of persons who probably might be capable of conducting such researches; and in consequence of there being no such assistance assigned to such persons as a State laboratory, in which they could obtain the use of apparatus, and of a really fitting building, constructed with sufficient solidity for the purposes of research, a great many persons are prevented from entering upon researches of that kind by the want of means; and it has been contended that by providing laboratories, at the expense of the State, you would be doing no more for such persons than has been done for learned men by providing them with great public libraries, as you would be only providing them with the opportunities of research, which otherwise they could not have?—My fear would be that there would be a difficulty in providing laboratories in sufficient numbers to satisfy all, as you can provide books at the British Museum to satisfy all, and that the result would be that very often those who are least fitted to obtain any useful result would engross the instruments. For the purpose of really first-rate workers, I think that the Government might very advantageously be liberal; but such liberality I think would best take the form of an increased grant to the Royal Society. But I should be doubtful whether it was possible by any moderate expenditure of funds to provide an expensive class of scientific instruments of all kinds for all the persons who might be inclined to use them." Qu. 13,590.

Evidence relating to the Establishment of Physical Observatories.

On the general question of the Establishment and Maintenance of Physical Observatories, Lord Salisbury agrees that:

* * * "Some of these institutions which have been alluded to in your Grace's question, especially observatories, clearly fall within the duties of the Government; and certainly, from all that one hears, it is probable that their duty in that respect is inadequately performed, and that observatories for a much larger range of observations might with great advantage be multiplied." * * * * Qu. 13,575.

Sir George Airy thus states his view on the subject:

"When I began to be an astronomer, such questions as those of the constitution of the sun and the like were not entertained." * * * * Qu. 10,481.

"Are you prepared to express an opinion as to whether it is an object which would be a proper one for the Government to take up as a State establishment?—The Government are already pushed very hard in their estimates. The screw is always put upon them, 'Cannot you reduce the estimates a little more?' And then it would always come to a question of extensive feeling in the House of Commons, and of popular feeling out of the House of Commons; and I am confident from what I have seen that those two bodies would not in every case support an extension." * * * * Qu. 10,485.

"Should you say that it is an object which is not very likely to be prosecuted with sufficient vigour unless taken up by the Government?—I do not see how it could go on except it were taken up by the Government. I do not believe that it could go on in any other way." Qu. 10,486.

"It is not likely, you think, to be prosecuted by private individuals, or by other public bodies such as the Universities?—No, I think that their funds are almost all required for other objects, and the difficulty even of getting the business into shape is extremely great." * * * * Qu. 10,487.

"Then such observations, in all probability, will either not be made at all or must be taken up by the Government?—That is my view." * * * * * Qu. 10,488.

Mr. De La Rue's opinion is thus given in reply to question 13,066:

"I think that the time for the State providing means for reducing observations has now come: when the State should take up, besides mathematical astronomy (which deals with the places of the stars and planets, and the moon especially), physical observations, more particularly observations of the sun, which appear to me to bear directly upon meteorological phenomena." * * * * Qu. 13,066.

He says further, in regard to observations of this nature, that they necessitate "a "certain staff of assistants, and require continuous superintendence, hence it is necessary "that an amateur astronomer who undertakes such work should have leisure during

" the day, and that he should be able to pay for duly qualified assistants, and such men " have to be highly paid."

Sir W. Thomson points out the importance of multiplying such Observatories :

Qu. 10,698. * * * " In respect to the observatories, it might be necessary to have several observatories for astronomical physics in this country, if it were only to secure observations of interesting conjunctures, notwithstanding the varieties of the weather, that there may be in different parts of the country ; and, again, observatories for astronomical physics ought most certainly to be founded in other parts of the British dominions than England, Ireland, and Scotland ; in other latitudes and on the other side of the world."

Dr. Siemens expresses the same view in the following Evidence :

Qu. 11,789. * * * " An observatory or several observatories should be established for carrying on physical research, research to obtain information on general subjects, such as solar observations, magnetic observations, and other subjects that might be thought desirable to obtain continually information upon." * * * * *

Qu. 11,864. " I think that almost the only new establishments which you recommend are certain physical observatories ?—Yes."

Qu. 11,865. " What would be the principal object of such observatories ?—For the purpose of magnetic observations, solar observations, and other general inquiries into physical phenomena."

Qu. 11,866. " Do you contemplate the establishment of more than one such observatory ?—Probably more than one would be desirable."

Qu. 11,867. " Do you contemplate the establishment of any such observatories in any of the colonial possessions of the country ?—Yes, I think so."

Qu. 11,868. " Speaking generally, would they be costly establishments to found ?—Not very costly, not so costly as astronomical observatories."

Dr. Frankland has also given Evidence on the importance of promoting the study of

Qu. 11,073. Astronomical Physics, pointing out that " It would be necessary, in connexion with the " Physico-Astronomical Observatory, to have the means of performing various chemical " experiments and making physical observations. Of course the chemical operations " would be quite subsidiary to the cosmical observations there."

Qu. 13,067. Mr. De La Rue, in reference to locality and organization, in answer to the question whether provision for carrying out Observations of this character should be in connexion with the Greenwich Observatory, says :

" In connexion with the Greenwich Observatory, yes, but at the Greenwich Observatory I should say not. I do not think, in the first place, that there is space enough at Greenwich, and the duties of the staff are already so very onerous that it would require a separate establishment for such special work ; besides other new buildings it would entail a chemical laboratory, and there is hardly space for those at Greenwich. I believe also that it would cause too divided attention on the part of the Astronomer Royal, if he were called upon to personally superintend investigations in the physics of astronomy, although I think it would be very desirable that any new establishments, if they are to exist, should be affiliated to Greenwich."

Being asked whether the new establishment should be in the neighbourhood of Greenwich ? he replies :

Qu. 13,068. " Not at all necessarily so. In fact Greenwich would not be at all desirable for some class of observations, it is much too near London."

Qu. 13,069. And in answer to the question " Would you place the proposed new observatory for " those purposes in any respect under the control of the Astronomer Royal ?"—

" It would be desirable that the State should have to deal only with one astronomer. Possibly by the increase of the claims upon his attention it might be desirable for the Astronomer Royal to have directors under him, so that he should not have to devote so much time to details even of the Greenwich Observatory, but I do not think that the State ought to have to deal with a great number of astronomers, indeed there might be some difficulty in its doing so."

Qu. 13,071. He says further, " In order to obtain a daily record, I would advise that one or possibly " two observatories should be established in India, and one at the Cape of Good Hope." " At the Kew Observatory it was frequently cloudy for several consecutive days."

Admiral Richards says :

Qu. 11,625. " If you are going permanently to establish physical observatories, I should prefer to see separate ones. I think that the physical work probably would be better separated from the Royal Observatory."

Qu. 11,626. " You think that the two classes of observations are so distinct in character as to render that desirable ?—Of course there is a certain amount of meteorology that must be observed at the astronomical observatory ; but it need not be of any extended character."

Qu. 11,991. Mr. Spottiswoode's Evidence is as follows :—

" The Observatories which you recommend could, in your opinion, be attached to existing Observatories ; an Observatory for Solar Physics, for instance ?" " This might be met by an extension of the existing Observatories."

Qu. 11,992. " Do you think that it would be as useful, if attached to Greenwich, as if a special observatory were established for the purpose ?—I have no doubt that if an independent observatory were adapted to that purpose and furnished with adequate instruments, and manned by such a staff as one could wish, more would be done in such an independent observatory, so manned, than by a branch of the Royal Observatory at Greenwich, but, at the same time, that would involve such a much larger expense, that I thought that the question of expense would perhaps outweigh the scientific advantages to be gained by it."

" Do you think that a great deal might be done by making some additions to the present Observatories ?"

"A great deal, because in a large observatory there are, not unfrequently, instruments only partially employed. For example, at Greenwich there is a large and very fine instrument suited to the investigation of solar physics, which is, at all events, largely disposable for such observations." Qu. 11,993.

It will be seen that most of the Witnesses dealing with Physico-Astronomical Observations recommend that, whether or not they be placed under the control of the Astronomer Royal, they should certainly beconducted by Special Directors, and be placed by preference in localities which the Witnesses deem to be better adapted to the purpose than Greenwich.

Such is not the opinion of the Astronomer Royal himself. Sir George Airy thus deals with the question specially referring to the difficulty as to space at Greenwich, and the mode of management:—

"Do you think it would be practicable to adopt any measures at the present observatory at Greenwich to make observations of that character?—I think it is possible that it might be done, but I am not prepared with a plan at present, and I am very much inclined to think that the difficulties in these matters will be rather in detail than anything else. There is always a difficulty in keeping an observatory of rather an indefinite character in such a state that it will satisfy the public demands." * * * Qu. 10,482.

* * * "It has been found necessary within the last three or four years to extend our grounds at Greenwich. * * * Judging from what occurred in our case, I do not think that there would be any difficulty in further extension; where it would be in sufficient proximity to the Royal Observatory to be under the same general control." Qu. 10,483.

"If a department of that kind were instituted, do you see any objection to its being placed under the Astronomer Royal, or would it give him too much to do?—It would give him much to do, but a great deal may be effected by organisation, especially with the license to have officers of good position under him; to have lieutenants of a good class." * * * * Qu. 10,484.

A Resolution in general accordance with the views expressed by Sir George Airy was transmitted to us in July 1872, by the President and Council of the Royal Astronomical Society. This Resolution is in favour of the extension of the Royal Observatory at Greenwich and other existing Astronomical Observatories, and does not recommend the Establishment of an independent Government Observatory for the cultivation of Astronomical Physics in England. Appendix VII., Vol. II. p. *31*.

In connexion with some points on which differences of opinion have been expressed in this Evidence, we give the following extracts from a Paper handed in by Colonel Strange, consisting of questions addressed by him to Professor Sir W. Thomson, Professor Hilgard, the Secretary of the American National Academy of Sciences, and Professor Balfour Stewart, and to M. Faye, the President of the French Academy of Science; and their replies thereto. Appendix VII., Vol. II. pp. *27–31*.

Colonel Strange's questions, and the replies to them, were as follows:—

"(1.) Is the systematic study of the solar constitution likely to throw light on subjects of Terrestrial Physics, such as Meteorology and Magnetism?

"(2.) What means, at present known to Science, are available for studying the sun?

"(3.) Do you consider that Photography (one of the assumed means) will suffice for the purpose?

"(4.) Do you consider that the class of observations (defined in your answer to my question 2) are such as can be efficiently made in an observatory maintained by the State, or that any of them would be better left to the zeal of volunteer astronomers?"

"[Addressed to M. Faye only.]

"(5.) Do you consider that it would be advantageous to carry on Physico-Astronomical researches on an extensive scale, and Meridional observations, in one and the same observatory, under a single director?"

Sir W. Thomson:—

* * * * * * * * *

"The subject of investigation in any observatory for Astronomical Physics is so very different from that for which the great Astronomical observatories at present existing were founded, that I believe generally it would not be good economy of resources to attempt to adapt the old observatories to the new investigations. The instruments adapted for accurately determining the positions of the heavenly bodies, which constitute the most important part of the great observatories hitherto established, are scarcely adapted to give any contribution towards Astronomical Physics. New instruments designed for the work of the spectroscope, and new buildings to contain them, are necessary. A chemical laboratory, and an extensive system of galvanic batteries and electro-magnetic apparatus are required for the new kind of Astronomical observatory. I doubt very much whether one man could act effectively as executive chief of an observatory of Astronomical Physics, and at the same time of an observatory of the old kind."

Professor Hilgard:

"(1.) That the systematic study of the sun's constitution is likely to throw light on subjects of terrestrial physics, I would unhesitatingly affirm; yet without expressing the belief that the minor meteoric or magnetic variations are dependent on changes taking place in the sun.

"(2.) The available means for studying the sun at present known to science are, in my apprehension, in addition to observations made with the eye, solar photography, photometric and calorimetric observations, and spectroscopic observations, combined with laboratory experiments necessary for the interpretation of the latter.

"(3.) I do not think that photography alone will suffice for the purpose indicated, since it will give little else than a registration of solar spots, the study of which by means of the spectroscope appears to be also of prime importance.

"(4.) I perceive no difficulty in organizing the several classes of observations above mentioned systematically, so as to be efficiently made in an observatory maintained by the State. Similar considerations to those upon which the maintenance of meteorological and magnetical observations is based, would warrant a provision for systematic observation of the sun.

" The value of the latter, as of the former classes of observations, largely depends upon their regular continuity, which cannot be expected from the zeal of volunteer observers, who must look for their reward to results of immediate interest."

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Dr. Ba.four Stewart :

" In reply to your first question, I cannot help thinking that a study of the solar constitution is likely to throw light on the subjects of Terrestrial Physics, such as Meteorology and Magnetism. My reasons are :—

" (1.) That I consider the *fact* of a connexion between sun spot activity and disturbances of the earth's magnetism to be very well proved, although we are ignorant of the *nature* of the connexion.

" (2.) The recent researches of Mr. Baxendell, Mr. Stone, Professor C. P. Smyth, and others, render it extremely probable that there is likewise a connexion between the period of solar activity and the meteorology of our globe.

" (3.) The recent researches of Messrs. Warren De La Rue, Stewart, and Loewy, as well as those of Professor Wolf, render it very probable that there is a connexion between the positions of the chief planets and the behaviour of sun spots.

" (4.) The recent observations of Messrs. Browning and others render probable a connexion between the appearance of the planet Jupiter and the state of the solar disc.

" I think that all these, taken together, can leave us in little doubt of our duty with regard to solar observations. If we were not only perfectly sure of a connexion, but likewise knew all about the nature of this connexion, the necessity of studying the sun would yet be as strong as that of recording the positions of the various planets with the view of verifying the law of gravitation. But inasmuch as here the nature of the connexion is unknown, it is of imperious necessity to study the sun with the view of accumulating a sufficient number of good observations which may ultimately enable us to determine the nature of this unknown connexion.

" We ought to remember how greatly the accurate observations of Tycho Brahe contributed to the generalizations of Kepler.

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" In reply to your second question, I would enumerate the following means of observation of the sun :—

" (1.) Eye observations through a telescope.
" (2.) Photography.
" (3.) Spectroscopic observations.
" (4.) Actinic observations.

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" In reply to your third question, I do not consider Photography sufficient for the purpose. I think that eye observations, more particularly when combined with the spectroscope, are essential to enable us to know what is going on in the sun from minute to minute, and unless we know this, I do not well see that we are ever likely to arrive at a true theory of solar disturbances, or of the connexion between these and the disturbances of the meteorology and magnetism of the earth. Could we ever have ascertained the velocity of the solar currents without the aid of the spectroscope ?

" As a self-recording instrument for registering the actinic effect of the solar rays has been perfected by Dr. Roscoe, and as it is a point of importance to study the influence of the solar rays upon vegetation, I think that whenever the sun's surface is regularly studied, actinic observations ought, from this cause as well as from their physical importance, to be included among the duties of the observatory.

" In reply to your fourth question, believing that a long continued and systematic series of observations is beyond the means of volunteers, I think that the four kinds of observation of the solar surface which I have specified ought to be made in an observatory maintained by the State. Indeed, for some of them more than one observatory would be requisite, for I think it an object of great importance to obtain a daily record not only of the position but of the area of every group of spots which appears on the surface of the sun. But to obtain this more than one observatory would be necessary, for we must be independent of the influence of weather ; and to be so we must have stations so distributed that when it rained at one station it might reasonably be expected to be fair at another.

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" I think that the study of the sun ought to be systematically conducted in an institution for the purpose working under Government, and connected with a number of stations sufficient to ensure a good record of what takes place on the solar surface, independent of the influence of weather.

" It appears to me also that such an institution should have a laboratory as well as a workshop connected with it."

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M. Faye :

" 1. L'étude de la constitution physique du soleil ne me paraît pas appelée à répandre de grande lumière sur la Physique Terrestre, c'est-à-dire sur la Météorologie et le Magnétisme. L'action solaire est actuellement caractérisée par une constance bien remarquable, sauf de petites variations accidentelles ou périodiques de peu d'importance. L'étude directe de ces divers sujets de Physique Terrestre suffit amplement. Mais il en est autrement des âges géologiques dont l'histoire me paraît liée intimement à des changements progressifs d'ont on reconnait la possibilité dans l'activité interne du soleil.

" Toutefois on ne peut nier que les recherches nouvelles qui ont eu pour but de rattacher certaines périodes dans les phénomènes magnétiques aux phénomènes également périodiques du soleil ne méritent intérêt et considération.

" 2. Les moyens dont nous disposons aujourd'hui pour l'étude du soleil sont au nombre de huit :—

" 1°. Étude des mouvements de la photosphère par les taches et les facules. (Carrington.)

" 2°. Étude de la constitution chimique de la photosphère et de la chromosphère. Variations, plus ou moins rapides, de cette constitution. Analyse chimique continuelle de la superficie solaire.

" 3°. Étude des mouvements de la chromosphère, éruptions, protuberances, etc. Distribution de ces phénomènes selon la latitude.

" 4°. Étude des variations périodiques de la surface, par les precédés de Schwabe et ceux de l'Observatoire de Kew.

" 5°. Étude des éclipses totales, auréole, couronne, etc., au moyen d'expéditions lointaines.
" 6°. Études des changements séculaires de l'activité solaire au moyen des données de la géologie.
" 7°. Étude analogique du soleil au moyen de l'observation des étoiles variables ou nouvelles.
" 8°. Application de la mécanique moderne à l'étude des mouvements internes qu'on peut supposer dans la masse solaire.

"3. Le moyen le meilleur d'étudier les mouvements des taches et des facules est incontestablement la photographie. C'est surtout par là qu'on peut espérer de rencontrer des phénomènes auxquels s'appliqueront tôt ou tard les lois de la mécanique. Mais ce n'est là qu'une face de la question. La spectroscopie n'est pas moin indispensable. C'est par elle que la physique et la chimie peuvent s'appliquer aux études solaires auss bien que la mécanique. Réduire cette étude à la photographie ce serait se condamner à ne voir qu'une face de la question. Je ne veux pas que cette opinion puisse être sérieusement soutenue.

"4. Il suffit d'envisager l'importance du but des études solaires et la variété du moyen d'action que la science moderne nous présente pour penser que le moment est venu de confier les études à un ou plusieurs établissements pourvu de grandes ressources, et pouvant fonctionner avec continuité pendant un laps de temps illimité.

" Sans doute on devra compter sur le concours puissant des volontaires de la science. Mais le concours se présente toujours avec des restrictions quant aux ressources, à la continuité, et à la durée, lesquelles me paraissent peu compatibles avec les résultats à obtenir.

"5. Je suis d'avis que les études doivent être poursuivies dans des établissements spéciaux; que leur introduction dans les observatoires astronomiques serait nuisible à l'astronomie proprement dite, sans pouvoir donner tous les résultats que procurerait une division bien nette du travail. L'expérience que nous en avons en France me paraît décisive."

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Evidence relating to Meteorology.

For the reasons which have already been stated, we have taken a considerable amount of Evidence with reference to the Meteorological Observations at present carried on in the United Kingdom, whether at the cost of the Government, or of Societies or Private Observers. To some points in this Evidence we think it necessary to call attention: of these the most important are those which relate to the Meteorological Office.

This Office is under the Management of the Meteorological Committee of the Royal Society, the Functions of which are thus described in the Report annually presented to Parliament:—

"The Meteorological Committee consists of Fellows of the Royal Society who were nominated by its President and Council, at the request of the Board of Trade, for the purpose of superintending the Meteorological duties formerly undertaken by a Government Department, under the charge of Admiral FitzRoy. Preface to Report for 1872.

" The Committee are credited with a sum of 10,000*l.* voted annually in the Estimates, for the administration of which they are wholly responsible, and over which they are given the entire control.

" The Meetings of the Committee are held once a fortnight, or oftener when necessary, when every subject on which action has to be taken by their executive officers receives their careful consideration. The duties of the Committee are onerous, and *entirely gratuitous*; they were accepted, and are very willingly performed by the members, on account of the earnest desire they severally feel for the improvement of Meteorological Science."

The position of the Committee is anomalous. In the words of the Director of the Meteorological Office—

"The Government distinctly disclaims all connexion with us, whilst the Royal Society equally disclaims all control over us, except merely the nomination of the members of the Committee." Qu. 13,867

"As a matter of fact, all that the Royal Society does is to nominate the members of the Committee?— That is all." Qu. 13,868

"Having so done, it ceases to have any control whatever, does it not?—Entirely." Qu. 13,869.

"What is the precise relation between the Office and the Government?—That the Government gives a vote of 10,000*l.* every year, and that it calls for no account of this money, excepting the account annually presented to Parliament." Qu. 13,871.

"Who audits the accounts?—The members of the Committee. There is no formal audit, because, as the Government would not recognize any audit excepting its own, the Committee considered that it was not worth while paying an auditor if such audit would not be recognized, and, as a matter of fact, two of the members take the trouble of auditing the accounts every year." Qu. 13,872.

"What, in your opinion, are the chief advantages and disadvantages of such an arrangement as compared with those of the direct management of the Office by the Government?—The chief advantage is the perfect freedom from political management. The risk in being connected with the Government is that if a new President of the Board of Trade comes, he may reverse the action of the preceding one. The existence of a scientific supervision for the Office is exceedingly important; it acts as an intermediate party between the public and the Office. I may mention a decided disadvantage which results from the Office not being connected with the Government, namely, the loss of *prestige*. The difficulty is, that if we are sending instruments by sea or by railroad, if we do not call them Government instruments we cannot get as much attention paid to them, and it is my opinion that we should get more co-operation from the merchant navy if we were an office of the Board of Trade. We should have more *prestige* as acting directly from the Government." Qu. 13,873.

The following very clear account of the objects which the Meteorological Committee propose to themselves is taken from the Evidence of Major-General Strachey, one of the Members:—

"I would, then, state generally what I understand to be the objects which the Meteorological Committee Qu. 14,212.

has to superintend. These are, first, the collection of meteorological data from ships' logs, with a view to the preparation of maps for the use of sailors, showing the probable, or it may be termed the average, meteoro-
Qu. 14,212. logical elements all over the ocean, on the chief line of trade routes, for the several months in the year. Included with these is the investigation of the ocean currents. This branch of duties is carried on under Captain Toynbee. The second branch of the business is the collection and daily publication of meteorological observations made on the British Isles and neighbouring coasts, extending from the coasts of Scandinavia to France, and partly to Spain. Although at the outset of the issue of warnings as to probable bad weather was not contemplated, yet after the Committee had been in operation for a few months it was considered desirable again to undertake this, and in the first year of the Committee's existence the issue of warnings of anticipated stormy weather was resumed. I daresay Mr. Scott has told the Commissioners, that within the last few months there has been a little more detail given in the warnings. Originally they were mere warnings that stormy weather was likely to occur. Now there is a statement also given of the probable direction from which the wind is to come, and whether it will be of extreme force. The third of the objects is the recording at certain specially-organised observatories, seven in number, maintained under the direction of the Committee, of the principal meteorological elements, with self-recording instruments; with the intention of obtaining a continuous record with as great accuracy and precision as possible, and thus of procuring accurate data for the scientific study of meteorology by all persons who are interested in that science. I should add that the Committee has, within the last month or two, from the commencement of this year in fact, begun to print and to issue monthly the detailed observations made at these seven observatories. The Committee also publishes quarterly reports, which contain diagrams embodying the observations at the seven observatories, and an analysis of the weather over the British Isles, of which the details are furnished in the daily reports. There is no doubt that the publication of those quarterly reports is an useful addition to the daily reports, which are extremely voluminous, and not very easy for persons to follow who do not devote themselves to the subject. The last of the specific duties of the Committee is the supply of meteorological instruments for the Royal Navy and Mercantile Marine. Besides various miscellaneous references come from the Board of Trade, to which, of course, the Committee gives such answers as it is capable of doing."

It is admitted that the objects thus described do not exhaust the whole of Meteorology, and that the Committee in their selection of these objects have been, to a great extent, guided by the proceedings of the Meteorological Department of the Board of Trade, which existed prior to, and which has been superseded by the Committee. Thus Major-General Strachey says:—

Qu. 14,215. "The Committee is now in reality doing no more than continuing the exercise of certain functions which had, in the course of time, been thrown upon the Board of Trade by the position which that Department occupies in connexion with the public administration."

Qu. 14,216. "Has the consequence been that the action of the Committee has been from the outset rather in a practical direction than in one of original research or scientific observation, properly so called?—I think distinctly that such is the case, and that it has necessarily followed from the position in which the Committee was placed. If a reference is made to the earlier papers, and to the Report of the gentlemen on whose suggestions the present arrangements originated, there perhaps is an indication that they anticipated something more in the way of scientific research than has actually occurred; but the turn that things have taken seems to me the necessary result of the sort of duties that were put upon the Committee under the essential condition that it had but a limited sum of money to spend."

Qu. 14,217. "Have any results of scientific importance in your opinion been obtained by the action of the Committee?—In the direction of what one may call investigation of an absolutely scientific character, I should say none at all. Of course the observations that are made at the special observatories are valuable scientific information, and so far one has no right to say that scientific results have not been produced; but I do not think that these can properly be referred to as specific results of anything that the Committee has done. To the best of my belief there has been nothing undertaken in the way of original investigation into the specific physical causes of any of the phenomena which are recorded, nor any original research, properly so called, in relation to any of the several branches of meteorology. The Committee hardly has appliances at its command for any such investigations, and, the funds at its disposal being limited, it was hardly possible that it should attempt them. It is also no doubt quite true that the observations which are made at the seven observatories do not include any matters which are of great importance in physical science, and which would properly come within the range of meteorology."

Qu. 14,218. "Are the funds at the disposal of the Committee in your opinion insufficient for doing anything more than has been actually done at present?—I should say distinctly that this is the case. The Committee has always considered that it is bound to attend primarily to the special objects before referred to, which were in a specific manner made over to it, and it finds that after this has been done there is no money left for other things."

Again, the same Witness expresses a decided opinion that the State should do more for the promotion of Meteorological Science than it does at present, but entertains some doubt whether any increased duties could advantageously be allowed to devolve upon a body such as the Meteorological Committee:—

Qu. 14,226. "Can you state the directions in which you think the State should intervene?—This seems to me an extremely difficult question to answer. The fact is that the form in which the State might in a satisfactory way intervene must depend upon the extent to which it is disposed to intervene. If one knew that the Government really desired to assist in the development of scientific meteorology, it would be possible to make a scheme, but I do not see how anybody could make what I may call an abstract plan which should have any real utility in it. My own impression is that so long as there is no greater interest taken in this sort of matter than at present, probably the best thing to do is to leave the expenditure of what money the Government choose to give for the purpose under the control of some such body as our Committee; but I should further say that if the Government is seriously in earnest in taking the matter up, it would then be the proper thing to have a public department that should manage the business. Then again, if there were a public department, it must be a part of an organised system; and in order to secure an efficient public department to supervise such matters, it seems to me that it would be necessary to have some officer connected directly

with the Government, an Under-Secretary of State, or some such person, who should be responsible that the executive scientific staff properly carried out the whole of the operations of their several departments."

"Are you disposed to think that the Meteorological Committee might in any way extend its sphere of action with advantage?—As matters are now I should think it is extremely doubtful. I look upon the Meteorological Committee as being mainly a controlling body to supervise the expenditure of a definite sum of money in a definite way. At all events that practically has been their position. There has been no virtual change from the time that they were started up to the present time." Qu. 14,285.

"Do you think that that money would be spent better in some other way; that is to say, supposing the thing had to be started afresh, are those objects which the Committee at present have to carry out exactly those that you would have given them to carry out?—I should say in general terms that the whole of the objects which the Committee has charge of are reasonable objects. I do not think that there is any one of them that it is not desirable to attend to. As to whether the precise method of dealing with them is the best possible will be a matter of opinion, but I do not think that I could very usefully go into that." Qu. 14,286.

"Does it occur to you that there is anything else which should be added to the functions of the Committee?—My general impression, as I implied before, is that the Committee is a quasifinancial body having certain scientific knowledge. Its duty is not strictly speaking to direct scientific research or scientific operations, but it is to see that a certain sum of money which the Government thinks may reasonably be applied to collecting and publishing meteorological observations, and doing certain other matters, is not unreasonably applied. It exercises a check upon the persons who have actually to carry out those duties, as I understand it; and I do not think myself that, with a body constituted as the Meteorological Committtee is, you can expect more from it than that." Qu. 14,287.

"Do you think it would be desirable that the Committee should be entrusted with money to enable it to have any observations collected, scientifically discussed, and turned to scientific use?—I think it would be much better if any such fund were not given to a body like the Committee. If some individual were selected, and the entire responsibility put upon him, I think it would be a much better plan." Qu. 14,288.

"You want to do away with the Committee altogether?—I think so, certainly; supposing always that I am at liberty to replace it according to my own conceptions of what is best." Qu. 14,289.

The same view is expressed by Professor Balfour Stewart—

"Would you organize the Meteorological Committee in any really different form to that which at present obtains?—I should be inclined to dispense with the Meteorological Committee altogether, and substitute a Meteorologist Royal, or whatever his appellation might be, a single official who should be responsible to the Government in the same way as the Astronomer Royal is responsible for his department. I do not see why the one department should be on one footing and the other department on a different footing. I think that there are grave disadvantages with a department administered by an unpaid committee." Qu. 14,035.

"Would you appoint a Meteorologist Royal corresponding with the Astronomer Royal?—Yes, whatever the name might be; I should appoint an official very much corresponding to the Astronomer Royal and responsible to the same extent. A board of visitors would not be objectionable, but the direction of an unpaid committee appears to me to be very objectionable." Qu. 14,036.

The same Witness considers that the subject of Meteorology naturally divides itself into two heads, (1), Physical Meteorology, of which "the object would be to ascertain the Physics of the earth's atmosphere, and perhaps of the earth's ocean," and which must consequently be regarded as a branch of Terrestrial Physics; and (2), Local or Climatic Meteorology, involving a number of Inquiries having special relation to Health, Agriculture, and various Human Interests. The distinction is one which perhaps does not admit of being very closely pressed. For example, it is not clear to which of the two heads the Observations upon Rain-fall should be referred; not to mention that any series of Meteorological Observations, with whatever object undertaken, must have a special value with reference to the Locality at which they are made. Professor Stewart is further of opinion that while Physical Meteorology should receive even larger support from Government that it does at present, Climatic Meteorology might in the main be left to voluntary and local exertions. Qu. 14,031. Qu. 14,059.

"Would you leave the other branch of the subject, climatic meteorology, to individuals and local efforts?—Yes, I think so, possibly supported to some extent by funds from the Government, but I should not put such branches under the superintendence of a central board at the present moment." Qu. 14,037.

And again,—

"Would you leave climatic meteorology altogether to societies and to individual effort?—At the present moment it appears to me to be a matter that might best be left in that position, and that a central authority would do no good in a question of this kind, but rather do harm; in fact, rather tend to depress than to encourage these local efforts. I have no doubt that a great deal might be done by the zeal of local individuals, but if the thing were undertaken in its present state by a central board, which would do little but register a number of observations, I do not think that any good would at the present moment be done." Qu. 14,045.

Such aid as Government might give to Climatic Meteorology, should, in the opinion of the Professor, rather take the form of Grants to Societies, than of any extension, in this direction, of the Functions of the Meteorological Office, for the double reason that it would be undesirable to discourage local efforts, and to dissipate the energies of the Meteorological Office by diverting them from Physical Meteorology. Qu. 14,047.

"As far as the money is concerned, I consider that a mere matter of detail, but I should be very strongly against the Meteorological Committee undertaking anything but Physical Meteorology; I think that they Qu. 14,039.

ought to confine their labours to that. If they at present undertake all those branches of meteorology bearing upon the various individual human interests, it appears to me that you will leave them no energy to attack the problems of physical meteorology. I think the great point is to put physical meteorology somewhat more into the position of a branch of physical science; at the present moment it appears to me to occupy a very low position indeed."

It appears that within the last two or three years the Meteorological Committee have made great efforts to extend their work in such directions as might be most likely to help in the promotion of Scientific Meteorology. Thus, they have commenced publishing the individual values derived from their self-recording instruments; and they have undertaken regular Observations upon Atmospheric Electricity. But the efforts of the Committee to extend their operations are limited by insufficiency of funds.

Qu. 14,436.

Qu. 14,438. "Is there a want of funds for a more complete treatment of the subject of land meteorology?—A very serious want of funds. As I mentioned before, for any serious discussion like that of the hourly values for all the elements for five years we are not provided with a sufficiency of funds; in fact the amount of our staff for land meteorology would be sufficient to discuss the results for one observatory, but not for seven. It is in that sort of way that the original provision of clerks who were to discuss the work was quite insufficient, the amount of materials being so enormous."

Mr. Scott also informs us that:—

Qu. 13,925. Supplementary Evidence. "Arrangements have been concluded between the Meteorological Society and the Meteorological Office, and have come into effect on the 1st January 1875. The principal features of these arrangements are that the Observers belonging to these two organizations are supplied with an uniform schedule for recording their observations, and that the Society undertakes to furnish to the Office monthly returns from certain selected stations for publication with the returns from its own stations, in consideration of a certain payment, which will probably average about 50*l.* per annum."

"An invitation has been issued to the Scottish Meteorological Society to co-operate with the Office on similar terms, and the Meteorological Committee are not without some hope that this proposal may be accepted."

Besides the sum of 10,000*l.* which is placed on the Civil Service Estimates and is annually paid to the Meteorological Committee, the Government incurs a certain expenditure on account of Meteorology at the two National Observatories of Greenwich and Edinburgh. This expenditure for the year 1874–75 amounted to 1,221*l.* for Greenwich, and 115*l.* for Edinburgh.

A further small annual payment of 150*l.* is made by the Registrar General for the Reports of Meteorological Observations which are printed in his Monthly Returns. These Reports are supplied by Mr. Glaisher, the observations being made at different stations in various parts of England, by unpaid private observers, whose co-operation Mr. Glaisher has been able to obtain. The Evidence shows that the work is done under regulations which are sufficient to ensure its general accuracy; and it is obvious that the annual payment of 150*l.* hardly covers the expenses incurred, and affords no remuneration for the trouble taken in organizing and controlling the System of Observations.

Evidence relating to Tidal Observations.

Evidence in reference to Tidal Observations has been placed before us by Dr. Joule and Professor Sir W. Thomson.

Dr. Joule is of opinion that—

Qu. 10,568. "With regard to the sea level and the tides, although the laws with regard to the tides are pretty well known, they ought to be continuously observed, if only for the purpose of registering the changes arising from the alteration of banks, depth of channels, &c. Also with regard to the sea level, there have been reports from time to time with regard to the inroads of the sea on our coasts, but sufficient steps do not appear to have been taken to ascertain the facts in those cases. It seems to me very important to be acquainted with any alterations in the configuration of the earth which may be taking place, however minute those alterations may be."

He thus expresses his views as to the manner in which these Inquiries may be carried on:

Qu. 10,576. "Would that be a work which ought, in your opinion, to be carried on from day to day by a permanent establishment at such places?" "I believe that self-registering apparatus have been devised which would enable the mean sea level to be registered, and the tides to be registered, without very much trouble."

Qu. 10,577. "Is it a sort of work which can be carried on by public officers stationed at any of the ports, or would you require a separate staff?" "Probably it might be carried on by the officers at the stations. I do not think it would be necessary for anyone to be exclusively occupied in such a work."

Sir W. Thomson's Evidence on this point is as follows:

"In addition to those institutions which you have recommended, you consider, do you not, that it would be advisable that the Government should undertake secular observations of the tides?" "Yes, certainly, secular observations of the tides with accurate self-registering tide gauges, with the triple object of investigating the science of the tides, of perfecting our knowledge of the actual phenomena of the tides, both in respect to navigation and as a branch of natural history, and, thirdly, with a view to ascertaining the changes of the sea level from century to century." Qu. 10,715.

"Is anything of the kind done at present?" "There are several tide gauges, some of which have been carried on with great care, others with not sufficient care, and none with any security of permanance." Qu. 10,716.

"Was not it in connexion with the Ordnance Survey of Great Britain?—No sufficient steps have been taken to ascertain whether the sea level is changing relatively to the land in any part of this country." Qu. 10,719.

"Would you think a large number of stations requisite for the observations of the tides to which you have alluded?—Yes, a large number. The phenomena of the tides are of great complexity, but not of baffling complexity, provided that we make the observations at a sufficiently great number of points." Qu. 10,720.

"Would the duties attached to such observations take up the whole time of the persons who had charge of them?—By no means. They could undertake other duties. A tide gauge may be put under the hands of a careful harbour master or officer of the coastguard service at any station, but it must be under inspection to secure accuracy. The most careful and scrupulous of such men cannot make sure that the instrument is giving accurate results; and they cannot, except under instruction and occasional inspection, give out recorded curves, that they can be quite sure of being accurate in all points of scientific nicety; but the inspection that is required to secure accurate results would be a very simple and moderate matter." Qu. 10,721.

The accurate Reduction of Tidal Observations, without which, of course, they are useless, has not hitherto been undertaken by any Department of the State, and we are indebted to the zeal of individuals for the results which have been obtained. The reductions are laborious, and require the employment of paid computers. The following Memorial from the British Association for the Advancement of Science to the Lords Commissioners of the Treasury, put in evidence by Sir William Thomson, shows the difficulty that has been felt in procuring the moderate sum required for the Reductions:—

"MEMORIAL to the Right Honourable the LORDS COMMISSIONERS of HER MAJESTY'S TREASURY. Appendix ix. Vol. II., p. 32.

"The Memorial of the British Association for the Advancement of Science.

"Humbly sheweth,—

"1. That in the year 1867 the British Association appointed a Committee 'for the purpose of promoting the extension, improvement, and harmonic analysis of tidal observations.' From that time until the present, under committees reappointed from year to year, the proposed work has been carried on. The mode of procedure adopted, and the results obtained up to the month of August 1871, are fully stated in the accompanying series of printed reports.

"2. The primary object of this investigation is the advance of tidal science, but the Committee have uniformly kept in view the practical application of their results to Physical Geography, Meteorology, Coast and Harbour Engineering, and Navigation.

"3. A large mass of valuable observations, recorded by self-registering tide gauges during the last 20 years, having been found available, the Committee have applied themselves, in the first place, to the reduction of these observations, and have deferred the object of promoting observations in other localities until the observations already made have been utilized to the utmost.

"4. The work thus undertaken has proved, as was anticipated, most laborious. The calculations have been performed, under the superintendence of Sir William Thomson, by skilled calculators recommended by the Nautical Almanac Office. The funds required to pay the calculators, and to print and prepare tables, forms for calculations, &c. to the amount of 600*l.*, have been granted by the British Association in four successive annual allowances of 100*l.* each, and a sum of 200*l.* voted at the last meeting. The last grant barely sufficed for the work actually in hand, and to secure the continuance of the investigation additional funds are necessary. The Council of the British Association, therefore, directed the Tidal Committee to make an application to the Government for assistance, the amount at present asked for being limited to 150*l.*

"5. It seemed to the Council that after the Association had done so much in the way of actual expenditure of time by the members of its Committee, and had given such a large contribution from its very limited funds, enough had been done to show the object to be one for which assistance may reasonably be expected from Government. On representations made by Colonel Walker, Director of the Trigonometrical Survey of India, the Indian Government has already granted the means of defraying the expense of making tidal observations in India, and applying to them the methods of reduction devised by the Committee of the British Association. The Council hope, therefore, that the Government of this country may be similarly diposed to assist in a matter of national importance.

"(Signed) WILLIAM THOMSON,
President of the British Association."

"May 21, 1872.

The Lords Commissioners of the Treasury did not accede to the Prayer of the Memorial, so that, at present, there is no guarantee that the Observations which have already been accumulated, and those which are still in progress, will ever be adequately discussed and utilized.

Evidence relating to the Extension of the Government Grant administered by the Royal Society.

The strong and concurrent Evidence which we have received as to the usefulness of the Government Grant, as at present administered by a Committee of the Royal Society, has led us to inquire whether this Grant might not be advantageously extended; and

the Witnesses whom we have examined on this point are unanimous in expressing the opinion that great benefits might be expected from such an extension.

Qu. 11,570. Thus, to the Question, "Have you formed any opinion as to whether it would be "desirable that the Government Grant of 1,000*l.* a year, placed at the disposal of the "Council of the Royal Society, should be increased or not?" Professor Owen replies: "It has been so admirably applied and with such gain to Science, that there cannot be "a doubt that it would be a great benefit to Science if it were doubled to begin with."

Qu. 11,995. Mr. Spottiswoode, the present Treasurer of the Fund, states his opinion that an extension of the Government Grant would be desirable, and expects that the minimum which might be voted every year would increase materially.

Qu. 12,214. Professor Grant gives his opinion "that it is very desirable that the grant should be enlarged." He also considers that it "would be expedient that wider publicity should "be given to the fact of its being generally available to persons engaged in scientific "investigations."

Qu. 13,135. Mr. De La Rue is of opinion "that it is administered exceedingly well and very carefully." He considers that the amount should be increased.

Qu. 13,590. From the Evidence given on page 13, it appears that Lord Salisbury also is of opinion that the Government Grant might be increased, with the object of affording liberal assistance to "first-rate workers."

Appendix XIV., Vol. II., p. 67. In a Memorial presented to us by the Royal Society of Edinburgh, it is recommended that a corresponding Grant be placed at the disposal of that Body, for the Promotion of Science in Scotland. The claims of Scientific Workers in Scotland to participate in the Grant equally with those in other parts of the United Kingdom, have been fully recognised, and we think it of importance that there should be but one such Grant for the whole of the United Kingdom and one body responsible for its administration. In the measure hereinafter recommended we have suggested that the Administration of future Grants should be assigned to a Council of Science which should include the Representatives of the Scientific Societies of the United Kingdom.

Evidence as to the Payment of Scientific Workers.

On this branch of our Inquiry, the Evidence laid before us, both by Statesmen and men of Science, is to the same effect, and in favour of increased State Aid. It has also especially been urged upon us, that to afford, by direct pecuniary aid, the means of livelihood to men of distinction in pure investigation would be a great advantage to science, as competent investigators would thus be enabled and encouraged to pursue a strictly Scientific Career.

Qu. 13,553. Lord Salisbury is of opinion that the cause of Science is hindered by the want of a sufficient career for scientific men, giving the following statement of his reasons:

"I am induced to think so, by noticing how very much more rapid the progress of research is where there is a commercial value attached to the results of it, than in other cases. The peculiar stimulus which has been given to electrical research, in the particular direction of those parts of it which concern the telegraph, is a very good instance in point, and the extent to which researches into organic chemistry have almost clustered themselves round the production of coal tar colours is another instance in point. And therefore it is difficult to avoid the conclusion that research is really hindered by the necessity under which those who are most competent to conduct it feel themselves, of providing for their own support by means of the talent and the knowledge which they possess."

Qu. 13,523. Lord Derby takes the same view:—

"I think that, in one way or another, where you have a man of very great eminence as a scientific discoverer, it is unquestionably the duty of the State to provide him with means and leisure to carry on his work. Whether that is to be done by giving him an office under the British Museum, or in any similar institution, or whether it is to be done by simply granting him a pension in recognition of eminent scientific service, or in whatever other way it is done, it seems to me to be immaterial, but I certainly consider that it is a very important part of the public duty, to relieve men who have shown an eminent capacity for original discovery and research from the necessity of engaging in a lower kind of work as a means of livelihood." * * * *

Qu. 10,736. Sir W. Thomson, in a reply to which we have already referred, stated his opinion on this point as follows:

"That men should be enabled to live on scientific research is a matter of most immediate consequence to the honour and welfare of this country. At present a man cannot live on scientific research. If he aspires to devote himself to it he must cast about for a means of supporting himself, and the only generally accepted possibility of being able to support himself is by teaching, and to secure even a very small income, barely sufficient to live upon, by teaching, involves the expenditure of almost his whole time upon it in most situations, so that at present it is really only in intervals of hard work in professions that men not of independent means in this country can apply themselves at all to scientific research." * * * *

Professor Henry, the distinguished Director of the Smithsonian Institution in the United States, who was good enough to appear before us when he was in this country, gave the following emphatic evidence in the same direction :—

"My idea would be that if the funds were sufficient, and men could be found capable of advancing science, they should be consecrated to science, and be provided with the means of living above all care for physical wants, and supplied with all the implements necessary to investigation." Qu. 1520.

Professor Balfour Stewart, after referring to the instances of wealthy persons who undertake Scientific Research in this country, points out that the number of those so circumstanced is very small in comparison with the number of able men who are willing to give their time and capacities to Observations and Research. He goes on to say that able men, and men competent to conduct research, suffer in this country from not having sufficient means at their disposal to proceed as they would like to do. Qu. 11,419. Qu. 11,420.

"Do you anticipate, then, that if there were any intelligent centre for the distribution of a sufficient fund to persons having the requisite capacities for observation and research, but not having the means, the distribution of such a fund would have any benumbing influence upon original observation and research?"—"No, I should think quite the contrary; it would encourage it very much." Qu. 11,421.

Mr. Gore also advocates the enlargement of the present system. Qu. 10,902.

". . . . I should strongly advocate that the present system should be enlarged, so that the investigators should not merely be reimbursed for all that they have expended, but also paid in some measure for their time and labour, because each investigator has to give up a profitable employment in order to find the time."

He then gives his own personal experience, which probably resembles that of many of those who, without private fortune, engage in pure research.

"I refuse a great many engagements in analyses and other scientific matters for the manufacturers who come to me. * * * I gave up some pupils a short time ago to enable me to have more time for original investigation." Qu. 10,902.

Some of the Witnesses seem to have considered the Pecuniary Aid which they think should be afforded, more in the light of Rewards for work done than as an Aid to work to be done. Thus, Dr. Joule, is of opinion—

"That a small sum of money in recognition of scientific labour would be in many cases a most useful help as well as a great encouragement, and if the Patent Laws are retained they might be supplemented with provisions to meet the case of those discoveries to which the Patent Laws do not apply." Qu. 10,654.

Dr. Siemens is of opinion that the Government might promote original research by liberal grants to the Learned Societies; remarking that this is done now to some extent, but might be done with advantage to a greater extent. Qu. 11,771.

He then suggests that the Government might also encourage Scientific Research "by granting through Societies, rewards for successful results obtained by independent research. In many instances the Patent Law provides for the reward, but in other cases of pure science the Patent Law does not apply, and the results of original research are left unrewarded." Qu. 11,771

Mr. De La Rue is of opinion that if men are not in a position of fortune to continue their researches, in some cases materials and even money might be granted to them. Qu. 13,054.

Referring to the extent and value of the Original Researches in Chemistry carried on in Germany, he ascribes them "to the care which is given to the cultivation of every branch of science; and moreover to the positions and places at the disposal of the Government which are given from time to time to men who render themselves eminent in Science." Qu. 13,094. Qu. 13,095.

With regard to the Scale on which such Remuneration or Payments for Maintenance should be made, Lord Salisbury observes :—

"I should say, taking the parallel [that of certain offices in the Church], to which I have already alluded, that an income of about 1,000*l.* or 1,500*l.* a year would be the kind of income which would suffice for the purpose that I have in view." Qu. 13,569.

And he would also add Provision for Retirement.

With reference to the safeguards against abuse which would be necessary, Lord Salisbury continues :— Qu. 13,568.

* * * "It would, for their [the investigators'] own interest, and to save them from invidious comments, be desirable, to impose upon them the necessity of publishing, either in the form of books or in the form of lectures (but not sufficient in number really to impede their work), an account of the result of their labours during each successive year. Perhaps one or two stated lectures in the course of a year, to be delivered to University students, would be the best means of imposing upon them that test of industry." Qu. 13,567.

Lord Salisbury further recommends that aid of this kind should be given directly and with as little concealment by ostensible duties of another kind as possible; adding:

Qu. 13,560. * * * "If any money is to be given, as I think it ought to be given, for the purpose of furnishing a career to men who are really engaged in research which is not pecuniarily profitable, I think that it would be far better given directly and openly than given under the form of an office which would practically be a sinecure."

In contrast with this view, that the endowment should be given directly, we think it right to quote the opinion of the late Professor Rankine:—

Qu. 9515. "I think there is no general principle, but every case must be judged of on its own merits. The other thing which is wanted, besides money, is the leisure time of competent persons. It seems to me that it is out of the question for any State to provide or endow such a set of persons, and that it would be impossible for any department of the Government, either to judge who were fit persons, or how they ought to be employed, or what would be a proper remuneration for them. And I believe that if any such system were instituted, it would only lead to abuse. Setting aside such leisure time as men may have who are of independent fortune, and do not require to practise any profession or special occupation, I would say that it appears to me that in order to ensure that other competent persons shall have the requisite leisure, it is desirable that there should be offices with other functions attached to them, but those functions should be of such a nature that the holder of the office may have leisure time for original research." * * *

Remarks on the foregoing Evidence.

The great advances in Physical Science which have been made in this Country, and within this century, by such men as Dalton, Davy, and Faraday, without aid from the State; the existence of our numerous Learned Societies; and the devotion of some few rich individuals to the current work of Science; at first sight appear to reduce the limits within which State Aid to Research is required in this country.

But whilst we have reason to be proud of the contributions of some great Englishmen to our Knowledge of the Laws of Nature, it must be admitted that at the present day Scientific Investigation is carried on abroad to an extent and with a completeness of organization to which this country can offer no parallel. The work done in this country by private individuals, although of great value, is small when compared with that which is needed in the interests of Science; and the efforts of the Learned Societies, not excepting the Royal Society, are directed to the Discussion and Publication of the Scientific Facts brought under their notice; these Societies do not consider it any part of their corporate functions to undertake or conduct Research.

It will have been seen, from the extracts from the Evidence, that amongst the Witnesses who have advocated an increase of State Assistance are some who have made great sacrifices in time and money in the cause of Scientific Research.

But whatever may be the disposition of individuals to conduct researches at their own cost, the Advancement of Modern Science requires Investigations and Observations extending over areas so large and periods so long that the means and lives of nations are alone commensurate with them.

Hence, the Progress of Scientific Research must in a great degree depend upon the aid of Governments. As a Nation we ought to take our share of the current Scientific Work of the World: Much of this work has always been voluntarily undertaken by individuals, and it is not desirable that Government should supersede such efforts; but it is bound to assume that large portion of the National Duty which individuals do not attempt to perform, or cannot satisfactorily accomplish.

The following considerations have been suggested to us by the Heads of Evidence relating to (1) Laboratories, (2) Observatories, (3) Meteorology, (4) Tidal Observations, and (5) the Payment of Scientific Workers.

1. The first condition of scientific investigation is that there should be Collections, Laboratories, and Observatories accessible to qualified persons. The evidence has shown that at present, for certain branches, these do not exist or are incomplete.

Moreover there can be no doubt that the Government Service should, to a great extent, contain within itself the means of carrying on Investigations specially connected with the Departments. Even having regard only to the current wants of the State, additional appliances are necessary.

Three distinct ways have been suggested in which the State might assist in providing the Aids to Investigation which are required by private Individuals. It has been proposed: first, that competent Investigators should receive Grants in Money enabling them to provide themselves with means for conducting their Researches; secondly, that Laboratories, designed primarily for the Service of the State, and those of Universities and other similar Institutions receiving Aid from the State, should be placed, under proper conditions, at the disposal of such Inquirers; thirdly, that Laboratories should be erected by the Government specially designed for the use of private Investigators, though, of course, also available for the service of the State. Wherever the first of these methods can be conveniently and economically adopted, we are disposed to consider that it is the simplest and the best; but it must be remembered that for many Researches apparatus of a costly, but durable character, are among the primary requisites; and that to provide these separately for each investigator would involve a large and unnecessary expenditure. It appears to us that the difficulty thus arising might be adequately met by the adoption of the second of the above suggestions. Our attention has, indeed, been called to the inconveniences which might arise from the admission of independent workers into University or State Laboratories. But, notwithstanding this difficulty, we think the experiment is one which ought to be tried, and till it has been tried we should hesitate to recommend the erection by the State, for the especial use of private Investigators, of Laboratories which would certainly be costly, and might possibly be only imperfectly utilized.

2. Upon a Review of the whole of the Evidence relating to the subject of Astronomical Physics, we are of opinion that an Observatory for that branch of Science should be established by the State. In the study of Solar Physics, continuity of the observations is of the greatest importance; and owing to our variable climate, continuous observations of the sun in this country are subject to peculiar difficulties which should be duly considered in the choice of the site for such an Observatory. The neighbourhood of London is less favourable to Physical Observations than many other sites which might be found, and for this reason we should prefer that a Physical Observatory should be placed elsewhere than at Greenwich. On other grounds, also, we think that the Observatory for Astronomical Physics should be an Institution entirely distinct from any of the National Observatories for Mathematical Astronomy. The subject of Mathematical Astronomy is vast enough to occupy adequately the whole energies of a Director, and it is especially important that Astronomical Physics should have the undivided attention of the Head of an Observatory, because its methods, which are of very recent invention, are as yet incompletely developed, and because, depending, as they do, on a continual comparison of celestial phenomena with the results of experiments in the laboratory, they are entirely different from those of Mathematical Astronomy.

Our opinion as to the desirability of such an Institution is confirmed by the example of Foreign Nations; Observatories for Astronomical Physics being already at work in various parts of Italy, and their immediate erection having been determined on at Berlin and at Paris.

We venture to express the hope that similar Institutions may before long be established in various parts of the British Empire. The regularity of the climatic conditions of India, and the possibility of there obtaining favourable stations at considerable heights, render it especially desirable that arrangements should be made for carrying on Physical Observations of the Sun in that country.

3. With respect to Meteorology we are of opinion that the operations of the Meteoro logical Office have been attended with great advantage to Science and to the Country. The subject of Meteorology is a very vast one, and any scheme for its proper cultivation or extension must comprise — (1) Arrangements for observing and registering Meteorological Facts; (2) Arrangements for the reduction, discussion, and publication of the Observations; (3) Researches undertaken for the purpose of discovering the Physical Causes of the Phenomena observed. The resources placed at the disposal of the Committee are inadequate to cover the whole of this wide field; and, having due regard to all the circumstances of the case, we believe that in selecting certain parts of it, as the objects of their special attention, they have been guided by a sound discretion.

We are also disposed to consider that although, as we have already said, the Meteorological Committee occupies an anomalous position, no other form of organization could advantageously have been adopted under the actual conditions. We think, however, that if, as we shall herein-after recommend, a Ministry of Science should be established, the Head of the Meteorological Office should be made responsible to the Minister. We fully concur

with the opinion expressed by the Witnesses that many branches of Meteorology can only be effectually promoted by an organization having the support of Government; and we would draw especial attention to the consideration that, if Meteorology is to take rank as a branch of Terrestrial Physics, the observations must be made at stations widely dispersed over all parts of the earth's surface, and those taken by Observers of different Nations must be so arranged as to be comparable with one another. It is obvious that the intervention of Government would greatly facilitate the attainment of both these objects.

We are very unwilling that any Scientific Observations which can adequately be carried on by Individuals, or Associations of Individuals, should be undertaken by a Department of the Government. So far as the local interests connected with Climatic Meteorology suffice to ensure due attention being paid to that branch of science, we should prefer to see it left mainly to Scientific Societies, any assistance the Government might afford being merely subsidiary. That useful results may be obtained by voluntary effort is evident from the work carried on under the direction of Mr. Glaisher, and from the case of the Scottish Meteorological Society, which has succeeded, with very narrow means, in organising a valuable System of Observations on the Meteorology of Scotland. It is, however, important that any Grants for the promotion of Meteorological Observations in aid of voluntary efforts should be made on some systematic principle; and the attainment of this object would be furthered by making them subject to the Control of a Minister, who would be cognizant of all the facts relating to the expenditure of the Government upon Meteorology.

We may point out that the returns furnished by the Scottish Meteorological Society and Mr. Glaisher, are adopted by the Registrars General, and are recognized by Committees of Parliament in discussions affecting the Public Health, the Supply of Water, and other matters of the same kind. The value of Observations undertaken, as in this case, by private Individuals or voluntary Associations, must vary from time to time according to the efficiency of the persons principally concerned in their superintendence. We feel, therefore, that the question how far it is proper that such Observations should receive official sanction, cannot be decided *à priori*, and must be left to the judgment of the responsible Minister for the time being.

4. With regard to Tidal Observations, it will be seen that, in the opinion of the Witnesses, these have not hitherto been conducted and reduced systematically. Considering the agencies which the Government can employ for the purpose of making these Observations, the importance of providing proper Superintendence for them, and of securing their Reduction, we think it desirable that they should be carried on under Government control. The expense involved would chiefly consist in the Establishment at proper points, and Verification, of Tide Gauges, and in the Reduction of the Observations; these being entrusted to officers of Government already stationed at the ports and on the various coasts of the Empire.

5. The Witnesses have expressed themselves strongly as to the Justice and Policy of Remuneration to Investigators for their Time and Trouble, and the Evidence also shows by implication how great must have been the sacrifices of those who without private fortune have hitherto devoted their great talents and their valuable time to such work without any remuneration whatever.

It has hitherto been a rule in the granting of Government Aid to Scientific Investigators, subject, so far as we have been able to ascertain, to but very few exceptions, that such Aid should be limited to what was necessary to meet the expenditure actually incurred on instruments, materials, and assistance.

To grants made under these conditions we think that considerable extension might be given.

It is hardly necessary to assert the principle that when Scientific Work is undertaken at the request of the Government, the State is not only justified in paying, but is under obligation to pay for what is done on its behalf and for its service. But we desire to express our belief that there are many instances of unremunerative Research in which the benefit conferred on the Nation by those who have voluntarily engaged in it establishes a claim upon the State for compensation for their time and labour. Without such compensation much important work must remain unperformed, because it must be expected that many of the best men will not be in circumstances enabling them to devote long periods of time to unremunerated labour.

It is a matter of course that State Aid shall only be given to Investigators whose capacity and industry have been placed beyond a reasonable doubt.

IV.—The Central Organization which is best calculated to enable the Government to determine its action in all Questions affecting Science.

The functions of the Government with regard to science may be summed up under the three following heads:—

First. The Treatment of the Scientific Questions incident to the Business of the Public Departments.

Second. The Direction of Scientific Instruction when given under the Superintendence or Control of the State.

Third. The Consideration of all questions involving State Aid towards the Advancement of Science, and of Administrative Questions arising out of such Aid.

It would be difficult to enumerate exhaustively all the various topics comprehended under these three Heads, and it will be sufficient for the purpose of showing how wide is the field of action of the State in regard to Science, if we point out that under one or other of these heads are included all Scientific questions affecting the Army, the Navy, the Public Health, the Mercantile Marine, Public Works, Government Scientific Establishments; the Elementary Instruction in Science under the Department of Education in Primary Schools, in the Science Classes connected with the Science and Art Department, and in Secondary Schools so far as they are subject to Government control; the Aid which is now given, or which it is desirable should be given, to Universities and other Bodies not directly connected with the State, for the Middle and Higher Scientific Instruction, and the Control which the State either does or should exercise over them in virtue of such Aid or otherwise; the Appointments to all Scientific Offices in the gift of the Crown; Grants to Museums and their Control by the State; Aid to Scientific Expeditions of every kind; the Establishment and Direction of State Laboratories and Observatories; Grants in Aid of such Laboratories not under State Direction, and in Aid of Scientific Research; and generally the allotment and control of Public Funds for similar Purposes.

The majority of the Witnesses who have given evidence in relation to this branch of the Inquiry, express dissatisfaction with the manner in which questions under the preceding heads are now determined, and either recommend the Appointment of a Special Minister of Science or of a Minister of Science and Education.

In most cases the Witnesses recommend that such a Minister should, in regard to Science, be advised by a Council. Others, however, are of opinion that the Functions of such a Council might be exercised by an Administrative Staff of the usual kind.

Before continuing our remarks on this subject we beg leave to lay before Your Majesty extracts from the Evidence which has been placed before us regarding the Appointment of a Minister of Science.

Extracts from the Evidence relating to the Appointment of a Minister of Science.

We have received a large amount of Evidence in favour of the Appointment of a Minister of Science. There has been almost complete unanimity among the Witnesses on this point. We give the following extracts:—

Professor Owen:

"I conceive that the recommendation by Bentham in the last century of such a minister can hardly fail to be practically adopted before the close of the present century, and that the necessity of having a minister for such a purpose will be recognised." * * * * Qu. 11,537.

Sir W. Thomson:

"Would you contemplate that a new department of the State should be constituted for directing the scientific work of the Government?—It would be quite necessary to have a Minister of Science; it is indeed, I think, generally felt that a minister of science and scientific instruction is a necessity." Qu. 10,747.

"Not a minister of other instruction?—Specially of scientific instruction, and not under any national education board, but a minister of science and scientific instruction. The minister would necessarily be in Parliament and a political man, but it would be very rare that he could also be a scientific man, and perhaps not desirable that he should be a scientific man, but he must have able scientific advisers always at hand." Qu. 10,748.

"Could any such duties be well assigned to any existing department of the State?—I believe not." Qu. 10,749.

"You spoke of the necessity for having a minister of science, do you conceive that it would be requisite to have a cabinet minister for education and a second cabinet minister for science, or would you contemplate that the minister for education should be the minister for science?—I do not wish absolutely to fix it beforehand; on the whole I think, however, that the title of minister of education would not suffice. If there is to be a minister, it must be a minister of science and education. There might be a minister of science and education, with a chief secretary or under-minister for national and elementary education, and another for the advancement of science and for the higher scientific instruction. But naturally the minister of education must act for the masses; that must be his great duty, and however much he might wish to act for science, he has still a great duty to the masses. On the whole, I think that it would be preferable to have a distinct minister Qu. 10,759.

of science and scientific instruction. A minister of science and scientific instruction, as a subordinate to a chief minister of science and education, might probably be a very good arrangement."

Qu. 10,764. "The minister of science administers knowledge to the whole country."

Col. Strange:

Qu. 10,980. "It seems to me that in the first place there should be some means of bringing science fully before the nation through Parliament. I know of no means of doing this that is in accordance with our constitutional procedure, except through a minister of state; and therefore assuming science to be a matter of enormous national importance, I think it is essential that it should be all brought under one minister of state, who should be responsible to Parliament for everything which is done in the name of the nation to further science, and who should frame his own estimates and keep them distinct from those of departments which have little or nothing to do with science. * * * * * I think that there should be an estimate for science just as there is an estimate for the army and for the navy." * * *

Qu. 10,982. "What I should be glad to see would be a minister for science, but I daresay that if proper assistance were given to such a minister, he might superintend other departments as well; for instance, as on the continent, he might superintend education and the fine arts. I think it would be preferable that he should be for science only. I think there is quite enough for him to do in England, for it to be done thoroughly; but rather than have no minister I would assign to him also education and the fine arts."

Qu. 10,983. "There would be a difficulty, would there not, in defining the boundaries between the duties of the minister for science and the minister for education?—I think not. I think one would relate to education, which is quite a distinct thing from national research, and I think that they should be kept as distinct as possible. I think one great evil now existing is the mixing up of those two things. Throughout my evidence I have here and there expressed the same opinion that they should be kept distinct, one being the means, the other the end; instruction I conceive to be the mode of growing a certain number of persons fit to investigate."

Mr. De La Rue:

Qu. 13,036. "I think that science ought to be recognized in the ministry by the appointment of a science minister, in order that all matters relating to science might come properly under the cognizance of the Government, and that whenever the Government sought the aid of scientific men it should be through the intervention of the science minister." * * * *

Mr. John Ball:

Qu. 7222. * * * "If science is to be aided effectually, and at the same time controlled effectually, there should be some permanent officer in the department of the Government that has its relation with science, whose duty it should be and who should be responsible for making himself generally aware of the state of science and the doings of its cultivators, and who should be the proper person to advise the Government, not as to the best mode of deciding a strictly scientific question, but as to where the means for solving it are to be had. I look upon it at present as being a wholly haphazard matter how questions of science or connected with science and affecting the progress of science are decided in the public offices, and I speak from some slight personal acquaintance with the matter during the short time that I was in the public service in Parliament."

Qu. 7233. "You stated, did you not, that you thought it desirable that there should be some permanent official to represent and advise the Government in its relations to science?—Decidedly."

Mr. Gore:

Qu. 10,813. "I think there should be a scientific department of the State, which should have the control of the money expended by the State upon scientific matters."

General Strachey:

Qu. 11,875. "The first conclusion that I arrive at is, that all questions relating to scientific matters that arise in the operations of the Government should be dealt with by one of the chief ministers of the Crown, and the officer at the head of the Education Department seems to be the most suitable of such officers. It has been, I know, suggested by some persons that it would be better if there were a separate department for science. That I venture to doubt." * * *

Qu. 11,876. "Under such an education and science department there would be a natural division of the duties, which would probably lead to the appointment of some permanent officer in the position of an under secretary of state, who would have specific charge of the scientific duties of the department as distinguished from the educational duties, which constitute a distinct branch of administrative work." * * * *

Qu. 11,878. "The principal officers in the proposed scientific branch of the department should be, by their scientific qualifications, capable of disposing of the ordinary current business under their charge." * * * *

Dr. Sclater:

Qu. 12,043. "Do you agree with [Col. Strange's] views as to the creation of a Minister of Science and a Council of Science?—Yes, I agree generally with his views; I think that it would be very desirable for the interest of science."

Qu. 12,044. "Do you think it would be desirable that the existing State scientific institutions should be removed from the control of the Admiralty, the Office of Works, and other departments under which they are now placed?—I think it would be a very great advantage that they should be removed from those departments and placed under one minister."

Qu. 12,045. "Have you any opinion as to whether the work could be done by a minister of education, supposing such a minister were appointed?—I think it would hardly be expected that a minister should be appointed only for science; and as I believe it is the case in continental countries that that department is given to the minister of education, I think that we could not follow a better example here."

Professor Balfour Stewart:

Qu. 11,505. "I think it [the ministry of science] might form a division, perhaps, of the ministry of education."

Mr. Farrer:

Qu. 12,673. "I dislike very much the idea of establishing new departments of the Government. If it were possible that this business could be placed upon the Minister of Education, who is becoming more and more important, I think that would be much better than establishing a separate department for the purpose."

Sir George Airy does not appear to be convinced of the advantages likely to be derived from the creation of a Science Minister, so far as it would affect the Scientific Departments.

"Do you see any inconvenience arising from the several scientific institutions that are more or less connected with the Government being under different departments?—Not that I am aware of." Qu. 10,523.

"You are content that the Royal Observatory at Greenwich should remain under the Board of Admiralty. You do not require to have a Minister of Science, or a Minister of Education?—No; we are naturally connected in these respects with the Admiralty." Qu. 10,524.

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The proposal to establish a Council of Science.

A proposal to establish a Council of Science was brought before the Government by the Royal Society in 1857, upon a Report from the Government Grant Committee of that Society.

The object of the Committee was (Evidence of Sir E. Sabine, qu. 11,117) to determine "whether any measure could be adopted by the Government which would improve the Position of Science or its Cultivators in this Country."

The report, as quoted by Sir E. Sabine (Qu. 11,119), was as follows:

"With regard to the question of which the consideration was referred to the Government Grant Committee on the 11th of July 1855, namely, whether any measures could be adopted by the Government or Parliament that would improve the position of science or its cultivators in this country, the Committee beg leave to recommend the following resolutions:— Qu. 11,119.

"1. The Committee regard with much satisfaction the steps already taken in the Universities for advancing the study of physical science by including several branches of it in the public examinations, and express their hope that the improvements thus introduced may receive the extension which the interests of science require, and that the public schools may be thereby induced to make physical science an integral part of their course of education.

"2. The Committee recommend that the establishment of classes in metropolitan and provincial schools, where those who have not the means or opportunity of studying at the Universities may be taught the elements of physical science on a systematic plan, be promoted by grants from Government in aid of such funds as may be locally contributed for that purpose.

"3. That the formation of provincial museums and libraries be encouraged in like manner, and that provincial lectures, accompanied by examinations, be established in Great Britain in towns which request this assistance, and engage to provide a part of the expense, such lectures to be in aid of the schools above-mentioned, so that by means of the two combined a sound knowledge of the principles and application of science may be systematically taught.

"4. That duplicate specimens from the British Museum and other institutions, supported at the public expense, be distributed to provincial museums.

"5. That national publications bearing on science be more extensively circulated than they are at present by additional donations to societies and individuals engaged in the cultivation of science.

"6. That the sum placed annually by Parliament at the disposal of Government for the reward of Civil Services, 'useful discoveries in science and attainments in literature and the arts,' be augmented; that the portion to be appropriated to science be defined, and that it be sufficiently large to admit of the grant of annuities of the nature of good service pensions as rewards of eminent scientific merit.

"7. That the sum placed at the disposal of the Royal Society for the advancement of science be not necessarily limited to the annual grant of 1,000*l.*, when on any occasion special reasons may be assigned for an additional sum.

"8. That scientific officers be placed more nearly on a level in respect to salary with such other civil appointments as are objects of ambition to educated men.

"9. The Committee regard with much satisfaction the steps already taken for the concentration of the principal scientific societies in Burlington House, and trust that the period is not far distant in which permanent accommodation will be afforded to the principal scientific societies in buildings to be erected near the same site, and in pursuance of the same general plan.

"10. While it may not be expedient to interfere in any way with the functions confided to the President and Council of the Royal Society in reference to the distribution of the Parliamentary grant, or with the ancient and recognized relations between the Royal Society and the Government, at the same time it appears to the Committee that much benefit would arise from the formal recognition of some board which might advise the Government on all matters connected with science, and especially on the prosecution, reduction, and publication of scientific researches and the amount of Parliamentary or other grants in aid thereof; also on the general principles to be adopted in reference to public scientific appointments; and on the measures necessary for the more general diffusion of a knowledge of physical science among the nation at large; and which might be consulted by the Government on the grants of pensions to the cultivators of science.

"11. Assuming that the above proposal should meet with the approval of Her Majesty's Government, it will be desirable to ascertain what mode of constituting such a board would inspire them with most confidence in its recommendations. Two modes may be suggested in which such a board might be organised. First, the Government might formally recognise the President and Council of the Royal Society as its official adviser, imposing the whole responsibility on that body, and leaving it to them to seek advice when necessary in such quarters as it may best be found, according to the method now pursued in the disposal of the Parliamentary grant of 1000*l.* The second method would be to create an entirely new board, somewhat after the model of the old Board of Longitude, but with improvements. The question as to which alternative shall be adopted is properly a subject for the consideration of the Government.

"12. Such of the above recommendations as involve the expenditure of money, might be eventually carried out by appropriating to this purpose a certain portion of the fees received from the grantees of patents, after

providing for all expenses which ought to be defrayed from that source. The Committee are satisfied that no application of these fees could be devised more appropriate than the devotion of a portion of them to the encouragement of abstract science, to which practical art is under so many and such important obligations."

The proposal to establish a Council of Science has recently been revived by Colonel Strange.

Amongst the Witnesses who recommend the Appointment of a Council, there is a great diversity of opinion as to its Constitution and Limits of Action. As regards its Constitution, it will be seen from the Summary of Evidence which we shall give subsequently, that while some of the Witnesses are in favour of a Council very limited in numbers, others would desire to have it sufficiently numerous to include Representatives of nearly every branch of Science, as well as Men of known Administrative Ability.

In regard to its Limits of Action, the main difference arises on the two questions, whether the Council should or should not have the power of Initiating Inquiries, either directly or by suggestion to the Minister, and whether or not it should itself undertake the actual work of Investigation required for State Purposes.

As to the Mode of Remuneration, the opinions vary between those which advocate annual payments to permanent officials, and those which are in favour of payments for attendance at meetings.

The Opinions of the Witnesses who are opposed to any such Council are based, in the main, upon one or more of the following objections:—

1. That Government can get the best advice without it.
2. That it would be liable to come into collision with Ministers.
3. That it would not work harmoniously with our General System of Administration.

The Evidence of three eminent Statesmen possessing great administrative experience——Lord Derby, Lord Salisbury, and Sir Stafford Northcote,—is in strong contrast (so far as the proposal to establish a Council of Science is concerned) with that which we have received from many persons holding official positions in various Branches of the Public Service. The Opinions of these latter, as to the Inefficiency of the Organization of their Respective Services in regard to questions affecting Science, we have already quoted in the First Part of this Report, and it will be seen, from the quotations we are now about to give, that they in general consider the creation of a Council to be the proper Remedy.

Extracts from the Evidence in favour of the Establishment of a Council of Science.

We fear that no mere extracts from the Evidence of Colonel Strange would represent in an adequate manner the views which have led him to recommend the formation of a large and highly-paid Council of Science. It would scarcely be fair to him, as the most prominent advocate of the proposed measure, to do otherwise than refer to his Evidence at length, pp. 75 to 92, and 125 to 135, Vol. II. of Evidence.

Sir W. Thomson's Evidence with reference to the Establishment of a Council of Science is as follows:

Qu. 10,677. "Do you think that a single body would be better than a number of small committees for advising the Government on the great variety of questions which from time to time would be likely to arise?—Yes, certainly."

Qu. 10,678. "The questions which might be referred to such a Council would differ very much from one another, and extend over a wide range, would they not?—Yes, but there would be an unity of design and action, with a multiplicity of knowledge and skill at command, secured by a single council, and those conditions cannot, in my opinion, be secured at all by occasional committees, or committees working separately and independently of each other." * * * * * *

Qu. 10,679. "A scientific council would relieve the Government of all responsibility in such matters, and would be responsible itself in a general way for all its proceedings to a political chief and to Parliament." * * *

Qu. 2694. "Have you formed any opinion as to the constitution of such a committee as we have been referring to: how the members of it should be selected?—I have no other opinion than that the men whose advice may be considered as most valuable and useful to the Government ought to be asked, quite independently of their connexion with any institution, whether under the Government or in the universities, or in connexion with any public or private body in the country."

Qu. 2695. "You would contemplate that committee being formed by the Government itself, and not that the universities or the scientific societies should have the right of nomination?—Certainly by the Government: but aided by recommendations from the universities and scientific societies, and from this proposed consulting committee after its first constitution."

Qu. 2868. "Would you have them a permanent body, with, it may be, a certain number of members going out by rotation, or in the event, suppose, of a change of Government, would you throw over the whole body?—A non-political body, I think, would be necessary for good action."

Qu. 10,691. "Would you leave the selection of each appointment to the Government of the day, or would you allow scientific societies or other bodies to recommend, or would you propose that the Government should be obliged to consult such bodies?—I would prefer that the Minister of Science should have the appointment."

Dr. Frankland thus deals with Colonel Strange's Proposal:

"Are you acquainted with Colonel Strange's proposal for the establishment of a consultative council of science?—Yes, I have heard from him some of the chief ideas that he entertains on that subject." Qu. 11,082.

"Are you disposed to consider that such a council would be desirable?—I think so. I am not prepared to say that it should be constituted exactly in the way that Colonel Strange mentioned, but a council of that description would be exceedingly desirable, on many grounds, for furnishing the Government with trustworthy scientific opinions in cases requiring them." * * * Qu. 11,083.

"Are you of opinion that the advice of such a council, even on matters to which the larger proportion of the members of the council had not paid special attention, would be valuable?—Yes, I think it would, because those members of the council who were thoroughly acquainted with the subjects would be expressing their opinion to men conversant with scientific methods, and they would be able to convince their colleagues with respect to the opinion that the council generally ought to give upon the matter. It would be a very different thing from that of convincing a parliamentary committee, for instance, upon a scientific point, because all the men upon the council would have received a scientific training, and would understand the bearing of scientific arguments." Qu. 11,086.

"Have you considered at all how such a council could best be appointed, whether would you leave it to one of the ministers to appoint and select the proper persons to serve on the council?—I should think that it must ultimately fall upon the minister, but he might be assisted by the presidents of different learned societies or by the council of the Royal Society, in whom I think everyone would have confidence." Qu. 11,087.

Mr. Farrer suggests the formation of a Council which might be closely connected with the Royal Society.

"Have you any suggestions to offer as to the best modes, as it appears to you, of solving problems which from time to time present themselves?—I think if upon purely scientific questions there were some scientific body of some kind to whom the Government departments could as a matter of course refer for the solution of such questions as this, it would be a great advantage." Qu. 12,634.

"I have looked at the suggestions that have been made by Colonel Strange and others, and I do not think that any Government department or its professional officers would listen to the dictation of any council of purely scientific men; they would probably say, and say with justice, that they knew more about what was wanted than any such council could know. Every now and then in the course of practice in those cases a new scientific question does arise; such, for instance, as the question concerning deviation of the compasses. In such a case as that we required the best scientific assistance we could get; and in the case of sulphur in gas, and water impurities, we now require it." Qu. 12,636.

"I give with great hesitation a suggestion upon a point upon which I really am scarcely competent to suggest anything, namely, whether you had not better make use of what you have at present, namely, the Royal Society or a committee of the Royal Society, rather than attempt to establish any new body. No new body that you could establish would have the prestige, reputation, and influence that the Royal Society has. That is a matter not to be created; it is a matter which has grown with centuries. You have also in the Royal Society itself a scientific public to whose opinion any council or committee appointed by it would or might be made amenable; and my suggestion would be that you should endeavour to create some committee or body out of the Royal Society which should bear a fixed relation to the Government, which should meet regularly, and the members of which should be paid something, as the directors of a joint stock company are paid for their meetings, to whom the Government should have a right to refer, who should feel that they had on the one hand a duty towards the Government, and who on the other hand should be bound to make public all their proceedings, so that they would be responsible to the public scientific opinion of the country. That is the best suggestion that I can make, but, as I say, I am very ignorant upon the subject." Qu. 12,643.

Admiral Richards is of opinion that the appointment of a Minister of Science and of a Council stand and fall together; and thinks "that the one would not be of very much value without the other." Qu. 11,585.

But, as regards the Admiralty, the Department which he knows best, he would prefer that it should be able to decide Scientific Questions within itself. He says:

"I think that the Admiralty requires the aid of such a council less, perhaps, than any other department of the Government, for this reason, that there are not very many questions, purely questions of science, that come under the notice of the Admiralty; and then we have the Astronomer Royal to refer to, who is a host in himself, and if any question arises which we do not refer to the Astronomer Royal, we generally ask the President and Council of the Royal Society, and we have never found any difficulty in getting assistance. The only department of the Admiralty which might require such assistance beyond this, is perhaps the Constructors' Department, in the designs for ships of war. But as regards that, my opinion is that it would be far better to have some scientific designer attached to that department than it would be to refer such questions to a council even." Qu. 11,591.

As to the Admiralty deriving any advantage from the appointment of the proposed Council, he adds: Qu. 11,592.

"There would be this advantage, I think, which they would derive, that they would be freed from the political pressure which is brought frequently to bear upon the Admiralty upon questions of that kind. The whole responsibility of deciding upon a measure would be thrown upon the council."

"Do you think that would be a desirable result?" "I think that it would be desirable in all departments of the Government; it would be very agreeable to the Government of any day, I should think, to escape the responsibility of deciding on scientific questions on which they may not be very intimate, but in which they may be believed to be interested parties." Qu. 11,593.

"Do you think that the work would be better done?" "I think it would. I should say there could be no doubt about that, but unless the Government are prepared to vote a very considerable sum every year for Qu. 11,594.

the advancement of science, which I am quite of opinion that every Government ought to do, I think very little benefit would accrue from having such a council."

Qu. 11,427. Dr. Balfour Stewart is also in favour of a Council:

"You have no apprehension that the Government, if advised by men of the highest scientific capacities, would be likely to operate so as to control science, and to fetter the operations of individuals, or to benumb and discourage Original Research and Observation?"

"I think not. I think that the great desideratum is to put more means at the disposal of private individuals, and, of course, this must be done by some sort of administrative body."

Qu. 11,515. "In what way would the advice of the council be better than that of the individual members of that council, who are the highest authorities on the question under review?—Because I think that science has a number of bearings, and that a question might involve, not one branch of science, but a great many, and you might, for instance, have to call in various men of science of different kinds. In order to answer this question, you might have to call in, not the advice of one member of the council, but the advice of a number. Of course there are a number of questions regarding which some of the members of the council would naturally be silent, but perhaps a good many of them might be interested in answering a particular question, and would give their answer. In a case of that kind I should fancy, however, that it ought to come as from the whole body, because, really, in most questions now-a-days, the question would not involve one particular branch of science only, but it would involve the joint operation of two or three branches of science."

Qu. 11,516. "Take, for instance, such a question as that which has been recently referred to a committee, the efficiency and stability of ships of war, would there be any advantage in referring a question of that kind to the council, rather than to a committee specially appointed, as has been done on the occasion to which I refer?—I think that if there were a council of this kind, the council would have power to associate other people with them in a case of that kind. Science is so ramified, that the council would not be able of themselves to settle all questions; but upon particular questions, such as you name, very likely they would associate other people with them."

Qu. 11,517. "Do you think that they would be more likely to make a judicious selection of the persons to be consulted than the Minister of State would be, without the advice of such a council?—I think so, because a Minister of State is not likely to know the capabilities of various men. There are a number of men known to scientific bodies as profoundly conversant with particular branches of science, but their knowledge of those subjects does not appeal to outsiders, it only appeals to those who are cognizant with that particular subject." * * * *

Dr. Roscoe is in favour of a Council, and would give a voice in its appointment to the Learned Societies:

Qu. 7436. "Can you make any suggestions as to the mode in which Government aid could be best carried into effect?—I do this with the greatest diffidence; but it appears to me that the system of a consultative council, to advise the executive on matters of scientific instruction, is the true one. I believe it is a work which it is almost impossible that the executive can do properly without advice received in some form, and that appears to me the form in which it is most likely to be productive of the greatest good."

Qu. 7437. "Have you any suggestions to make as to the constitution of such a council?—I should be inclined to think that a council, formed on the same plan as this Commission, so far as regards the class of its members, would be a very proper one to advise the Government."

Qu. 7438. "Would you think it advisable that the Government should name its own consultative council, or that some of the members should be nominated by the societies?—I should provide for a certain number of scientific men being upon the council, and desire that the Government should nominate (for you may trust the Government to do it with fairness), as well as the societies; that is, the lay members should be appointed by Government, and the professional ones by the various scientific societies." * * * *

Qu. 12,043. Dr. Sclater agrees generally with Colonel Strange's views, and thinks that a Council "would be very desirable for the Interests of Science."

He then proceeds to state his opinion as to its Constitution:

Qu. 12,046. "Have you formed any opinion as to the constitution of a consultative council to assist this minister?—My idea would be that the heads of the different scientific institutions that are put under the control of the department of science and the minister of education might form a consultative body and be called a council of science, and that there might be certain other members added to assist them in deliberation, if it were thought necessary, such as representatives of the College of Physicians, the College of Surgeons, and of the scientific branches of the Army and Navy."

Qu. 12,047. "Colonel Strange's proposed council would consist of 30 members at least; do you think that that would be too numerous a body?—I think that a less numerous body might suffice, because I see that, in many cases, however numerous the body was, it would be necessary to call in special assistance."

Qu. 12,049. "If a council were constituted in the manner that you propose, should you contemplate that, as a rule, they would be capable of giving advice themselves on most questions that would arise, or would they generally find it desirable to call in further assistance?—I think, that in most cases, they would be quite competent to give an opinion to the Government; but that sometimes on particular questions, it would be necessary to go elsewhere for advice, and that, in such cases, there would certainly be somebody in the council who would know exactly where to put his hand upon the right man for the purpose. For instance, a question might arise in some special department of Natural History: in that case, the council would naturally refer to the head of the State Museum of Natural History to know if he could give an opinion himself, and if not to inform them who could give an opinion upon the point. Thus, I think that with the aid of a small council of science of, perhaps, 20 members, every question requiring solution by the Government as regards science might meet with very fair consideration and be very easily settled."

Qu. 12,054. "Have you any misgivings as to whether such a council would command sufficient public confidence amongst men of science?—I have no misgivings at all upon that subject. I should say that they would meet with general support from men of science. Most men of science, I think, see that something of the sort is

imperatively required. All lament the piecemeal way in which scientific subjects are dealt with by Government, in consequence of their being subdivided amongst all these different offices, and of there being nobody to appeal to upon a question of science, and, therefore, I think the proposal to establish such a council would meet with universal acceptation amongst scientific men."

"Then, in the case of investigations which were required to be undertaken, how do you conceive that they would be dealt with?—I should say that the member of the council representing the particular branch of science would be called upon to present a preliminary report of how he proposed to set about any particular investigation. He would say, to do this I shall require the assistance of such and such persons for so many days, or for such and such time, or to send here or to send there, and would bring these requirements in the shape of a preliminary report before the board, and, if this were approved, would carry out the investigation. Then he would present his report upon the result of the investigation, and the council as a body would consider it, and recommend its adoption by the Government or otherwise." Qu. 12,074.

"Then do I understand that you would prefer, as a general rule at least, that the members of the council should themselves carry out such investigations as might be required from time to time, rather than that they should merely indicate to the minister the person, outside the council very probably, who they thought was best competent to carry out the investigation?—I do not think it would be necessary to draw a hard and fast line upon such a question as that. I think that in many cases it would be better that the council, as a whole, should report to the Government on the best way in which any particular scheme might be carried out. I do not think that it would be necessary to introduce a rule that you should invariably go to the member of the council representing that particular science if advice were wanted upon that branch. But the council would naturally turn to the representative of the particular science for an answer; they would naturally look to his advice first." Qu. 12,075.

"I understand you to mean that the duty of the members of the council should be to know where to go in order that particular questions should be answered, whether it were to go outside the council or to go to one member of the body?—Yes, that is my opinion." Qu. 12,076.

His remarks on the question whether there should be on the Council men having Administrative Experience are as follows:

"I think that the heads of great scientific institutions must have administrative experience. If a man has to manage an institution like the Royal Observatory at Greenwich, or the State Museum of Natural History, he must have the command of a great many men under him, and must be acquainted with the business of the institution, and must have gained his administrative experience. He could not fail to be a person of administrative experience." Qu. 12,085.

"But, taking the application of scientific laws to specific departments of the Government, the army and navy, for example, would it not be important that there should likewise be on the council some men of special knowledge of the mode of facilitating the adaptation of scientific laws to those departments?—I think, certainly, that the army and the navy, which are the branches of the service, perhaps, most requiring scientific assistance, should be represented by one or more members at the board, and no doubt the Government would take care to secure a first-rate man for what I should consider a post of the very highest honour." Qu. 12,086.

As to the numbers composing the Council, he considers "that it would not be advi- Qu. 12,095.
"sable to have a larger Council than was absolutely necessary," for the reason that a small body of men generally work better and do more work than a large body; at the same time he does not think that 20 would be a very large number.

Dr. Hooker, the President of the Royal Society, gives it as his opinion "That the Qu. 12,138.
"general proposition, that the Government should be aided by scientific persons, is an "excellent one, both with respect to the administration of the existing Government "Scientific Institutions, and with respect to the occasional grants which the Government "may be called upon to make for scientific objects." Like Dr. Roscoe, he thinks that the Council should not consist exclusively of Scientific men.

Mr. De La Rue thus gives his opinion:

"There ought to be a board of advisers which should consist of men eminent in different departments of science. I can only speak as to those branches of science to which I have paid some attention, and I should put in the first category that there ought to be on the board a chemist of eminence, there ought also to be a physicist, an astronomer, a mathematician, particularly one who has paid attention to the application of mathematics to science, and an engineer or two engineers, one who has given attention to the construction of great works, such as railroads and bridges, that is to say, civil engineering, the other a mechanical engineer. I do not speak of a biologist or a physiologist, because other witnesses are much more competent to speak as to the necessity for such men than I am." Qu. 13,037.

"But do you think that all branches of science ought to be represented on the council?—Undoubtedly." Qu. 13,038.

"Can you give the Commission any idea as to the number which you think it would probably be necessary to provide for?—About 10 or 12 men, I imagine, would sufficiently represent science." Qu. 13,040.

He would give some voice in the selection of the Members to certain Societies, and would not require the Members to "relinquish any other position that they might already hold." Qu. 13,036–13,041. Qu. 13,050.

As to the numbers of the Council, he says that "If 12 men were not found to be Qu. 13,052.
"sufficient to include all branches of knowledge, it would be desirable to increase the Qu. 13,119.
"number." He proposes "that special advisers might occasionally be called in who Qu. 13,120.
"would be remunerated according to their attendance." * * * *

He considers that the usual permanent staff of a Secretary and Assistant Secretaries, even if they were men of Science, would not be sufficient; urging as a reason that

Qu. 13,125. "Science is really now so extensive that one could hardly imagine any secretary so to be intimately acquainted with every branch of science as to be able, even with the aid of his assistant secretaries, to advise, or to point out where to obtain specific information on every question which might be brought under consideration. I think, therefore, that there would be a very great advantage for the Science Minister to have a sufficiently numerous Advising Council."

He considers that promptness of action would be promoted by the appointment of a Council:

Qu. 13,126. "There ought to be a body of men who could be immediately called together, whose time was so far at the disposal of the State that they might be assembled on every occasion and at any time to advise the Science Minister. Then we should get prompt action, instead of questions being allowed to drag over years and years without any practical solution being come to."

Qu. 13,131. But even if a Council were appointed, he thinks that such branches of the Government as the Admiralty, the War Office, and the Public Health Office "should be specially "scientific, each in its own department."

Qu. 13,134. In answer to the question, "Have you no fear that there might be some collision, or, "at any rate, considerable friction, between that Council and the Scientific Departments "of the Public Service?" he says:

"Probably at first there might be, but ultimately I believe the confidence of those directors of the departments would be gained by the very sound advice which they would receive from a body constituted as I conceive it ought to be."

He does not think the Government Grant Committee could be so modified as to render a Council unnecessary.

Qu. 13,135. "Supposing 5,000*l.* or 10,000*l.* were given to the Royal Society to aid investigations, I do not think that that in any way ought to weigh in the consideration of the establishment of a science minister whose functions would be altogether larger and much more important. We want science really cared for in England by the State, and we want all State questions relating to science properly considered by a body capable of dealing with them."

Professor F. Jenkin is in favour of an Elective Board:

Qu. 1658. "I think that the judging of the applications for assistance, applications for the endowment of new chairs, and the application of Government patronage generally as regards science might be managed by the following system. Supposing that instead of the grant being given simply by the Department itself (speaking now of the Committee of the Privy Council) there were a representative board composed of men of science, composed of professors who could advise—I will not say that they should have the power of deciding—I would rather leave that with the Government, but that they should have the power of reporting at any rate upon each of those applications, I think that the Government would get better advice than it can command at present. My idea is that this board should be an elected board, that each of the existing colleges (you could easily choose the colleges and universities) should appoint one member at such a board as that; but however the choice was made, if there were something like a representative board of scientific men to advise the department, even if their recommendations were not necessarily acted upon, but that they were simply a reporting body, I think that the Government would be better able to decide on such subjects than they can now do, and that their decisions would give greater satisfaction."

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Qu. 1659. "I do not know how otherwise the Government is to decide who is really the best man. We cannot have competitive examinations for professorships, I think, and the system of irresponsible testimonials has come to be in a monstrous state. A man really prepares a blue book; every man one has ever spoken to sends for a testimonial, and you get a whole library of those testimonials." * * *

Professor Martin Duncan points out an important way in which the Council could be utilized:

Qu. 7704. "With reference to any endowment that might be granted by the Government, have you formed any idea as to the control under which the administration of such endowment should be placed?—That is a matter which I have thought over, and I see that it might lead to great difficulties. The Government might wish to nominate a Professor of King's College, and such a professor might be objectionable to the Council of King's College, and I think it would be more satisfactory to scientific men if all those appointments were placed under the care of a board of scientific men of position, and who would be responsible to the Government for their nominations, and for the duties of the professors being well carried out. There would be no difficulty in obtaining such a board, because the presidents and officers of the learned societies, which have charters, would make a sufficiently good board, and a board beyond doubt as regards their scientific acquirements and their desire to uphold science. To leave the matter entirely in the hands of the Government would, perhaps, not lead to very satisfactory results."

Qu. 11,973. Mr. Spottiswoode considers Colonel Strange's suggestion the most complete and perfect that has yet been made, and states that he has "always looked upon it as an arrangement to the carrying out of which all others should be directed;" at the same time, however,

he considers "the proposal is a large one," and suggests that "it might be worth consideration whether some intermediate scheme for earlier action should be proposed."

His opinion on the Appointment of the Members is thus expressed:

"If any council (without at present going into its constitution) were appointed, in whose hands do you think that appointment should be placed?—I think it clearly should be in the hands of the Minister with whom it would be in direct relation." Qu. 11,974.

"You would leave the choice absolutely to him, and not make the appointments in any respect *ex-officio*?—There might very well be certain *ex-officio* members, such, for instance, as the Astronomer Royal for the time being, the President of the Royal Society for the time being, and perhaps others." Qu. 11,975.

"The greatest importance would attach to the first constitution of the council?—Certainly." Qu. 12,013.

"How would you advise the minister to proceed in order to act wisely in that appointment?—I should suppose that he would obtain advice from the leading men of science of the day, and with their advice it would not be difficult to form, at all events, the elements of such a council, although he might not be able at once to complete a very fully organized body. If those first appointments were made, he would have the full advantage of the advice of those members in completing the entire list." Qu. 12,014.

"If such a consultative council were appointed, you would probably contemplate that it would be mainly composed of persons now to be found on the council of the Royal Society, or on the committee of recommendations of the British Association?—Yes, I should imagine that it would be mainly composed of Fellows of the Royal Society." Qu. 12,038.

"How would it work if there were some arrangement by which the council of the Royal Society should propose a certain number, two or three persons out of whom the Government might select one on any vacancy?—I see no objection whatever to that proposal." Qu. 12,039.

"That would secure, as a general rule, the appointment of persons of the highest scientific qualifications on the council?—I think it would." Qu. 12,040.

Sir Henry Rawlinson thinks that the Council should be merely consultative. He regards the nomination of a Permanent Council of Science as the natural remedy for the "spasmodic" action on the part of the Government, and adds: Qu. 12,562.

"It appears to me that the chief and most important point in this matter has reference to the appointment of a Council, rather than to the nomination of a Minister. I think with a Consultative Council of Science there would be a corresponding uniformity of action." * * * * * * Qu. 12,552.

"In the Council of India we have no power of initiation. The initiative rests with the Minister, or, practically, with the executive officers, acting, I may say, on the inspiration of the Minister, and the measures are only brought before the Council, in a subsequent stage, for their approval or disapproval." Qu. 12,562.

We have already quoted the Evidence of this Witness as to the difficulties which the Government Departments, and more especially the Indian Council, meet with for want of authoritative Scientific Advice. In answer to question 12,564, he goes on to say:

"I may mention to the Commission, in reference to this subject, that the desirability of such a council is constantly brought to my observation through another channel, namely, through my duties in the Council of India, where we perpetually have references before us, which we are really unable to deal with. These references recall most forcibly to us, and very frequently, the necessity for the existence of such a council as I have proposed." * * * * Qu. 12,564.

"Should you apprehend that a minister would find it a very difficult task to constitute a council in such a manner as to command the confidence both of the public and of scientific persons?—No, I should think not. I should think a minister, with the latitude of selection which he would have in a country like this, would have no difficulty in bringing together a council of 10 or 15 gentlemen whose qualifications and reputation would command the respect of the world, and whose opinion would fortify him in his decisions, and be of great national benefit." Qu. 12,587.

General Strachey has given us some important Evidence as to the Appointment and Functions of a Council of Science:

"The persons who are employed in the public administration are certainly as a class not amongst those who have anything deserving the name of scientific education; therefore, for a long time to come, it is not to be expected that the members of the Government, or their chief subordinates, will have any such general knowledge of science as would enable them at all satisfactorily to deal with the scientific questions which come before them. Therefore, I conclude that it is absolutely essential for the Government, under any circumstances, to get advice from outside; and then comes the question as to how this advice is to be got. If there is no recognised and regularly organised body whose business it is to give advice to the Government on such subjects, then the only thing that a minister can do is to get his information from unrecognised and irresponsible authorities, persons whose opinions, perhaps, may be very valuable, but still persons of whom the public never can have any cognizance; and private advice given in that way seems to me given in the worst possible form. If, then, that form of advice is bad, how can you obtain advice of proper intrinsic value on the multifarious subjects on which it is certain to be needed by an administration really striving to advance science to the utmost, and how can you secure its being given under a sufficient sense of responsibility, and in such a way as to carry the greatest weight possible to the mind of the minister who is expected to act upon it? And here I would repeat that any specific proposal to give effect to such an idea must be made to fit into the general form of the administration; and I, therefore, consider that the best course would be to adopt the proposal that has been made by many persons, that there shall be some sort of council constituted to advise the responsible Government department as to its proceedings in connection with science." Qu. 11,879.

This Witness objects to the proposal that the Council should be elected by, or selected mainly from Scientific Bodies, or Educational Establishments, and considers that—

Qu. 11,879. "The only way to lead a Government in the proper course which they should pursue in relation to science is, to give them advisers whom they have agreed to accept, and whom they are, therefore, forced to admit as trustworthy and satisfactory guides. The only way in which that sort of relation between them can be established, I think, is to put a specific responsibility upon the Government to nominate. I think, too, that there would be, under such an arrangement, an action of a similar character in the other direction, and that a person who was specifically nominated by the Government to perform those particular duties would have a much stricter responsibility put upon him, so to act and so to advise the Government as to produce satisfactory results, than if he were merely developed, so to speak, by the operation of some external body."

Qu. 11,882. "I think that in order to put propositions in a practical form and in an acceptable form before the minister, it is desirable that there should be persons in the advising body who have a certain amount of administrative experience. Also, I think that, as society is constituted now, there should be in it persons of what is commonly called superior social position, such persons having certain advantages in getting access to the minister, and in guiding public opinion, which others have not. What should be aimed at, in short, is a practically useful body rather than an eminently theoretical scientific body; and I should say that a body not differing materially from this present Commission has the sort of constitution which would secure the best exercise of the influence which I conceive that this advising body should exercise. I think that all that would be necessary to enable it to do all that could possibly be required of it, would be to entrust it with suitable power, where the occasion required, for making specific references, or for calling into its councils persons specially qualified to advise it, who were not permanently upon the Commission. I think that an arrangement of that sort could be carried out without any particular difficulty."

Qu. 11,883.
Qu. 11,884. He thinks that the body should not be very numerous, suggesting nine as a sufficient number, on the ground that the larger the body the more divided is the sense of responsibility, and also on the ground that under certain circumstances the larger the body the less is the weight that is attached to its opinion.

He would give considerable Initiative Powers to the Council:

Qu. 11,885. "Would you propose that this council should initiate proposals itself, as well as consider subjects on which its advice was asked?—Yes, I think so. I think that the greatest freedom of action should be given to the Council; that it should be in a position to make any representation that it thought desirable to the minister on the subject of science." * * * *

He disapproves of the suggestion that the Council of the Royal Society should perform the Functions of a Council of Science:

Qu. 11,886. "Would such a body as you are proposing supersede the Government Grant Committee?—Yes, certainly; and I would take the opportunity of saying that it is a question that is open, and which I believe has been discussed, whether the Council, for instance, of the Royal Society, with or without any addition, might not be made to perform satisfactorily some or all of the functions which it has been suggested should devolve upon this Commission. But I think not. And the principal reason that I have for thinking that such a body as the Council of the Royal Society is not suitable for the purpose is, that it cannot have that specific responsibility put upon it which should be put upon a body such as I have spoken of, and that it is got together for totally different purposes and objects. The council of the Royal Society has to manage the business of the Royal Society, and is not at all selected to advise the Government on matters connected with the advancement of science, or the application of science in the operations of the public departments."

Qu. 11,887. "And one-half of their number is changed every year?—Yes."

Qu. 11,888. "You could not make the minister responsible for the action of the council of the Royal Society, or of its committee?—Not at all."

Qu. 11,889. "Because the nomination of the council and of the committee is by a body of constituents over whom the minister has no control?—Quite so; the minister would have a perfect right to repudiate any scheme which they put forward, or any advice they gave; I mean that he would be justified in doing so on the ground that he was not responsible for their selection." * * * *

He is in favour of the advice of the Council being made public, as a rule, but subject to the discretion of the Minister.

Qu. 11,889. "There would be cases, for instance, in which the minister might ask a question as to the relative qualifications of two scientific men for some post, and the commissioners would give an opinion, and their reasons for that opinion, but it would not be right that the grounds on which they formed it should be made public; still, as a rule, the more complete the responsibility put upon everybody connected with the commission for the opinion that he gave on any subject that came before it, the better would it be."

With regard to the Financial Duties of such a Council, he would wish it to prepare stimates with reference to any expenditure they might propose.

Qu. 11,890. "They should place any proposals that they had to make in a definite form before the minister, but I would not hand over any lump sum to them as is done now in the case of the Royal Society. I understand that the Treasury give a thousand pounds a year to the Royal Society, to spend in their own way on scientific objects. I think myself that this system is essentially vicious; to make a homely comparison, it is as though I desired to absolve myself from all responsibility in connection with the suffering and poorer class of the community, by giving the first beggar I met sixpence. The Chancellor of the Exchequer hands over a

thousand pounds to the Royal Society, and thinks that he has done all that is necessary for the promotion of Science."

He does not propose that the Council should supersede the Scientific Branch of any Public Department; but is of opinion that a Council would strengthen the hands of the responsible Chiefs of such Departments:

"I think that the idea of placing such matters as the construction of ships for the Navy, or the form of guns, or of small arms, or of projectiles, and so forth, upon a body of this sort is altogether a mistake; that is not a function that should be put upon such a body; it is not really what is wanted. The departments of the Government that have to carry out those particular duties are responsible for possessing the necessary knowledge; for instance, the department that builds ships has within its own body all the necessary means of acquiring the information requisite for designing proper ships and for building proper ships, or, at all events, if it has not, it ought to have; and if there is a defect in the organization of those bodies, they ought to remedy the defect themselves; they ought to introduce amongst their officers proper people." Qu. 11,890.

"There is not the slightest reason to doubt that the responsible officers in the Controller's Department knew perfectly well that the "Captain" was not a safe ship, but their opinion was overridden, and if Admiral Robinson and Mr. Reed had had a body of this sort to refer to, if they could have challenged the Admiralty board to take a scientific opinion from this body as to whether their views were right or wrong, great good would have resulted." * * * * Qu. 11,890.

As regards the special use of the Council in reference to the Administration of India, the evidence of this Witness is so full and so important that we must refer to it in extenso at pages 213 and 214, Vol. II. of Evidence.

Captain Galton would desire to see a Council whose duties should be principally administrative.

"I should not advocate the formation of such a council unless that council could be given duties other than those of a consultative nature. I do not believe in mere consultative councils. If a council is to be appointed, it must be a council for some other objects, and I think there is quite sufficient reason for the appointment of a scientific council or commission, or whatever you like to call it, for certain other purposes, and that when it was constituted for those other purposes, which are practically administrative purposes, the council might be advantageously consulted upon other subjects by the Government." Qu. 12,980.

"You have pointed out that there are a very considerable number of Institutions connected with Science which are supported by the State; do you consider that there is sufficient system in the present arrangements?—I think that the institutions which are maintained by the State for scientific purposes are maintained upon no principle whatever with regard to their administration. You have got the British Museum under Trustees, you have got South Kensington under the President of the Council, you have Kew under the Office of Works, you have the Botanic Gardens at Edinburgh, I think, under the Queen's Remembrancer. You have the Observatory at Edinburgh as part of the University of Edinburgh, and you have the Observatory at Greenwich under the Admiralty, besides several others. You have every possible variety of jurisdiction, and, consequently, it seems to me that you have a great waste of power; there is the School of Chemistry, and the School of Mines, and the Museum at Edinburgh, all under South Kensington Museum, and the Meteorological Department, which is partly under the Royal Society and partly under the Board of Trade. There is no possibility of getting any correlation between those different scientific bodies, and if you are to get proper unity of administration you must bring them all under one head, or to one focus. I should recommend placing them all under a scientific commission or council, and I should place that council probably under the Privy Council; but I should make it a body for administering all questions connected with all the scientific institutions, or all grants made by the Government for scientific purposes in the country, and I should give to this Council the same status, with regard to its administration, or very much the same, that the Indian Council have." * * * * The parliamentary head of the Department, if he differed from them in opinion as to their recommendations upon the scientific questions connected with those institutions, or any other that might be founded, should record his differences of opinion in a minute." * * * Qu. 12,984.

'Have you considered what would be the best mode of constituting such a council?—I should keep it to as limited a number as would represent sufficiently the different branches of science. I do not think that you could possibly have a smaller number than five or six. I think they would want a secretary, and, of course, they would have to meet tolerably frequently for the administration of these mattters." Qu. 12,988.

The Council, in his opinion, should be nominated by the Minister of the Department, or the Prime Minister. Qu. 12,989.

He further considers that all questions as to grants of public money for purposes connected with Science should be referred to the Council, instead of being granted or refused "hap-hazard." Qu. 12,000.

Dr. Siemens would "assemble the Heads of Departments at frequent intervals for the "discussion of general questions, and would propose to add to their number such "men as the President of the Royal Society, the President of the Institution of Civil "Engineers, and at least one Representative of the two great Universities. This Board "would decide general questions appertaining to the Advancement of Science." Qu. 11,796.

He would regard the opportunities of meeting together, thus given to Heads of Departments, as one of the great advantages of such a Council. Qu. 11,857.

Qu. 11,800. Qu. 11,801. Qu. 11,802. Qu. 11,803. He thinks that the number of the Council should be about 20, and that the greater part of its members, being Heads of Departments, should not receive payment as members of the Council. The four additional members whom he proposes, he considers would probably decline remuneration.

The Functions of the Council of Science, with regard to Research, would, according to this Witness, be very limited:

"Would it be desirable, in your opinion, that this Council, or any scientific Government department, should undertake experimental research?—I think not; my impression is that scientific research should be left as free and open as possible. If gentlemen were specially instructed to make experimental research they would be, I consider, in a somewhat false position. They would be morally obliged to produce results in order to satisfy the public mind that they were doing their duty, and science or scientific research cannot be measured by such a standard of results. I consider that a man should always have some absolute duty to perform, some drudgery work, which might be made as light as possible; but my impression is that he would not be in a satisfactory position, either to himself or as regards the public, if discovery were his only duty."

Qu. 11,846. "Your opinion was that the Government should not direct scientific research, but I think I understood you to say that it was desirable that they should direct inquiries to be made in reference to subjects of direct national importance?—Yes."

Qu. 11,847. "And those you think should be carried out chiefly by commissions in each case appointed for the purpose?—Yes, by commissions appointed for the purpose. I think that there should always be a direct practical object in view."

Qu. 11,851. "If those inquiries were directed by a Government council of the nature of the one which you have sketched, do you think that they would be more likely to be successful than if they were left to make their investigations in a more independent way?—I think I would as much as possible leave investigations in the hands of individuals. I would make inquiries through committees or commissions, because they have the means at their disposal for collecting information which private individuals have not."

Qu. 11,858. Qu. 11,860. There should be a Ministry of Science and Education, which would constitute an important Department of itself, the Minister being the Head of the Council. "There are "Political Men of highly cultivated minds, or even with a great knowledge of Science, "who would be quite capable of taking such a position."

Qu. 11,938. Qu. 11,939. Mr. Anderson appears not to be thoroughly convinced of the advantage of a Council. He thinks there is at present more sound Scientific Knowledge in the Government Departments and at the disposal of the Government than is generally supposed, but that if a Council should be appointed, a small number would be better than a large one. He considers that seven would be sufficient, and admits that without the assistance of some Qu. 11,941. such Council as this, he sees no "symptom at the present time" of the Government causing such inquiries to be made as he thinks desirable.

Professor Jellett thinks that every science should be represented on the Council:

Qu. 12,812. "Supposing there were no person in the council who was qualified to judge; for example, supposing the subject were a medical subject, and you had no medical man upon your council, I think that when you came to discuss the report you would find yourself in some difficulty. You would be almost entirely at the mercy of the irresponsible individual outside who had given the advice."

Qu. 12,815. "Of course I could not carry on the subdivision to any very great length. For example, take the subject that I am myself most conversant with, applied mathematics. I do not want to have a representative of acoustics, or a representative of optics; one representative of applied mathematics would do."

Mr. Milne-Home would have a local Council for the encouragement of Research in Scotland.

Qu. 12,449. "I understand you to contemplate the establishment of a board solely for Scotland?—Yes, for Scotland solely."

Qu. 12,451. "I think that if the board were formed in England, with sub-committees in Ireland and Scotland, it might answer the purpose, but I do not see how it is possible that gentlemen in London, unconnected with Scotland, can have that knowledge which is desirable with regard to individuals applying for grants. If there were no board of that kind, the London board would require to make inquiry through individuals selected by themselves, and who would not have the same responsibility as persons officially appointed."

Appendix XVI., vol. II., p. 71. Mr. Justice Grove, who was unable to attend before the Commission, has stated his opinion in an interesting letter which we have given in our second volume, Appendix XVI. He is "not very sanguine as to the working of such a Council, but thinks the experiment worth trying."

He fears that "a large or highly paid permanent Scientific Council * * * would lead "to political intriguing for place; and not the best men of science but the ablest men of "the world would succeed," and that "scientific men, moreover, are not, as a body, suited for the work."

He looks upon General Strachey's proposal, "a continuation of the present Commission, permanent as a body but changed as to individuals," as the most hopeful.

He sees no reason "why the members should not be paid a reasonable salary for "their time and trouble, but would not put this too high, because, if obtained, it "would lead to the political-interest-making system."

The extracts which follow have more especial reference to the Functions which the various Witnesses propose the Council should fulfil.

The late Professor Phillips:

"I think, first of all, it would deal with all questions such as are now presented to the Government Grant Committee." Qu. 3138.

"And would it aid in directing research?—Yes. The Government Grant Committee has very limited means of maintaining anything of a permanent character, and I think, therefore, that this new board would recommend, in a case of that kind which we are discussing with regard to the formation of special observatories, some grant for the purpose of research requiring many years to be continued, and for which apparently it would be very difficult, or next to impossible, to find any other successful mode at present." Qu. 3139.

"Do you consider that any questions regarding the scientific education of the country would come under such a board?—No doubt they would; there would be, I conceive, a very natural alliance between such a great subject as that and the definite prosecution of physical research, but I have limited my own views in the first instance to subjects connected with the teaching, experimenting, and continually observing of physical phenomena." Qu. 3140.

"If such a board were established and got into full work, do you not think that a large part of the time of the members of the board would be occupied in those duties?—I do, indeed." Qu. 3141.

Sir W. Thomson:

"The main object of such a council would, in my opinion, be to advise the Government on all scientific questions which might come under the attention of the Government, and on all scientific works actually undertaken." * * * * Qu. 10,675.

Another object of the council would be to advise the minister of science in all applications for the expenditure of money to promote scientific investigations. Applications are frequently made to the Government of a singular character which could not be classed; some of those applications may be thoroughly deserving of support, and others may be of a most frivolous character. All such applications should be referred to one responsible council. At present the Government must be very much annoyed by occasional applications, and I have no doubt that the want of a permanent responsible and trustworthy adviser or body of advisers to whom all such applications can be confidently referred, must be seriously felt. I may mention as an instance of applications of that kind, the applications made by the British Association for funds for the late and previous solar eclipses. The testimony of the Royal Society and the British Association to the importance of the object was no doubt in this case accepted immediately by the Government as a sufficient certificate that the object was a suitable one for the expenditure of public money. But there are many other applications even by the British Association itself which the Government feel must be referred to some competent adviser.* Then there are many applications made altogether by private individuals for assistance in some department of scientific investigation; those would naturally fall to be all summarily rejected at present, but it would be advisable that they should be handed over to a council of responsible advisers, who would take each case on its own merit." Qu. 10,689.

"Would you be so good as to inform us whether you have formed any opinions as to the best system of appointing such a council?—The council ought to represent the different branches of science, and the practical applications of science. Pure mathematics ought to be represented in the council; mixed or applied mathematics according to the old-fashioned nomenclature as generally understood ought also to be represented; chemistry cannot be shut out; physics must of course be represented and ought to be represented separately; astronomy, both what was formerly called physical astronomy and of course the new science of astronomical physics, ought to be represented. I do not believe that astronomy could be properly represented under one head; astronomical physics must, in my opinion, be separately represented. Geology should be separately represented, and also the various branches of natural history; physiology also, and medical practice in general, should be represented. I have spoken of applied mathematics, I meant rather mathematical dynamics than applications to art and mechanical operations. Then practical applications should be represented, mechanics and mechanical engineering, then again civil engineering and geodesy, mining engineering, statistical inquiries, and the scientific branches of Her Majesty's service ought to be thoroughly represented. Engineer and artillery officers and the navy should be represented both in its navigation department and in the department of seamanship, and the department of gunnery. The mercantile interests of the country and the agriculture of the country ought certainly to be represented. The universities ought to be represented amply—the English universities, the Scotch universities, and the Irish universities. Also practical telegraphy, which is a very distinct branch of engineering, civil engineering or mechanical engineering would not sufficiently represent it." Qu. 10,690.

"Do you think that the functions which are proposed to be assigned to the scientific council would not interfere in any way with the existing scientific departments of the Government; for example, the Medical Department of the Privy Council, or some of the other Government scientific departments?—I think it would relieve the departments from pieces of scientific work at present given to them, because there is no other body to whom they can be given, and for which they are by their organisation and *personnel* almost necessarily ill fitted and insufficiently competent." Qu. 10,750.

"You would leave to these departments their administrative functions, but give them the advantage of consulting with the council upon higher questions of science on which they desired information?—Yes, certainly; every question of science that falls under the notice of any department of the Government would naturally be referred to the scientific council." Qu. 10,751.

Captain Galton:

"I should make it [the Council] a body for administering all questions connected with all the scientific institutions, or all grants made by the Government for scientific purposes in the country, and I should give to this council the same status with regard to its administration, or very much the same, that the Indian Council have; that is to say, that the parliamentary head of the department, if he differed from them in opinion as to their recommendations upon the scientific questions connected with those institutions, or any other, that might be founded, should record his differences of opinion in a minute. Of course as he would be finally responsible to Parliament he must have the final power; but I should put the same check over him that is put over the Secretary of State for India, that he must record his differences of opinion, and his objections to their recommendations, or rather his reasons for not adopting the recommendations of this council, in a written Qu. 12,984.

"* As, for example, that for assistance to the Tidal Investigation. See Appendix IX. Vol. II. p. 32."

inate which would be capable of being produced in Parliament if necessary. Of course the remuneration for those scientific gentlemen who would have to give a considerable part of their time to this council, ought to be of a sufficient nature."

Qu. 12,985. "Would you place the management of all the Government institutions connected with science in the hands of this council?—I should place the administration of it in the same way that the administration comes to the different Government departments now. The officers in charge of the British Museum would report to those gentlemen on all expenditure of money, on changes, and other matters of that sort. All their estimates would come up through this council, and all their expenditure would be sanctioned through it, and any questions arising in their administration, for instance, changes recommended, or new regulations, would be administered by this scientific council, instead of being administered by the separate heads of the departments who now administer them."

Dr. A. W. Williamson:

Qu. 12,687. "Could you enumerate what you consider would be the principal duties of this council, supposing it to be established?—I should put the specific duty upon them of preparing a complete report of the national resources available for scientific instruction and research, according to the sense of the word public which I am just now describing it, namely, those which are available for that purpose, and not for the promotion of the profit of individuals; and then that such a report should be re-edited annually, so that one should be able, by referring to it, to know what the funds of the institution are, and what they are doing respectively. I think that it would be of immense value that there should be one general source of information upon that point, and then I have no doubt they would be applied to for many improvements, which would be needed in those institutions; and they would have to investigate the question so brought before them or referred to them by the Secretary of State for that department. I should think it likely that it might be found desirable to refer to this council for advice in the selection of committees to investigate practical matters; for instance, the matter of gunnery, or other matters which are not matters of pure science, and that they would be able to recommend the choice of suitable persons for any work of that kind in which scientific principles would have to be applied to some practical purpose. In fact, the number of questions relating to science which come before the Government now, directly or indirectly, are, I suppose, considerable; and from what I have been able to learn of late on that matter, I should think that a good many people must be incidentally employed, to the extent of a great part of their time, by giving advice upon such matters."

Qu. 12,694. "Then you would not propose that the Government, if it wanted advice upon such subjects, should go to the council of science in order to obtain it?—I conceive that the Government might with advantage go to the council of science in order to find the individuals most competent to advise them upon such a practical point; but I think that the Government ought not to expect advice on such matters from the council itself. I do not see how the council could include matters of that sort with the really important questions of science itself without losing their homogeneity and unity of action. That would include all human activity almost, for scientific principles can be applied to all kinds of doings."

Dr. Roscoe:

Qu. 7438. "The great duty of such a permanent body would be to lay down some sort of system, according to which Government aid to science must be given, and to prevent (if possible) the expenditure of national moneys upon ill-considered or one-sided schemes. The results of a systematic Government effort is seen in the case of the German universities, in which, for comparatively small amounts of national expenditure, great results are obtained, whilst, I fear, that with us (for want of system) the opposite condition of things more nearly holds good."

Qu. 7439. "You would not desire that it should consist solely of men of science?—No, certainly not. I am of opinion that the presence of the lay element is essential, because many questions will occur which are not purely scientific, such as the necessity for establishing new colleges, or aiding existing ones, and on these points the opinions of experienced (perhaps local) non-professional men would be of the greatest value."

Mr. De la Rue:

Qu. 13,091. "Supposing that there had been such a Consultative Council as you propose, would it not have been advantageous to take their advice upon the expediency of such a proceeding?—I think that it would be one of the functions of such a council undoubtedly to advise the Government upon questions of that nature [the purchase of the College of Chemistry by the Government], and with regard to all other scientific matters, grants of money, or the establishment of fresh teaching establishments."

Qu. 13,092. "Then one advantage would be that the public would know on whose advice any such step had been taken by the Government?—Yes."

Dr. Siemens:

Qu. 11,798. "What do you consider would be the principal duties of such a Council?—To name commissioners for special inquiry, to discuss generally the amounts of the grants to be given to learned societies, and to advise the minister with regard to innovations proposed in Government departments. Take, for example, an invention of ordnance; if such a question, after a preliminary examination by the department concerned, were brought before the general body, it could there be discussed for the guidance of the Minister of Science, to ascertain whether such an innovation was based upon sound scientific principles, and what course of experiments should be pursued to lead to the best results. By referring it to the Minister, and having it discussed before such a Council, a great deal of unnecessary expenditure might often be saved where, through the want of sufficient information, the experiments are conducted by the departments in a somewhat unscientific manner. Another duty of the Council would be generally to direct the publication of the scientific information obtained through the different departments."

Qu. 11,799. "Do you consider that it would be the duty of such a Council to initiate proposals on matters connected with Science, or merely to give advice when asked for?—Only to give advice when asked for, but the departments should be held to communicate with the Minister all important questions brought before them, who, with the advice of the Council, would direct inquiries to be instituted in many cases where the department would have simply rejected the proposal."

Mr. Reed:

"If a department of the Government were contemplated as an advising department only, I believe it would be an impracticability. But it has been suggested to this Commission, I believe, or at any rate I have heard it suggested, that a scientific department might relieve certain existing departments of the State of some of the duties in connection with science and art. If that were so, if a department of the State had positive executive duties to perform, and were to have the promotion of those independent inquiries and the giving of advice to other departments attached to it as a branch of its duty, and not as its primary duty, I am disposed to think that such a department might work exceedingly well." Qu. 12,711.

"Do you think that the other departments would be willing to defer to the opinion of this special department?—I should be afraid that they would be willing to defer a little too often, and that the risk of such a department would be in a branch like the Admiralty, for instance, refusing to do some of the things which it now does, without first referring to this independent department, and that I am afraid would be an obstruction to the executive officers of the Admiralty; and unless the department were exceedingly well worked, it might operate as a disadvantage on the whole." Qu. 12,712.

"I should prefer myself to see a much smaller council with a larger power of reference than Colonel Strange seems to contemplate." Qu. 12,715

"By a power of reference, you mean that of obtaining advice outside itself?—Yes." Qu. 12,716.

Extracts from the Evidence against the Appointment of a Council.

We now proceed to give extracts from the Evidence of those Witnesses who object, on various grounds, to the creation of a Council.

The late Professor Rankine objects to a Permanent Council. He is "afraid of abuses arising if there were a permanent tribunal. I am doubtful how it would work." But he thinks that "if the Council of the British Association or the Council of the Royal "Society were selected, there would be as little objection to those bodies as to any "body that can be thought of." Qu. 9557. Qu. 9558.

Sir G. Airy thinks a paid Consultative Council could not do very much to assist the Government.

"There have been bodies of that kind from time to time. The Board of Longitude was a very useful body for a time, when the struggle was rising about accepting the theory of gravitation and generally introducing it, especially into the formation of lunar tables for the aid of nautical astronomy, and also the subjects connected with it; and that Board of Longitude undoubtedly did good service for a time, but somehow or other it died away; it became an object of contempt; there appeared no reason for keeping it up at any expense and it was abolished, and nobody seemed to regret it. Then the Admiralty had an institution of three scientific advisers, but I believe the scientific advisers perished in nearly the same way after a time; and I think that so far as the experience of those bodies has gone it supports the idea that it will be better for the Government, when occasion requires it, to get the best advice that it can." Qu. 10,522.

He considers that the Council of the Royal Society would be "the best body to which the Government could have recourse in any matters of that kind." Qu. 10,544.

Professor Owen is in favour of a Minister of Science, with a permanent Under-Secretary and Administrative Staff; but adds,—

"With regard to the Consultative Council, several objections occurred to me in considering that matter. The consultative council would, no doubt, be formed with the full concurrence, and in complete harmony with the views of the Permanent Under-Secretary. You may take it either way; a consultative council, if it were established, would hardly get on with its work, unless it found a permanent officer in harmony with its views. Assuming the Permanent Under-Secretary with a consultative council established, what would be the probability of the Minister going beyond such machinery in reference to any information or advice which he might require with regard to any movement or change in reference to science? I doubt very much whether he would go outside or beyond that body for advice and information. And what do you find? You find, for example, in reference to my own especial science, one Naturalist on the recommended Council. Now there are, and I suppose there always will be, three or more naturalists who might each severally think that they were entitled to a seat and a word on that Council. You would find two naturalists, at least, who are respectively at the head of some public Natural History Establishment; one might have a bias toward zoology, another toward botany, a third, perhaps, toward geology. Supposing a question were to come before the Science Minister with regard to the assignment of Government collections of Natural History made in Government Voyages, where would the determination be?—In all probability with that naturalist who was a member of the consultative council, and such position would give him, in my humble opinion, an undue advantage." * * * Qu. 11,537.

"Supposing that a single naturalist were a member of that council, the question would be whether, in a case of this kind, he would deal quite impartially between Mr. * * * * * and Mr. * * * * *, and so with regard to any other analogous case; it is always uncertain how far social relations of friendship, and intimacy, and so on, might not have their effect in such a question." Qu. 11,538.

He does not approve of the present state of things, but he thinks that a Minister and a permanent Secretary, who could obtain Advice when thought necessary, would be a better remedy than a consultative Council. He adds, "I think that a body, representing "a consultative Council, would do its duty much better if selected by the Minister of "Science, or the Minister of State for Science, for the special question before him," and also suggests:— Qu. 11,551. Qu. 11,553.

"There would be the power of applying to the councils of the different scientific societies, the council of the Linnæan Society for one, the council of the Geological Society for another, and the council of the Zoological Society for a third class of questions in natural history, to say nothing of the council of the mother of all our learned societies, viz., the Royal Society; in these we have already a guarantee against any dictatorship or arbitrary decision." Qu. 11,559.

The Earl of Derby would like to be more satisfied as to the reality of the grievance:

Qu. 13,514. "I do not, as at present advised, see what the difficulty is of obtaining the best scientific assistance when any Government department chooses to call for it. As a matter of fact the names of the most eminent men in every department of science are perfectly well known, and they have always, as far as I am aware, been very creditably ready to give their assistance when it has been asked for; and I should be inclined to think that if there are cases where a Government department has not had the benefit of that assistance, it has rather been because it was not asked for in time than because there was any difficulty in obtaining it."

Qu. 13,515. His Lordship also is "very sceptical either as to the necessity, or as to the utility, or "as to the successful working of such a Council."

"One objection to it is that if matters for which the head of a department is responsible are to be referred to the council, and if upon those matters the council is to pronounce an authoritative opinion, you will very materially lessen the responsibility of the one person who ought to be responsible to Parliament. I may take an instance: I have seen it stated in some of the evidence which has been given before the Commission that if the Admiralty had had proper advice as to the construction of ships, a great disaster which is fresh in all our memories would not have occurred. It seems to me impossible to suppose that you would get any competent person to advise the Admiralty in the matter of shipbuilding if he were to be under two masters, that is to say, if his plans were to go, on the one hand, to a scientific council to be approved by them, they having nothing to do with the question of expense, and, on the other hand, to go to the head of that department and to Parliament to be approved again by those two parties, they having nothing to do with the science of the matter, but looking principally to the expense. I think that that would entirely destroy the responsibility of the executive officer, and would destroy that independence which he ought to have in the performance of his functions. If you want scientific advice in a matter of that kind I would place it in the department rather than outside, or, which is practically the same thing, I would refer the specific question upon which the opinion is wanted to one or more of those persons who could bring the highest scientific authority and ability to bear upon it. It strikes me further that if you are to have a council including all the departments of science, and if that council is to pronounce its opinion collectively upon all matters submitted to it, you will in fact have every question decided by a great majority of persons who, however eminent in their own department of science, know very little of the particular matter in question."

Qu. 13,517. In reply to the suggestion that "One function [of the Council] would probably be, "to advise the State as to the application of money for the higher teaching of science and "for scientific research, and also to advise the Government with respect to any applica-"tions that may come before it for grants of money connected with science," Lord Derby thinks that "is a matter which falls strictly within the province of the Minister of
Qu. 13,519. Education;" and although he is quite aware of the fact that "if one man is selected as "the general adviser of some particular department of the Government upon a matter "of science, it is not improbable that there may be some jealousy in the minds of certain "other people who think that they could give quite as good advice, or possibly better;" it seems to him that "unless the proposed Council is to be unlimited in number, pre-"cisely the same difficulty will arise under that system. There will be a large number of "persons outside it who will think that they have a better claim to be in it than those "who actually are there; and precisely the same feeling of jealousy would then exist, "and would produce the same amount of inconvenience."

Qu. 13,521. In reply to qu. 13,521, he adds, "you may be quite sure that any Minister who "wants an opinion upon a scientific matter will try and get the very best opinion that "he can. He has no possible interest in doing otherwise; on the contrary, he has the "greatest possible interest in doing that. And, on the whole, I think that a man in that "position, with what I may call an unlimited command of assistance and advice, is quite "as likely to make a good selection as anyone else could do for him."

Qu. 13,522. He does not admit the analogy of the Indian Council, and as regards the argument from the alleged uncertainty of Government action in respect to Science, more especially as to Grants of Money, he thinks this arises chiefly from considerations depending upon the state of the Revenue in each year, and expresses his opinion that "it might be
Qu. 13,540. "quite legitimate to grant 4,000*l.* or 5,000*l.* for exploration in Africa at a time when the "finances of the country were prosperous, and to withhold a similar grant at a time "when the nation was economizing to the utmost."

Qu. 13,541. He admits that, even apart from financial considerations, a great deal of uncertainty "pervades the whole of our administrative system;" and is "an inevitable condition of "living under a popular government."

He further urges the following objection to the proposal of a Scientific Council on a large scale:

Qu. 13,550. "I believe that you would have a great deal of heartburning and jealousy on the part of men desiring and failing to get into it; and I think that if you brought together 25, 30, or 40 of the most eminent men in science, it would be found that the practical direction of that body would very likely be in the hands of men who are by no means the highest scientific authorities. The conduct of administrative business and the management of men is an entirely different thing from the conduct of scientific research, and it might very possibly be that those who would take the lead in managing the affairs of such a council would be those whose time and attention were the least devoted to purely scientific work, and who although they might possess a good deal of administrative ability might possibly not by any means stand at the heads of their respective branches of science."

With regard to the proposal to constitute the Council of the Royal Society the recognised advisers of the Government, he expresses the opinion that it would not be possible to refer "matters concerning all branches of science to a more competent body "of men than the Council of the Royal Society, constituted as it generally is." But he adds, "My objection to giving to that body an officially recognised position as the "permanent Advisers of the State is this, that you thereby take it out of the power of "the Government to say who their advisers are to be, because the members of council "are appointed by a process with which the Government has nothing to do." Qu. 13,551.

Lord Salisbury is opposed to a Council because he has "never seen anything to lead him to believe that such a Council of Science would have anything to do." Qu. 13,560.

He further thinks "that the Government would always get better opinions, on any "scientific point that arises, by applying to the most distinguished scientific man in that "particular branch at the time, than it would by having a set of permanent officers to "give advice on such subjects." * * * * Qu. 13,566.

In answer to qu. 13,563, he says that "it could hardly be contemplated that any such "Council could give a stability to the Policy of the Government in matters connected "with Science, because, of course, the stability of the policy of the Goverment depends "upon the stability of our whole political arrangements;" and (qu. 13,564) "the "House of Commons would never feel itself prevented from reversing the decision of a "Council of Science of that kind."

Lord Salisbury agrees with Lord Derby, in not considering the Council of India a case in point; he explains that "a veto has been lodged with this Council, enabling them to "prevent any expenditure of which they disapprove. But no similar difficulty arises in "questions of science. There are no large sums of money arising from the taxes of a "distant people that have to be expended, and, therefore, no special check is required "upon Ministers with regard to that matter. * * * Besides that, the Indian Council, "beyond its checking power, is really simply a bureau of administrators. The councillors "act as under-secretaries." * * * * Qu. 13,565.

He thinks that on many points on which a Minister might refer to the Council for advice, there might be reason to apprehend "a series of minority reports."

"Supposing a council of 12 or 16 scientific men: although undoubtedly upon a great number of matters they would be unanimous in opinion when they were dealing with that which is known and accepted as scientific fact, yet on all the border points between knowledge and speculation their opinions would most probably differ, and the position of a minister who had before him two or three sets of opinions, in entirely opposite directions, would not be much more hopeful than that of a minister at present who has no opinions at all." Qu. 13,582.

"Whatever errors there may be in the opinions of one individual, at least they have an unity and a courage which is very often wanting to the compound opinion of a dozen men." Qu. 13,583.

He attaches no importance to the supposed advantage arising from the advice of a Council being subject to public opinion to a greater extent than that of individuals; considering that the admission of reporters would be a hindrance to business, while without their presence "the public at large would know very little of its proceedings;" and in reply to qu. 13,600, "I think that what has been proposed by the Witnesses who "recommend a Council is, that in every case in which an opinion is asked they should "furnish a Report of the reasons for the advice which they give?" he expresses fears, "that if the Council were constructed on that principle, the Ministers, who usually have "their time very fully occupied, and are desirous to avoid work as much as possible, "would consult the Council as little as possible." Qu.13,595–6. Qu. 13,600.

So far as the mere Administration of Funds granted by the State for Scientific Purposes is concerned, he is of opinion that no better channel than the Government Grant Committee of the Royal Society could be found.

"There is no body which is so thoroughly well constituted for the purpose of representing the scientific world as the Committee of the Royal Society." Qu. 15,603.

"You prefer that to any new-fangled scientific council?—Yes, certainly. We know how it works, and it would be pretty sure to go on working as well as it does now." Qu. 13,604.

The Evidence of Sir Stafford Northcote is to the same general effect as that of Lord Derby and Lord Salisbury:

"My own leaning would be to throw the responsibility, as now, upon the heads of the different departments, leaving them to get the best scientific assistance they could, but providing for the maintenance of such relations between the Government and some scientific body external to the Government, such as the Royal Society, perhaps, as would enable the Government to take advice from that society as to the best men to consult, and also as to the possibility of the work that was proposed to be undertaken." Qu. 13,635.

"I should have thought that some kind of payment might be made to the society, which the society might expend, and by employing such officers as it thought proper to keep all the correspondence, and to refer it to the proper persons; and then, my idea would be, that supposing at the Board of Trade, for instance, some Qu. 13,636.

new question arose upon which scientific information was wanted, the President of the Board of Trade would write to the Council of the Royal Society, and would say, such and such business has to be done, and I want such and such advice. Then the secretary, or whoever it might be, would bring the subject before his council, and would write back, What you propose appears to be feasible; you ought to consult Mr. so-and-so, or professor somebody, and you would then be placed by an independent authority in direct relations with the proper man to deal with the subject. Then it would be a question of remunerating that gentleman by a fee as you would remunerate a lawyer by a fee, for the service which he was to render."

Qn. 13,637. He thinks that a Council "would cause jealousy on the part of the Departments; and that it would also very likely cause jealousy on the part of other men of Science."

"I feel sure that there would be a great deal of jealousy on the part of the departments if any council were appointed to regulate the conscience of the Government in scientific matters, and to say how money ought to be spent, what money ought to be spent, and what ought to be done, and what ought not to be done." * * *

"With regard to that case of which I was speaking, of the School of Design, I know that there was very great jealousy at that time. The organization of that council was this:—A certain number of eminent architects, sculptors, and painters, and other persons were put upon [the Council], and they partly fell out among themselves, and then it was necessary for the President of the Board of Trade, who was responsible for the spending of the money, to side with one party or the other, and to decide what was to be done, which he was, of course, not very competent to do. Then came a great deal of external jealousy on the part of the other artists whose views were set aside, and there was, at the same time, a good deal of jealousy on the part of the Board of Trade, it being told that because these artists held this and that, therefore they were to spend the public money in this way or the other way."

And he speaks of similar jealousies as having arisen between the Committee of Military Sanitary Organization and the Military Members of the Indian Council:—

"Similarly, I might mention as an instance in which I saw the germs of jealousy, the Committee of Military Sanitary Organization, which is referred to, I see, by Captain Galton in his evidence. Whilst I was at the India Office it was perfectly true that a great many questions were referred to that Committee, and they gave very valuable advice, but I could see that there was a great deal of jealousy on the part of those who were the military members of the Council of India of the interference, as it was said, of this Sanitary Committee. The military members said, 'We are the people who are responsible for the spending of the money and for 'doing what is to be done, we do not see why those gentlemen, who have nothing to do with that, are to 'dictate to us; and we will not accept their suggestions.' Then would come from the Sanitary Committee remonstrances, and they would say, 'We have special knowledge of this subject; it is what we are paying 'attention to; and we think it very wrong that you should not attend to our suggestions, and that you should 'spoil what we are doing.'" * * * *

At the same time he does not agree with Lord Salisbury in his approval of direct reference by the Minister to an individual.

Qn. 13,647. "I do not like the present system of applying to irresponsible advisers, and I should desire to see some more systematic mode of proceeding adopted."

In reference to one of the proposed functions of the Council, that it should advise the Government on the Management of Institutions like the Meteorological Office, the British Museum, and the Royal Gardens at Kew, he would still prefer the advice of a body not appointed by the Government.

Qn. 13,654. "I doubt whether such a council would either command public confidence very long, or command the respect which it should have from the Government itself, if it were a creation of the Government. You might appoint in the first instance some very eminent men. Probably you would not get a great many of the most eminent men to give a great deal of time to work of that sort, and you would have to take those who were willing to spare the time necessary for the discharge of the duties of the council. They would continue for some time in office, and they would adopt certain ideas, and their constant contact with the Government would rather lead them to say, 'This sort of thing cannot be done,' because they would take into consideration administrative points, and would not give purely scientific advice. They would, therefore, cease to possess the confidence of the public outside. There would also be more eminent men who would say, 'These are old 'women who are going on in a certain routine, and we do not attach much value to what they say.' And, on the other hand, they would not have the same advantageous independent position for offering advice or making suggestions to the Government which a body recruited *ab extra* from the scientific world would have."

Upon the suggestion that a Council advising on the Advancement of Science should also advise on Scientific Education, he remarks:

Qn. 13,656. "I think that it would be very desirable that the Council of Education, or the Minister of Education, should have the advice of good scientific persons to assist him in directing the scientific education of the country; but I should doubt its being very advantageous to mix up that work with the other kind of duties to which you have referred."

Dr. Carpenter's Evidence is also in favour of recourse to the Council of the Royal Society whenever the Government requires advice on subjects involving questions of Science.

Qn. 10,931. "I think that there is a great advantage in having any question of that kind discussed, not merely by the representatives of one department of science, but by the representatives of the scientific body generally,—the *corps scientifique* of the nation. Under the present constitution of the Royal Society, the Council of the Royal Society may be regarded as a very true representative of the scientific life, so to speak, of the nation. It would doubtless, if it saw occasion, seek the advice (as it does at present in the administration of the Government Grant) of competent men outside its own body."

But he considers that "the present state of things" is unsatisfactory in so far as "there is no Systematic Arrangement for the Promotion of Science." Qu. 10,934.

Sir E. Sabine, President of the Royal Society for many years, appears, on the whole, to incline to the opinion that it would be best that the Royal Society should remain the official adviser of the Government in scientific matters; suggesting, however, that in particular cases "Special Committees might be appointed with such emoluments as it "might be proper to recommend." Qu. 11,122. His Evidence contains some interesting statements relating to the Board of Longitude, which formerly existed, and which he acknowledges to have rendered "valuable services to the country during the period of its existence," Qu. 11,129. matters being frequently referred to it which it was admirably adapted to judge of.

Remarks on the foregoing Evidence relating to the Establishment of a Ministry and Council of Science.

We have given careful consideration to this part of the Inquiry entrusted to us; and, in the course of our deliberations, we have been led to attach much importance to the facts stated in the First Part of our Report, which show that the Scientific Work of the Government is at present carried on by many different Departments.

There is nothing to prevent analogous, if not actually identical, investigations being made in each of these, or to secure to one department an adequate knowledge of the results obtained, and the circumstances under which they were obtained, by another.

Investigations admitted to be desirable, nay, practical questions, the solution of which is of the greatest importance to the public administration, are stated by the witnesses to be set aside because there is no recognised machinery for dealing with them; while, in other cases, investigations are conducted in such a manner as to involve a needless outlay of time and money, because they were originally planned without consultation with competent men of Science.

Passing to the question of the Advancement of Science, we have arrived at the conclusion that much has to be done which will require continuous efforts on the part of the Administration unless we are content to fall behind other Nations in the Encouragement which we give to Pure Science, and, as a consequence, to incur the danger of losing our pre-eminence in regard to its Applications.

These considerations, together with others which have come before us in the course of our Inquiry, have impressed upon us the conviction that the Creation of a Special Ministry dealing with Science and with Education is a Necessity of the Public Service.

This Ministry would be occupied (1) with all questions relating to Scientific and General Education, so far as these come under the notice of Government; (2) with all questions incidental to the application of National Funds for the Advancement of Science; and (3) with all Scientific Problems in the Solution of which the other Departments may desire external Scientific Advice or Information. It would also be desirable that the Department should receive Information as to Scientific Investigations proposed by other branches of the Government, and record their progress and results.

It is not within our province to express an Opinion as to whether the subject of Art should be included among the Functions of this Department; but we are satisfied that the Minister's attention should not be distracted by any immediate Responsibility for affairs which have no connexion with Science, Education, or Art.

We have considered whether the Official Staff of such a Ministry, however carefully selected, could be expected to deal satisfactorily with all the varied and complicated Questions which would come before the Department. We have given full weight to the Objections which have been raised against the creation of a Special Council of Science, and to the Arguments in favour of referring Scientific Questions to Learned Societies, or to Special Committees appointed for the purpose, or to private Individuals; but nevertheless we have arrived at the Conclusion that an additional Organization is required through which the Minister of Science may obtain Advice on questions involving Scientific considerations, whether arising in his own Department or referred to him by other Departments of the Government.

Such questions have from time to time been referred to the Council of the Royal Society, in which the best Scientific Knowledge of the time is fairly represented. The Committee chosen by that Council for the Administration of the Government Grant of 1,000*l.* per annum in Aid of Scientific Investigations has performed its work to the satisfaction of the Government, of men of Science, and of the Public. But if much more is to be done for the Advancement of Science than at present, and if the Departments in conducting their Investigations are to have the benefit of the Scientific Advice which appears

now to be frequently wanting, the Council of the Royal Society, chosen as it is for other purposes, could scarcely be expected to take upon itself Functions which, it is true, are not different in kind, but which would involve increased Responsibility and the Expenditure of additional time and trouble. Moreover, amongst the questions on which the Departments would require Scientific Advice, there would no doubt be many requiring a Knowledge of the peculiar exigencies of the Public Service, which would be more readily understood and solved if some persons in direct relation with the Departments formed a part of the body to be consulted. It is obviously of great importance that the Council should be so constituted as to possess the confidence of the Scientific World, and we believe that this confidence would be extended to a Council composed of men of Science selected by the Council of the Royal Society, together with Representatives of other important Scientific Societies in the United Kingdom, and a certain number of persons nominated by the Government. We also believe that such a Body would deserve and receive the confidence of the Government; and that it would be well qualified to administer Grants for the Promotion of Pure Science.

The general opinion we have expressed as to the proper Remuneration of Scientific Work would be applicable to the Members of this Council, but the degree and manner in which the principle should be applied in this instance must be so largely dependent on circumstances that we cannot make any specific Recommendation on the subject.

It would be impossible that the Council should in all cases undertake the direct solution, by itself or even by Sub-Committees, of the problems submitted to it. In many instances, especially when experimental investigations are required, its duty would be accurately to define the problem to be solved, and to advise the Minister as to the proper persons to be charged with the Investigation.

We are of opinion that the Council should not have the power of initiating Investigations; it should, however, not be precluded, in exceptional cases, from offering to the Minister such suggestions as it may have occasion to make in the Public Interest.

We believe that Reference to such a Council would be found to be so useful and convenient that it would become the usual course in cases of difficulty, but we would not diminish the Responsibility or fetter the Discretion of any Minister by making such Reference obligatory, or by preventing a Reference to Committees or to Individuals chosen by him, whenever that course might appear to him to be more desirable.

Conclusions and Recommendations.

I. The Assistance given by the State for the Promotion of Scientific Research is Inadequate, and it does not appear that the Concession or Refusal of Assistance takes place upon sufficiently well defined Principles.

II. More complete means are urgently required for Scientific Investigations in connexion with certain Government Departments; and Physical as well as other Laboratories and Apparatus for such Investigations ought to be provided.

III. Important Classes of Phenomena relating to Physical Meteorology, and to Terrestrial and Astronomical Physics, require Observations of such a character that they cannot be advantageously carried on otherwise than under the Direction of the Government.

Institutions for the study of such Phenomena should be maintained by the Government; and, in particular, an Observatory should be founded specially devoted to Astronomical Physics, and an Organization should be established for the more complete Observation of Tidal Phenomena and for the Reduction of the Observations.

IV. We have stated in a previous Report that the National Collections of Natural History are accessible to Private Investigators, and that it is desirable that they should be made still more useful for Purposes of Research than they are at present. We would now express the opinion that corresponding Aid ought to be afforded to Persons engaged in important Physical and Chemical Investigations; and that whenever practicable such persons should be allowed access, under proper limitations, to such Laboratories as may be established or aided by the State. Fourth Report.

V. It has been the practice to restrict Grants of Money made to Private Investigators for Purposes of Research to the Expenditure actually incurred by them. We think that such Grants might be considerably increased. We are also of opinion that the restriction to which we have referred, however desirable as a general rule, should not be maintained in all cases, but that, under certain circumstances and with proper safeguards, Investigators should be remunerated for their time and labour.

VI. The Grant of 1,000*l.*, administered by the Royal Society, has contributed greatly to the Promotion of Research, and the amount of this Grant may with advantage be considerably increased.

In the case of Researches which involve, and are of sufficient importance to deserve, exceptional expenditure, Direct Grants in addition to the Annual Grant made to the Royal Society should be made in Aid of the Investigations.

VII. The proper allocation of Funds for Research; the Establishment and Extension of Laboratories and Observatories; and, generally, the Advancement of Science and the Promotion of Scientific Instruction as an essential part of Public Education, would be most effectually dealt with by a Ministry of Science and Education. And we consider the creation of such a Ministry to be of primary importance.

VIII. The various Departments of the Government have from time to time referred Scientific Questions to the Council of the Royal Society for its Advice; and we believe that the work of a Minister of Science, even if aided by a well-organized Scientific Staff, and also the work of the other Departments, would be materially assisted if they were able to obtain, in all cases of exceptional importance or difficulty, the Advice of a Council representing the Scientific Knowledge of the Nation.

IX. This Council should represent the chief Scientific Bodies in the United Kingdom. With this view its composition need not differ very greatly from that of the present

Government Grant Committee of the Royal Society. It might consist of men of Science selected by the Council of the Royal Society, together with Representatives of other Important Scientific Societies, and a certain number of persons nominated by the Government. We think that the Functions at present exercised by the Government Grant Committee might be advantageously transferred to the proposed Council.

All of which we humbly beg leave to submit for Your Majesty's Gracious Consideration.

(Signed) DEVONSHIRE.
LANSDOWNE.
JOHN LUBBOCK.
JAMES P. KAY-SHUTTLEWORTH.
BERNHARD SAMUELSON.
W. SHARPEY.
THOMAS H. HUXLEY.
G. G. STOKES.
HENRY J. S. SMITH.

J. NORMAN LOCKYER,
Secretary.

June 18th, 1875.

APPENDIX TO EIGHTH REPORT.

APPENDIX .

EXTRACTS from the ESTIMATES for the FINANCIAL YEAR 1874–75.

TOPOGRAPHICAL SURVEY.

	£	£
Pay and extra pay of, and allowances to, staff	7,002	
Extra pay, and allowances to non-commissioned officers and sappers	15,700	
Pay, &c., of Civil assistants, meresmen, and labourers	95,068	
Travelling expenses	3,425	
Fuel, light, &c.	1,700	
Stores	4,250	
Contingencies	4,855	
Civil Service Estimates.)		132,000

HYDROGRAPHICAL SURVEY.

	£	£
Salaries, wages, and allowances, Hydrographical Department	8,480	
Drawing, engraving, printing, and mounting charts	11,000	
Instruments, repairs, chart boxes, &c., books, and contingencies	1,000	
Coast and other surveys (hire of ships, extra pay, &c.).	26,500	
Pay to the Officers and Crews of Her Majesty's ships and vessels employed in the surveying service; also the pay of those employed in hired vessels and boats, but borne on the books of Her Majesty's ships	40,728	
Victuals, &c., for ditto	12,220	
Stores, machinery, and coals supplied to surveying ships and vessels, and also repairs	31,720	
Medicines, &c., supplied to ditto	153	
Pilotage of ditto	50	
	131,911	
In these figures is included an additional sum of 10,856*l.* (over and above the ordinary requirements of the service) to provide for the employment of Her Majesty's ship "Challenger," on a voyage of Scientific Research round the world	10,856	
(Navy Estimates.)		121,055

GEOLOGICAL SURVEY OF THE UNITED KINGDOM.

	£	£
ENGLAND :—		
Salaries	11,589	
Travelling	1,800	
Incidental expenses	250	
SCOTLAND :—		
Salaries	3,065	
Travelling	450	
Incidental expenses	220	
IRELAND :—		
Salaries	4,376	
Travelling	970	
Incidental expenses	200	
(Civil Service Estimates.)		22,920

ASTRONOMY.

	£	£
ROYAL OBSERVATORY, GREENWICH :—		
Salaries, wages, and allowances	3,914	
Contingencies	1,728	
(Navy Estimates.)		
EDINBURGH OBSERVATORY :—		
(Civil Service Estimates)	690	
OBSERVATORY AT THE CAPE OF GOOD HOPE :—	3,371	
(Navy Estimates.)		9,703

METEOROLOGY.

	£	£
METEOROLOGICAL COMMITTEE :—		
Appointed to conduct Meteorological Observations and Experiments on behalf of the Government	10,000	
(Civil Service Estimates.)		
ROYAL OBSERVATORY, GREENWICH :—		
Salaries, Magnetic and Meteorological branch	805	
Contingencies	416	
(Navy Estimates.)		
MAGNETICAL AND METEOROLOGICAL DEPARTMENT, WOOLWICH :—		
For the Reduction and Publication of Observations:		
Salaries	446	
Contingencies	150	
(Army Estimates.)		
ROYAL OBSERVATORY, EDINBURGH :—		
Allowance for Meteorological work	115	
(Civil Service Estimates.)		
REGISTER OFFICE, GENERAL, ENGLAND :—		
Reports of Meteorological Observations furnished to the Registrar General	150	
(Civil Service Estimates.)		12,082

BOTANY.

	£	£
ROYAL BOTANIC GARDENS, KEW :—		
Establishment	3,714	
Travelling	40	
Clothing	85	
Police	1,170	
Works	537	
Maintenance	11,250	
Furniture	250	
Rents	46	
Rates	300	
Contingencies and incidental expenses	180	
(Civil Service Estimates.)		17,572
EDINBURGH BOTANIC GARDEN :—		
Allowance for the Royal Botanic Garden	1,400	
Allowance to the Regius Professor of Botany in lieu of a house	120	
Salary of the Curator	230	
(Civil Service Estimates.)		1,750

BOTANY—*cont.*

	£	£
BOTANIC GARDENS, DUBLIN:—		
Salaries and wages - - -	1,598	
Incidental expenses, including purchase of seeds and plants -	550	
(Civil Service Estimates)		2,148
		21,470

STANDARDS DEPARTMENT OF THE BOARD OF TRADE.

	£	£
Salaries - - - -	1,383*	
Incidental expenses - -	680	
(Civil Service Estimates.)		2,063

[* In addition to this sum, there are the salaries of two Third Class Clerks and two Supplementary Clerks, at present employed in this Department.]

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For Her Majesty's Stationery Office.

ROYAL COMMISSION

ON

SCIENTIFIC INSTRUCTION AND THE ADVANCEMENT OF SCIENCE.

VOL. III.

Minutes of Evidence, and Appendices;

Analyses of Evidence;

Index to the Eight Reports (with their Appendices) issued by the Commission,

AND

The General Index to the Evidence; to the Analyses of the Evidence; and to the Appendices to the Evidence given in Vols. I.—III.

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

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MINUTES OF EVIDENCE

TAKEN BEFORE THE

ROYAL COMMISSION

ON

SCIENTIFIC INSTRUCTION AND THE ADVANCEMENT OF SCIENCE.

No. 6, Old Palace Yard, Westminster, Wednesday, 22nd April 1874.

PRESENT:

THOMAS HENRY HUXLEY, Esq., LL.D., Sec. R.S., IN THE CHAIR.

SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
WILLIAM SHARPEY, Esq., M.D., F.R.S.
HENRY JOHN STEPHEN SMITH, Esq., M.A., LL.D., F.R.S.

ROBERT H. SCOTT, Esq., M.A., F.R.S., examined.

R. H. Scott, Esq., M.A., F.R.S.
22 April 1874.

13,861. (*Chairman.*) You are, I believe, the Director of the Meteorological Office?—I am.

13,862. The Meteorological Office was originally under the Board of Trade, was it not?—There was a Meteorological Department under the Board of Trade, but the title of Meteorological Office has been given to it since the change in the administration of the office.

13,863. When was that Department of the Board of Trade instituted?—I think in the year 1854; it was the result of the Brussels Conference in 1853, and the whole account of the preliminary negociations are to be found in certain Notes submitted by Sir Edward Sabine to the Royal Society, which are printed in the 15th volume of their Proceedings. The Report of a Committee appointed to consider certain questions relating to the Meteorological Department, Board of Trade, is before the Commission. That report, which was presented to the Government in 1866, and on which, as a basis, the present office has been constituted, says, "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 ap-"pointed as its head." The precise date of the formation of the original Department I can procure if necessary, it was about September 1854.

13,864. What were the steps which preceded the transfer of the Meteorological Department of the Board of Trade to its present management?—When Admiral FitzRoy died, the opinion of the Royal Society was asked as to the future management of the Department, whether it had done its work, and whether it was to go on, and the Royal Society recommended that an inquiry should be held, as there was no information before them upon which to form an opinion. Sundry negociations were then carried on, and the result was that a Commission of three members was appointed by the Government. Of those members one was nominated by the Government, or rather by the Board of Trade, being Mr. Farrer, another by the Admiralty being Captain Evans, Chief Naval Assistant to the Hydrographer, and the third was Mr. Francis Galton, who was nominated by the President and Council of the Royal Society. They then held an investigation into the office, and their Report was presented to Parliament. I believe copies of it are in the hands of the Commission.

13,865. The office was then organised in consequence of the Report of that Commission?—The Commission recommended that the management and control of the office should be handed over to a scientific body.

13,866. Was the organization of the office as it at present exists the result of the report of that Commission?—Yes; the Royal Society were then asked if they would consent to undertake the control, and the whole of the correspondence is printed in Parliamentary Paper, No. 240, of Session 1867.

13,867. In what sense do you mean that the Royal Society were asked if they would undertake the control; has the Royal Society at present any sort of control over the Office?—The Royal Society has not, but it was asked whether it would appoint a Committee who should control it under the Government. In fact, the position is perfectly anomalous; the Government considers us under the Royal Society, and only lately the senior Secretary of the Royal Society has told me that he always considered us under the Board of Trade; but the Government distinctly disclaims all connexion with us, whilst the Royal Society equally disclaims all control over us, except merely the nomination of the members of the committee.

13,868. As a matter of fact, all that the Royal Society does is to nominate the members of the Committee?—That is all.

13,869. Having so done, it ceases to have any control whatever, does it not?—Entirely.

13,870. What is the present organization of the Meteorological Office?—The Committee consists of ten members (it originally consisted of eight), and they manage the office through me, and I have the assistance, in maritime meteorology, of Captain Henry Toynbee, a gentleman from the merchant navy.

13,871. What is the precise relation between the Office and the Government?—That the Government gives a vote of 10,000*l.* every year, and that it calls

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22 April 1874.

for no account of this money, excepting the account annually presented to Parliament. It has only recently begun to audit the accounts, as I shall state when I give my evidence upon the financial matters. The money is handed to me instantly the vote is passed, and until the year is out nothing more is asked.

13,872. Who audits the accounts?—The members of the Committee. There is no formal audit, because as the Government would not recognize any audit excepting its own, the Committee considered that it was not worth while paying an auditor if such audit would not be recognized, and, as a matter of fact, two of the members take the trouble of auditing the accounts every year. The form of audit is printed in the first appendix to our annual report, but I shall return to this subject more minutely hereafter.

13,873. What, in your opinion, are the chief advantages and disadvantages of such an arrangement as compared with those of the direct management of the Office by the Government?—The chief advantage is the perfect freedom from political management. The risk in being connected with the Government is that if a new President of the Board of Trade comes, he may reverse the action of the preceding one. The existence of a scientific supervision for the Office is exceedingly important; it acts as an intermediate party between the public and the Office. I may mention a decided disadvantage which results from the office not being connected with the Government, namely, the loss of *prestige*. The difficulty is that, if we are sending instruments by sea or by railroad, if we do not call them Government instruments we cannot get as much attention paid to them, and it is my opinion that we should get more co-operation from the merchant navy if we were an office of the Board of Trade. We should have more *prestige* as acting directly from the Government.

13,874. (*Professor Smith.*) Would you express any opinion as to the balance of those advantages and disadvantages which you have mentioned?—I think that the matter might be perfectly and simply arranged if the Government would allow us to call ourselves the Meteorological Department of the Board of Trade, managed by a Committee of the Royal Society, *i.e.*, if Professor Stokes' idea were allowed to be carried out, but the Government refused that permission in 1867, and stated that there was to be no connection. I think it is merely a fanciful idea on the part of the Government to protect themselves against claims for compensation. They made a careful statement that there were to be no claims for compensation on the part of the employés of the Committee, and that we were in no respects servants of the Crown.

13,875. How often do you say that the Committee meet?—They meet regularly every fortnight, and the last Monday of the month for drawing cheques, and in addition there are extra meetings if necessary. The reason they do not meet every week is that several of the members are members of the Geographical Society's council. Theoretically they meet every week if there is business, but they really meet every fortnight, and the last Monday, which comes to three or four meetings every month.

13,876. (*Chairman.*) Has the constitution of the Committee been modified since 1867?—Dr. Miller died and Mr. Spottiswoode has resigned, their places have been filled up, and in addition two members have been added to the Committee.

13,877. The change of constitution has only been personal, I believe?—Only personal.

13,878. How do they manage the office?—They meet weekly, or rather theoretically they meet weekly, practically they meet three or four times a month, excepting in the long vacation; in fact, they meet whenever they are wanted. Their action is recorded in the several volumes of minutes which are before the Commission.

13,879. What is your own position?—My own position is that of Director of the Office, and my duties were laid down after I had been there for two years, but since that they have been modified by the resignation of the Secretary to the Committee, and I have undertaken the secretary's duties as well.

13,880. Would you like to give any fuller definition of your own position than that?—I can give nothing excepting that I am the sole person who is responsible for everything under the office; that everything is managed through me, and that from the beginning all correspondence with the Government was conducted by me, and not by the Secretary to the Committee.

13,881. What is the position of the Marine Superintendent, Captain Toynbee, as regards yourself?—He has been appointed to render assistance to me in all matters connected with maritime meteorology, such as correspondence, the collection of observations from the sea, seeing captains, and superintending the publication of the marine work, for all which he is responsible to the Committee; but he is not summoned to the Committee meetings. He takes charge of the office in my absence.

13,882. Does he take his directions from you, or carry out his own work independently?—Practically he carries on his own work independently, but he takes his directions from the Committee through me officially.

13,883. What staff of clerks is employed?—There are 19; there are four senior clerks; there were three juniors; the number was increased yesterday to six. I mean that they were promoted from being temporary clerks. Then there are nine temporary clerks, an office keeper, and an engraver.

13,884. Are the occupations of the staff stated officially in any document?—In the annual report they are regularly stated.

13,885. Are they defined by the Committee to begin with, or do you define the duties of the staff yourself?—I arrange them, but report to the Committee on all matters of any importance whatever that are placed on the minutes of the Committee. I always refer to the Committee for all matters that seem to me to require it. There is some discretion allowed to me, but the minutes of the Committee are exceedingly full.

13,886. You have not mentioned whether you are accommodated in any public building?—I thought that was understood. We are certainly not. We were formerly; in the year 1869 we left.

13,887. (*Professor Smith.*) The rent that you pay is very considerable indeed?—I forget the precise sum, but it is about 500*l.* (N.B. 538*l.* 17*s.* 0*d.*)

13,888. (*Chairman.*) Your operations partly take place at sea and partly on land; to what extent is the sphere of those operations limited in either case?—At sea it is limited to British ships and British observers, and on land to stations within the British Islands; directly excluding the Colonies.

13,889. Was not the Office originally founded for maritime meteorology?—Yes, entirely.

13,890. To what extent is that branch of science still pursued?—We expend about 2,000*l.* a year on it. It is very hard (because the proportion of my salary cannot be put exactly down to it) to distribute the salaries for administration; but not quite one quarter of the amount which we get is expended in maritime meteorology.

13,891. What is the relation of the Office to the Royal Navy?—Formerly, under Admiral FitzRoy, the Royal Navy contributed a portion of the expenses of the office taken on the navy vote. The first year that the Committee took charge of the office the special vote for the Royal Navy also appeared on the Civil Service estimates, but it was afterwards cancelled. Now we supply all the meteorological instruments used in every ship in the navy, but we receive nothing in return. We simply keep a stock of meteorological instruments in the Meteorological Office, and in the dockyards, for which the storekeepers are responsible to the office, but that is all that we do. We supply the registers, and those registers may be sent to us if the officers choose to do it, but practically they are sent to the Admiralty, and we do not receive observations in return. It is simply a matter of course.

Every captain, according to the size of his ship, draws the quantity of instruments which he requires.

13,892. Do those returns officially go to the Admiralty?—Yes, the logs for the working of the ship, but the special meteorological registers, if kept, are sent to my office, but of these there are only about three or four a year.

13,893. Have you no opportunity of inspecting the ordinary meteorological registers of temperature, the barometer, and so forth, which are kept on board every ship?—None whatever, unless I obtain the logs from Somerset House by requisition. Practically we do not get much from the Royal Navy, but we do get a great deal from certain officers belonging to it.

13,894. You are in relation in some way with the Royal Navy by having the Hydrographer upon your Committee?—Yes; certainly the Hydrographer is *ex officio* a member of our Committee, and most meteorological questions referred to the Admiralty are sent to the Committee, as for instance, the question about the transit of Venus. The Astronomer Royal asked for meteorological instruments for the transit of Venus, but he was referred to the Meteorological Office, and the instruments were drawn from that office instead of being procured by a special vote for this service.

13,895. You put it in this way, that the relation between you and the Royal Navy is that the navy gets a great deal from you, but does not give anything to you?—I do not mean to imply that. We get our grant on the condition of supplying the navy to the extent of 500*l.* or 600*l.*

13,896. What is the relation of the Office to the merchant service?—We lend instruments to any captain of whose competency we are satisfied, and receive his observations in return.

13,897. Does any merchant captain, who thinks fit to apply, get the instruments from you?—If he shows that he is able to observe.

13,898. Who is the judge upon that matter?—Captain Toynbee entirely. At the sea ports if a man cannot see Captain Toynbee there is a certain form filled up, and questions are asked about any new man before the instruments are supplied.

13,899. Do you get any large number of returns from the Merchant Service?—Not very many. The number of ships supplied on an average of seven years is only 75 per annum. The difficulty has been this; we thought at one time that we could get co-operation by speaking to the large steamboat companies, like the Cunard Company, but we found that the instant any *order* was issued to a captain to observe, he ceased to observe. We have simply to make personal friends of the captains. I must say that the quality of the observations is very high indeed, and certainly the opinion of a good many men of experience, like Professor Buys Ballot of Utrecht, is that too much is asked for in maritime meteorology, and that observers are afraid of undertaking the duty.

13,900. Agents at certain ports are mentioned in the reports. What are their duties and remunerations?—They are stated at page 78 of the Minutes of Proceedings for 1873. There are men in the ports of Liverpool and Aberdeen, and one or two other ports, and they receive a small fee, and that fee is increased if the observations forwarded are good.

13,901. You pay upon results to a certain extent?—Yes. What I should wish particularly to observe, as there has been a misunderstanding about the agency, is that the amount of money is really not very much; perhaps 20 or 30 ships are supplied in other ports, and that is divided between three or four agents; not more than 10*l.* a year in each case. It is not creating highly salaried officers at the sea ports, but it is the only way that we can get observations. For instance, some of the most important observations that we get are from the whalers and are got through the agent at Aberdeen.

13,902. Are observers paid or remunerated in any way?—Not in the least, unless that they have the free use of valuable instruments. If they send first-class observations we present them as a compliment with a book, worth 2*l.*, of Admiralty charts. There is no payment of any sort or kind, but then they receive publications which would interest them.

13,903. Is there any idea of a modification of the system in respect of the supply of ships?—We are thinking of asking ships to send us their own logs, instead of taking our form of register, and possibly we might get more information if we borrowed the ship's log, than if we demanded always our form of register. The question is now under deliberation.

13,904. Do you consider it important that the Office should be in connexion with the Board of Trade?—Decidedly, for the reason which I mentioned before, that almost every captain, unless he is a man whom we know most intimately, writes to us saying that he will observe for the Board of Trade. They do not know much about the Royal Society, and unless we were able to say that we had an indirect connection with the Board of Trade, I think that we should not get even what co-operation we do.

13,905. When was the idea of a comprehensive scheme for the land meteorology of the United Kingdom first thrown out by the Government?—I must now refer to the original letter of the Royal Society in 1854. I am not in possession of the letter of the Government to which this was an answer, but the answer of the Royal Society, which appears at page 8 of the Appendix of the Report of the Committee in 1866, says, "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." Those were Mr. Cardwell's words at that time.

13,906. That is the reply to the letter from the Government?—Yes, it is the letter from the Royal Society to the Government, which contained the original orders under which Admiral FitzRoy organized the office in the year 1854. It is the first official statement on the part of the Royal Society of what was to be required from the office.

13,907. What are the broad features of the present system?—The system is that we have certain observatories with continuous observations, recorded automatically, distributed over the country, and those records are examined at a central observatory, and then sent to the Meteorological Office for discussion.

13,908. When was this system devised and by whom?—It was devised, I believe, by the then President of the Royal Society, Sir Edward Sabine, and was contemplated and recognised as having been proposed, when the Report of the Commission of Enquiry was presented, for they refer to it. The whole of the statements of these preliminary negociations are to be found in that paper of Sir Edward Sabine's in the 15th volume of the Proceedings of the Royal Society.

13,909. How many observatories are there?—Seven.

13,910. What is the central observatory?—The Kew Observatory.

13,911. What are the names of the stations?—Kew, Falmouth, Stonyhurst, Glasgow, Aberdeen, Valencia, and Armagh. The idea that was contemplated was six stations in the first instance, as mentioned in another letter from the Royal Society, dated 15th of June 1865, and the additional station to those originally contemplated by the Royal Society has been Valencia.

13,912. Has any idea ever been entertained of utilizing Greenwich as the central observatory?—There has been a good deal of correspondence between the Astronomer Royal and the Committee with reference to this subject of late years. As soon as the Astronomer Royal became President of the Royal Society, a certain correspondence passed, which was contained on the Minutes, and the result was that things went on as they did before. There was no change in the management. The references to the correspondence are all on the Minutes, and if the

R. H. Scott, Esq., M.A., F.R.S.

22 April 1874.

Commission would wish me, I could quote the particular statements.

13,913. Perhaps you could tell the Commission briefly what was the general tenor of the correspondence?—The first letter was a letter about the expense of our publications. Perhaps, I think, it might be better if I explained this. The first notice was in the Minutes of 1871, page 61: "Mr. Scott stated he "had received a letter from the Astronomer Royal, as "President of the Royal Society, asking for some "information respecting Kew, which he had sup"plied unofficially." Then comes, in the year 1872, this report: Mr. Scott reported that this letter "had "contained an inquiry relative to the cost of the "Quarterly Weather Report, to which he replied that "he was not able to give the precise cost of the "publication of the curves in the Quarterly Weather "Report, as the expense of that work was borne by "the Stationery Office." I then reported that the Controller of the Stationery Office had informed me of the amount of expense in question. The Astronomer Royal wrote again (January 13th, 1872) to ask for the information. That is at page 1 of the Minutes of 1872, and the reply then, which is exceedingly important, is this: "The Meteorological Committee "hope that the Astronomer Royal will not attri"bute to them any discourtesy if they ask him "to be so good as to inform them whether he re"quests to have the information he desires in his "private capacity, or as President of the Royal "Society, because a question of grave import may "arise if there should exist any misunderstanding as "to the constitution of the Committee and its relation "to the Royal Society. On this point they take "leave to refer the Astronomer Royal to the third "paragraph on page 3 of Parliamentary Paper "No. 246, session 1869, enclosed herewith, which "runs as follows: 'It may seem scarcely necessary "'to state that the Royal Society, further than "'having, at the request of the Government, nomi"'nated the superintending Committee (of the Me"'teorological Office), and retained the right of filling "'up vacancies, should such occur, is in no way "'connected with the Meteorological Office.' The "Committee, with the sanction of the Board of Trade, "would have no objection to furnishing the Astro"nomer Royal in his private capacity with the facts "relative to the cost of the plates in the Quarterly "Weather Report, which have been recently communi"cated to them by the Controller of the Stationery "Office." The answer of the Astronomer Royal is to be found at page 3 of the same Minutes, and it is in these terms: "I have to acknowledge your letter of "the 16th, conveying the request of the Meteorologi"cal Committee to be informed whether the com"munication of the amount of expense incurred for "meteorological plates was asked by me in my "private capacity, or as President of the Royal So"ciety. I admit the propriety of this inquiry, and "reply as follows: I disclaim any authority in con"nexion with the Royal Society to control the daily "proceedings of the Meteorological Committee. (For "precise understanding of the relation between the "two bodies I am indebted to your courtesy in send"ing me a copy of the letter M. 3,611.) Neverthe"less, the close connexion implied by the original "formation of the Committee, and the continued ap"pointment of members in case of vacancy, seems to "make it matter of duty in the officer representing "the Royal Society to be acquainted with the gene"ral proceedings of the Committee. These, whether "in action or in expense, are subjects not of private, "but of public interest, and are so recognised by the "Committee in the publication both of its active mea"sures and of its immediate expenses; and it would "seem, therefore, that the communication of amount "of another branch of expense, hitherto not known to "the Committee, might now be expected by the Royal "Society. Probably if I had not become President I "might not have made this inquiry, and, so far, the "inquiry is connected with my presidential character. "I should, however, be glad, on other grounds, to be "possessed of the knowledge to which I refer. I "might, perhaps, consider the propriety of thus re"cording the observations of this observatory, which "would depend (among other elements) on the ex"pense. I have only to add that I am fully sensible "of the respect which is due to a committee of "gentlemen who have gratuitously given so much "time and labour to an object whose importance with "them I entirely appreciate." Then I was instructed to furnish the information, and the letter, which was prepared, as all important letters are, by me, and submitted to the Committee before being sent, was as follows: "I am instructed by the Committee to inform "you, in reply to your letter of the 18th, that the "Controller of the Stationery Office has intimated to "them, in his letter of the 11th instant, that the cost "of transferring and lithographing the plates for the "seven observatories in the report, is 88*l.* 3*s.* 1*d.* per "quarter, or 352*l.* 12*s.* 4*d.* per annum. I am to draw "your attention to the fact that this estimate is framed "on the cost of the first two quarters for 1870, being "the latest for which the accounts have been re"ceived," and so on. I need not read the remainder of the letter. Then comes a letter which the Council of the Royal Society suggested to the Astronomer Royal to submit to the Committee. The Astronomer Royal says, at page 6 of the Minutes for 1872: "At the meeting of the Council of the Royal So"ciety on the 18th instant, I submitted for the "consideration of the council the question of charg"ing the Royal Observatory of Greenwich with "those meteorological observations which are at pre"sent carried on at Kew Observatory for the purposes "of the Meteorological Committee, and for which at "present a subvention of 250*l.* annually is paid by "the Government. At the suggestion of the officers "of the society, my paper addressed to the council "had been printed, and I now enclose a copy, "which I request you to lay before the Meteorologi"cal Committee. It will be perceived that my "idea was (and I still judge it most probable), that "the selection of observations had been made by the "Royal Society, and therefore that all remarks on "them ought to be addressed to that society. Some "doubts, however, having been expressed on that "subject, I most willingly undertook to communicate "my proposal to the Meteorological Committee also, "a course which, under any circumstances, I should "have considered at some time indispensable. Should "the Royal Observatory be charged, as I propose, "with the observations in question, the Meteoro"logical Committee may be assured that the most "careful attention will be given to their require"ments." This enclosure was headed: "Confidential, "for the use of the Members of the Council of the "Royal Society only." "The President submits the "following remarks to the Council. The institution "and discussion of extensive meteorological observa"tions has been undertaken by Her Majesty's Govern"ment, mainly at the instance of the President and "Council of the Royal Society. The Meteorological "Committee is virtually a committee of the Council, "and the annual accounts of expenditure are pub"lished by that Committee. These circumstances "appear to leave it perfectly within the competence "of the President to remark on the nature of some "parts of the outlay incurred in prosecuting the "objects of the Meteorological Committee. Among "the expenses is an annual grant of 250*l.* to the Kew "Observatory, for meteorological observations made "there as at one of the stations of the Meteorological "Committee. Now, in estimating the propriety of "this grant, it is to be remarked that within a few "miles of Kew, is the Meteorological Department of "the Royal Observatory of Greenwich, instituted by "Her Majesty's Government several years before the "establishment of that of Kew, maintained by the "Government at considerable expense, more com"plete in its equipment than the Kew Observatory, "at least equal to it in the excellence of its instru-

" ments, and under the most careful daily superin-
" tendence, and perfectly able to furnish to the Me-
" teorological Committee, at insignificant expense,
" all that is now furnished with an annual expense of
" 250*l.* to the Government. It cannot, I think, be
" considered right still to load the Goverment with
" this unnecessary expense. And I propose to the
" Council that steps be immediately taken for the
" transference to the Royal Observatory of the obser-
" vations in conjunction with the Meteorological
" Committee now taken at Kew. As Superintendent
" of the Royal Observatory, I engage that everything
" practicable shall be done to render its observations
" available to the Meteorological Committee. My
" remarks do not in any degree apply to other ex-
" penses incurred at Kew for the Meteorological
" Committee, to which, on general grounds, I see no
" objection."

13,914. I apprehend that document was simply sent on, on the recommendation of the Council, as the personal act of the Astronomer Royal?—Entirely.

13,915. That document was not in any way adopted by the Council?—I have not examined the Council minutes, but I have been informed that it was negatived by the Council. The circumstance was simply that the Astronomer Royal said, I most willingly undertake to lay before the Council of the Royal Society my proposal. There was no responsibility of the Council connected with it. My reply then is found at page 9: "In reply to your " letter of 22nd ultimo I am directed to state, in the " first place, with reference to the second and third " paragraphs in that letter, that the Meteorological " Committee are not *officially* informed of what may " have taken place at the Council of the Royal Society " on 18th ultimo. They consider that the rela- " tions between the Society and themselves are fully " and explicitly defined in the correspondence con- " tained in Parliamentary Paper No. 240, 1867, and " in the Report of a Committee appointed to consider " certain questions relating to the Meteorological " Department of the Board of Trade, &c., presented " to Parliament in 1866, where the original letter " from the President and Council of the Royal Society, " dated June 15th, 1865, has been reprinted (App. " p. 111). In this report you will find the original " recommendation of the Kew Observatory, as the " central observatory of the land meteorology of the " British Islands, and a summary of the relative " duties and responsibilities of the central observatory, " and of the five" (in a note, "subsequently increased " to six,") " affiliated observatories to be established " in different parts of the British islands, and to be " supplied with self-recording instruments verified " and compared with the Kew standards. The " scheme thus originally suggested, and afterwards " examined and approved by a committee appointed at " the request of the Board of Trade, was adopted by " Her Majesty's Government, and is carried out by the " Meteorological Committee. It is not, in the opinion " of the Committee, their duty to report to the " Council of the Royal Society any portion of their " proceedings. As a matter of courtesy, however, a " copy of their Minutes, which are printed but not " published" (those copies which are before the Commission), "is forwarded annually to the Society. " A full report is regularly sent to the Board of " Trade, which is subsequently presented to Parlia- " ment, by which body the requisite funds for carry- " ing on the whole of their establishment are voted. " The Committee would express their well-considered " opinion that it would not be possible for them to " retain Kew as an efficient establishment for the " control of their other observatories, and for the " verification of meteorological instruments, unless " the various operations of a continuously-recording " meteorological observatory were carried on there. " It is an essential part of any system such as theirs " is that the normal observatory should be controlled " by an independent unpaid governing body, and " should not be connected with an official paid depart- " ment of the Government, over which they have no " power. In conclusion, I am directed to add, that " the Committee do not consider it their province to " enter into any discussion with the head of any other " observatory of the suggestion contained in para- " graph 3 of your enclosure, wherein you proposed " 'to the Council of the Royal Society that steps be " 'immediately taken for the transference to the " 'Royal Observatory of the observations in con- " 'junction with the Meteorological Committee now " 'taken at Kew, &c.,' but will be ready to advise " the Board of Trade, under which department they " act, if they should be consulted in the matter." The final letter of the Astronomer Royal is this, on the 8th of February 1872:—"Dear sir, I have not " yet succeeded in procuring the two papers (of 1866 " and 1867) to which you refer in your letter of " February 2nd, and would ask if you could lend " them for a day or two. On other points I would " only assure you that I make no claim of interference " with the proceedings of the Meteorological Depart- " ment, and that I have no feeling but one of respect " towards the Meteorological Committee. But the " question of original organization, which naturally " was not determined by them, appears to be open to " me. The opinion which you cite, on the necessity " of retaining Kew as an active observatory, is worthy " of the most respectful attention, however much it " may differ from my own. Will there be any objec- " tion to my reading your letter at the Council of the " Royal Society on February 15th," and I was in- structed to reply that we had no objection whatever. Since that there has been no further communication.

13,916. Are there any extra stations provided with a partial self-recording outfit?—There are three supported by the Committee, and three co-operating. With regard to those supported by the Committee, there is one at Sandwick Manse in the Orkneys, with an anemometer managed by the Revd. C. Clouston, a very old observer. There is an anemometer at Holyhead. There is an anemometer at Yarmouth, and, in addition, the Duke of Northumberland furnishes us with records from Alnwick Castle. The Marquis of Londonderry has allowed us to put up at Seaham an anemometer lent us by another gentleman, Mr. Crossley of Halifax, who also sends us observations from his own station. Those are the stations from which we get continuous records.

13,917. How many telegraphic reporting stations are there in the United Kingdom?—There are 29 in the United Kingdom for the morning reports and seven for the afternoon ones.

13,918. What is the relation of the Observers to the Office?—They are paid usually 5*s.* a week, and in a few places 1*s.* 6*d.* a week extra for furnishing sea reports, and they all hold their offices directly under the Meteorological Office, which is different from all other meteorological organisations, excepting that of the United States. We have almost entirely got free from the Post Office, because it is necessary that we should have the power of dismissal from the duties of reporter, and that the men should not be changed from station to station without our being consulted.

13,919. Are these stations inspected regularly?—Since I have been director they have always been inspected till within the last two years, when I found that one or two stations (and I think there were four last year) might be omitted, that it was unnecessary to visit every year. The stations have gone on for six years perfectly regularly. The telegraphic reports showed that they were working well, and that it was possible to omit them, but this duty of inspection, owing to the want of funds, had only in a very few instances been undertaken during Admiral FitzRoy's time.

13,920. You say that the pay of those observers is at the rate of 5*s.* or 6*s.* a week, and you retain the power of dismissing them. What kind of persons are those observers?—Their other duties are stated in the last Report. If I take the Report for 1872, a

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list of observers is given there, at page 65 of Appendix VII. The first observer is a schoolmaster, the master of a navigation school at Sumburgh Head; the next is the gardener of a gentleman of extensive property at Stornoway; the third is a ship carpenter who lives at Thurso, and has been a good deal at sea; the fourth is a watchmaker, and so on. Some of them are telegraph clerks, and in six cases we have men of a very high stamp. We have the observatories at Oxford and Cambridge and the services of the assistants there. We have Dr. Merrifield, a fellow of the Astronomical Society at Plymouth, and we have Mr. Lowe at Nottingham, and Mr. Hartnup, junr., at Liverpool.

13,921. Do these persons send their telegrams as anybody else would send them?—Yes, precisely, excepting that they have passes, and whenever we send a telegram it has the right of precedence over all, excepting Government messages, when it has got the Meteorological pass on it.

13,922. Does the Office receive co-operation from volunteer observers, and to what extent?—It does to a very considerable extent, and the extent is increasing. A list of the volunteer observers is to be found in the Report for 1872, at page 22. A considerable number of gentlemen furnish us with observations of various degrees of completeness, and they receive printed results in return. This is very important, because it has frequently been stated, and is still uncontradicted officially, that we had no person in connexion with us who was not paid.

13,923. In what ratio does the number of volunteer observers stand to the paid observers?—We cannot, in a statement of that kind, well give the details, because we have not commenced yet to furnish returns from the volunteer observers. The number of names that are down at present is 40 volunteer observers, but they do not all send full returns; 40 gentlemen supply information freely to us of various kinds.

13,924. Have the public displayed a readiness to co-operate with the Office?—The number of volunteer observers is constantly increasing. I get a letter like this from a man, saying "If you will only call me your observer I will promise to send you anything you want." We decline any control over volunteer observers, because we have no right to control men whom we do not pay.

13,925. Has the idea of mutual action between the Office and the Meteorological Society been ever mooted?—In this matter I would wish to hand in to the Commission the Minutes of this year (*delivering in the same*). It is a very simple matter, and you will find it at page 18. Recently the Meteorological Society in London has proposed to co-operate with us, and we have said that we should be ready, but that we had no funds at present by means of which we could give them any remuneration for the increased work which would be thrown upon the Society.*

13,926. The proposition came, did it not, from the Meteorological Society?—Yes, but then I may say that it is in harmonious action, because I am the foreign secretary of the Meteorological Society, but it did certainly originate with the Meteorological Society.

13,927. (*Professor Smith.*) What was the nature of the concerted action that was proposed between the Office and the Meteorological Society?—Nothing has been laid down completely, because of the letter from the Meteorological Society, simply saying that they wished to co-operate, but the general idea is, that if we had money by means of which a small grant could be allowed to them, we might get all the eye observations, as distinguished from the self-recording ones, through them, and that we might transfer the volunteer observers to the Meteorological Society, and recognise it as a collecting body. That is a possible basis for negociations, but it has not come so far as that, simply because the Meteorological Committee have no money as yet to offer.

13,928. (*Chairman.*) Do you think that the motives which lead the public to volunteer observations to the office would operate so strongly in leading them to volunteer to give assistance to the Meteorological Society?—A great many of these gentlemen are Fellows of the Meteorological Society, and I know one or two who would be reluctant to give observations to the Office, for fear that it would damage the Society. I think there would be a possibility of starting harmonious action between the Society and the office.

13,929. You have had some correspondence, have you not, with the Scottish Meteorological Society?—There has been constant correspondence almost.

13,930. What has been the tenor of that correspondence?—The main tenor has been a wish to obtain a grant of money to aid the society.

13,931. Did that body from the first raise objections to the establishment of an organization embracing Scotland as well as England and Ireland?—Apparently not, for with regard to the Report of the Committee of Inquiry, which is contained in the Parliamentary paper, number 206, 1867, they approved entirely of the Report excepting the question of whether or not the direction of the wind should be indicated in storms.

13,932. Will you mention what their objections were?—It is a very long correspondence. The first letter was my letter of January the 19th, 1870, asking them to put me into communication with their observers at certain named stations. Their reply was that it would give them sincere pleasure to be of any service to the Committee, but their observers "give their "valuable services, not only gratuitously but as a "sort of favour to the Society," and therefore they say "the Council do not feel themselves in a position to "ask their observers to undertake the labour of "filling up other than the Society's schedules, and "the more so as having been asked by the Registrar-"General for an additional schedule, the Council "were assured that in some instances this request "would be refused. The Council, therefore, after "due consideration of the matter, regret that they "cannot see their way to sanction any direct com-"munication between your Committee and the Society's "observers; but on the other hand the Council being "desirous to give what assistance they can to the "Meteorological Office, have instructed Mr. Buchan "to supply whatever information is contained in the "existing schedules, and to use every endeavour to "procure further information from such of the ob-"servers as may be disposed to afford it." In reply I sent a number of forms at once. The next communication is in the Minutes of 1870, at page 35, an extract from the Minutes.—"Mr. Scott's letter "having been read, the Council, before instructing "Mr. Buchan to proceed with the filling in of the "schedules which had been forwarded from the Me-"teorological Office, resolve, with the view of pre-"venting any misunderstanding between the Meteo "rological Committee and the Council, to propose the "following as the basis of agreement: 1. That the "Meteorological Committee forward the schedules to "be filled up to the Society's office, stating the date "from which the extracts of observations are to be "made; 2. That the extracts of observations be "made or verified by the Society's secretary under "direction of the Council, and be then forwarded "by him to London; 3. That in the event of the "Meteorological Committee requiring any explana-"tions they shall apply to the Council for such in-"formation; 4. That no direct communication shall "take place between the Meteorological Committee "and the Society's observers." The reply to that was that the Committee accepted the first three terms—that the schedules were to be furnished, that extracts were to be made by the secretary, and that explanations were to be procured through the secretary. The Committee then stated to me that they would conduct all their communications with the observers through the Council with the excep-

[* See Supplementary Evidence in Appendix III., p. 5.]

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tion of four gentlemen named, with whom we were at that time in Communication, but the agreement was not to preclude the establishment of other stations in Scotland by the Committee, independently of the Scottish Society. The answer to this was the answer upon which the whole thing has turned. At the same time the Scottish Society had, *pari passu*, carried on negociations with the Government asking for a special grant, and the reply of the Board of Trade to the Scottish Society was this, at page 37 of the Minutes:—"That the Board have carefully considered the memorial and the statement enclosed in your letter, and that they are unable to find any grounds on which they can entertain and submit to the Treasury any proposition for a separate grant of public money to the Scottish Meteorological Society. The Board of Trade will, however, be pleased to hear at any time that an arrangement has been effected between the Meteorological Committee of the Royal Society and the Scottish Meteorological Society whereby the Scottish Society will co-operate in carrying forward the objects sought to be attained by the Meteorological Committee. If and when such an arrangement is made, the Board of Trade are satisfied that the Meteorological Committee will pay to the Scottish Society a proper sum in consideration of the services rendered." The Minute which I am now going to read refers to both those negociations, and it is to be found at page 51:—"The meeting having had laid before them the resolution of the Meteorological Committee of date 4th April, resolved to agree to the same, except with reference to the last paragraph, referring to the establishment of new stations in Scotland, with regard to which the Council beg to express a hope that the Committee would do them the favour to communicate with them before establishing such stations. The meeting had at the same time before them the answer by the Board of Trade to the memorial of the Council asking for a separate grant of public money, in which answer their lordships state that, whilst unable to move the Treasury to give a special grant, their lordships will be pleased to learn that an arrangement had been effected between the Meteorological Committee and the Scottish Society whereby the latter will co-operate in carrying forward the objects sought to be attained by the Committee. The Council resolved to agree to this proposal, and, in accordance therewith, to intimate their desire to co-operate with the Committee, leaving to the Board of Trade to fix the amount of the sum to be paid in consideration of the services rendered. In any such arrangement it will of course be understood that the independence of the society in the management of its affairs shall be in no wise affected." The difficulty in that matter was in my opinion that the society meant a grant of 300*l.*, and we meant a grant of 20*l.* or 30*l.* The amount of co-operation that we were prepared to pay for was certainly not 50*l.* per year, and they gave me to understand that they would take nothing less than 300*l.* Then comes a letter of the 9th of May 1870, which has been suppressed in certain correspondence printed by the Scottish Society. A private letter was written to me by Dr. Keith Johnston in these terms:—"On the 27th ultimo I transmitted to you extract from Minutes of Council of the Meteorological Society, asking your Committee to suggest terms of an arrangement between you and us. Some of our friends in Parliament have written to say that in the view of the impending discussions in the House of Commons on the subject of the annual grant of 10,000*l.*, they are very anxious to learn whether a satisfactory agreement has been effected between your Committee and us. They say that such an agreement, if it could be referred to in the course of the discussion, would strengthen their hands in upholding the grant against sundry enemies to its continuance. We shall be glad to receive an immediate reply from your Committee." That letter has been suppressed in any account of the correspondence which I have seen as emanating from the Scottish Society. My answer to that was:—"Dear Sir,—The excerpt from your Minutes was laid before the Committee" (I did this without showing it to the Committee, but I showed it afterwards), "but they did not instruct me to send any further reply. It does not contain any request that this Committee should 'suggest terms of an arrangement.' It simply asks us to let you know when we are about establishing new stations in Scotland, which we shall of course do. The co-operation which we *have* asked for is, as regards the observations of wind and weather, out of my application, for which, in January last, the correspondence has arisen. The Committee do not meet till Monday next. Could you kindly let me know whether there could have been any mistake in copying the words of the excerpt sent to me? It most certainly contains no request of the nature indicated in your letter." The answer to that was: "Dear sir,—I regret that you did not clearly understand the meaning of the communication I sent you from our Council meeting of the 26th ultimo. It may not have been very explicitly stated in my letter, as the papers were not at hand at the time. But our meaning was simply to ask if your Committee are prepared to recommend to the Board of Trade that we should have the grant of such a sum of money as will enable us to engage a clerk and other assistants, in order that we may co-operate with you in the manner indicated by the board. It will, therefore, be a favour if you will bring the matter before your Committee at your meeting on Monday next, and communicate to me the result of their deliberations by that day's post, in order to guide our society in their future proceedings." I was instructed to reply as follows: "In reply to your note of the 13th instant, I am directed to acquaint you that the Meteorological Committee are not prepared to recommend to the Board of Trade that your society should receive a grant of money to enable them to engage a clerk and other assistance. The co-operation the Meteorological Committee proposed is explained in my letter of January the 17th, and in the memorandum (No. 17) already forwarded, and of which I now inclose another copy. You will observe by the first paragraph, second page, that the form is to be filled up only whenever a storm, or very sudden change of weather, is noticed; and also occasionally when specially requested by letter. The expense incurred from time to time in obtaining and forwarding this information, the Meteorological Committee are prepared to defray." This arrangement has never been acted on. The sole information ever received from Scotland has been at one time in my absence, when Captain Toynbee was working up a storm in the Atlantic in February 1870, and when he wrote for, and received, certain information from Scotland, but for a space of three years no information whatever was received. Then a further correspondence arose about the establishment of the station at Stornoway, because I considered that the whole of those arrangements had lapsed owing to the non-fulfilment of their part of the bargain. They consider that the bargain is binding upon us, and that sending the observations in one instance, whereas they had undertaken to send it in *every* case of a storm, was a fulfilment of their part of the bargain, and a further correspondence has been carried on which is exceedingly long, but it has all been an argument as to the meaning of that last excerpt from the Minutes. The last words of a Minute of their Council of date June 14th 1870, stated that they had "agreed that the failure of their negociations with the Royal Society Committee should be reported to the Board of Trade," and we considered that that referred to the failure of the whole of their negociations, while they maintained that it referred only to the failure of a part. There is a matter which I should very much like to submit to the Commission. I have here a memorandum which I submitted some years ago to

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Sir John Lubbock, but the state of the case has not changed since. It shows the amount of our expenditure on outfit and arrangements for the three kingdoms, showing what it was in the years 1869–70, and it is not materially changed of late. If the Committee wish it, I could make it up for the last year, but I think that the year named would do. The expenses for the United Kingdom are as follows:

STATEMENT showing the NUMBER of SELF-RECORDING OBSERVATORIES, TELEGRAPHIC REPORTING STATIONS, and STORM SIGNAL STATIONS, established by the METEOROLOGICAL COMMITTEE; and the NUMBER of PLACES supplied with FISHERY BAROMETERS, to the end of the Year 1869.

Stations, &c.	England.	Ireland.	Scotland.
Self-recording Observatories -	3	2	2
Telegraphic Reporting Stations -	9	4	6
Drum Signal Stations - -	70	10	26
Fishery Barometers - -	54	18	40
Do. do. supplied during 1869.	3	1	3*

* One of these repaired only.

STATEMENT showing approximately the AMOUNTS paid for METEOROLOGICAL ESTABLISHMENTS and SERVICES in SCOTLAND compared with other portions of the UNITED KINGDOM during the Financial Year 1869–70.

Services.	England.	Ireland.	Scotland.
	£ s. d.	£ s. d.	£ s. d.
*Establishment of Observatories.	959 4 6	822 16 10	782 17 10
Expenses at Observatories.	1,398 10 3	811 14 2	586 14 6
Observatory computations.	161 14 3	107 16 0	107 16 0
Telegraphy—reports to office.	†458 17 8	458 17 8	458 17 8
Telegraphy—warnings issued.	157 17 0	52 12 4	105 4 8
Telegraphy — computations.	168 18 9	75 1 8	112 12 6
Fishery barometers supplied.	12 15 0	4 5 0	9 8 0
Totals - -	2,358 12 11	1,510 6 10	1,380 13 4

* The Establishment was *prior* to the year 1869; all other charges were actually paid within that year.

† The cost of telegrams is roughly estimated to be about equal for the three kingdoms. In 1869 an Irish message cost more than two English, and a Scotch message cost about one-and a half English. These figures have therefore been altered since 1870 but not materially.

There is another question which I ought to refer to. Formerly the Society did work much more harmoniously with the office, in fact the office assisted it, as Admiral FitzRoy had assisted the Society materially in its establishment. There have recently been very unpleasant negociations carried on at various times. Up to the time that the Committee was appointed, whenever the Society wished to establish a foreign station, say in Jerusalem, in the Faroe Islands, or in Iceland, they came and got their instruments from the Meteorological Department, but the instant the Royal Society Committee came into operation they, not being allowed to lend instruments for use abroad, this was at once put an end to, so that the Society has received practically nothing since the Committee has been established, excepting the instruments which had been previously lent for use at foreign stations as above described, which are presented to the Society, the total value being about 100*l.*

13,933. Do the coastguard and light-house officials co-operate with the office?—We could obtain, and did at one time obtain, co-operation from the coastguard, and I am at present engaged in some negociations which are going on exceedingly harmoniously with the English and Irish Light-house Boards about sea temperatures. The coastguard officials presented us with reports on wind and weather to test our storm warnings in the years 1868 and 1869, and the fact has been, that we found that no two coastguard watchmen agreed in their reports, owing to the circumstances that these men were in coves and in landing places differently sheltered from the winds, whereas the ships were outside the headlands and felt winds which did not reach the observers on shore, so that the observations did not agree with each other, and we have actually had to cease using them. I may say that the men were not paid for the work. We got it because we had the power in connection with the Board of Trade to obtain information from the coastguard, but of course we did not dare to ask for too much. We could at once move the Controller of the coastguard, but the work would be ordered, and we should not get anything worth having.*

13,934. Has there been any reason for the non-establishment of a series of stations of the second order?—Perhaps as the title "second order" is perfectly new, and it has been only defined last year in Vienna, I may say what I mean by that: I mean stations which take less than six observations a day; in fact, ordinary stations, which still are good stations, but they do not take as many observations as could be obtained at a first-class observatory. It would appear to be interfering with the Registrar General's work, and Mr. Glaisher's organisation, if we were to commence to publish. I am prepared to publish something like 20 stations, but I am waiting till I get a larger number to begin to publish. At present our land publication simply consists of the records of some of our self-recorded observations, seven in number, and of certain publications connected with the telegraphic stations.

13,935. Has the chief reason for the non-establishment of a series of stations of the second order been a desire not to interfere with some which already exist?—Certainly. I mean that we do not wish to bring ourselves into direct collision unless there was such an amount of public benefit likely to be produced as would justify it. I do not think that 20 stations over the British islands would justify it. It would be considered that it was merely a beginning, a getting in of the thin end of the wedge. I have not been urgent in this matter. We have always said that so long as the Registrar General publishes his returns, the Committee have not thought it necessary to issue information of a similar nature, and they have not at present made up their minds to publish.

13,936. Has any correspondence passed between the Government and the Committee as to the Quarterly Returns issued by the General Registry Office?—A very considerable amount of correspondence has taken place just lately.

13,937. What is the tenor of that correspondence?—Nothing has ever been mentioned with relation to the preparation of these returns on the estimates until this year. The Treasury thought that Sir George Airy did it (I can show that by a letter of July 9th, 1858, signed by Sir C. Trevelyan), whilst it was a private arrangement with Mr. Glaisher. When inquiry was made into this (I do not know how that originated), they found out that there was a small allowance of 150*l.* a year, and the Treasury asked whether we could not undertake to do the work. The correspondence went on, and we finally stated that we were perfectly ready to undertake the work without making a charge of 150*l.* a year. There was a good deal of extra correspondence which passed, with enclosures and various things, which have not been printed in the Minutes, but the whole of the corres-

[* See Supplementary Evidence in Appendix III., p. 5.]

pondence ended by our saying that we were perfectly ready to furnish the information to the Treasury without any increase of payment. These two charts will show, if you glance over them, what we could do (*handing the same to the Chairman*). The blue marks are the stations which we could substitute, and the red marks are the stations which the Registrar General published in his last report. I append a list according to the counties. See Appendix A.

13,938. (*Dr. Sharpey.*) Did not Mr. Glaisher represent that he had sources of information which were not open to the Meteorological Committee?—Yes, and we replied to that; but we have not yet asked for special observations from any of his stations, and we do not think that any important ones have been left out in our list. But without counting any of these stations, excepting those which are actually in our pay for telegraphic reports, we could substitute a more complete list.

13,939. (*Chairman.*) Is the Meteorological Office willing to furnish returns for the Registrar General's Tables?—Yes, and to submit a satisfactory list of the stations.*

13,940. What is the nature of the British rain-fall organisation?—Entirely private. Mr. Symons organised it many years ago. I am not quite certain in what year, but I think it was about 1860. He has since 1864 regularly received a grant from the British Association, and occasional grants from the Government Grant Committee for investigations connected therewith.

13,941. Do you see any practical difficulty in the way of granting the money required from the Meteorological Office?—Certainly. Mr. Symons would not accept it unless as a donation. The Meteorological Office as at present constituted could not grant money without exercising a control. I have recently seen Mr. Symons as regards this very subject. I said I am going to speak about your organization, and I should like to know whether you will support what I say. He said, "I must have absolute and entire control," or at all events he gave me to understand that.

13,942. Has not the British Association discontinued its subsidy, so that there would be no chance of Mr. Symons getting it?—The subsidy of the British Association is of comparatively minor importance to him. The expense exceeds the subsidy, I am told, by nearly 1,000*l.* a year. I would rather that these statements should come from Mr. Symons directly, but I know as a matter of fact that the gentlemen who furnish him with observations also furnish him with money. He is apparently seriously out of pocket in the proceeding, and he has appealed to the country to subscribe, but the country has not subscribed, I suppose, saying that we are there, and that we ought to do the work. Last year a committee of his friends was called together to ask him how they could help him out of the difficulty, and he said that he would accept of no help which did not leave him absolutely free even from the Meteorological Society, which is a small society, and connexion with which he declined. If any balance sheet is published by him and I can furnish it, I will add it to my evidence.

13,943. Supposing that the present British rainfall organisation ceased to exist, could the Meteorological Office take it up?—It would not take it up on the same scale. I do not think that 1,600 stations for the United Kingdom are wanted.

13,944. Do you think that the facts could be determined by the office in a better or less expensive way?—Not in a better way. Mr. Buchan's investigations in Scotland, where the surface is very irregular, have clearly shown that the rainfall in one catchment basin bears no proportion to the rainfall in the next catchment basin, and that there is no proportion as to height; that you would want gauges in every parish; it is impossible to say to what extent. My private opinion is that there are more stations than are requisite for the *meteorology* of the country, but not for the *rainfall* from an engineering point of view. Supposing he wanted to know what rainfall you could get for waterworks, say at Leeds, Mr. Symons would probably want no more stations than he has. The organization has grown up with Mr. Symons, and it certainly will fail entirely with him. He was formerly for a time a clerk in the Meteorological Department, and his organization is certainly entirely dependent upon his life.

13,945. Do you consider his work important?—I think that perhaps too much is made of it, but I think that he has done a great deal of important work.

13,946. With reference to the water supply of a town, you would take into account the rainfall, would you not?—Yes; I may take a good instance, that of Middlesborough, a town which has risen in a few years. I do not know whether he would have enough stations there to supply the necessary information, but I do not see how 1,600 stations could be justified from an office such as ours.

13,947. As I understand that you consider it to be the business of the Meteorological Office to determine the rainfall for general meteorological purposes, but not to determine it for local purposes?—We cannot attempt to determine it for local purposes. If Mr. Symons ceased to carry on his organization and we had to undertake it, we might get a good deal of information, but it would not be done in anything like so minute a manner as Mr. Symons does it.

13,948. Is the Meteorological Office frequently consulted about legal questions, either in the Admiralty or in the other courts?—Yes, constantly in the Admiralty Court as regards collisions, and to a certain extent in the other courts. I may instance the case of a ladder being blown down in a certain storm at the East End, and we were written to and asked what was the force of the wind, and whether the fall of the ladder was justifiable. Constantly in cases of collisions one of our clerks has to go and give evidence with our observations if we have self-recorded observations.

13,949. Is any charge made for supplying that information?—None whatever, or rather none that touches the office. The clerk who goes as a witness gets a fee, but the office gets nothing whatever. If a serious amount of information is copied out the expense of copying is charged, but there is no fee whatever.

13,950. What other meteorological systems are there in existence at home besides those of the Meteorological Office and of the General Register Offices in London and Edinburgh?—There are a very considerable number of various kinds. There is Greenwich, which itself is only an observatory, not a system. There is the organisation of the Army Medical Department, which is at present being organised in conjunction with the Meteorological Office. There are certain stations under Sir Henry James of the Royal Engineers, and I believe the Navy Medical Department has some stations, but I am not sure about that. Then the Meteorological Society is organising a system, and the Scottish Meteorological Society has certain stations (in addition to those from which returns are published by the Government) connected with its Medical Department; and there is the Rainfall Organization, of which I have been speaking so much. But speaking of Government organisations, there are certainly three, and up to a recent time there was a fourth, Sir Edward Sabine's office, under the War Office, which is still called the Magnetic and Meteorological Department.

13,951. Do you think it would be desirable to centralise the systems which exist at present?—I think certainly so. There is no doubt that it was the unanimous opinion, both at Leipzig and Vienna, that there should be centralisation to increase harmonious action. I have a letter here from a man of very great eminence in meteorology, a gentleman in the colonies, Mr. Meldrum, of the Mauritius, and with the leave of the Commission I will read a portion of this letter, as

[* See Supplementary Evidence in Appendix III., p. 5.]

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a colonial suggestion of what might fairly be done. What he says is this:—"If I had time, and were sure that, "there was any chance of the subject being taken up, "I could develope a theory as to what should be done "to promote meteorology in the British Empire. I "would (1), have a central office in London; (2), "partly convert the Kew Observatory into an in- "stitution for training meteorological and magnet- "ical observers, and discontinue the Meteorological "and Magnetical Department at Greenwich; (3), "obtain from Parliament an annual grant of at least "30,000*l.*; (4), have an arrangement made by which "the colonies would contribute, say, other 30,000*l.*; "(5), have the administration of the Imperial Fund "placed in the hands of some one or more persons in "London who should be responsible to Parliament; "(6), the colonies to consent to the directors being "selected by the Central Office in London, and the "directors, with the advice of the Central Office, to "choose their assistants; (7), the observations, &c., "to be published in London."

13,952. What organisations of note exist in the colonies?—There is one in the Canadian Dominion under Dr. Kingston; there are various systems in Hindostan, the most important in Bengal, under Mr. Blanford, and in Bombay, under Mr. Chambers; the Madras organisation, under Mr. Pogson, one in the North-West Provinces, under Dr. Murray Thomson, and one in the Punjaub, under Dr. Neil. Then there are several in the Australian colonies and Tasmania. There is one for Victoria, I think, under Mr. Ellery; there is one for Tasmania, under Mr. Abbott; there is one in New South Wales, under Mr. Russell, one in South Australia under Mr. Todd, one in Queensland under Mr. MacDonnell, and there is one in New Zealand, under Dr. Hector. The organization of the Meteorological Society of the Mauritius, under Mr. Meldrum, is only that of an individual island, you cannot say it is an organisation; it chiefly interests itself in maritime meteorology. I may say that this organisation at the Mauritius has a different character from any other, because, as I believe, it first took its origin from a bequest. It was started by Dr. Thom. I do not know who gave the money, but the society has property independent of the Government at the Mauritius.

13,953. Has the Meteorological Office any stations at all abroad?—Certain stations. This commenced with the British Association. In 1857 the British Association recommended that anemometers should be placed abroad, and two were placed, one at Bermuda, which is there still, and one at Halifax, which was afterwards removed. Then the next important thing was that Lieutenant Rokeby went out in 1864 or 1865 to Ascension, and took about two years' observations there, and came back in 1867. Since then observations are now going on at Bermuda, and we have supplied certain instruments to the Bahamas, and to Sombrero. There were instruments deposited by Admiral FitzRoy at the Falkland Islands lighthouse at Cape Pembroke, and two in King George's Sound, in West Australia and Breaksea Island and Point King, but those two stations are only 7 miles from each other, I believe.

13,954. Does the Government sanction the existence of stations of this kind?—In the case of certain stations which are controlled by the Board of Trade, or the lighthouses which are controlled by the Board of Trade, and are considered home lighthouses, such as the Falkland Islands, Sombrero, and the Bahamas. The whole of the correspondence with West Australia is complete, and is to be found in the Minutes for 1873. There is nothing personal as regards the men, it is personal as between the colony and the office, as the governor considered that such a small colony as that should not contribute anything to the work, whilst the opinion of the Home Government was that the Home Government should contribute nothing.

13,955. Have any results of importance been derived from those stations?—Very important work as regards the anemometer at Bermuda. We have published the result of four years' observations at Bermuda in our last Quarterly Weather Report, and have got most important results from it, but there is very great difficulty in managing those stations from the impossibility of inspection. At the Falkland Islands the observations are very nearly worthless, they come in so very irregularly.

13,956. Have you any relations with foreign systems of observation?—We have very intimate relations of exchange with all the systems of observations, of the existence of which I am acquainted.

13,957. Is there any community of system among you?—We are attempting to make a community of systems. There is no system in existence that starts on the same principle as we do of requiring self-recorded observations from its individual stations, that wholly arose out of a meeting at Cambridge in 1845. The organizations are different in different places; in some places, as for instance, I believe, North Germany, the observers are paid a small sum, and in almost all systems the observers are called upon to do the preliminary calculations themselves, whereas in this country we do them all at the central office. Professor Dove's observers in North Germany are many of them schoolmasters; the observers of the Austrian organisation, which is very extensive, are, I fancy, in the position of country gentlemen. Some of them are gentlemen connected with religious establishments, others are doctors; in fact the average is rather higher than the middle-class observers that you will find throughout this country, and the Austrians are not paid. In France the organisation is in a very extraordinary state, indeed I may say that there is nothing organised at all. Instruments are supplied to the Écoles Normales, but the observations are not thoroughly controlled, there is no proper organisation in hand in France.

13,958. Is there any pains taken to compare the instruments used by the British and Foreign observers?—Measures have been adopted at Vienna for that purpose, but the only steps that have been taken in this country have been that the standards at Kew and Greenwich, which do not agree exactly with each other, have been considered as standards to be compared, and foreigners have come here for that purpose, but we have not gone abroad to compare with their standards. There was a sub-committee appointed at Vienna for organization, and the report of that committee is to be found at page 61 of the Report of the Meteorological Congress at Vienna. At page 36 it appears that that report was adopted and received, and the matter has been referred to the Permanent Committee which now exists, to see how far perfect harmony can be brought into existence.

13,959. What was the first attempt at convening an International Conference?—A number of gentlemen were invited to meet at a meeting of the British Association at Cambridge in the year 1845. I do not think there were many oral deliberations there, but there is a good deal of correspondence printed in the Report of the British Association for the year 1845, which shows what took place at that time, and since the failure of that year was because they would not agree to harmonious working as to hours, out of that meeting arose our self-recording instruments; I do not know who besides Sir John Herschel and Sir Edward Sabine were the organizers, but amongst them were Professor Dove and Professor Kupffer, and three or four others. I can give a list of the gentlemen who took part in it. Perhaps I may mention that notice of that conference has generally been omitted, and it has been almost forgotten, but that was the first step long anterior to anything that has been recently done.

13,960. The last conference seems to have been at Vienna, in 1873?—Yes, it was held last year.

13,961. Has any action been taken to secure that the resolutions of the Vienna Congress will be carried out?—A permanent committee has been appointed to see what we are doing, and to arrange for summoning another Congress in three years.*

[* See Supplementary Evidence in Appendix III., p. 5.]

13,962. Are you a member of that Permanent Committee?—I am a member of that Committee.*

13,963. What advantages have been derived from those conferences, do you think?—The great advantage is getting to know the men, but we are gradually approaching towards uniformity. There is only one matter on which I had to stand up against the whole conference, until General Myer came, and that was the introduction of the metric system. The present position of the metric system, which is the point at issue, is that there are more stations in the United States, England, and its colonies than in the whole of the rest of the world put together,† and, therefore, it is the place of the advocates of the metric system to give way to us, instead of our giving way to them, as there would be more disadvantage in introducing the metric system than in introducing the English system everywhere; and of course, being under orders from the Government, I could not give the slightest sanction to any adoption of the metric system. But on all other questions there has been the greatest wish to work harmoniously with them. One important thing which would be worth noting has been the unanimous agreement that means are to be for five years, and for the same five years or "*lustra*;" that the first period of means will begin at 1871, and work till 1875, and the next will be from 1876 on. And we are trying to introduce an uniform scheme of publications, so that you can get the same sort of information from each country. We are gradually approaching each other each conference. We did something in this way at Leipsic, and perhaps more at Vienna. In 1873 there was a decided wish on the part of the members to give way if it was for the benefit of the public.

13,964. What is the amount of the annual grant to the Committee?—10,000*l.* a year.

13,965. Is that as much as was proposed by the Committee of Inquiry in 1866?—No; the Committee of Inquiry in 1866 asked for 9,900*l.* for the annual establishment and 2,900*l.* for outfit. The sum of 10,000*l.* was subsequently increased to 10,570*l.*, because that Admiralty grant had been omitted to be struck out of the estimate (the whole of that is stated in the correspondence in the Minutes for 1867). They allowed 10,570*l.* the first year, and 10,000*l.* every year after.

13,966. (*Professor Smith.*) A considerable sum is for outfit, is it not?—Yes.

13,967. (*Chairman.*) Did the Treasury give any indication of its wishes as to the operations of the Committee?—It is in the same letter, which, for this purpose, I may perhaps read; it is at page 55 of the Minutes of 1867. "My Lords will, however, consent that for "these purposes the sum of 570*l.* expressed in the "estimates to be 'for meteorological services under "'the Admiralty,' shall be available for expenditure "by the Committee appointed by the Royal Society at "the request of the Government in addition to the "sum of 10,000*l.* I am to observe that, in assenting "to insert the latter sum in the estimates for the "current year, my Lords were aware that they were "proposing a less sum than had been estimated for, "and they intended that the arrangements to be made "by the Committee should be curtailed accordingly. "It now appears that the Committee anticipated the "decision of this Board as to the exact amount to be "proposed in the votes when they gave orders for "instruments, &c., to be made. My Lords cannot "hold themselves responsible for these orders, and can "only regret that they were given before the Com"mittee had ascertained the precise amount of public "money that they could look forward to for the "purpose."

13,968. Is the amount of the grant large as compared with the amounts allowed in other countries?—It is large as compared with the amounts allowed in most European countries, but in this document before me, which is the last Report of the Chief Signal Officer for the War Department of the United States for the last year, the amount allowed for that work for weather telegraphy alone is 50,000*l.*, exclusive of the salaries, which are all in the military vote. The amount allowed to us is certainly larger than elsewhere in Europe, but the work is different. Nobody else has anything like 2,000*l.* to pay for the marine work, and, as meteorological votes go, no doubt it is liberal as compared with other countries.

13,969. Can you give us an idea of what the grant is in Germany; take Austria for example?—There is no amount so large as ours. The whole vote, every penny that is spent, is accounted for by us, and there is no drawing salaries from other sources or anything of that kind. Moreover, the telegraphy is usually conducted free of expense abroad. I append the budgets for Russia and Austria (APPENDIX B).

13,970. Then we are to understand that the grant can in no way be described as a grant in aid of the Royal Society?—Not in the slightest degree. The Royal Society has nothing whatever to do with it. After the first year we wrote to have the title altered, and they did alter the title in the estimates, and put it down as "The Meteorological Committee of the "Royal Society." But as I said, it is not until the end of the seventh year that they have recognised that it is not a grant in aid, and that the whole expense is borne by the Treasury.

13,971. Then that title, "The Meteorological Committee of the Royal Society," is misleading?—It is appointed by the Royal Society, and the official title by which the Government call us is "The Meteorological Committee of the Royal Society."

13,972. Is any surplus refunded to the Treasury?—No. We were ordered, in the first instance, to re-pay the surplus. That was by a letter of the Treasury in Parliamentary Paper 240, 1867, page 13:—"I am "desired to say that in assenting to insert in the "estimates a lump sum of 10,000*l.*, my Lords under"stood that the whole of the arrangements would be "undertaken by the Committee on their own respon"sibility, and that no claims will be made upon the "public purse over and above what that sum will "cover, and that any saving out of that sum will be "surrendered to the Exchequer, as in the case of other "votes." Those are our original orders. At the close of the first year, when the financial year was out, I wrote a formal letter to the Board of Trade, which you will find in the Minutes for 1868, page 35, asking by whom the accounts were to be audited. The Board of Trade sent to the Treasury, and the Treasury wrote back to say that, "As the sum of "money placed at the disposal of the Meteorological "Committee of the Royal Society is considered as a "*contribution* towards the expenses of the researches "undertaken by them at the request of Her Majesty's "Government, it is unnecessary that the accounts of "the Committee should be subjected to audit on behalf "of the public." That carries with it the non-surrender of the balance.

There is one matter which perhaps I might mention with reference to almost my first answer. Our communication with the Government is with the Board of Trade, officially with the Secretary. We have no official access to the Treasury excepting through the Board of Trade, nor even with the Admiralty excepting through the Hydrographer. We are distinctly affiliated to the Board of Trade.

13,973. So that, although the Board of Trade will not own you, you do really, in a sort of irregular way, get at the Government through them?—Yes; and we never spend any money on a new object unless the Board of Trade order us to do so. If any money is asked for, supposing that a subsidiary grant were asked for by any person or persons, we should apply to the Board of Trade for leave to spend the money in that way.

13,974. Do you mean that you do not feel yourself

[* See Supplementary Evidence in Appendix III., p. 6.]

† Dr. Hann gives in his paper, "Fortschritte der Geographisthen Meteorologie:—

Number of stations with English inches and Fahrenheit	-	739
" " " metre and Celsius	-	609
" " " Paris lines and Reaumur	-	114

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at liberty to administer the funds in your hands as you like?—Not for such a question as to whether a new station is to be put on for storm warnings. For investigations, we are perfectly free; but when a person makes a claim for an allowance out of this fund (say that a person asks me for new lanterns for a new station), we always say that the Board of Trade must sanction it.

13,975. Then, in fact, the Board of Trade is responsible for a large part of your expenditure?—The Board of Trade protects us from non-scientific claims for expenditure. If any station wants storm warnings, we ask the Board of Trade whether that is such a station as should be authorized.

13,976. So that it does appear that, as to certain parts of your expenditure, you do not feel yourselves at liberty to do as you like?—We do not, and we do not wish to, because we think that we should not be able to resist pressure from without.

13,977. To that extent the Board of Trade is really responsible for your expenditure?—Yes, to that extent.

13,978. It does keep a control over your expenditure; that is to say, if they refused their assent, you would not make a grant?—Certainly.

13,979. How is the grant paid to the Commitee?—As soon as it passes, I write a letter to the Secretary of the Treasury and get it.

13,980. What banking account do you keep?—We keep a current account with the Bank of England, and a deposit account with the London and Westminster.

13,981. Does the Committee derive interest from the deposit account?—Yes, we derived 186*l.* interest last year. The interest in the last year's report, owing to the bank rate being so high, was so large an amount.

13,982. Does the Committee keep a regular check on your financial position from time to time?—It prints on its minutes quarterly statements of its liabilities, whilst a detailed monthly statement (*handed in*), when filled up, is handed in by me to the Committee to see how fast they are spending their money. That was carried on after the first year. They found that they did not know how much money they had to spend, and so this plan was devised. The quarterly accounts are abstracts of the monthly accounts, and if I take any one, say the last quarterly account which we have printed (I have not printed the one for the last quarter), we show that up to the 31st of December we have spent 7,500*l.*, and we have a liability of 1,200*l.*, making a total of about 8,700*l.*

13,983. Are the orders for work and so on given on an estimate accepted by the Committee?—Any estimate for expenditure, excepting routine work, such as ordering new instruments, is always submitted by me to the Committee.

13,984. And are there contracts with instrument makers?—We receive a very considerable discount on all instruments which we get for the public service. I order perhaps 100*l.* worth of instruments without asking the Committee. The instruments are kept on record, and there is a complete history of each instrument, but I do not go to the Committee for every supply of that kind. Anything new is always submitted to the Committee if it exceeds 5*l.* or 10*l.*

13,985. How are the cheques drawn and the accounts managed in the office?—They are drawn monthly, and the accounts are all submitted to me, and countersigned by me, and then the cheques are countersigned by me before they are presented to the Committee for signature.

13,986. Does any member of the Committee sign them?—Any one member; but, as a rule, unless in case of urgency, or in case of absence, they are always drawn at the Committee.

13,987. And are they countersigned by a member of the Committee?—The signature is by one member of the Committee, mine is only a countersignature; but any one member will do, and the cheque is always placed upon the Minutes.

13,988. At what periods are the salaries paid?—They are paid every month.

13,989. Are all the salaries annual?—Some are, all those whom I have called clerks upon the establishment, as distinguished from those called temporary clerks, are paid according to annual salaries, the others are paid according to weekly salaries.

13,990. What proportion do the salaries bear to those in the public offices?—That is an exceedingly difficult question to answer. My own impression is that the salaries are very considerably less than those in other public offices, even when compared with "supplementary" or "assistant" clerks.

13,991. Will you state with what other civil servants you have made the comparison?—The Civil Service is in such a state of re-organisation at present, with a new Commission issued a fortnight ago, that one does not know what state it is really in. Those gentlemen who came to the office from the Board of Trade Department did so because no definite promise of promotion was offered at that time by the Board of Trade, but soon after they left a re-organisation of the staff at the Board of Trade took place, and they have lost materially by the change. However, the salaries are low compared with those in other public offices. Upon this point I beg to hand in the following table:

RETURN showing PROPORTION of SALARIES in METEOROLOGICAL OFFICE compared with those of other Offices. Data taken from Civil Service Estimates, 1874–5, and other sources.

Office.	Clerks.	Assistant Clerks, &c.	Writers, &c.
	£ £	£ £	£
Board of Trade -	200 to 800	80 to 400	—
Charity Commission -	90 „ 650	—	—
Civil Service ditto -	100 „ 500	80 „ 200	—
Greenwich Observatory	350†	†180 „ 250	—
Local Government Board.	90 „ 800	250 „ 400	—
Lunacy Commission -	100 „ 500	—	—
Patent Office - -	100 „ 450	130 „ 160	*150
Privy Council -	100 „ 800	90 „ 250	160 to 200
Registrar General -	300 „ 420	90 „ 280	*90
Stationery - -	90 „ 500	—	*85

† Assistants. * Average.

The salaries in the Meteorological Office vary from 100*l.* to 250*l.* for clerks, and from 50*l.* to 100*l.* for temporary clerks.

13,992. Is there any allowance for over-time work?—Yes; the regulation about that is that no clerk is allowed to earn more than half his salary. Some of those who receive small sums could easily earn more than half their salaries, but such a state of things would be impossible for one of the senior clerks.

13,993. What regulations are enforced to prevent this work from interfering with the regular work?—The regular work is never allowed to be done in over hours, except in certain cases, like telegraphy, but there are special investigations which are carried on besides the work of the office.

13,994. Is the system more advantageous to the office than the employment of extra hands?—That is a very difficult question to answer, but we believe that it is on the whole more advantageous, because we have not room to put extra hands, and that would involve additional rent and additional supervision. Besides that, a man who is on the staff would be more likely to carry out our own ideas than a fresh clerk who would require a good deal of teaching. In fact our present staff have experience which the office would have to pay for if new men were engaged.

13,995. What are the financial arrangements with the observatories?—The arrangements, speaking generally, were, that every observatory was to get 250*l.* a year for doing the work, but that has been modified

in two cases. In the case of Armagh, Dr. Robinson is only paid the amount which he is out of pocket by the salary of his assistants, and his chemicals. In the case of Valencia, we have to bear the entire expense, and the cost of that very closely approaches 600*l.* a year, solely because we have to pay the whole 250*l.* as salary to get a superintendent to live there. I may say that it is the cost and expense which has prevented us from establishing a station in Caithness, Orkney, or Shetland, or anywhere far north. There is no existing observatory to which they can be affiliated. But in the other cases we simply allow the 250*l.* to be spent as they choose. They have to find their chemicals and their assistants, and to keep the instruments going, for small repairs. For instance, when a thermometer is broken it has to be paid for, because it is caused by carelessness.

13,996. What financial arrangements do you make with other observers?—Some of the gentlemen who superintend the anemometers and self-recording instruments for us are paid something like 10*l.* or 15*l.* a year, but not more than that.

13,997. Does the office pay for the transmission of its telegrams?—It does pay almost entirely, as a private person, excepting that we do not pay the money down; we pay at the end of the year, or we pay quarterly.

13,998. Is there any reduction of cost in the case of office telegrams?—Recently there has been. In the case of the companies we had a considerable reduction of 30 per cent. The Government withdrew that, and lately they have begun themselves to utilize some of our returns, and they allow us to be charged at press rates for all observations which they can themselves utilise. There were certain returns of wind and weather formerly furnished to the Press Association by the Post Office which were not very satisfactory, and we offered to give them copies of our returns if they would give us the boon of press rates. But at present for storm warnings and everything else we pay simply 1*s.* for each message of 20 words.

13,999. What would be the saving if the Government were to forego this charge?—We believe about 1,100*l.* annually for simple transmission; but of course we do not consider the idea of foregoing the whole charge for telegraphy which amounts to nearly 3,000*l.*, as that includes the charge of the payment of observers, and discussions, &c.

14,000. Would not a reasonably free use of the telegraphic wires enable you to receive and issue intelligence much more satisfactorily than at present?—Certainly. We only get now one telegram per day from all stations, and from a few selected ones two, but in case of a sudden storm we cannot get information enough, owing to its cost. I may also say, that every storm-warning that is sent all round the coast costs us nearly 5*l.*, so that it comes to be a serious question of expense, how often one can modify those messages.

14,001. That constitutes a sort of practical drag upon your sending information?—Yes. I put down 7*l.* because there are about 130 stations at 1*s.* a-piece.

14,002. Would you prefer such an indirect allowance to an increased grant of equal amount?—I certainly would prefer a grant of equal amount, because I should still be absolute over the observers, but if I am to be dependent on the Post Office for the observations, and they receive nothing from me, I shall be unable to get a man removed, or, what is more important, to keep a good man if the Post Office wants him elsewhere. I think if we were put in connection with such a large office as the Post Office, we should be unable to manage the thing efficiently in a scientific point of view.

14,003. If I understand the suggestion properly, this "reasonably free use of the telegraphic wires" means simply that the observers whom you do employ should be able to communicate with you more frequently than they do, and without expense?—Without additional expense. The Post Office would consider then that those would all come as official messages, and they would consider that they furnished them, although they got no pay for them, and they would not care about the work.

14,004. Is any work done for other parties, such as foreign institutions, upon commission?—To a great extent. For instance, Mr. Meldrum has received from us a considerable quantity of information for certain charts, which I shall speak about subsequently, and there is a certain amount of work done in the way of copying and furnishing information. A very serious matter arises about that, because we are asked by the Foreign Maritime Meteorological Offices to furnish, free of charge, all the information that they may require to discuss. We are the collecting party, and they have got discussing power, but the whole of the time of our clerks would be taken up copying if we complied with their request; we simply charge the cost of copying, and the cost of all the work done is charged to the people who give the commission.

14,005. Is such work always charged for?—Unless it is in the way of exchange. For instance, if an office like the Observatoire National of Paris sent us a very large supply of information from its own stations of a different nature, we should not charge them for the exchanges, or it would be on a lower scale; and also if it is a very small thing we do not make a charge.

14,006. What are your rules about the supply of unpublished information?—Anyone who chooses can get it by paying the cost of the copying, and when he publishes it, saying that he has got the information from the office.

14,007. The balance sheet for 1872 shows on the debtor side a sum exceeding 200*l.* received, can you explain to the Commission those entries?—We get very considerable orders for instruments for public institutions abroad. For instance, for Dr. Kingston there are outstanding orders considerably exceeding 100*l.*, indeed I think as much as 200*l.*, for instruments for the Canadian stations. The whole of those instruments are ordered by us, and the money passes through our accounts, so that our balance sheet rises to 10,200*l.* by these transactions instead of 10,000*l.*

14,008. Is there any profit to the Committee upon such transactions?—No monetary profit; I have got a very large order at present (although this will not pass through our accounts) from the Admiralty of Berlin for instruments connected with the transit of Venus. It is simply done as a matter of friendship. The orders are made payable to me, but nothing whatever, excepting the cost of actual work in the office in packing, &c. is charged.

14,009. Is there a serious want of extra funds?—I should say a very serious want for working the office thoroughly, as regards carrying out investigations. I think that the estimate of the Committee of Enquiry did not provide anything like sufficient for the clerks; even allowing for all the salaries, there is nothing like enough men. I think there was an insufficient staff originally contemplated. We have not been able to carry out the ideas which were contemplated by the Royal Society originally, as regards many discussions and investigations which were to be carried out. The Observatories are calling out for more money. Then, as to the question of telegraphic stations, it is very much wanted to increase their number, and there is money wanted for experiments.

14,010. There are two series of experiments being carried on by me: one by aid from the Government Grant, and the other at the expense of the Meteorological Committee. The one by the Government Grant is on anemometers. The Meteorological Committee have got thermometers on the Pagoda in the Royal Gardens, Kew, at various heights to test the influence of elevation on their indications, and we should very much like to be able to spend some money if we had it on testing thermometers, and on various physical

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experiments connected directly with our Meteorological Observations.

14,011. Where is the habitation of the Meteorological Office?—Formerly, up to the year 1869, we held the old office in No. 1 Parliament Street. In 1869 we received notice to quit, and we took two flats in 116 Victoria Street, and then afterwards took a third.

14,012. Do you pay rent for them?—Yes.

14,013. A heavy rent?—We pay less there than we should pay for very much worse accommodation in Parliament Street. We paid 538*l.* 17*s.* last year.

14,014. That forms a considerable item in your expenses?—Certainly.

14,015. (*Professor Smith.*) I see that you derive some income from subscriptions for your charts?—Yes.

14,016. Is that source of income increasing or not?—It is not materially increasing. I think one might say that it is not much above 300*l.* a year that we get from the charts, and this barely pays the postage. It is as I say not materially increasing, but it is keeping on very steadily. We have an issue of upwards of 500 copies, but that is a question which will come on subsequently. There is no doubt whatever that these charts have materially improved the position of the office with the country, they are very popular.

14,017. How is the expenditure created for the marine observations?—Last year's account will give the best idea for the whole year. That would include Captain Toynbee's and the clerks' salaries, but it includes also the cost of new instruments and repair. The abstract of accounts shows 400*l.* for the superintendent last year, 300*l.* for the supply of instruments to the Admiralty, 500*l.* for the supply of instruments to the Mercantile Marine, and 970*l.* for discussion and reductions.

14,018. How does that 900*l.* for discussion arise; who makes that charge?—There is the clerk at a salary of 230*l.* for taking care of the instruments; there is the head clerk at 250*l.*; and there is another clerk at 150*l.*, and there are three juniors at less than 100*l.* a year each, speaking roughly.

14,019. Do you consider that that account of returns that you have now stated indicates success in that department and the duties of the office?—The case as to that is that we are discussing the work which was collected in the office in former times, and have derived important results from it, while the Committee of Inquiry recommended that the work of dealing with the old materials should be subservient to working with the new.

14,020. (*Dr. Sharpey.*) Is there a large accumulation of materials?—A very large accumulation, about 3,000 logs. We find that the material which we now get is very small in quantity, but it has materially changed its character. We cannot get so many observations round the Cape of Good Hope, because the number of ships taking that route has greatly decreased. The Suez Canal has altered that. The use of steamers, which is increasing every day, materially affects the correctness of the observations of wind. We cannot get a knowledge of the wind so well from modern logs. We found that the old logs, when they have been sifted, formed a most important mass of materials. I think subsequently, when we are speaking of the usual work, I will explain at a little more length the way in which we have had to work, and I have brought a chart with me which will show some of the questions about this matter.

The witness withdrew.

Adjourned to to-morrow at 11 o'clock.

APPENDIX A.

List of Meteorological Stations now in communication with the Meteorological Office, compared with those now in communication with the Registrar General. The stations are arranged according to their counties and countries.

No observers in connexion with Registrar General's office have been *specially* asked to join Metorological Office for this return.

England and Wales.

Counties.	Meteorological Office Stations.	Registrar General's Stations.
Cumberland	Silloth	Silloth.
		Carlisle.
		Cockermouth.
Lancashire	Stonyhurst Observatory.	Stonyhurst.
	Southport.	Eccles.
Cheshire	Liverpool Observatory, Bidston.	Liverpool Observatory, Bidston.
Flintshire	—	Hawarden.
Caernarvon	—	Llandudno.
Anglesey	Holyhead.	—
Cardigan	Aberystwith	Lampeter.
Pembroke	St. Ann's Head.	—
Gloucester	—	Gloucester.
Somerset	Portishead	Taunton.
Cornwall	Scilly (St. Mary's).	Truro.
	Helston	Helston.
	Falmouth Observatory.	
Devonshire	Barnstaple	Barnstaple.
	Plymouth	Sidmouth.
Channel Islands	Guernsey	Guernsey.
	Jersey (St. Helier's).	
Hampshire	Hurst Castle	Bournemouth.
	Lymington	Lymington.
		Osborne (I. W.)
		Strathfield Turgis.
		Aldershot.
Sussex	Brighton	Worthing.
	Crowborough Beacon	Brighton.
		Eastbourne.
Kent	Acrise (near Folkestone).	Greenwich Observatory.
Suffolk	—	Somerleyton.
Norfolk	Norwich	Norwich.
	Yarmouth	Holkham.
Yorkshire	Hull	Hull.
	Scarborough	Moorside.*
	York	Bermerside.*
	Moorside	Bradford.
	Sheffield	Leeds.
Durham	Seaham.	—
Northumberland	Allenheads	North Shields.
		Bywell.
		Allenheads.
Notts	Nottingham	Nottingham.
Derbyshire	—	Derby.
Stafford	Oscott.	—
Cambridgeshire	Cambridge Observatory.	Wisbeach.
Hertfordshire	—	Royston.
Bedfordshire	—	Cardington.
Oxfordshire	Oxford	Oxford.
Berkshire	—	Streatley.
Wiltshire	—	Marlborough.
		Salisbury.
Surrey	Kew Observatory	Weybridge.
		Battersea.
Middlesex	Chiswick	Chiswick.
		Camden Town.

Scotland.

Hebrides	Stornoway (Island of Lewis).	—
Orkneys	Sandwick Manse.	—
Shetlands	Dunrossness (Sumburgh Head).	—
Inverness	—	Culloden.
Nairn	Nairn.	—
Aberdeen	Aberdeen Observatory.	—
Lanarkshire	Glasgow Observatory.	—
Ayr	Annanhill (Kilmarnock).	—

Ireland.

Donegal	Moville.	—
	Dunglow.	
Sligo	Markree Castle.	—
Galway	Galway.	—
King's County	Parsonstown.	—
Kerry	Valencia Observatory.	—
Cork	Roche's Point (near Queenstown).	—
Dublin	Dublin.	—
	Kingstown.	
Down	Armagh.	Milltown (near Banbridge).
	Donaghadee.	

* These two stations are very close together.

APPENDIX B.

ALLOWANCES IN AUSTRIA AND RUSSIA FOR METEOROLOGICAL OBSERVATIONS.

	£	s.	d.	£	s.	d.
Austria (1869):						
* Director	210	0	0			
* First assistant	130	0	0			
† Second „	110	0	0			
* Assistant	42	0	0			
* Messenger	37	16	0			
Computers	54	15	0			
				584	11	0
Instruments, &c.	120	0	0			
Registers	160	0	0			
Inspectors	40	0	0			
Remuneration to observers	20	0	0			
				340	0	0
Draughtsman	48	0	0			
Telegraph messengers	24	0	0			
„ expenses	12	14	0			
				84	14	0
				£1,009	5	0

* Residences provided at the Central Meteorological Institute.
† With allowance of 22*l.* 10*s.* for residence.

	£	s.	d.
St. Petersburg (1872):			
‡ Director	282	10	0
Assistant	217	10	0
Observers	625	0	0
Computers	125	0	0
‡ Secretary	125	0	0
‡ Intendent	78	12	0
Engineer	70	6	0
Scientific purposes	937	10	0
Inspections	187	10	0
Printing	625	0	0
Office contingent expenses	781	5	0
Maintenance of Meteorological Stations	625	0	0
	£4,680	3	0

‡ These have residences provided at the Observatory.

R. H. Scott, Esq., M.A., F.R.S.

22 April 1874.

Thursday, 23rd April 1874.

PRESENT:

THOMAS HENRY HUXLEY, Esq., LL.D., Sec. R.S., IN THE CHAIR.

BERNHARD SAMUELSON, Esq., M.P.
WILLIAM SHARPEY, Esq., M.D., F.R.S.
GEORGE GABRIEL STOKES, Esq., M.A., LL.D., Sec. R.S.
HENRY JOHN STEPHEN SMITH, Esq., M.A., LL.D., F.R.S.

BALFOUR STEWART, Esq., LL.D., F.R.S., further examined.

B. Stewart, Esq., LL.D., F.R.S.

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14,021. (*Chairman.*) Has anything occurred since you were last before the Commission, to lead you to wish to add anything to what you then stated on the question of meteorology?—To some extent the position of things has changed since then; for instance, I stated in my last evidence that one great disadvantage under which meteorologists laboured was the difficulty of procuring individual observations, except at very great expense. Being anxious to do what I could to remedy this grave inconvenience, I was the means of getting a petition signed and presented to the Meteorological Committee, and they have now acceded to the prayer of this petition, and, beginning with the present year, they are prepared to publish the individual values derived from their self-recording instruments. There is another point in which the position seems to be changed. At the time when I last gave evidence I did not think that regular observations were made with regard to Atmospherical Electricity excepting at Greenwich and Oxford. I hear now, however, that the self-recording instrument of the Meteorological Office for electricity is complete, and I hope that soon we may have continuous electrical observations undertaken by that body. I know it was in contemplation some time since that they should undertake that work whenever their instruments were complete.

14,022. Has anything been done with respect to observations of the sun's heating power?—None, with respect to the sun's heating power; the instrument, so far as I can see, requires to be devised for that purpose. But with regard to the sun's actinic effects, Dr. Roscoe has devised a self-recording instrument, which he hopes will soon be adopted, and already the Kew Committee, Mr. Meldrum, Director of the Mauritius Observatory, and Mr. Ellery, Director of the Melbourne Observatory, have promised to give a trial to this instrument. Besides this, another instrument of his construction, not self-recording, is already adopted to some extent in the Russian Observatories.

14,023. The Meteorological Office, I believe, has done nothing with regard to actinic observations, or with respect to the sun's heating power?—No, nothing. There is another point in which I think advance has been made. At the moment when I gave my evidence the photographic observations of the sun's disc which had been taken at the Kew Observatory for 10 years were just discontinued, but now I am given to understand that similar observations are regularly taken at Greenwich by Sir George Airy, and I think that very probably observations of the same kind will be undertaken in India and in the Mauritius. Also I think that Mr. Langley, the Director of the Alleghany Observatory, in America, may possibly undertake observations of the same kind. After the transit of Venus we shall probably have a good many photoheliographs at our disposal, and it is possible that some more extensive use will be made of those photoheliographs after the transit of Venus has taken place.

14,024. Do you think that the Meteorological Office ought to take charge of those instruments, and to utilize them?—I am not sure that the Meteorological Office ought to do so. Although I have no doubt that solar observation is intimately connected with meteorology, it is questionable whether they should be put together. In my opinion, an institution for the purpose of solar observations would be better than that the thing should be taken up by the Meteorological Office.

14,025. In a special observatory?—Yes, in a special observatory, probably with head-quarters in this country, and with certain stations in our different colonies, one great object of which would be to render it quite certain that we should have every day a record of the sun's surface either at one station or at another.

14,026. Where would such an institution as that be lodged?—Supposing it were lodged in this country, such an institution, if it were to take charge of the sun, would require to take spectroscopic, as well as photographic observations, probably in some place where the climate was most favourable. Of course climate is at a disadvantage as far as this country is concerned; but, on the other hand, being near the

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centre of scientific work in England is a counterbalancing advantage.

14,027. If you could not have those advantages, this country would not be a good place to establish such an observatory in?—No, I should not think it would be a good place to establish such an observatory in.

14,028. Would such an observatory as that be a very costly institution?—No, I do not think it would be very costly.

14,029. You would have such an institution as that kept entirely apart, would you not, from the Astronomical Observatory?—Yes, I would have it kept entirely apart.

14,030. And not under the control of any of the existing head institutions?—No, I think not.

14,031. Do you suggest that the aid of the Government is needed more especially for one branch of meteorology as compared with another?—I think that, as far as I can see, the subject of Meteorology naturally divides itself into two heads. There is first of all physical meteorology, of which the object would be to ascertain the physics of the earth's atmosphere, and perhaps of the earth's ocean; and then there is climatic meteorology, which has a number of branches, each relating to different human interests. It might be an advantage, for instance, to study certain particulars with regard to disease, or with regard to agriculture, or with regard to fisheries, particulars that might be different from those which would be required for the study of the physical meteorology of a country. It appears to me that the most legitimate object for Government aid is physical meteorology; that is a branch of the subject which certainly could not be studied to advantage by private individuals, and it necessarily calls for Government action.

14,032. I suppose that the business of the physical meteorologist would be rather to explain phenomena by the application of the laws of physics?—Yes; first of all to collect the phenomena properly, and then also to explain them.

14,033. (*Professor Smith.*) Will you describe to the Commission the exact difference between the two terms, physical meteorology on the one hand and atmospheric and climatic meteorology on the other?—For instance, with regard to living beings, I am not sure that it is known exactly in what way the constituents of the atmosphere may be supposed to affect the human body or the various plants, and an investigation with regard to that would appear to be very different from any investigations with regard to the physical causes of the motions of the earth's atmosphere. Then, with regard to mines, explosions, fisheries, agriculture, and to all the various interests, there are various observations which should be made; but I question whether those different branches have advanced to such a point as to render it desirable that such observations should be undertaken by any central authority at the present moment. One sees very well why a central authority should be necessary to obtain the physics of the earth's atmosphere, but I cannot say that I think a central board could undertake those other points so well perhaps as local boards, who are more especially interested in certain localities. I do not think that the science has developed sufficiently to warrant the construction of a central board.

14,034. (*Chairman.*) Do you think that those subjects fall into the province of the present Meteorological Office?—I should be inclined to think that the Meteorological Office would do better to confine itself to physical meteorology alone. It evidently occupies a position of strength if it does so, because it is quite unquestionable that private individuals could do nothing to occupy the same position. If, however, it extends itself for instance to making investigations in certain localities with regard to mines or fisheries it occupies a position, as it appears to me, which is very much more open to objection.

14,035. Would you organize the Meteorological Committee in any really different form to that which at present obtains?—I should be inclined to dispense with the Meteorological Committee altogether, and substitute a Meteorologist Royal, or whatever his appellation might be, a single official who should be responsible to the Government in the same way as the Astronomer Royal is responsible for his department. I do not see why the one department should be on one footing and the other department on a different footing. I think that there are grave disadvantages with a department administered by an unpaid committee.

14,036. Would you appoint a Meteorologist Royal corresponding with the Astronomer Royal?—Yes, whatever the name might be; I should appoint an official very much corresponding to the Astronomer Royal and responsible to the same extent. A Board of Visitors would not be objectionable, but the direction of an unpaid Committee appears to me to be very objectionable.

14,037. Would you leave the other branch of the subject, climatic meteorology, to individuals and local efforts?—Yes, I think so, possibly supported to some extent by funds from the Government, but I should not put such branches under the superintendence of a central board at the present moment.

14,038. For example, what would you say with regard to those observations that are at present published by the Registrar General?—This is a matter which I think ought to be decided by the Registrar General.

14,039. The question arises in this way: the Registrar General is a public officer, who has to be paid out of the public money; the Government naturally says, Here is a body to which we grant a certain large sum, and we do that instead of our being required to pay all the separate items?—As far as the money is concerned, I consider that a mere matter of detail, but I should be very strongly against the Meteorological Committee undertaking anything but Physical Meteorology; I think that they ought to confine their labours to that. If they at present undertake all those branches of meteorology bearing upon the various individual human interests, it appears to me that you will leave them no energy to attack the problems of physical meteorology. I think the great point is to put physical meteorology somewhat more into the position of a branch of physical science; at the present moment it appears to me to occupy a very low position indeed.

14,040. (*Dr. Sharpey.*) Do you consider that the practical applications of meteorology should be conducted by private individuals entirely; for instance, would not the telegraphing of the weather require a central establishment?—Yes; I think that weather telegraphy as at present undertaken by the Meteorological Office certainly ought to be continued to be undertaken by them, but I should even imagine that when the thing is properly developed, when the laws are properly understood, it would then become simply the working out of some physical law, which might ultimately be detached from them altogether. At the present moment, what they undertake is to convey information, and that is a thing which requires, from its peculiar nature, to have something like a centralised office in order to undertake it. You have all those stations in different parts of the kingdom, and correspondence with the different stations abroad, and in order to get that information, I do not see that it could be undertaken except through the Meteorological Office. At the present moment I should say that that is a very legitimate subject for that office to undertake.

14,041. It may be a long time before you could deduce the applications?—Yes, it may be a very long time.

14,042. (*Chairman.*) The observations which are collected for the Registrar General have to be brought to the central office, have they not? The collecting and reducing them does not take very much trouble. It is almost clerical work, is it not?—Yes. The collecting and reducing them does not take very much trouble; but if it is supposed that the object of the Meteorological Committee is, as a matter

of principle, to be confined to physical meteorology and those branches of meteorology which could not well be undertaken, except through an agency of that kind, it appears to me that it would be detrimental to the office to dissipate its energies by the consideration of problems which really are more connected with the other branch of meteorology than they are with the physical branch.

14,043. The point is, whether it would be really a dissipation of energy, and whether such work as you have just been referring to might not be managed by persons who were not occupied with those higher problems in the office?—I think that that is simply a matter of detail. The Registrar General, I imagine, at the present moment, is responsible to the Government for the information, and it is a matter of detail upon which I should not feel myself competent to give evidence. I should leave that to him. He is the responsible person. Let him get any person that he thinks best to undertake the publication of those observations. I do not think that it should be undertaken by the Meteorological Office as the Meteorological Office. If there are individuals there who seem to satisfy the requirements of the Registrar General, I think that that is a point for him to determine.

14,044. The question takes a practical shape, as it comes before the Government, in this way: a sum is put down in the Estimates for getting Meteorological Observations for the Registrar General, and the Government immediately say, We pay 10,000*l.* per year for getting meteorological observations, why should not the Meteorological Office do it; why are we to be called upon to pay a separate sum?—If that is the shape that the question takes, it would be a perfectly sufficient answer, from my point of view, to say the Meteorological Office ought to confine itself to physical meteorology, and this is not a branch of physical meteorology. Meteorology has come to that stage, that physical observations ought to be taken by an office that confines itself to that purpose.

14,045. Would you leave climatic meteorology altogether to societies and to individual effort?—At the present moment it appears to me to be a matter that might best be left in that position, and that a central authority would do no good in a question of this kind, but rather do harm; in fact, rather tend to depress than to encourage these local efforts. I have no doubt that a great deal might be done by the zeal of local individuals, but if the thing were undertaken in its present state by a central board, which would do little but register a number of observations, I do not think that any good would at the present moment be done.

14,046. For example, the Scottish Meteorological Society has made a proposition to collect a number of observations of the kind to which you are now referring, and they ask for a certain subsidy on that ground; do you think that that would be a desirable way of giving aid to that particular branch of meteorological science?—I think it would. It appears to me that the Scottish Meteorological Society are doing a great deal of good. I know at any rate that Mr. Buchan, the Secretary of that Society, is a very distinguished meteorologist, and there are a number of persons in Scotland who take very great interest in some of these points. The Marquess of Tweeddale, the President of that Society, takes great interest in some meteorological points in connexion with climatic meteorology in its relation to agriculture and the fisheries, and I think that, under present circumstances, it would be a good thing to encourage those local efforts that are taking such a hold upon the mind of the meteorologists of Scotland.

14,047. So that if the Government aid is to be given to climatic meteorology, you would rather have it in the shape of subsidies to societies?—Yes.

14,048. Do you think that the sphere of operations of the Meteorological Office should be extended to the obtaining of information regarding the less frequented oceanic regions?—I think that ultimately, if meteorology is to become a science, we should obtain information regarding the less frequented oceanic regions; but I should not be prepared to say that in the meantime any definite steps should be immediately taken with regard to that. It is a subject which requires more thought than I have bestowed upon it, and it ought to be left to develope itself more gradually. The point that I should wish to bring before the Commission at the present moment is the fact that if meteorology is ever to obtain rank as a physical science, we ought to have sufficient general knowledge of the meteorology of our globe. At the present moment it appears to me that the knowledge that we obtain, for instance, of the oceanic regions, is very much like the kind of knowledge that we obtain of the meteorology of a country by taking observations as we are being carried along its various highways or in railway trains; we get a few observations in the most frequented regions, but the other regions are almost utterly unknown.

14,049. Would you recommend the undertaking by the Government of special expeditions to extreme northern and southern regions?—I should recommend the undertaking of such expeditions by the Government, and I think from a number of points of view that such expeditions are very desirable.

14,050. (*Professor Smith.*) With reference to the publication by the Meteorological Office of the individual values in the observations, which I think you stated you had urged upon them, is that a very expensive operation?—I obtained some preliminary information with regard to its expense, and I think, as far as I can see, it would not take more than 150*l.* a year for the mere printing. It would take some clerk's work in the office in order to get the thing into shape, but how much additional clerk's work I am not prepared to say. The mere printing of 100 daily copies would not take more than 150*l.* a year.

14,051. Do you state that as yet there are still no records of atmospheric electricity excepting at Greenwich and Oxford?—Not yet, but I hope the Meteorological Office will very soon have such.

14,052. With reference to climatic meteorology and any assistance that might be rendered by the Government to it, you seem to be of opinion that any such assistance that was rendered for the northern part of the kingdom would perhaps be most properly rendered by means of the Scottish Meteorological Society?—I should imagine it would under present circumstances.

14,053. Do you think that there is any voluntary association, or any body of persons in England, who could be employed to render the same service in England that the Scottish Meteorological Society might render in Scotland?—There is the Meteorological Society in England.

14,054. To come to physical meteorology, supposing the Meteorological Office, with its duties, were strictly confined to physical meteorology, would the plan of operations that you would recommend be something similar to what exists now; I mean a certain limited number of observatories over the country?—I think so; I should not be prepared at the present moment to advocate any very great change. There may be deficiencies, but in such a case, when the observations were properly reduced and discussed, we should be in a better position to see what points were deficient and what points might be supplemented by further observation.

14,055. You would wish that those observations on atmospheric electricity, the sun's heating power, and actinic observations should be taken at most of the meteorological observatories?—I think that electrical observations stand upon a somewhat different footing from observations of the sun's heat, and actinic observations. If, for instance, there was a physical observatory for the sun I should imagine that actinic and also heating observations might be put under that observatory, supposing there was an instrument for recording well the observations of the heat of the sun.

14,056. Observations on atmospheric electricity ought, you think, to be taken by meteorological obser-

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vatories generally?—Yes, no doubt. The processes for doing it would be quite analogous to the processes connected with their other instruments, and I have little doubt that the Meteorological Committee contemplate doing so, in fact, I was led to believe, when I was connected with them, that that was one of the things which they contemplated doing when they got a perfect instrument, and I understand that now the instrument has been pretty nearly rendered complete.

14,057. I understand you to recommend that the Government should continue to do what it does, that is, really to support physical meteorology even more largely than at present?—Yes, I think so.

14,058. Do you think you could state any special claims that that science has upon the Government for its support as compared with other branches of physical science?—I think the claims would be that when the laws regulating the motions of the earth's atmosphere come to be much better known than they are at the present moment, immense benefits of a material kind might be expected to flow from the proper appreciation of those laws. For instance, Mr. Buchan, the Scottish meteorologist, showed that there was a connection between the disposition of the isobaric lines and the weather. He showed that on one occasion, when there was an intense cold that came over this country one winter, there was a very low barometer here and a high barometer in the region of Siberia, and consequently there was a transmission of colder air from those cold regions to the regions here. It seems to me that things might be put into such a state that we might anticipate the advent of such weather, probably for some days. That is one of the possible things, and it seems also possible that if the science developes we might perhaps ultimately be able to tell what kind of season might be anticipated. I do not mean to say that we shall ever be able to prophesy stormy weather much in advance, but at any rate we might possibly bring things to such a state that we might be able to tell to some extent what kind of season would be most probable.

14,059. Will you be so good as to state your opinion as to the value and desirableness of keeping up the observations of rainfall which have hitherto been carried on by a Committee of the British Association?—It appears to me that these observations of rainfall are of very considerable value. I am not quite sure whether their value is not more connected with the climatic branch of meteorology, than it is with the physical branch of meteorology, but to some extent the observations have a physical bearing as well as a climatic bearing. There is no question that it is a case where locality enters very widely into consideration. At the present moment it appears to me that they have been exceedingly well undertaken by Mr. Symons. I do not know whether he would be inclined to give them up if he did not receive support. I have no doubt that he would prefer to undertake the continuance of those observations himself, provided that he received some little pecuniary support in some way.

14,060. You would prefer on the whole to see that system of observations carried on by voluntary associations, assisted it might be by the Government, rather than to see it placed under the Meteorological Office?—I should.

14,061. (*Professor Stokes.*) What do you conceive to be the objections to the management of the Meteorological Office by an unpaid committee?—When the Meteorological Office was reconstituted, Government naturally consulted the late President of the Royal Society, Sir E. Sabine, who was at the same time an old and active meteorologist. Naturally, also, Sir. E. Sabine had a voice in the nomination of his colleagues, who composed, along with himself, the Meteorological Committee. These colleagues were men of scientific standing, and of business habits; but, although interested in meteorology, they were not all meteorologists. They very naturally chose Sir E. Sabine as their chairman. When in the course of time Sir E. Sabine proposed a method of reducing the observations accumulated by the Committee, it might have been thought by those of the Committee who were meteorologists that the science had developed sufficiently to render something more necessary than his method, yet the constitution of the body was such that Sir E. Sabine was able to carry his views. These views of course came officially before the public as the views of a body of men who were selected as best qualified to conduct the meteorological affairs of this country. I presume that if any question had been raised in an official manner about the views of the Committee, they might have replied that had they been selected for their task by competent authorities, that they spent a great deal of time in superintending the Office, for which they received no remuneration, and that if Government were not pleased with their manner of conducting the Office, they had better make some other arrangement. In fact, it appears to me that an unpaid body of men cannot be held responsible in the same way as a single responsible and salaried official.

14,062. Do you conceive that such an object as a comparison of the general temperature of the different seasons of the year, with regard, for instance, to the public health, could be better accomplished by a limited number of stations at which continuous observations were taken, or by taking the average of a very considerable number of stations scattered over the kingdom, and managed by amateurs?—It appears to me that the information which we get from the self-recording instruments is rather of a differential than of an absolute character. It tells us of certain fluctuations. I am not sure that I should absolutely rely upon the records of such instruments as giving any idea of certain peculiarities of the climate of any place that might affect individuals or that might affect plants. It appears to me that, on the whole, the information derived from them is rather of a differential than of an absolute nature. In order to have all the peculiarities of the country properly represented, you might require to have a great many observations very near one another in different localities; for instance, take Sandown and Ventnor in the Isle of Wight, those places are near one another, but I imagine that Sandown has rather a bracing climate while Ventnor has a very relaxing one.

14,063. My question referred to the average climate throughout the kingdom, because it is obvious that for any particular locality the observations that are taken there would show the climate of that locality better than any average obtained from the kingdom; but for general averages for general national use my question was whether such could be better obtained from a few stations at which observations were taken under authority upon which we could rely, or whether it was requisite to take the mean of observations at a great number of places, for which we should have to depend upon the observations of amateurs?—I think, in order to get proper information about the climate of the country, certainly some check ought to be kept upon the observations. We should be sure that the observations are tolerably good. You must visit the places occasionally, and see that the instruments are in good order, and that the observations are properly conducted.

14,064. Do I understand you aright to say that you think that the best result would be obtained by numerous stations, even although you should have to depend for the results there obtained upon amateurs, provided you had a person to visit them so as to check the mode of taking their observations, rather than by a few stations in the kingdom which were under a central management, and the results obtained at which were sent to the managing body to be dealt with as a check upon them?—I do not think that observations at a few places would meet a case of this kind. You would require to have a number of places. If you take the self-recording instruments of the Meteorological Committee, what, for instance, actuated the chairman of that body to fix upon those places? He knew that certain bodies in these places were not only capable to conduct such observations, but certain to have con-

venient rooms where observations of that kind could be carried on. Stonyhurst was one, Kew another, and for a similar reason Glasgow, Aberdeen, and Armagh were selected. The choice had not much reference to climate, with the exception that the observatories were spread at certain distances over the kingdom, one being in the south-west of Ireland, where the weather comes from the Atlantic. Thus, other considerations than the considerations of mere climate induced the Committee to fix upon those stations. I should not consider that results derived from the self-recording instruments at those stations would afford good evidence with regard to peculiarities of climate.

14,065. You mean as regards the temperature, and not merely as regards the rainfall, because the rainfall is so very local?—Yes, the rainfall is so very local, and the temperature is very local too. It appears to me that the barometer is an instrument that is not so local; but some curious fluctuations in temperature take place, and if there were two thermographs, one at one place, and one at another very near to it, you might get very different results. I think we tried that at Kew, putting one in the observatory and one in a small house outside, but the thermographs did not exhibit the same fluctuations at the same moment. You got fluctuations, but not precisely analogous fluctuations.

14,066. In the mean temperature, as recorded by the two, was there any particular difference?—No doubt the daily differences would run the same way in the two cases, but whether the mean temperatures would be absolutely the same I am not prepared to say.

14,067. (*Mr. Samuelson.*) You have drawn a distinction between physical and climatic meteorology, and you have stated that you think that the Meteorological Office would do best to occupy itself chiefly with physical meteorology. Before this matter was taken in hand by the Meteorological Office it was in the hands, was it not, of the Meteorological Department of the Board of Trade?—Yes.

14,068. What was the nature of the observations made by that Department; was it chiefly in the direction of physical or of climatic meteorology?—The observations had chiefly reference to the weather, and in that way I think they were observations more having reference to physical meteorology, that is, physical meteorology regarded from perhaps a practical point of view. Admiral FitzRoy had certain stations from which observations were telegraphed to him with the object of enabling him to predict as well as he could impending storms; and also he got the logs of vessels with a view to getting a knowledge of ocean meteorology—that is certainly a branch of physical meteorology.

14,069. When the functions of that department ceased, the Meteorological Committee was charged with the organisation of the Meteorological Office: was it intended that any change should take place as to the nature of the observations which were to be conducted by that Office, as compared with those previously conducted by the Meteorological Department of the Board of Trade?—It was intended to render the observations much more complete, and to put them on a much more scientific basis.

14,070. But still the character of those observations was to be chiefly that of physical meteorology?—Yes, I understand so. I do not know that the words physical meteorology were mentioned. I do not think that any distinction of that kind was made. It is only recently that an endeavour has been made to divide meteorology into those branches. It was a science quite in its infancy, and the division had hardly been thought of perhaps at that moment.

14,071. What were the observations that were intended to be undertaken in consideration of the grant of 10,000*l.* per annum by the Government?—They wished to have a complete scientific knowledge of the meteorology of the country.

14,072. (*Dr. Sharpey.*) Was not one object to extend the land observations as distinguished from marine observations?—That was one. Whatever the term used was, there is no question that at the moment when the new office was constituted it was physical meteorology that they contemplated. I do not fancy that Admiral FitzRoy's meteorology was of a climatic nature at all; it was really an attempt to put meteorology upon a physical basis. He got the statistics of the ocean, that was one point, and another point was to see what the atmospheric currents were, more especially with the view, whenever those atmospheric currents were violent, of giving warning to the different ports. No doubt it had a practical bearing, but at the same time I conceive that it was a practical application of physical meteorology.

14,073. (*Mr. Samuelson.*) How far do you think that the intentions which were entertained at the time of the establishment of the Meteorological Office have been carried out practically by the office?—It appears to me that they are putting the storm warnings upon a very good footing, so far as I can judge from the figures, and I have no other means of judging; but it appears to me that they are gradually working it out very well.

14,074. And in addition to that they are doing other work which was not contemplated at the time, because the utility of it was hardly sufficiently appreciated?—I am not sure whether they have undertaken anything very recently, but as long as I was there they did not undertake any new work except what was laid down in the first general programme.

14,075. Certain work has I think been done by Mr. Glaisher?—Yes.

14,076. What is the character of that work; is it parallel to the work done by the Meteorological Office, or is it distinct from it?—I think it is distinct from it, it being more of a climatic nature. I should say that Mr. Glaisher has shown certainly very considerable energy in pushing meteorological matters before this country. He has created a large amount of interest in meteorology.

14,077. Are you aware of some correspondence that passed between the Registrar General and the Treasury on the subject of the grant which Mr. Glaisher has hitherto received, in order to enable him to conduct certain observations?—Yes, I have been led to understand that there has been such a correspondence.

14,078. And the result of that correspondence is, that the grant to Mr. Glaisher is intended to be limited by the Treasury to the year ending the 31st March 1874, so far as the correspondence goes?—Yet, I think that the subject being in connection with the death rate is not a subject which ought to be undertaken by the Meteorological Office. So far as my opinion stands, I think that the Meteorological Office ought to limit itself entirely to physical meteorology.

14,079. If you will refer to a letter which forms a part of the correspondence between Mr. Scott, the Director of the Meteorological Office, and the Registrar General, you will find that he states that the Committee having a staff competent to discuss the returns would be most happy to meet the wishes of the Treasury by supplying such returns (namely the returns which have hitherto been supplied by Mr. Glaisher) free of charge?—I still think that it is highly inexpedient that the Meteorological Office should undertake anything but physical meteorology.

14,080. Assuming that the Office is in possession of information for the purposes of physical meteorology, would you still consider it undesirable that they should communicate it to the Registrar General for the purposes which it would serve with him?—I think that is a detail which might be left to the Registrar General. The Registrar General, I consider, so far as that is concerned, is the responsible officer. Provided that my view were followed I should consider that the responsibility of the Meteorological Office was entirely with reference to putting physical meteorology upon a proper footing. Under these circumstances, even though there might be some additional expense incurred, it appears to me that it would be undesirable that they should have anything to do with the other branch. The publications are regularly made and I

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suppose that these publications would be at the service of the Registrar General as much as they would be at the service of any other meteorologist. If the Meteorological Office make these publications regularly, the Registrar General has access to such publications.

14,081. If the publications of the Meteorological Office furnish the Registrar General with the same information as is now furnished by Mr. Glaisher, you think that there would be no occasion to pay for Mr. Glaisher's observations in future?—If they do so; if these publications absolutely give the same information that Mr. Glaisher gives, then surely the Registrar General can get it in that way; but I cannot conceive that they do. Physical meteorology requires one condition of things, and climatic meteorology another, and I cannot conceive that the same information would serve both purposes.

14,082. You cannot conceive that in the course of the investigations which are required for physical meteorology observations could be obtained which should serve the purposes of the Registrar General?—I think that it is highly inexpedient to mix the two objects. If you were to take an observation partly with reference to climatic but partly with reference to physical meteorology, the chances are that you damage the excellence of the observation. Something must be uppermost in the mind in fixing on any given set of observations, and you cannot take an observation the main point of which is to find the physical atmospheric condition of a place, and at the same time to find the peculiarities of the place as regards the death rate or some human interest.

14,083. Could you make that more plain by examples?—One example is this; for instance, the Registrar General would wish observations in certain districts where it would be of no importance to the Meteorological Office to have them. The Meteorological Office dealing very much at the present moment with the weather and the winds, and especially the high winds that come into this country, their stations are more particularly stations upon the coast; but the Registrar General, dealing with the general climate of the country throughout, would require to have a great number of stations inland. There evidently the conditions that satisfy the one are very different from those which satisfy the other.

14,084. In the two maps that are before the Committee, the map containing the blue dots marks the stations of the Meteorological Office, and the map containing the yellow dots marks those stations which are at the disposal of the Registrar-General through Mr. Glaisher. Would you have the kindness to compare those two maps and state whether, in your opinion, the stations already established by the Meteorological Office would be likely to answer the purposes of the Registrar General?—I do not exactly see what is meant by the stations of the Meteorological Office inside the coast. There is one, for instance, at Moorside, one at Sheffield, one at Nottingham, and one at Cambridge, and I see there is one at Parsonstown, where Lord Rosse lives, and at Parsonstown no doubt they could get very good observations. Those are, I presume, stations that they have got recently with the object of finding out the meteorology of the country more perfectly.

14,085. Do you think, from your point of view as to their functions, it is objectionable that they should concern themselves with observations at those stations?—No. I do not think it is, but I think all the observations taken by them should have reference to physical meteorology. You cannot do the two things. With reference to the considerations of climate and death rate, it is just possible that there might be much light thrown upon the subject by observations in the locality and under circumstances which would be absolutely of no use to the Meteorological Office considered as an office for ascertaining the physical meteorology of the country.

14,086. You would, in the first instance, leave it to the Registrar General to determine as to what are the best means of obtaining the information?—Certainly.

14,087. And if he should require information of a different nature from that which the Meteorological Office is enabled to supply from information obtained for its purposes, you would then consider it inexpedient that they should take any special steps to enlarge their inquiry in the direction required by the Registrar General?—Yes, certainly; therefore I should limit their aid to the publication of observations, bearing in mind that a perfect separation ought to be kept between the two branches. It would be inexpedient for the one office to go and supplement the work of the other in any way except by its publications. When once the publications are given, the Registrar General may make what use he likes of them, but I think it is inexpedient that the Meteorological Office should in any way undertake work that has not reference to physical meteorology.

14,088. You are aware, are you not, that the grant which Mr. Glaisher has received is a very small one?—Yes; I think it is exceedingly small.

14,089. And, consequently, it could only represent an amount of clerical work which is not very large?—Just so. If the Registrar General thinks that that work should be increased and the grant supplemented, that is a question for him to consider.

14,090. If, on the other hand, the Director of the Meteorological Office should consider that the work required by the Registrar General is so small that it could easily be done in his office, would that weigh with you at all as to the decision you would come to with reference to the office doing it or not?—I do not think it would; I think it highly inexpedient. It appears to me that the great danger is of mixing up in the minds of the Meteorological Office or Meteorological Committee these two points, which ought to be kept perfectly distinct, and it would ultimately be a true saving of money, because it would tend to the excellence of the observations, that the two branches should be considered as absolutely distinct. If we wish to know the physics of a place we must certainly make our observations solely with regard to that, and also if we wish to know the death rate of a place we must make our observations with sole reference to that point.

14,091. Are there any Government departments, so far as you are aware, in other countries, corresponding to the Meteorological Office?—Yes; in different countries of Europe and in America there are corresponding departments.

14,092. Do you know what is the constitution of any of those departments?—I have not got accurate information on this point, but, so far as I can make out, their great object is physical meteorology, and especially with reference to storms. That is one of their great objects, to ascertain the progress of the weather or of storms, as they affect the atmosphere of our earth. That appears to me to be the great object with which all those institutions were founded. Whether all of them have recognised the distinction between those two branches of meteorology I am not prepared to say. It appears to me that the late Mons. Quételet of Brussels did not. He devoted a great deal of attention to climatic and statistical meteorology.

14,093. You believe that when this board was established in England, it was not intended that it should devote itself to such observations?—No, I think not. I am not sure that those words were used, for I am not sure that the distinction between the different branches of meteorology, or rather of two sciences both requiring observations of the same instruments, was so well understood as now.

14,094. (*Professor Smith.*) Will you look at the First Report of the Meteorological Office, at page 6, where they describe their functions under three heads very concisely, and will you read them?—"The "functions of the present Committee are divided into "three great branches. I. Ocean Meteorology.—The "object of this branch is to deduce the meteorology "of all parts of the ocean from observations made by "ships. The surface of the ocean is conventionally

" portioned off by lines of latitude and longitude into " a vast number of sections, and the meteorology of " each section is discussed as though it were an " independent district. The issue of instruments to " ships is also undertaken by this branch. II. Tele- " graphic Weather Information.—This branch of the " functions of the Committee comes most prominently " before the public, but it must not therefore be " assumed that it is the most useful or important " part of their work. III. Land Meteorology of the " British Isles.—The new feature of this branch " consists in the establishment of seven land observa- " tories provided with self-recording instruments. " Its object is two-fold, first to give accurate data for " a discussion of the law of storms and weather " changes, and secondly, to ascertain meteorological " constants, thereby performing with great precision " for the land stations that which is accomplished " with moderate precision by Branch I. for the entire " ocean." It appears to me that this has no reference to such points as death rate at all, but simply reference to physical meteorology.

14,095. According to the views which you entertain, is there any part of the functions which are described in the First Report which you think ought to be abandoned by the Meteorological Office?—No, I do not think that any part of this work should be abandoned.

14,096. Does it seem to you to represent pretty fairly what you understand by physical meteorology?—I think so; I think it is a very good statement indeed.

14,097. Do you consider it fairly describes what ought to be done?—As far as physical meteorology is concerned, I think, very likely, that something more should be done. I do not know that electricity is mentioned here, but I think they intended to do it themselves. I know that they had an idea of determining fairly what the physics of our atmosphere really were.

14,098. (*Mr. Samuelson.*) There is no analogy between what is required by the Registrar General and that which was laid down by the Board itself, as being the work which they were to perform?—No, I do not think there is any analogy. Ultimately, in the progress of that science which the Registrar General represents, it might be desirable to make chemical observations in drains, and to put thermometers in different localities where there is bad air, but that is not at all information that would be of any use for physical meteorology.

14,099. (*Chairman.*) Surely the information which the Registrar General needs comes properly under the head of "Land Meteorology of the British Isles," does it not?—I think that is a question of wording. I think the information that he needs is connected with the subject, but it is the subject viewed from a perfectly different point of view.

14,100. (*Mr. Samuelson.*) The land meteorology in the words of that report is limited, is it not, to seven stations?—Yes, it is.

14,101. And on the map which represents the work of the Meteorological Department there is, at any rate, a number of stations considerably in excess of seven?—Yes. Still, if those stations are put there in order to obtain a better account of the physical meteorology of the British Isles, although it seems to be in addition to what they considered their own functions, I should not object to that. I think that what they ought to do is to obtain a perfectly complete account of the physical meteorology of the British Isles, and, as far as possible, of the ocean; and I think they should confine themselves to that.

14,102. With regard to the organization of the Office, you have stated that you would prefer the appointment of a Meteorologist Royal to an unpaid Committee?—Yes, I think so, only you are of course aware that that Committee has an officer who bears the title of Director of the Office.

14,103. Do you consider that there is any analogy between the responsibilities attaching to that office and those which you would wish to attach to the head of the Meteorological Department?—There is a very strong analogy as far as their work is concerned, but I think there is no analogy as far as the responsibility is concerned. A Meteorologist Royal would be responsible to the Government in the same way as Sir George Airy is responsible. From his internal knowledge of the subject, he would initiate and work out the subject without being under the orders of an unpaid Committee. What the Director of the Meteorological Office has to do, is simply to carry out in an intelligent manner, no doubt, but still to carry out, the orders of the Committee.

14,104. You would consider the term "Director" as rather calculated to mislead?—I think it is calculated to mislead in the present instance. The subjects which the Director has to study are subjects given him by the Meteorological Committee, and his duty of course is to study them, and to advance those subjects in the most intelligent manner. Suppose that the Director thought that the subjects should be studied in quite a different way from the way in which the Meteorological Committee study them, then, as I understand, he could not direct, he would have no voice in the question. He simply has to carry out as intelligently as possible the orders of the Meteorological Committee.

14,105. That is to say, instead of being the Director, he is a secretary or an executive officer of the Department?—Yes, an intelligent executive officer.

14,106. Was that in accordance with the intentions of the Meteorological Committee when the office was organized?—Yes, no doubt.

14,107. His functions are not anything like those, for instance, of the Director of the Geological Survey or of the Topographical Survey?—That officer, I presume, is responsible to the Government, and he does what he considers best. I think that in the annual reports published by the Meteorological Committee, the Committee take the responsibility upon themselves.

14,108. (*Professor Smith.*) If you look at the last Report, they state, "for the administration of which " they are wholly responsible, and over which they " have the entire control?"—Just so.

14,109. (*Mr. Samuelson.*) Neither when the appointment of the Director was first contemplated, nor at the present moment are his functions at all parallel to those of the Director of the Geological or the Topographical Survey?—No.

14,110. (*Chairman.*) Do you think that the sum allotted to the office is sufficient to carry out all the functions that the Committee describe at page 6 of the First Report?—I think it is just possible that they might require a small addition, but if not quite sufficient it is very nearly so. I am not prepared to say absolutely whether, if they were to carry out atmospheric electricity, and discuss the results more fully than they do at the present moment, it would be sufficient. Some addition might be made, but I do not think that the addition would be anything very large.

14,111. I see in the Report of the Committee, at page 40, after mentioning the ocean statistics, they say that the expenditure under that head, amounting to 3,200*l*., ought to terminate in about 15 years, do you agree in that opinion?—It appears to me that it does not contemplate the fact that there are very few observations in certain localities of the ocean. If we are ever to come to a thorough knowledge of meteorology, it is essential that we should obtain much more information about the oceanic regions than we do from the logs of vessels which pursue a given route in the ocean. We must make an effort to employ our navy in such a manner as to get information with regard to the less frequented oceanic regions.

14,112. You do not think that that sum will become disposable in 15 years?—I think that some of it might possibly become disposable, but that is a point upon which I am not sure that I can give any definite information.

14,113. (*Mr. Samuelson.*) You have stated that you think that there should be institutions for special

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solar observations, and that they should not be under the direction of the individual or the body directing the meteorological observations? — I think that although, no doubt, solar observations are connected with meteorology, the two things are sufficiently distinct. If there were a re-organisation of the science of the kingdom, with something like a Ministry or Sub-ministry for Science, in that case such an official would take charge of all the various Departments; and I think that a Solar Observatory is a thing in many points very distinct from the Meteorological Office, just as it is from Astronomy. On the one side it has astronomical bearings, and on the other it has meteorological bearings, at least I am disposed to think that it has.

14,114. But do you think there would be work enough there to engage a special department and under special direction?—I think so; not, perhaps, a large department, but certainly there is quite enough to engage a special department.

The witness withdrew.

Adjourned to Tuesday next at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Tuesday, 28th April 1874.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

The Most Hon. THE MARQUESS OF LANSDOWNE.	THOMAS HENRY HUXLEY, Esq., LL.D., Sec. R.S.
BERNHARD SAMUELSON, Esq., M.P.	HENRY JOHN STEPHEN SMITH, Esq., M.A., LL.D., F.R.S.
WILLIAM SHARPEY, Esq., M.D., F.R.S.	

The Rev. ROBERT MAIN, M.A., F.R.S., examined.

Rev. R. Main, M.A., F.R.S.

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14,115. (*Chairman.*) I believe you are the Radcliffe Observer, and have charge of the Radcliffe Observatory?—Yes.

14,116. Has not the system of meteorological observations been for some years in operation in that observatory?—We can give continuous observations from the year 1811, that is to say, the ordinary observations; but the photographic observations commenced with the year 1854. There has been a continuous series of photographic observations from 1854, and of ordinary observations, three per day, commencing with the year 1811.

14,117. The Commissioners would be much obliged to you to state to them the principal results of the observations at your Observatory?—We have attended, I may say in the first place, accurately to everything that relates to climatic meteorology; that is to say, we have given every element for the determination of the climate of Oxford, including daily, mean monthly, and mean yearly values of all the meteorological elements. We have also computed accurately the diurnal variations of all the meteorological elements; that is, of the results for the barometer, the thermometer, the hygrometer, the pressure of dry air, and the wind both in velocity and direction. These are all represented in as scientific a shape as they can be, by means of Bessel's Interpolation Formula, which is applied to all the results, not only to the wind, but, commencing with the barometer, to all the rest. The constants for the terms depending upon the sine of the sun's hour angle and its multiples, are given for all these and for the mean monthly results of the wind, which, as is well known, has been formerly a subject of very great trouble to ordinary meteorologists, on account of their never having undertaken the labour of computing by a strictly mechanical method. What is called Lambert's Formula was applied; but that did not help much. It was, in the first place, only an approximate formula, and, until I took up the subject on coming to Oxford I believe that the directions and velocities were never combined; that is, that the pressure of the air was always left out of the account, and consequently when we wished to get the mean direction of the wind the very light air in a certain direction counted just as much as a storm in that direction. I have by ordinary mechanics computed the monthly and yearly resultants of the wind for a series of years commencing with 1859, and this has led to some of our most curious and interesting results. I have copied some tables contained in the Radcliffe Observations which will enable the Commissioners to see what I mean. The first is as follows:—

YEARLY MEAN DIURNAL CHANGE of the VELOCITY and DIRECTION of the WIND.

The formula in each case gives the Bihorary Horizontal Velocity at any hour $\frac{x}{15}$ reckoned from noon, in terms of x and the Mean Daily Bihorary Velocity.

Year.	miles.
1859	$20{\cdot}8 + 3{\cdot}81 \sin (x + 87^\circ) + 1{\cdot}35 \sin (2x + 105^\circ)$
1860	$21{\cdot}5 + 3{\cdot}75 \sin (x + 82) + 1{\cdot}08 \sin (2x + 117)$
1861	$19{\cdot}6 + 3{\cdot}25 \sin (x + 84) + 1{\cdot}13 \sin (2x + 89)$
1862	$20{\cdot}8 + 3{\cdot}37 \sin (x + 91) + 1{\cdot}09 \sin (2x + 115)$
1863	$21{\cdot}0 + 3{\cdot}45 \sin (x + 85) + 1{\cdot}20 \sin (2x + 91)$
1864	$19{\cdot}5 + 3{\cdot}58 \sin (x + 75) + 1{\cdot}11 \sin (2x + 93)$
1865	$18{\cdot}7 + 3{\cdot}25 \sin (x + 87) + 0{\cdot}98 \sin (2x + 96)$
1866	$22{\cdot}3 + 3{\cdot}83 \sin (x + 75) + 1{\cdot}07 \sin (2x + 106)$
1867	$21{\cdot}1 + 3{\cdot}31 \sin (x + 82) + 1{\cdot}11 \sin (2x + 100)$
1868	$21{\cdot}6 + 3{\cdot}87 \sin (x + 80) + 1{\cdot}34 \sin (2x + 107)$
1869	$21{\cdot}4 + 3{\cdot}20 \sin (x + 83) + 1{\cdot}33 \sin (2x + 103)$
1870	$19{\cdot}5 + 3{\cdot}36 \sin (x + 84) + 0{\cdot}81 \sin (2x + 87)$
1871	$18{\cdot}2 + 3{\cdot}45 \sin (x + 83) + 1{\cdot}24 \sin (2x + 97)$
1872	$19{\cdot}6 + 2{\cdot}91 \sin (x + 79) + 1{\cdot}15 \sin (2x + 92)$
1873	$19{\cdot}0 + 3{\cdot}56 \sin (x + 84) + 1{\cdot}12 \sin (2x + 89)$

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This table relates to the diurnal change in the observed horizontal velocity of the wind, and a mere glance will show how very constant this variation is for each year, the constants of the first and second terms, depending on the sun's hour angle, are not exactly invariable, because they depend upon the actual velocity of the wind; but they are very nearly so, and the mean of a long series of years would give almost as correct and unchangeable a result as some of the constants determined in astronomy. I do not think that there is any one element in meteorology up to this time discovered which is so constant as this mean daily change for Oxford in the direction and velocity of the wind. If the Commission will allow me, I will hand in this second table:—

MEAN HORARY DIRECTIONS AND VELOCITIES.

The following Yearly Mean Velocities and Directions at every two hours of the day are derived from Seven Years' Observations (1859 to 1865).

h.	Mean Direction.	Mean Velocity (Biborary). miles.
0	S. 47·41 W.	15·58
2	49·46	15·35
4	47·52	13·83
6	46·00	12·08
8	41·33	12·02
10	40·27	11·74
12	41·43	11·84
14	42·29	11·58
16	41·57	11·55
18	44·10	11·64
20	44·50	13·32
22	47·43	14·78

This second table gives the results of observations for seven years, and, of course, with actual numbers for the bi-hourly intervals of the day. The change in the direction of the wind and in the velocity during the time that the sun is above the horizon, is very marked indeed. During the time he is below the horizon the direction is sensibly constant as is also the velocity. I will now hand in another table which gives results of some interest and importance:—

Year.	Yearly Resultant Direction of Wind.	Yearly Mean Hourly Horizontal Velocity.	Mean Yearly Temperature.	Yearly Fall of Rain.	
	°	miles.	°	in.	
1859	S. 53½ W.	10·4	50·1	27·717	
1860	70½	10·8	46·8	31·006	Max. of frequency of solar spots.
1861	51	9·8	49·0	23·403	
1862	51½	10·4	49·5	27·417	
1863	41	10·5	49·9	22·365	
1864	20	9·8	48·5	18·255	
1865	16	9·4	50·0	28·717	
1866	12½	11·2	50·1	30·624	Min. of frequency „ „
1867	24	10·6	48·9	27·125	
1868	38	10·8	51·4	25·972	
1869	80	10·7	50·2	26·474	
1870	93	9·7	49·3	17·564	
1871	26½	9·1	49·2	21·137	
1872	63	9·8	50·1	29·477	
1873	59	9·5	49·1	23·178	

This third table is chiefly valuable as showing the apparent effect of the sun's spots period on the yearly mean direction of the wind. The year 1860 was the maximum of solar spot frequency, and the wind then is in a very marked way in an extreme westerly direction. It then goes backwards with tolerable uniformity, excepting in 1861 and 1862 (which were by some accident very nearly equal), until the year 1866, when it became nearly south, and that was the year of minimum frequency. Since the year 1871 we have got into another cycle, and it is evidently on the whole going back toward the south, so that we shall soon, in a few years, have completed a second cycle, leaving no doubt of the actual fact.

14,117*a*. The year 1871 seems rather an exception to the general law?—Yes. I was puzzled myself with that, but I believe that there was really a very marked southerly direction of the wind in that year, or rather that it was mixed up very much with east winds. I have been looking through the monthly records of the Meteorological Journal for that year, and I am sure that the mean monthly and yearly results computed mechanically for 1871 are borne out by the data of the daily results (in which the directions of the wind are estimated by the eye), and it must for the present remain as a puzzle and as an exception to the general law. We have certainly passed the maximum now, and are fast going towards the minimum. There are very few spots now. In the column of rain in the table (it may be accidental, or it may have something to do with the cycle) the year of maximum frequency and the year of minimum frequency has each a large quantity of rain. In the two years 1860 and 1866 the rainfall is greater than in any other years, but at the time when we ought to have got to the maximum again we get a very small quantity. We have absolute drought for two years.

I can also give a table of the results for the months of April and May of some curves of daily mean temperature, which I found occasion to draw for a number of years from 1859 to 1871, and I think they threw considerable light on those singular interruptions of temperature which we get both in April and in May:—

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Year.	Month.	Lowest Mean Daily Temperature.	Day.	Range of Disturbance.	Month.	Lowest Mean Daily Temperature.	Day.	Range of Disturbance.
		°	th	d. d.		°	nd	d. d.
1859	April	37	16	7 to 25	May	43½	2	28 to 7
1860	„	36½	10 & 14	7 to 15	„	48½ & 47	3 & 5	2 to 7
1861	„	39½	9 to 27 (several)	9 to 27	„	39½ & 42	27* & 4	25 to 2 & 2 to 6
1862	„	35½	11	5 to 20	„	48½	2	1 to 5
1863	„	42	7	5 to 8	„	39½	0	26 to 3
1864	„	36	5	3 to 10 (for 14th)	„	44½	28	20 to 2
1865	„	42 & 47	1 & 14	11 to 17	„	45	30	27 to 5
1866	„	40 & 43	4 & 9	2 to 6	„	38½	1	27 to 8
1867	„	44	11	6 to 13	„	48½	1	29 to 6
1868	„	37	12	5 to 10	„	45 & 57	27 & 5	21 to 8
1869	„	40	3	2 to 7	„	46½	1	27 to 2
1870	„	41	4	2 to 7	„	41	2	30 to 5
1871	„	39	6	4 to 12	„	47 & 46	30 & 4	26 to 2 & 2 to 6

* 27 denotes April 27.

In the April of this year 1874 there has been a cold period, though not in a very marked way. Before this warm weather set in, there was cold stormy weather, not so cold as it is in some years, but still cold enough to show that we have passed through the time of ordinary depression of temperature. This disturbance occurs frequently towards the middle of the month, but the actual time of minimum temperature is not quite so well defined as the one in May. Some of the disturbances are, as you would expect, greater than those in May, but with respect to the time not quite so well marked, although we should probably not be very far wrong if we assumed that before the middle of April we might almost with certainty predict something of the kind. In May almost the very day of the minimum temperature is marked. You will observe that 5 is the greatest number that we have in the column headed "Day," and, in fact, counting from the 1st of May on either side we have only deviations of two or three days in all the table, so that we may almost infallibly predict a cold period having its minimum temperature on some day a little before or a little after the 1st of May. And that leads us immediately to speculate on the cause of this disturbance, which has been a subject of a great deal of thought to myself, and I am convinced that it arises from disturbances in the Atlantic and the North Sea, as, in very many cases, the storms in England do. The glacier and field ice probably about this time begins to break up and get detached in the Polar seas, and large masses of it no doubt are brought down, and I should think, as the operations of nature on a large scale are generally tolerably uniform, that this would occur pretty nearly at the same time every year, and would give rise to this apparent periodicity of disturbance. It is therefore evidently necessary that if we wish to study our climate accurately for the spring months we must have more information with respect to the temperature of the currents of the north or frozen sea at that season. Information is very desirable from stations in Greenland, Iceland, and Spitzbergen, whenever we can get it, and from the observations of mariners who have been employed in those seas. I think it is a matter of very great importance to our climate that the northern seas should be studied very much more than they are now. When I asked some time ago the hydrographer on this very subject, (which interested me as it was new to me at the time,) what information I could get with respect to the changing currents, and the quantity of ice brought down off the coasts of Greenland and Spitzbergen, he gave me little hope of getting any adequate information from anything which exists at present. The Norwegians are doing a great deal, and the Swedes also, and it is quite right that the British Government should take part in any systematic labour which might be agreed upon for getting a better knowledge, both of the temperature of the currents and of the changes in them, and also on the fall of glacier ice. With respect to our own observations I think that that is almost all that I need say. I have sent a copy of one of our little books for the information of the Commission, to show the form in which everything is done, and that form, as I have stated, I have never had occasion to alter since I came to Oxford. I took some pains in compiling it so as to retain simply what was useful, and I have scarcely had occasion since to make any alteration in it.

14,118. Are you in the habit of corresponding in any way with the Meteorological Committee?—Oxford is made one of the stations, and we send every morning a telegram of the weather, which is included in the daily bulletin, but otherwise the actual correspondence, as it merely relates to this daily work, is carried on between Mr. Scott and my first assistant, Mr. Lucas. I occasionally receive a letter from Mr. Scott on some subject or other.

14,119. Then your observations at the Observatory are totally independent of any proceedings of the Committee?—Yes, and for some time we were not included in the list of stations, but within the last two or three years it was thought desirable to have, in addition to coast stations, some inland stations, and Oxford, as having photographic instruments, was selected for one, and Cambridge was selected for another, as likely to carry on a regular series of observations. Cambridge, I believe, has not photographic instruments, but still, as it is a fixed Observatory with a responsible chief, it was thought better, I presume, to include Cambridge.

14,120. Do you consider, as a general principle, that meteorological observations can be with advantage carried on at astronomical observatories?—Better than anywhere else, because there is a well organised staff, who are generally under the command of a highly scientific man, who can take advantage of the progress of science and modify his methods as he thinks fit, and can insure things being done in the best possible

way and with regularity. The work of private observers, of course, is very good, but there is no control over them. A series may be intermitted at any time without any one being blamed.

14,121. A great deal of work of that kind can be carried on without interfering in any objectionable manner with the Astronomical Observatories?—It can in general; but I cannot say that with respect to the reductions. I have always found my work a very heavy load; the computations are exceedingly heavy which I have been explaining just now; for instance, our yearly record for the wind would employ one man a fortnight to reduce. There are 144 mechanical equations, there being 12 bi-hourly results for each of the 12 months in the year, and each of these 144 computations involves a good deal of labour.

14,122. Is your staff larger than it otherwise would have been in consequence of your undertaking this class of observations?—No. I am of opinion that our staff till recently was too low for the work that is done, and, if I did not take a very great share of personal labour myself, it could not be done; and it has been a subject of regret to astronomers and others that I should be obliged to take so much work upon myself. In 1872 relief was afforded by the Trustees, with their usual liberality, by the addition of another computer to the staff, and this has been of very great service to the establishment. I would not recommend any new establishment to undertake the same amount of work with the same staff. I can do it, because I had a good training at Greenwich, and of course had become skilful in finding out every possible means of shortening the labour of computation and of organising the work. Our people have got into the way of working hard, but still there is no doubt that it is hard work. The astronomical computations and the meteorological together form a burden which few other observatories would willingly undertake. It was proposed, when I came to the Observatory, by the Trustees, that the meteorological observations should be given up, but I found almost as soon as I got to Oxford that the objections were so great to their being given up that I could scarcely resist them, and I therefore determined to attempt to continue them.

14,123. Do you know how far meteorological observations are carried on at other observatories, either in this country or on the continent?—They are carried on with regularity at Greenwich, but they have not been reduced till recently. The Astronomer Royal has lately taken them up, and the back observations are being reduced from 1848 to 1868. He is bringing his powerful mind to bear upon the subject, and I have no doubt that we shall get some very interesting results from them; but at the present time the reductions are not published. The observations taken at Greenwich, when they are reduced, will be very valuable; they are taken with photographic instruments, as ours are, only of a different construction.

14,124. Is anything of the kind done at any of the principal observatories on the continent?—Perhaps the most remarkable is that conducted by Professor Wild in St. Petersburg. The physical observatory, of which he is the director, is perhaps the best model possible of a great central observatory for a country such as Russia, which has outlying stations at such immense distances. At every station where there is an observatory the meteorological results are required to be reduced and to be sent in to the central observatory to Mr. Wild, and they are published annually, and there is a great mass of matter given, but I must say that at the present time it is in rather a repulsive shape. The observations are thoroughly undiscussed, and it will involve an immense amount of labour some day to do it.

14,125. Do those observations of yours involve any costly apparatus?—No, I do not think so. The work of one assistant is quite as much as in my small staff I can consider as appropriated to that work, and 20*l.* a year is spent for chemicals. If then I were to estimate the total expense of the meteorological department at 140*l.* a year, I think I should rather overstate than understate it. The expense is not more to the Radcliffe Trustees than that sum, including chemicals. It is not costly at all when the apparatus is once set up. The apparatus which we have at Oxford is that which was planned by Sir Francis Ronalds. There were two arrangements of photographic instruments originally invented, one by Sir Francis Ronalds, in which a piece of paper, developed in a plane surface, is moved on by clockwork in a direction at right angles to the ray of light, and another, invented by Charles Brooke, Esq., in which the paper is laid round circular glass cylinders. The latter, invented by Mr. Brooke, is the one used at Greenwich, but I consider that ours is the simplest, and involves the least labour, the paper requiring to be changed only every 48 hours, and I should think that the whole interruption to the whole morning's work is certainly not two hours. It does not interfere with our astronomy more than that. The sending of telegrams is a little addition to our labour, because, when astronomical observations are taken at night, imposing upon the observer the duty sometimes of staying up tolerably late, it is rather a hard thing that he should be obliged to turn out between 7 or 8 in the morning to prepare these telegrams. But Mr. Lucas, with his usual willingness, has undertaken it, and it goes on very well. I left it to his free choice, and if he had objected, I should have declined; but he did not object, and the thing goes on very well, though I could scarcely impose it on another assistant, with all the other duties which he has to discharge. Occasionally requests are made for additions to the observations arranged for originally, and it is necessary sometimes to refuse compliance.

14,126. Are you speaking now of the Meteorological Committee?—Mr. Scott, with the best intentions of course, wishes sometimes, for the sake of uniformity, to introduce some things which are apparently very proper and very right, but when one has been worked to the last ounce, it becomes a very serious matter to undertake anything else, and I have been obliged to tell him once or twice that we have been doing all that is possible as it is, in sending up the telegrams to the office.

14,127. (*Professor Smith.*) Do the Meteorological Committee pay in any manner the assistant at the Radcliffe Observatory?—They pay a trifling sum of 5*s.* a week, but a part of that is expended, because a boy has to be found to carry the telegrams, so that it is not a very large pay.

14,128. Is that the way in which the other meteorological stations are paid?—I do not know. Mr. Scott explained to me at first that that was all that they could afford to pay.

14,129. (*Chairman.*) Have you paid attention to the work which is carried on under the direction of the Meteorological Committee?—Yes, I have studied their synoptic charts very attentively every day, and I consider them very useful indeed. I can trace very rapidly indeed the connexion between the different elements that form the weather in those charts, and sometimes almost predict as they can themselves for the next day, but I suppose that other people see as well as I do that we want something on a very much more extensive scale. We want, in fact, international meteorology. We have in these synoptic charts, the coast of Norway, all the way up the coasts of England and Scotland, and the coast of Ireland, and several stations on the coast of France, including Toulon on the Mediterranean; also Corunna on the coast of Spain. There are also some foreign inland stations, as Paris, Charleville, Lyons, and Brussels; but the area is frequently too limited to give us the whole of a storm or to give us its history. I have sometimes found, especially in the case of a large anti-cyclone, that the space is not large enough to give the whole of the phenomena. For instance, we have been having, in the last month or two, some very remarkable specimens of anti-cyclones. I should explain that these are just the reverse of cyclones. A cyclone is a revolving

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mass of air in which the air turns from right to left in the northern hemisphere, and an anti-cyclone is on the contrary one which turns from left to right. And they differ, of course, in their physical properties; in one the centre is a centre of depression, and in the other it is a centre of greatest pressure. The theory of anti-cyclones, I consider, with respect to international meteorology, to be one of the most important possible, because it is well known that outside the area of the anti-cyclone there is a series of small cyclones, that is to say, a series of disturbances, and many of the storms originate in that way outside the area of greatest pressure. The four charts which are given are:—1. A chart of the isobars or lines of equal pressure; 2. A chart of the corresponding winds, which can almost be drawn by any person, without observation of the winds, with considerable accuracy, for the law of pressure regulates the direction of the winds; 3. A chart of the temperature; and 4. A chart of the general character of the weather with respect to cloud rain, &c. And, excepting that it would be desirable to extend them by international relations, and to have something on a much larger scale, which of course would involve very considerable difficulties in arrangement with other Governments, I do not know anything to object to these synoptic charts. They are done very well indeed, and they are exceedingly useful. I have no doubt that they answer pretty nearly every purpose on ordinary occasions for the British Isles, even for forecasts of the weather. One instance I remember in which I found that the French bulletin assisted me in the history of a storm, although it does not take in many more stations than ours does. Ours goes up to Haparanda at the top of the Gulf of Bothnia, and the French does likewise, but the French have some inland stations that we have not. They have Berlin and Madrid: and in one or two cases I have found it very important indeed that we should know what is going on in the interior of the great European continent. There is also another tract of country in which the Russians will ultimately assist us very much in meteorology as affecting our own climate, and that is Central Asia. During the winter the pressure is piled up over Central Asia; it is intensely cold, and there is invariably high pressure, whereas on the contrary the pressure upon the sea is very much smaller. But towards spring an equilibrium takes place; the pressure over the land diminishes, as you might naturally expect, when the earth becomes warm, and increases, as the summer goes on, over the Atlantic. The study of the whole of this phenomenon in a systematic way would be, I have no doubt, with respect to our climate, very useful indeed. We should be able to know when the equilibrium is restored, and what the excess of pressure is over the sea in summer, and what the excess of pressure is over the land in winter. But as the Russians have the Caucasus and the whole of Siberia, and are getting down towards Afghanistan, I have no doubt that they will do what they have done in their other territories, namely, institute meteorological observatories, and that we shall get a very great amount of information ultimately about these territories.

14,130. Is there, to a certain extent, co-operation at present between the different Governments with respect to Meteorology?—I do not think there is with respect to Governments. All that has been done is to have yearly conferences, which is a recent thing. The two conferences, whose results are published, are those of Leipzig and Vienna. I suppose it is intended that these shall be continued frequently in the capital of one country or another, and it is with the concurrence of the Governments, but I do not think that the individual Governments take any responsibility in the matter. I remember that General Myer, who attended on behalf of the United States at the Vienna Conference, said expressly that he could not pledge his Government to any thing.* He however considered it desirable that means should be taken to have simultaneous observations made at least once a day at stations distributed over the whole northern hemisphere, and a resolution to that effect was unanimously adopted.

14,131. Do you think that something more is required?—Yes; I think that there should be an international co-operation, and that that should be done with some authority.

14,132. Are you prepared to make any recommendation as to how that object could be carried into effect?—I think, for instance, that the British Government, before the next conference, might request to be furnished with certain recommendations, and, if they would enter into a correspondence with other Governments before that time, I venture to say that an international committee or delegacy might very easily be formed which would facilitate matters. I have no doubt that there would be some difficulty at first, but I do not see anything insuperable in the way.

14,133. It would be difficult, would it not, for an international committee to meet frequently?—Yes.

14,134. How often do you think it would be necessary that they should meet?—I should remark, when I say an international committee, I mean persons authorised by their respective Governments to decide upon a system of co-operation;—for instance, a general interchange of these synoptic charts throughout Europe.

14,135. That is not the case at present, I believe? No, it is not. The French publish their own separately. (*Bulletin International.*) And the Dutch, who are doing a great deal under M. Buys Ballot, have published their year book (*Jaarboek*, or *Annuaire*), but the results are not given daily. They have a system of telegraphy within Holland, but I do not think it exists beyond. Perhaps the very best specimen of this kind of work which exists at present, or at all events the best that I have seen, is "The daily bulletin of Weather Reports, "Signal Service, United States Army," taken three times in the day, for September 1872. It is probable that the volumes for the other months have appeared, but I have not seen them. I have had one or two of their reports, but this is the only one in which all the synoptic curves are given three times a day from the Pacific to the Atlantic, and as far north as they can go. It is an admirable volume for studying this kind of results, and I have no doubt that it would help us very much.

14,136. Is that kind of work undertaken by the State?—Yes; it is undertaken by the State, and it is done by the army. They spare no money where it is necessary. I think that our own military service might be made more effective than it is for our climatic meteorology if it were needed. Climatic meteorology has been, through other agencies, sufficiently attended to, as far as I know, in England, but still, for the training of officers and men, I think the first thing, where there is a permanent military station, should be the establishment of meteorological observations. It is so at the Camp at Aldershot;—observations are regularly published from the camp at Aldershot.

14,137. Is that under the direction of the Meteorological Committee?—I think not. I think it is quite separate.

14,138. Is there a separate vote for it in the Estimates?—I do not remember. I have only seen the observations which are included in the Registrar General's Quarterly Report. I suppose it began there with a view to a knowledge of the sanitary state of the camp, as part of the duties of the medical staff there.

14,139. With respect to what has been done under the direction of the Meteorological Committee, do you think that the work has been of much value?—Undoubtedly their forecasts of the weather are valuable and indispensable; and, as I said before, the synoptic curves are not only valuable now, but will be extremely valuable in the theory of Meteorology. And, as far as I know, it is the most important thing that could be. The quarterly reports of the weather which are published will also be very useful for the theory.

* See Vienna Conference, page 34.

All the observations for the quarter are discussed with great care, and curves are drawn of the different elements, and they have been urging on the publication of them with very great vigour. They have two sets going on now, one set to keep up the current ones, and another to get up those which were omitted before. I think they are nearly complete now from the time when they began them, and I consider the whole series to be exceedingly valuable.

14,140. Have you any suggestions to make with respect to the working of that system?—Nothing more than an attempt at an international extension. I do not know anything better with respect to their ordinary working than what is done at present, the publication of those daily bulletins and the quarterly reports.

14,141. You see no objection to the present system so far as regards its being under the management of an unpaid committee; or would you think it more desirable that it should be a regular Government department?—I am scarcely prepared to answer that question. I think it desirable certainly that, if an *unpaid* committee is employed, the members of it should be generally persons who have an intimate knowledge of the requirements of meteorology, and of course they should be all men of very great scientific attainments; but I think that special knowledge is very valuable there.

14,142. May the Commission understand you, on the whole, to be of opinion that the expenditure of 10,000*l.* a year has been productive, to a considerable extent, of good results?—Yes; undoubtedly it was a step in the right direction, and a very important one.

14,143. Do you think that that sum is sufficient for doing all that is desirable?—It is so much larger than the sums we scientific men have to deal with that one hardly knows. Their daily expenditure, I have no doubt, is very great, and without seeing the actual accounts of the way in which the money is expended I could not say. There is a considerable expenditure, no doubt, in lithographing the daily reports; but they ought partly to pay their own expenses, as they are sold.

14,144. In the earlier part of your evidence you stated, I think, that you thought it very desirable that regular observations, during a portion of the year, should be carried on in some northern countries, such as Greenland and Spitzbergen?—Yes, I think so, if there could be stations permanent or otherwise on Spitzbergen and Greenland. The Norwegians will take care of their own country. They are doing a great deal. I do not know that any country is doing so much for northern meteorology as the Norwegians. Professor Mohn has published an Atlas of Storms, which is an exceedingly instructive work, so that the coast of Norway may be fairly left to them. But I think undoubtedly Iceland and Spitzbergen and the coast of Greenland require very particular attention.

14,145. Are the Norwegian observations under the control of their Government?—I think they are made under the auspices of the Norwegian Meteorological Institute, and the Atlas is published with the co-operation of the Scientific Society of Christiania. I was in Christiania last year, and I called and saw their central office there. I did not see Professor Mohn himself, but he is one of the most active meteorologists of the day, and I think the Swedes also are doing very well.

14,146. Such further observations as you think desirable could only be carried on under authority from the Government?—Yes, this would be necessary, because there must be a station, which would of course be a very desolate station, and could scarcely be continued through the winter. It would, no doubt, be very expensive, and might be very troublesome; but I do not see that we can get very much more information without some stations in the Northern Seas.

14,147. If anything of the kind were undertaken, would you place it under the Meteorological Committee?—Yes. I think that the British Government might do something by co-operating with and assisting the efforts of the Swedes. The Swedes are willing to do anything, but they are poor as compared with ourselves, and by a little arrangement with Sweden I have no doubt that a good deal might be done.

14,148. Greenland is a Danish possession?—Yes. Of course both Sweden and Denmark might be called into the Council.

14,149. Are the Danes willing to assist in matters of this kind?—Yes, I think so. The Danes are scientific.

14,150. Are there any observatories of this kind in Iceland?—I dare say there are. I do not remember to have seen any observations, but Iceland is a well inhabited island, and there would be no difficulty in getting observations made. That country is cultivated and civilized, and no doubt there would be no difficulty whatever in getting anything done that we wanted.

14,151. Are those observations in the extreme north those that you consider the most important additions?—I think so, for our own climate a good deal depends upon the Northern Seas, and the disturbances in the Atlantic. Of course one would wish observations from as near the North Pole as possible down to the Mediterranean, because one class of storms that we have come up from Africa and from regions south of the Mediterranean, and we cannot get a very accurate idea of them without stations on the African coast, for instance, at Tripoli, Tunis, and other such places. Algiers sends meteorological telegrams to Paris.

14,152. Are there other matters connected with Meteorology which you would think it desirable that the Government should embrace in their operations?—It is proved that the variations on the sun's surface have a good deal to do with Meteorology, but in a practical sense I do not know whether one would urge the Government to undertake solar physical observations in direct connexion with Meteorology, especially as the establishment at Greenwich does now take the sun under its charge, and has the Kew photo-heliograph, and would be prepared, no doubt, to carry out everything that is necessary there. I do not think anything additional is necessary beyond what Greenwich will do.

14,153. Is there any class of meteorological observations which you think might be very well left to individuals?—The climatic certainly; nothing more needs doing on that head. I have no doubt that from almost every town in England of any size, we could get a good account of every element of the climate. For instance, there are 47 stations that report to the Registrar General quite gratuitously in England and Wales. The results are included in the Registrar General's Reports, and this is all done at a very trifling expense. And that I presume to be the reason that only the coast stations were chosen at first for correspondence with other coast stations in foreign countries. At first it was not intended to take inland stations at all, and these are very few now.

14,154. Do you know what has been done by the Scottish Meteorological Society?—This society was established about the year 1855, and observations made twice a day are communicated to it monthly from 93 stations. For 55 of these stations the reductions are performed at the Royal Observatory of Edinburgh by Professor Piazzi Smyth. For the remaining 38 stations the reductions are made by A. Buchan, Esq., Secretary of the Society, and the results are published in their Quarterly Journal. I do not think that they publish any bulletin; they would not be able to afford it. But I consider that a great deal has been done under Mr. Buchan. The meteorology of Scotland, through the means of the Scottish Meteorological Society, is now known very well indeed, I think.

14,155. There is also an English Meteorological Society, is there not?—Yes. I do not know that that is capable of doing much in the way of co-operation. Papers of some importance are read occasionally, and it is a medium for the publication of observations. For instance, I remember a few years ago, when I was

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in Constantinople, I called, at Scutari, on the observer there, a military man (Sergeant W. H. Lynne, R.E.), who was employed (I presume by the British Government) in making a regular series of meteorological observations, but he complained that he had no means of publishing them. As soon as I came back I put myself in communication with the Meteorological Society, and managed to get those reports from him, and they were published by them; that is one instance of good arising from that society.

14,156. Do you know whether the Meteorological Society is in communication with private observers generally in England?—Not more than the Astronomical Society. It would probably in a smaller degree perform the same office as the Astronomical Society has done; it gives an incentive to private industry in these matters, though this is not so much wanted in England, as we have a sufficiently large number of stations. Almost every gentleman, who wants something to do and has a good house and grounds, likes to do a little in the way of Meteorology, so that we get plenty of stations without much urging.

14,157. What means are there at present for private observers to make known to the public the result of their observations?—The Meteorological Society comes in admirably there, and I think that that is one of the principal uses of societies in affording the means for publication. Several valuable papers are published in the proceedings of the Meteorological Society.

14,158. (*Professor Smith.*) I think you said with respect to the meteorological observations at Greenwich that the reduction of them has commenced?—Yes, it was commenced about the year 1871, and is going on. Nothing has been published as yet, but when the Visitors met last time the Astronomer Royal reported that a good deal had been done, and that it was going on very vigorously.

14,159. Is the method of reduction the same as that which you have employed in the Radcliffe Observatory?—He takes the means according to an original plan. In his last annual report to the Board of Visitors he stated that, "the diurnal changes of the "dry-bulb thermometer, as depending on the month, "on the temperature waves, and on the barometric "waves, have been computed for the whole period "from 1858 to 1868." We may therefore look with some interest to the publication of these results.

14,160. I think you have expressed an opinion that at every astronomical observatory of importance, photographic meteorological observations should be carried on?—I think so. I think that at every fixed observatory it should be done.

14,161. Are such observations carried on at any of the colonial observatories?—At Toronto they are, I think.

14,162. Not at the Cape, for instance?—No, I think not at the Cape.

14,163. Would it be important that those observations should all be reduced on the same plan, if the system should become general?—Yes, I think so, in the same way that ours are. For instance, those results of ours, which I have been pointing out, lose a great part of their value, from their being the results of an isolated point on the earth's surface. When we consider what Meteorology is, that it deals with the great movements in the atmosphere, it is evident that observations at a particular point cannot tell us much under any circumstances; they may give us certain singular results, but if we could trace the law of those results, over a large area of the earth's surface, a great deal more would come from it. The only place where an attempt has been made, is at Liverpool, by a private individual (W. H. Rundell, Esq.), who corresponded some time ago with me. He has discussed some of the Liverpool results very well indeed.

14,164. Would it be important that in a country of the size of England, the stations where photographic meteorological observations were taken should be multiplied?—There is no need of many of them, but the number of observatories that could possibly do anything of that kind it is very small. Cambridge, for instance, might do it with a little addition to its staff, and Dublin might do it, and it might be done at Edinburgh, and those would be pretty nearly all which, I think, would be desirable.

14,165. You would say about five or six in the United Kingdom?—Yes, about five or six. In fact, I have mentioned nearly all the important observatories.

14,166. (*Chairman.*) Can this be done at private observatories?—I do not think that private observatories do it. The papers must be changed, and though they are only changed once every day, or every alternate day, it must be done regularly and systematically, which would confine an amateur too much.

14,167. (*Professor Smith.*) Is the original cost of photographic instruments considerable?—They were in the Radcliffe Observatory before my time, but I should think not. There is nothing very elaborate about them.

14,168. Are they likely to be changed, can there be much improvement in them?—If I were offered new ones freely, I have no doubt that some changes in the instruments might advantageously be made. I should like rather a larger scale, for instance. We have the result of 48 hours in a space of about 14 inches, and I consider that scale rather too small for delicate results, but our barographic results are, notwithstanding, almost comparable in the main with those taken with the utmost accuracy with a standard barometer, and I do not see that we should gain very much by more minute accuracy. The smallness of the scale tries the eyes of those who read off the photographs, because it is so minute. A transparent scale is applied to the paper, and a person who is not very cautious might, by erring by the thickness of an ordinary line, make a very serious difference in the result. It is only a person very much accustomed to such work that could read them out accurately at all. The thermometer results can be read out with rather more ease and precision.

14,169. It is, is it not, upon the photographic observations that you would mainly rely for the future progress of scientific meteorology?—At certain fixed stations; but, for the theory, I think, as I said before, we should rely more upon daily international communications. We want to see graphically represented before the eye what the atmosphere has been doing at a given instant throughout a large area, and all its large movements. We should probably then trace them to their origin sometimes, which we cannot do now.

14,170. Do you conceive that it would be an expenditure of money which would be really conducive to the interest of science, if that expenditure were incurred in connexion with international meteorology?—Undoubtedly; I think if there were any direct action of the Government, that is the direction which it should take; we want daily representations in fact of the movements of the atmosphere over very large areas.

14,171. (*Professor Huxley.*) If you obtained all the facts bearing upon the climate of England from one large circle, would you like to have observations from the Northern Seas and Siberia?—Yes; I think that our climate is especially affected in the spring months by the Northern Seas, but there are other times in the year when it is just as much affected by the southern gales which come up from Africa, and therefore we cannot have too large an area. I should think that the minimum would be from, we will say, as the northern point, the North Cape to the south of the Mediterranean.

14,172. Speaking roughly, would you say a circle with radius of about 2,000 miles?—Yes; probably about that.

14,173. (*Mr. Samuelson.*) I presume that you are not acquainted with the correspondence which has taken place between the Treasury and the Registrar-General and the Meteorological Office with reference to the observations made by Mr. Glaisher or under his

direction, and the payment made in respect thereof by the Government?—No; I have not seen that correspondence.

14,174. That correspondence has been referred to this Commission, will you have the kindness to look at it (*handing the same to the witness*)?—As I understand the matter, this actually takes out of Mr. Glaisher's hands the grant by which he received 150*l.*, and the grant terminates on the 31st March 1874.

14,175. I believe that the grant has been prolonged?—I was not aware of this correspondence. I must say, personally, that I should be very sorry that it should be taken out of Mr. Glaisher's hands. He states very truly that he has organized the staff of observers, and that many of them send their results partly out of friendship to him and at his personal request, and for various reasons which would not apply if they were to send them to the Meteorological Office generally, and it is very likely that for a time the whole thing would fall through. It is impossible at this moment to say what would be the effect of taking it out of his hands. We should lose, I have no doubt, a good many of the contributors.

14,176. I would call your attention to the letter of Mr. Robert Scott, dated January the 7th, 1873, addressed to the Registrar-General, in which he states that there would be no difficulty on the part of the Meteorological Office in conducting those observations and supplying them free of charge; and he states further, that the Committee "could not undertake to "pay any sum of money out of the grant with the "management of which they are entrusted for work to "be carried on by gentlemen not under the entire con-"trol of and in direct communication with the Com-"mittee," which means, of course, that they would not be prepared to pay any sum of money to Mr. Glaisher?—Yes, that is quite clear. I should think that at the present time it would be very unwise indeed to raise the question, as all is going on so exceedingly well in Mr. Glaisher's hands. As I said, he receives reports from 47 stations and communicates them to the Registrar-General, and the whole business, I believe, is done in an orderly and proper way, he himself being personally responsible for the goodness of the instruments used, the goodness of the observations, and everything else. He takes it upon his own responsibility, and does the whole of the necessary work, and the total expense to the Government is 150*l.* a year. I cannot see that we can, under any other arrangement, get so good results for the money, and the question is, whether we should get them at all to that extent if they were required to be sent to the Meteorological Office.

14,177. There is no doubt in your mind as to the goodness of the results ascertained on the present plan?—They are the best that can be possibly made. I have been visiting different parts of the country, and I have seen some of the stations, and I have seen the attention and zeal of the observers employed. I remember that at Silloth, near Carlisle, where I was staying for a week or two, I made acquaintance with the observer there, the Rev. Francis Redford, and I was surprised at the care and scrupulous exactness with which everything was done. I visited the instruments with him, and saw the zeal which he displayed in the work. I have very little doubt that that is the case with almost all the other observers, and that it arises mainly from the way in which the thing has been done under Mr. Glaisher, and the sort of friendly relation in which they stand towards him. You can get paid assistance of that kind from a great number of stations, but when it is done of free will, it must be done in a very delicate way, and it has been done I think, on the whole, as well as it could possibly be done; that is to say, there are a great number of stations, and the results are of excellent quality. The first thing that Mr. Glaisher did when he undertook this, was to go himself personally to visit all the stations. He began by getting the instrument makers to make alterations in certain instruments, and to send them to him to be tested. No instrument whatever is supplied to a station unless it has his own personal signature accompanying it, and such instruments have all been tested by himself, the thermometers for the temperature, and the barometers for their standard point. That was one great point. I do not think that there is any man in England who has such control over the instrument-makers as he has, and the extreme accuracy of the instruments of the present day compared with the former ones is, I think, mainly due to him. I know that he went personally to inspect the stations themselves, and to give advice to the observers wherever it was required. At one time he used to be travelling up and down on the railways in various directions very much indeed when all this was being settled. He has done all this; it is his own organization, and it would not have existed at all if it had not been for him; and I think that, unless there is very great reason indeed, it is a great pity to attempt to take it out of his hands, or to make any other arrangement. It may go on side by side with the work of the Meteorological Office. It is so much good work being done, which needs not necessarily (at least, at present) to come under the charge of the Meteorological Office.

14,178. I want to call your attention to the last paragraph in Mr. Scott's letter: "I am instructed to "point out to you that they could not undertake to pay "any sum of money out of the grant, with the ma-"nagement of which they are intrusted, for work to "be carried on by any gentleman not under the "entire control of, and in direct communication with "the Committee"?—That is to say that they could not pay Mr. Glaisher; that is quite clear, that would follow as a matter of course, because they would take all the responsibility of collecting the results, and because they must take the responsibility of seeing that everything is right, in fact be responsible for the whole, as Mr. Glaisher is at the present moment.

14,179. Unless they were to employ the agency of Mr. Glaisher?—Yes, but they say that they cannot pay him.

14,180. They cannot pay him, unless he would consent to be entirely under their control?—I am quite sure that Mr. Glaisher will not do that; but that of course is a private question. At the same time I am sorry that the question should have been raised at all by the Meteorological Office at the present time. The Registrar-General's returns have been going on exceedingly well, side by side with the results published by the Meteorological Office. The two did not clash at all, nor interfere.

14,181. The observers, although private observers, are now responsible to Mr. Glaisher?—They are all now responsible to Mr. Glaisher.

14,182. And of course, he takes care, being a scientific man, that that responsibility is not merely nominal?—Precisely so. You have the best possible guarantee from his character, and also from the length of time that the system has existed. He has worked it up into this system, and the breaking down suddenly of such a system would produce a positive mischief. If it had been feared that he was unable to superintend it, and that it might come into other hands, that would be a different question altogether; but I should have thought that, as long as he would continue it, all parties would be only too glad that he is willing to do it. The small remuneration which he receives, should hardly be mentioned.

14,183. Assuming as an extreme case that all private observers who are now supplying observations to Mr. Glaisher should be willing to supply them gratuitously to the Meteorological Office, some superintendence or inspection, on the part of the Office, would still be necessary?—Certainly. Professor Piazzi Smyth does what is necessary in Scotland.

14,184. And that would involve the expenditure of some money?—It would involve a journey sometimes, and other expenses in addition to computers. I cannot understand how Mr. Glaisher has managed to do it himself with so little. He is also obliged to employ one or two computers, and originally he had

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but 100*l.* a year. I am confident that he gains nothing but reputation. He could not then have gained a farthing from it, and I do not suppose that he does now, but it is simply that he has founded it, and that his reputation is involved in it.

14,185. So that the mere discussion of the returns for which Mr. Scott says the Committee has a competent staff would not be all that would be required?—I think not.

14,186. And the superintendence would necessarily involve some expense?—Certainly, in some shape or other, it must involve that, as all superintendence does. It must be paid for.

14,187. The superintendence of 47 stations at 150*l.* a year would probably not be considered by you to be a very heavy charge?—No. I have no hesitation in saying that the Government at the present time, under the Registrar-General, gets its information for nothing, at least it gets Mr. Glaisher's services for nothing; and that the sum which Mr. Glaisher receives is very nearly, if not all, expended upon the necessary expenses which he incurs.

14,188. Which expenses would have to be incurred by some one?—Yes, certainly, and most likely a great deal more. I am surprised at the smallness of the sum.

14,189. So that the transfer of those observations from Mr. Glaisher to the Meteorological Office would probably involve an increase of expense instead of a diminution?—An increase of expense, and no possible gain to science. I do not see that in any case there would be any gain. Supposing, which is an extreme possible case, that we should get it done as well as it is now, what advantage is there in making the change unless for symmetry?

14,190. (*Professor Huxley.*) There would be a small advantage in transferring it to a permanent office, that it would not be then entirely dependant upon Mr. Glaisher, seeing that he is not a young man?—Just so. It will probably be necessary to make some arrangement at some time or other.

14,191. Whatever is done now, in your opinion it would be necessary for the Government to consider the question by and bye; so that it is merely deferring the question?—Quite so. It will have to be considered; but I presume that Mr. Glaisher is willing to continue it, and that the difficulty arises from some technical matter of account with the Treasury. It appears very unwise to have raised the question at all just now; and I fancy it has arisen from the fact of its coming to them, under the head of Meteorology simply, and they do not see why there are two distinct departments paid; but I think that it might be explained to the Government that the objects of the two are very different indeed. The one is connected with climatic meteorology and had its origin in connexion with the sanitary condition of the kingdom, and the other is more connected with physical meteorology.

14,192. (*Chairman.*) Your view is, that if the Meteorological Committee had to take this up, and had to do it out of the 10,000*l.* a year, they would have to reduce some other portion of their work?—Yes, if the whole of that sum of money is expended now. I do not think that there would be any ultimate saving to the Government in any case. They would come upon them for some further grant if the money were expended.

14,193. (*Professor Huxley.*) Do you think that there is any reason why the Meteorological Committee should not take up that kind of meteorological observation?—No; ultimately I do not see any reason. I think it is very proper that a little more centralization should be used; but what I observe is, that it is unwise now to raise the question, when it is going on so well; when here is a gentleman of the highest capabilities for this employment, who has made it the business of his life, whose scientific career has been wholly devoted to it, and we are getting the results of all his experience and knowledge, and of his tact in inducing observers to take the work, and to do it well, without any expense.

14,194. Your objection is to removing it from Mr Glaisher's hands now. You do not give us that opinion with reference to future arrangements?—No, certainly not. Some arrangement must be made after he is obliged to give it up.

14,195. (*Dr. Sharpey.*) Do you presume that 47 stations would be required in future to make those returns?—Yes; and that is a point which requires consideration, in fact the sanitary condition of the kingdom makes it desirable that every locality should have its observers. There are not too many stations; you cannot have too many. It every town of the British Isles, I think, there ought to be meteorological observations, especially, for instance, observations of the ozone, on which the public health depends more than on anything else. The quantity of ozone in two streets of a town sometimes very materially differs, and will give an indication of the probable health of the inhabitants. I merely mention that as a single instance of the importance of having every element.

14,196. (*Mr. Samuelson.*) If those observations had to be taken for the first time to-day, do you think that they should be properly entrusted to the Meteorological Office?—I think they might be, only the Meteorological Office must consider that they are for a purpose distinct from their present work. That sanitary point of view must be kept before them.

14,197. And to subordinate Mr. Glaisher to the Meteorological Office is an arrangement which you do not think would work?—I do not think it would work at all.

14,198. I will draw your attention to Appendix I. of the report of the Meteorological Committee of the Royal Society for 1872, in which you will see that a payment there is included of a sum of 2,632*l.* 1*s.* 8*d.* for expenses at observatories. I believe that Oxford is one of their stations under your direction?—Yes.

14,199. Would you be so good as to state to the Commissioners what sum out of the 2,632*l.* 1*s.* 8*d.* is paid to Oxford?—13*l.* for the year, that is 5*s.* a week, and the instruments are our own, and kept up at our own expense.

14,200. In the report for 1870 there is a charge of 978*l.* 17*s.* 3*d.* for new instruments. Have you received any portion of that?—Nothing.

14,201. There is a distinction, I believe, as regards the sums disbursed by the Meteorological Office between certain original stations and stations which have since been added?—The photographic records or copies of them are sent to the office from the original stations, and the results are given graphically and published in the Quarterly Weather Reports. The new stations, including the Radcliffe Observatory, send only one telegram daily containing the elements of the weather at 8 a.m. Ours is an observatory with self-recording instruments, but not supplied by the Meteorological Office, and it could easily send copies of the photographic records. But new instruments are charged distinctly to these observatories, and it does not come into the charge of 2,632*l.*? At Glasgow the instruments that they are using belong to the Meteorological Office, I presume.

14,202. Assume the instruments to exist, at what expense do you think one of the seven stations, having self-recording instruments, could be conducted, supposing them to be supplied with instruments?—I should think, speaking in round numbers, for 150*l.* a year, that is including the repairs of instruments, chemicals, and various other things that might be required, but that is the outside. 150*l.* a year, I think, is ample and leaving a margin.

14,203. That would be 1,050*l.* for the seven principal stations, leaving a margin of 1,563*l.* for those stations not originated by the Government, out of which you receive 13*l.*?—Yes, out of which we receive 13*l.* Indeed, I should say that we do not receive that, because it is necessary to pay the boy to carry the messages. In fact, what we receive is merely nominal. Mr. Lucas may get a trifling benefit from it, but I leave it to him.

14,204. (*Professor Huxley.*) Do you think that you

could get competent and distinguished men for all these stations to take charge of them, and give themselves up entirely to them for 100*l.* a year?—Under a director one of the ordinary assistants could easily be rendered quite competent for the duties required.

14,205. But the stations that we are now referring to are not under a director?—The principal stations ought to be under a competent person. One, I know, is under my friend Professor Grant, at Glasgow, and Armagh is under a competent head, Dr. Robinson. With regard to Falmouth, I do not know that there is any observatory there. At Stonyhurst there is, I imagine, a competent head. At Aberdeen I do not know whether there is an observatory, and Valencia is a most important station undoubtedly. Where there is no chief, and it is necessary to have a man of character to make the observations, of course the salary must be higher, but the mere addition to the expense of a fixed observatory like ours, ought not, I say, to be more than 150*l.* a year. If, for instance, a grant could be made to us of any kind to that amount, (though I do not desire it from the Government), it would be, I consider, of great service to science. We could carry on our meteorological observations very much better, and extend our operations if we had a little more money; but I am very anxious now, as the Trustees pay for everything, to keep down the estimates as much as possible. I have no doubt that everything relating to the expense of Ocean Meteorology is all right, and that the superintendent's salary of 400*l.* a year is very moderate.

14,206. (*Chairman.*) What proportion of the whole expense goes in Ocean Meteorology?—The greater part of the expense is for land meteorology, which I do not think the nation gets a fair return for. The telegraphy would naturally be a great expense. The heavy sum is certainly for land meteorology, and so far as I can see a great portion of that is absorbed by these seven stations.

14,207. (*Mr. Samuelson.*) Would not the computations for which 831*l.* is charged be done in London?—I suppose so. Still, everything is on a large scale. But as to what is charged for computations, I understand that what is meant by computations is a work of a most trivial character in comparison with the quarterly reports. There may be a good deal of taking means and that sort of thing, which requires a man with clerk-like habits; but there is very little that is scientific in it.

14,208. (*Professor Smith.*) Very different from the reductions which are necessary for the computations which you have given us?—Very different indeed. There is nothing but the ordinary meteorological reduction, taking means, and things of that kind, and applying certain corrections.

14,209. (*Mr. Samuelson.*) Still the amount of work would be large?—Yes; the amount of work would be very great indeed, as they receive observations from so many stations.

14,210. (*Chairman.*) Is there any other point in connexion with the subject on which you could make any addition to your evidence?—I am not aware of any.

The witness withdrew.

Major-General Richard Strachey, R.E., F.R.S., further examined.

14,211. (*Chairman.*) I believe you are a member of the Meteorological Committee?—Yes, I am.

14,212. You are thoroughly acquainted with the object for which the Committee was appointed?—I believe that I am. The general raison d'être of the Committee is fully explained in their earlier Reports. I daresay Mr. Scott has already gone into full detail on that subject, but I think that it may be advantageous if I also say what I understand to be the main objects for which it was formed, because it will show that there is no confusion of ideas in anything I may say hereafter on the manner in which the Committee actually executes its duties. I would, then, state generally what I understand to be the objects which the Meteorological Committee has to superintend. These are, first, the collection of meteorological data from ships' logs, with a view to the preparation of maps for the use of sailors, showing the probable, or it may be termed the average, meteorological elements all over the ocean, on the chief line of trade routes, for the several months in the year. Included with these is the investigation of the ocean currents. This branch of duties is carried on under Captain Toynbee. The second branch of the business is the collection and daily publication of meteorological observations made on the British Isles and neighbouring coasts, extending from the coasts of Scandinavia to France, and partly to Spain. Although at the outset the issue of warnings as to probable bad weather was not contemplated, yet after the Committee had been in operation for a few months it was considered desirable again to undertake this and in the first year of the Committee's existence the issue of warnings of anticipated stormy weather was resumed. I daresay Mr. Scott has told the Commissioners, that within the last few months there has been a little more detail given in the warnings. Originally they were mere warnings that stormy weather was likely to occur. Now there is a statement also given of the probable direction from which the wind is to come, and whether it will be of extreme force. The third of the objects is the recording at certain specially-organised observatories, seven in number, maintained under the direction of the Committee, of the principal meteorological elements, with self-recording instruments; with the intention of obtaining a continuous record with as great accuracy and precision as possible, and thus of procuring accurate data for the scientific study of meteorology by all persons who are interested in that science. I should add that the Committee has, within the last month or two, from the commencement of this year in fact, begun to print and to issue monthly the detailed observations made at these seven observatories. The Committee also publishes quarterly reports, which contain diagrams embodying the observations at the seven observatories, and an analysis of the weather over the British isles, of which the details are furnished in the daily reports. There is no doubt that the publication of those quarterly reports is an useful addition to the daily reports, which are extremely voluminous, and not very easy for persons to follow who do not devote themselves to the subject. The last of the specific duties of the Committee is the supply of meteorological instruments for the Royal Navy and Mercantile Marine. Besides, various miscellaneous references come from the Board of Trade, to which, of course, the Committee gives such answers as it is capable of doing.

14,213. Do you know how it happened that those matters came to be placed in the hands of the Committee?—As I understand, the Board of Trade, in the course of events, found that they had thrown upon them the duty of superintending matters involving more or less special scientific knowledge which they were not able very satisfactorily to control; it was suggested that a committee of scientific persons, who had given their attention to such subjects, would be a better body to undertake the supervision of those matters than the department itself.

14,214. Did the Royal Society, in undertaking to nominate the Committee, take upon itself any further responsibility in the matter?—No; on the contrary, the Royal Society has always distinctly stated that it has no specific responsibility for any of the acts of the Committee, and that all the Society does is to select, on behalf of the Board of Trade, suitable persons to form the Committee.

14,215. Has the nature of the proceedings of the Committee been influenced by the previous proceedings of the Board of Trade?—I think this is obviously the case, and that the Committee is now in reality

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doing no more than continuing the exercise of certain functions which had, in the course of time, been thrown upon the Board of Trade by the position which that department occupies in connexion with the public administration. I mean more particularly in dealing with the calls which from time to time were made upon the Government to give administrative assistance for the application of scientific knowledge, particularly in those matters which concern that part of the community who go to sea, including the Navy and Mercantile Marine. Then questions referring to the public health have led to a desire to get more accurate information as to the climate of the country, it having been gradually appreciated that climatic changes have an important effect upon the public health; and similar information has been seen to be desirable as regards all matters connected with agriculture. The Committee has, in a measure, been made responsible for furnishing such information to the public in the matter of weather, which, of course, is very important.

14,216. Has the consequence been that the action of the Committee has been from the outset rather in a practical direction than in one of original research or scientific observation, properly so called?—I think distinctly that such is the case, and that it has necessarily followed from the position in which the Committee was placed. If a reference is made to the earlier papers, and to the Report of the gentlemen on whose suggestions the present arrangements originated, there perhaps is an indication that they anticipated something more in the way of scientific research than has actually occurred; but the turn that things have taken seems to me the necessary result of the sort of duties that were put upon the Committee under the essential condition that it had but a limited sum of money to spend.

14,217. Have any results of scientific importance in your opinion been obtained by the action of the Committee?—In the direction of what one may call investigation of an absolutely scientific character, I should say none at all. Of course the observations that are made at the special observatories are valuable scientific information, and so far one has no right to say that scientific results have not been produced; but I do not think that these can properly be referred to as specific results of anything that the Committee has done. To the best of my belief there has been nothing undertaken in the way of original investigation into the specific physical causes of any of the phenomena which are recorded, nor any original research, properly so called, in relation to any of the several branches of meteorology. The Committee hardly has appliances at its command for any such investigations, and the funds at its disposal being limited it was hardly possible that it should attempt them. It is also no doubt quite true that the observations which are made at the seven observatories do not include many matters which are of great importance in physical science, and which would properly come within the range of meteorology.

14,218. Are the funds at the disposal of the Committee in your opinion insufficient for doing anything more than has been actually done at present?—I should say distinctly that this is the case. The Committee has always considered that it is bound to attend primarily to the special objects before referred to, which were in a specific manner made over to it, and it finds that after this has been done there is no money left for other things.

14,219. Has the Committee considerable control over the expenditure of the fund; if they think too much is going in one direction, could they put a stop to it, and turn the expenditure in another direction?—I am not aware that there has ever been any interference with the powers of the Committee in the way of spending the grant, but I presume that without a specific authority from the Board of Trade they could not modify the general system on which their work has been carried on up to the present time.

14,220. Do you consider that the directions in which money was to be expended were prescribed to the Committee by the Board of Trade?—Yes, so I understand. I understand that the Committee have a fixed programme, so to speak, which they have to follow in its general outlines.

14,221. Practically is the expenditure chiefly at the discretion of Mr. Scott?—To some extent, at all events; though hardly at his full discretion. He is the executive officer under whom all expenditure takes place, but the bulk of the money is paid away either in salaries or in telegraphic charges, so that one cannot say that Mr. Scott has any properly called discretion in the expenditure of the money. All the salaries are fixed by the Committee, and of course the charges for telegraphic messages are fixed according to the regular tariff.

14,222. Has the proportion in which the money is applied to the different objects of the Committee remained nearly stationary?—Very nearly, to the best of my belief; and such changes as seem to have taken place I think are rather apparent than real, and have arisen from transfers from one head of charge in the classification of the expenditure to another.

14,223. Do you consider all the objects as of great public importance?—I think that they all have a certain value, and that it is quite right that some public authority should attend to them.

14,224. You think that they are things that properly may be provided by the State?—Yes, I think so. I think that there are various reasons for considering meteorology to be a science in which it is extremely difficult to make any progress without assistance from the State. Meteorology is a science of extreme complexity, and no doubt it will take a very long time before it comes really to be worthy of the name of a matured science. From the manner in which the physical forces operate which produce atmospheric phenomena, it becomes necessary for their proper apprehension to view the conditions of a very large area simultaneously, as those conditions change from hour to hour or from day to day, or from one season of the year to another, and hence it is absolutely necessary that there shall be not only continuity but a very considerable breadth of view to insure success. For my own part I think that all experience has shown that observations such as are required are practically beyond the reach of private effort, and that the only chance of getting what is wanted done is through the assistance of the State. Neither does it seem to me that there is any greater reason for the State supporting observatories to be specially devoted to astronomy, for instance, than those to be devoted to physics or to meteorology; and although I should say that it would be an act of abominable barbarism to abolish the Observatory at Greenwich, it seems to me that there is no possible reason for its maintenance at the expense of the nation, which would not apply with equal or perhaps greater force to the endowment of observatories and laboratories of other descriptions.

14,225. Is it your opinion that the State should do much more for the promotion of meteorological science than it does at present?—Certainly it is, most decidedly.

14,226. Can you state the directions in which you think the State should intervene?—This seems to me an extremely difficult question to answer. The fact is that the form in which the State might in a satisfactory way intervene must depend upon the extent to which it is disposed to intervene. If one knew that the Government really desired to assist in the development of scientific meteorology, it would be possible to make a scheme; but I do not see how anybody could make what I may call an abstract plan which should have any real utility in it. My own impression is that so long as there is no greater interest taken in this sort of matter than at present, probably the best thing to do is to leave the expenditure of what money the Government choose to give for the purpose under the control of some such body as our Committee; but I should further say that if the Government is seriously in earnest in taking the

matter up, it would then be the proper thing to have a public department that should manage the business. Then again, if there were a public department, it must be a part of an organised system; and in order to secure an efficient public department to supervise such matters, it seems to me that it would be necessary to have some officer connected directly with the Government, an Under-Secretary of State, or some such person, who should be responsible that the executive scientific staff properly carried out the whole of the operations of their several departments.

14,227. Do you know at all what is done by other nations in this matter; has more provision been made elsewhere than in this country?—There is no question of that at all. I am not in a position to give any details; I suppose that some nations do more and some nations do less; but it is perfectly notorious that the United States, for instance, spend vastly more on meteorological science than we do.

14,228. And has the result been that meteorological science owes more to the United States than to this country?—I should think it certainly does. I may add, as I believe I said when I was examined before by this Commission, that my own impression is that the study of meteorology would be much more easily carried out to a satisfactory conclusion in a tropical country than in a country like this, which is so near the north pole, and where the disturbances are so extremely great as compared to what one may call the normal influences. Near the tropics, on the other hand, the disturbances are comparatively small, and the regular influences are extremely great, and I think we are much more likely to arrive at a satisfactory result where the normal forces are most strong and the disturbances least. And for that reason I have always done what I could to try and persuade the Government in India to do something in the way of meteorology there. But unfortunately that Government is extremely poor. From causes similar to those that have operated in England, the persons who control the acts of the Government do not know much about science, and do not care much about it, and it is extremely difficult to get anything done; but a little has been done, and of late years some improvement has been made.

14,229. In carrying on the business of the Committee, do subjects from time to time present themselves which you would be desirous of including, but which your funds do not permit you to include?—I think so, certainly.

14,230. What objects are you obliged to neglect from the insufficiency of your funds? Without enlarging the scheme altogether, are there any matters which you are obliged to pass by?—You may say in general terms that anything like a scientific analysis of the observations is prevented. There are no funds from which to pay anybody who could take up scientific investigations or deductions from the phenomena that have been observed.

14,231. And do you think that a number of observations are made of which no great use is made, which are not turned to the purposes to which they might be made available?—I am afraid that has been and is the normal condition of meteorology, that our shelves are filled with volumes containing masses of figures which practically nobody uses, or does much more than keep on their shelves. But I am not prepared to say that it necessarily follows that those figures are useless because they are not worked up into a very definite form. I think that the progress of knowledge, generally speaking, is accompanied by a very great deal of what on the surface appears to be useless labour and useless research. Before any good result is accomplished in anything, there is an enormous quantity of nonsense talked about it, and it is commonly set about in the wrong way. The process may be compared to the propagation of creatures in the organic world, in which an enormous effort is apparently necessary to produce any result at all, so that in a certain sense three fourths or more of the reproductive energies of nature are wasted, though eventually something comes of it.

14,232. (*Professor Smith.*) Are the observations that you are referring to as existing in great masses and very little used, observations that have been printed or that are kept in manuscript?—Both sorts.

14,233. (*Mr. Samuelson.*) I think you are aware of the correspondence which has taken place between the Registrar General and the Meteorological Committee and the Treasury, which has been referred to this Commission?—Yes.

14,234. With reference to that correspondence, I will ask you whether a letter dated January the 7th, 1873, from Mr. Scott to the Registrar General, was considered by the Committee?—Yes, I do not doubt that it was.

14,235. So that to all intents and purposes it was the act of the Committee?—Yes, practically it was so.

14,236. The Committee of course is aware of what has been done by Mr. Glaisher in the way of observations on climatic meteorology?—Yes, certainly.

14,237. And that he has the charge of some 47 stations furnishing important information to the Registrar General's office?—Yes; but I should explain that I have only a general knowledge of these circumstances, and no detailed knowledge, except what I have heard from people talking about it. As to Mr. Glaisher's connexion with the Registrar General, I have no personal knowledge derived from any inquiries that I have ever specifically made myself.

14,238. I assume that some specific knowledge must have been before the Committee, for Mr. Scott, on behalf of the Committee, as I understand, undertook to do gratis what Mr. Glaisher has hitherto done for the Registrar General?—I am not aware that Mr. Scott ever did that, and I am not aware that the Committee ever said it. As I understand it, what Mr. Scott says in this letter, and what the Committee intended him to say, is, that certain meteorological registers appear in the Registrar General's Reports, and that similar data could be supplied by the Meteorological Committee. I do not think it said anything more than that.

14,239. And, therefore, of course the Committee must have been aware of what the nature of those returns was?—Yes, because they are published in the Registrar General's Report, but I do not exactly see what connexion that has with Mr. Glaisher. It so happens that Mr. Glaisher's name is put at the top or at the bottom of some of the registers, but in the Committee offering or saying that they thought they were in a position to give similar information, there was no special reference to Mr. Glaisher, or anything that he had to do with the reports.

14,240. At any rate that they would be prepared to furnish the equivalent of the information which had been furnished to the Registrar General, and which information happened to be furnished by Mr. Glaisher?—Yes, they say that there would be no difficulty in supplying information of a similar character.

14,241. Mr. Scott here states that "the Committee "having a staff competent to discuss the returns "would be most happy to meet the wishes of the "Treasury by supplying such returns free of charge;" but the Committee would of course take into account that it would not be sufficient to discuss the returns unless those returns had been previously obtained?—I should say that they could not discuss them if they had not the returns.

14,242. Then there would be the expense of obtaining those returns from some 47 stations?—My impression is that the view that the Committee had on the subject is sufficiently stated in the letter. It states that "several private observers whose names "appear in the returns already supply observations to "this office, and the Committee think it probable that "a larger proportion of the remainder would do so if "requested;" and these are the observations which, as far as my recollection goes, Mr. Scott had reason

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to suppose that he could get readily and practically without expense.

14,243. Of course assuming that all the private observers who had previously supplied information to the Registrar General were willing to supply that information gratuitously to the Meteorological Office, some expense would still be incurred in verifying those observations?—I presume that Mr. Scott considered, as he says here, that "the Committee has a staff competent to discuss the returns," which means in reality merely to put them into shape, for that is the only discussion.

14,244. But something more would be required than the mere discussion of the returns, because some guarantee would be required, would it not, that those observations were faithfully made?—Within certain limits I suppose that would be the case.

14,245. The Committee appear to attach some importance to the verification of those returns, because, in the final paragraph of the letter, Mr. Scott says,—"I "am instructed to point out to you that they could not "undertake to pay any sum of money out of the grant "with the management of which they are intrusted, "for work to be carried on by any gentleman not "under the entire control of and in direct communica-"tion with the Committee"?—I think that represents the truth.

14,246. That is to say, that some superintendence would be required, and I suppose that superintendence would involve some expense?—I do not exactly know why that paragraph was inserted, to tell you the truth, but I believe it states the fact.

14,247. Do you recollect what is the number of stations now under the directions of the Meteorological Committee?—I fear that I have rather, unintentionally, been leading you astray in thinking I was on the Committee at the time this letter was written. In fact I was not; but the discussion on this matter has been continued to the present time, and I did not at first observe the dates of the correspondence.

14,248. In fact, personally you would rather not be responsible for this letter?—If I was not on the Committee, whether I wished it or not, I could not be.

14,249. The Committee are virtually responsible, are they not, for the duties of the Meteorological Survey?—Yes, for the operations that are carried on under Mr. Scott.

14,250. Then there is no great analogy between the position of Mr. Scott, who is called a director, and that, for instance, of the Director of the Geological Survey?—No, I think not. I think that Mr. Scott practically consults the Committee upon all the measures that he institutes or carries out; and as far as my knowledge of the Director of the Geological Survey goes, he manages his work altogether in his own way.

14,251. That is to say, the Committee is really the head of this department to all intents and purposes?—Within certain limits.

14,252. (*Chairman.*) Are they called upon to meet pretty frequently?—Yes, we meet sometimes once a week, but once a fortnight regularly.

14,253. (*Mr. Samuelson.*) What is the extent of their responsibility?—As far as my knowledge goes, Mr. Scott practically is responsible for the whole of the executive work, and the Committee exercise over his operations a general control.

14,254. Then, in point of fact, Mr. Scott is the Director of the Meteorological Office, under the superintendence of the Committee as a *quasi* visiting board?—I should presume that to be a very fair representation of the position. But my impression is, that the special function which the Committee have to perform is to look after the expenditure of the annual grant of 10,000*l.* made for meteorological observations. I have no specific knowledge on the subject, but I should presume that the Board of Trade thought that it was more satisfactory to have a body like the Committee to look after the expenditure of a large sum of money like that, than to hand it over to what you may call, without intending to use the term disrespectfully, a subordinate officer.

14,255. But as to what the functions of the Meteorological Office are, and ought to be, and as to any changes from time to time, you consider that Mr. Scott is virtually the originator, and that he is the responsible person?—I do not exactly understand the scope of your question.

14,256. Assuming the question to be whether any new work should be undertaken by the office, would that be a question, in the first instance, which Mr. Scott would have to consider and bring before you?—Certainly.

14,257. It would not be a question which would originate with the Committee?—In general terms nothing originates with the Committee, everything originates with Mr. Scott.

14,258. (*Professor Huxley.*) But you do not bind yourselves to the Committee originating nothing?—No. My last answer, I see, may lead to some misconception. I had reference to the regular duties of the office, and to the manner in which they were performed. Of course any member of the Committee may make any proposals that he thinks fit, and many proposals have been so made. But the fact is that every member of the Committee has got a great deal of other work to do, while the whole of Mr. Scott's time is devoted to that particular work, and it is the natural thing that he should do what he is specially employed to do and is paid for; he exercises full discretion in bringing forward any matters he pleases connected with the business of the Committee.

14,259. (*Chairman.*) If the Committee were to undertake to furnish the returns to the Registrar General that are now supplied by Mr. Glaisher, have you any apprehensions that they would be obliged to reduce their work in other directions?—I have no reason to suppose that. Mr. Scott is a very trustworthy person, to the best of my belief, and from what I have seen of him; and if he tells the Committee that he could prepare similar returns without additional charge, I have no reason to doubt that he could. Of course, as I do not know how every clerk in the office is employed all day, I can give no independent opinion on the subject myself.

14,260. He says that he wants more clerks and more money to do the work which has already been undertaken by the Committee?—Possibly; but this may mean only that the work would be better done with more power. I cannot say whether he means that he would specifically supply returns of the barometer and the thermometer, and so forth, from every one of the stations that is contained in the Registrar General's register, or whether he merely means to say that he could supply what to his judgment would be fair meteorological returns to illustrate the general conditions of the climate of England.

14,261. The Scottish Meteorological Society, I think, have asked to be allowed to share in the sum of 10,000*l.* granted for meteorological observations?—Yes; there has been a long-continued discussion of the subject.

14,262. Are you acquainted with the nature of the discussion?—In a general way, as I understand, the proposition is something of this sort: the Scottish Meteorological Society would like to have more funds at their disposal, which no doubt, if they had, they would be able to apply very usefully; and seeing that the Government gives 10,000*l.* a year to be spent on meteorology in some form, they have suggested that they should have a portion of it. Then it has been suggested that the portion of the meteorological observations which comes to the Committee from Scotland should be collected in the first instance by the Scottish Society; and that if an arrangement of that kind were made the Scottish Society might properly receive a corresponding share of the grant, and this I understand to have been estimated at 200*l.* The answer that has been given to this by the Meteorological Committee is something as follows: that we are not authorised under the conditions according to which we receive our 10,000*l.* to do anything but to spend it on specific objects, and we do not feel

ourselves to be justified in making a grant of 200*l.*, or of any specific sum, to another body for the purpose of doing the sort of work that we ourselves are doing. All that we feel ourselves to be justified in doing is actually to apply the money directly to the objects for which it was entrusted to us. Further, the Committee understood that the Scottish Society declined to receive the money as agents, so to speak, of the Meteorological Committee. They were understood to say, we will take it and spend it in our own way and give you our results, but we cannot accept the position of making the observations under your instructions or control. Now the position of the Meteorological Committee is, that they are responsible to the Board of Trade and to the country that particular information shall be got and shall be published day by day in a particular manner, and it has appeared to them that unless they can secure with complete certainty the regular fulfilment of that duty, they would not be justified in handing it over to anybody else on the chance that it might or it might not be carried out; and that, consequently, unless they retain the entire responsibility for the whole of the operations they would be going beyond what they have a right to do.

14,263. Are the Scottish Society's observations at all of the same character and with the same objects as those under the charge of the Meteorological Committee?—I fancy quite so. I do not think there is any distinction at all in the nature of the observations. I have not the least doubt in the world that the Scottish Society would be perfectly capable of superintending them and sending them forward regularly.

14,264. Then, to a certain extent, is not the work done over twice, that is to say, is it not unnecessarily repeated?—One of the specific causes of complaint of the Scottish Society was that the Meteorological Committee got one of their observers to supply the Committee with observations, and therefore, to a certain extent, the work is done over again. But my impression is that the duties entrusted to the Meteorological Committee are much more specific in their nature than might appear from the general course of the latter part of the questions that have been put to me; and that really the principal duty of the Committee as regards British meteorology is to collate the daily weather reports with the view of ascertaining whether in fact there is any probability of a serious destructive wind occurring on any part of the coast. The whole system of observation, as I understand it, is framed on that understanding. No doubt observations framed with that intention must to a very great extent embrace the whole area of the British Isles, and in a certain sense they give you a fair view of the general meteorological conditions of the whole country. The quarterly reports that are published by the Committee (excluding the registers of the seven special observatories, and a few special reports) are nothing more than an intelligent abstract in a continuous form of those daily reports, and the conclusions that are based upon them. Before leaving the question of the grant to the Scottish Society, I should say that the Meteorological Committee felt that if they did make or propose to make a grant of any description to the Scottish Society, there was no reason why the London Society should not get a similar grant, and as a matter of fact the London Society have pretty well asked for it, or at all events they have suggested that whatever is done to the Scottish Society should be done to them.

14,265. (*Dr. Sharpey.*) Have the London Society a set of observers?—No, not of paid observers I think, but they collect observations from a great number of gentlemen all over the country, who go to very great pains and very considerable expense in making observations, and having done that they are very ready to send them to that society, or to the Meteorological Committee, to get them published, and to get them amalgamated with the other similar returns.

14,266. (*Chairman.*) Is Mr. Scott in the habit of bringing details of that kind under the consideration of the Committee, or does he manage it at his own discretion?—The whole of the details come before the Committee, and the whole expenditure is sanctioned in detail. There was a meeting of the Committee yesterday, specially to examine the monthly accounts and to authorise the payments.

14,267. Are you ever in communication at all with the London Meteorological Society?—My impression is that a letter has been received from them, but not for any practical purposes of meteorology.

14,268. You do not mutually assist each other in fact?—Not at all. There is no relation at all between the Committee and any other scientific body. The Committee, if I am not mistaken, has purposely abstained from giving opinions on any but practical questions, though ready to receive all communications. The principal external relations, so to speak, of the Committee are with the directors of meteorology in foreign countries.

14,269. (*Professor Huxley.*) I presume that you attach considerable value to information upon climatic conditions?—Most certainly.

14,270. Looking at the matter as a meteorologist simply, without reference to your being a member of the Committee, supposing that you had to organise a system for the obtaining of such information as that, would you prefer to obtain it by means of a body like the Meteorological Committee, which has a definite continual existence, or would you prefer to leave it to private effort and the effort of societies?—My belief is that private efforts of individuals will be able to do a very great deal, but they will not be able to do much that can be done by a centralised and organised body like the Committee, particularly as it has funds at its disposal. I utterly disbelieve, that any body, if it had not a grant of public money, could secure a regular and a complete periodical publication at short intervals of such returns as are published by our Committee. In fact, looking at the expense of it, it is absolutely prohibitory. However rich any of the scientific societies are, the richest of them would be perfectly unable to do even so much, and that after all is by no means all that is desirable.

14,271. But at present, as I understand, you do not profess to supply the information as to general climatic conditions; your observations are made at fixed stations, either with reference to the purposes of the navigator, or else obtaining the data of scientific meteorology. They have not been extended over such a large number of stations as would be requisite to supply the sort of information which the Registrar General now publishes?—The number is certainly not so large.

14,272. As to its kind, you have not supplied the kind of information which is obtained by Mr. Glaisher from his 47 stations?—Not perhaps to that extent. The attempt has never been made to cover the country with meteorological stations for the purpose of ascertaining the climatic conditions of every square mile of the surface, so to speak, or in any detail.

14,273. Do you think it is desirable that that should be done; that we should have such accurate and systematically obtained information concerning the climatic conditions all over the country?—It is rather a difficult question to answer offhand, but my impression is that it would not be desirable to go to any very great expense to do that; I should consider that the essential scientific points connected with the meteorology of the country would be quite sufficiently arrived at by observations made at a comparatively few points in the country, and that the local details were of relatively minor importance, and that there was no necessity at all for devoting the expenditure of public money to any such detailed collection of facts, the value of which in a certain sense need not, however, be questioned.

14,274. At the present moment about 150*l* apparently of public money is so expended in the payment from the Registrar General to Mr. Glaisher?—I understand that to be the sum.

14,275. I suppose that the sort of observations that are to be included under the head of climatic meteorology are not of the rigorously exact kind which are made in your seven observatories?—Certainly not.

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14,276. And it cannot be so?—Certainly not.

14,277. Are they observations which could be made under the superintendence of the health officers over the country?—I should say they would unquestionably.

14,278. There is no such special difficulty about it that they could not be made?—Certainly not; what is wanted is that the observer should have proper instruments, and should receive instructions as to what he should do. If you make him understand what he has got to do, he has no difficulty in doing it.

14,279. I suppose that if the health officer supplied that information to the Meteorological Office, it would not involve any very great expense toreceive, collect, and publish the information?—I should think very little.

14,280. It would not be any very serious demand upon the time of your office, would it?—Of course that entirely depends upon the amount of the detail which may be required; but I confess that I myself should doubt whether the precise meteorological or climatic conditions of any particular town or district can be connected with the precise conditions of life or of health in that town or that district. I think after all that the meteorological tables which are to be found in the Registrar General's reports rather give a general indication of the state of the weather in the country at large during the year of which he treats than anything else.

14,281. You mean that the connexion between meteorological conditions and the public health is still imperfectly made out?—I mean that all that can be done at present is to establish a general connexion. For instance, if in the month of April we have had a comparatively warm month, the figures would represent that the month of April this year, as compared with other months of April, had been comparatively warm, and a comparison of the conditions of health of the two years might indicate some general connexion between the health and the range of temperature. But they would not afford data on which one could safely say that the health of this town has been good because the temperature there has been a degree higher, and the health of that town has been bad because the temperature there has been a degree lower, and so forth. In my opinion, comparing a series of places near one another, no precise connexion can be established between the variations in the state of the public health and the condition of the thermometer and the barometer.

14,282. So that there is no particular use from that point of view in keeping a register of the weather along with a register of births and deaths?—Not at every place where a register of births and deaths is kept, I should think. Of course, in all of these things, and particularly as regards the registers of the weather, a further difficulty arises from the expense of publication. You get together a huge pile of figures, and you do not know what to do with them when you have got them.

14,283. Do you know anything actually of Mr. Glaisher's system;—Not the least.

14,284. You can give no opinion about it?—Not at all. I was led to understand from figures that were pointed out to me (and I think there was some correspondence between the Registrar General and Mr. Scott on the subject), that there were several blunders in the registers, but that they are like other ordinary meteorological returns I should think is probable. I am not aware that they have any particular value, or that they are in fact different from similar sets of figures got in other ways.

14,285. Are you disposed to think that the Meteorological Committee might in any way extend its sphere of action with advantage?—As matters are now I should think it is extremely doubtful. I look upon the Meteorological Committee as being mainly a controlling body to supervise the expenditure of a definite sum of money in a definite way. At all events that practically has been their position. There has been no virtual change from the time that they were started up to the present time.

14,286. Do you think that that money would be spent better in some other way; that is to say, supposing the thing had to be started afresh, are those objects which the Committee at present have to carry out exactly those that you would have given them to carry out?—I should say in general terms that the whole of the objects which the Committee has charge of are reasonable objects. I do not think that there is any one of them that it is not desirable to attend to. As to whether the precise method of dealing with them is the best possible will be a matter of opinion, but I do not think that I could very usefully go into that.

14,287. Does it occur to you that there is anything else which should be added to the functions of the Committee?—My general impression, as I implied before, is that the Committee is a quasi-financial body having certain scientific knowledge. Its duty is not strictly speaking to direct scientific research or scientific operations, but it is to see that a certain sum of money which the Government thinks may reasonably be applied to collecting and publishing meteorological observations, and doing certain other matters, is not unreasonably applied. It exercises a check upon the persons who have actually to carry out those duties, as I understand it; and I do not think myself that, with a body constituted as the Meteorological Committee is, you can expect more from it than that.

14,288. Do you think it would be desirable that the Committee should be entrusted with money to enable it to have any observations collected, scientifically discussed, and turned to scientific use?—I think it would be much better if any such fund were not given to a body like the Committee. If some individual were selected, and the entire responsibility put upon him, I think it would be a much better plan.

14,289. (*Chairman.*) You want to do away with the Committee altogether?—I think so, certainly; supposing always that I am at liberty to replace it according to my own conceptions of what is best.

14,290. (*Professor Huxley.*) But there are other modes in which a scientific discussion of the results might be attained. Suppose, for example, that the Committee has it in its power to employ a scientific man, and to pay him, in fact, for discussing the observations and making the best that could be made of them, do you think it desirable that the Committee should be empowered to do that, and have funds to do it?—That would be an improvement upon the present system, that is to say, it would be an extension of the present system. It would add to the power of the Committee of doing what is useful; but I am not prepared to say that I think that a committee or a board is at all a desirable sort of body for the management of that sort of work. You get much better results by imposing individual responsibility. There are certain functions which committees and boards may exercise usefully; but I do not think such bodies are what is wanted in the present case. I think that you ought to have somebody who takes in the whole matter and the whole subject which is to be dealt with, and views it as a whole, and thinks of it as a whole, and deals with it as a whole.

14,291. You would put at the head of it somebody who should occupy the same sort of position with regard to meteorology, as the Astronomer Royal does with regard to astronomy?—I think so, certainly.

14,292. And you would let him make the best scientific use of it that he could?—I think so. But the practical difficulty in the way of starting a system of that sort is the fact that meteorology is in such an extremely immature condition, that I do not know that one could very readily find anybody who would be the proper man to put at the head of such an institution, because if large sums of money have to be spent, there is great responsibility resting upon the individual, whoever he is. If the money is spent improperly it is perfectly certain that the public will eventually find out that the money is so spent, and that will have the very worst result in the future as to getting similar grants of money hereafter.

14,293. So that on the whole possibly it might be the safest to keep to what exists?—My impression is

that what is actually wanted to begin with, for I think you must start with that, is an expression on the part of the Government or of the public that it is desirable to do more for the support of this branch of science. And really until that sort of feeling is established, as I said before, it is almost impossible to devise a scheme by which the thing could be done. It is a waste of trouble to propose or to think about it, if you know that the thing is not going to be done. Then I think that if the Government is going to spend increased sums of money on scientific objects, including scientific research, it is absolutely necessary to establish some proper controlling body, and that is the main difficulty. The main difficulty in all these things, when you go to the bottom of them, is the supervision or control, and what is wanted, therefore, is to have an organisation which shall secure the reasonable application of whatever funds become available to the ends to which it is desired to apply them. In this view some such body as has been talked of, a scientific council of some sort or a commission, acting under a recognised scientific public department, would probably be the most suitable to exercise a control over the heads of the various establishments, who would otherwise be left reasonably free to carry out their own views as to how their operations should be carried on.

14,294. (*Chairman.*) I gather that you would not think it advisable to change the present system, unless something much more extensive is aimed at by the Government?—That is my impression. I do not see myself that you could hit upon a better plan. I think there is something to be said in favour of the present system. It is not a very brilliant one, but still it is pretty good.

14,295. Should you like to have the funds at your disposal increased?—There is no doubt that if the funds were increased, and greater breadth could be given to the operations of the Committee, useful results would be produced. I think there is no question of that, but I confess that my own feeling is that what is specially wanted is that more should be done in the way of *bonâ fide* cultivation of the scientific part of meteorology, which up to the present time has hardly been touched.

14,296. Then you do not think that the Meteorological Committee, upon the whole, have done much for the advancement of meteorological science?—No; they have been collecting facts, but that is a totally different thing from deducing scientific results from facts.

14,297. Do you think that it is of great importance that attention should be directed to the natural agencies the operations of which are known as those dealt with by meteorology?—Certainly I do.

14,298. Can you give any illustrations of your opinion?—I have long thought, as I have mentioned before, that India was a place where meteorology might be studied with particular facility. Further, the experience which may be got there affords a most excellent proof of the vast practical importance of the appreciation of the physical causes which bring about meteorological phenomena. There is no question whatever that the great extent to which famines have prevailed in India, and the frightful results which have followed from them, have been to a considerable extent the result of a want of appreciation on the part of the Government of the fact that the droughts which cause famine occur according to a natural law, and that they are in reality the necessary consequences of the climate of India. If the Government had appreciated that fact as they ought to have done, and as various people have been trying to make them appreciate it for a long time past, they would have perceived that the only way to prevent famine consequent on drought is to supply that which is lost by the failure of rain, that is to say, to give water to the country; to provide the means of artificial irrigation, thing which has not yet been done otherwise than very imperfectly. The Government has gone on from year to year, seeing one famine succeed another, and as each one has come to an end they have hoped that it will be the last, and that another will not come. On such occasions as these a difficulty often arises, which has been felt at the commencement of the present drought, namely, that the rain fails over a large area, and it is not known where the worst results are to be anticipated, for the reason that the meteorological data that are collected are extremely scanty. The registers of the rain are very imperfect, and they are not put together with sufficient accuracy or with sufficient promptitude. Thus the fact that a drought is about to occur is not appreciated thoroughly and properly until the famine is actually upon the country. There is no question at all that the incompleteness of the meteorological records in India has in all cases aggravated the difficulties which have had to be contended with.

14,299. Is it not as much from unwillingness to be at the trouble and expense as from actual ignorance; because if they were asked, would not those who are concerned in the Government of India admit that in all probability there would be a famine there every few years?—I have been trying to persuade them for a great many years past that there is one remedy, and only one.

14,300. Do you think that means might be taken to prevent the recurrence of the famines?—Nothing could prevent the recurrence of the drought and the failure of the rains.

14,301. But could not sufficient water be stored to prevent the evil effects of the drought?—The fact of course is, that famine is the result of the want of food, and the want of food may be remedied in two ways; one is to supply the water which is necessary to secure the production of the food, and the other is to bring food to the place where it is wanted from other parts of the country. I think there is no year in which India, if it were left to itself, would not be able to supply itself with food, as a whole. Thus there are two classes of remedy. One is the provision of irrigation works, which will secure the largest supply of food that is possible; and the next is, the improvement of the means of communication, so as to provide the means of bringing the food to the places where it is wanted at the proper time. What has happened in this particular year in northern Bengal is the failure of rain, to begin with, and the consequent failure of the food produced there, combined with difficulties in the way of getting food there from other places. It was exactly the same in Orissa. In Orissa in 1866 the failure of the means of transport was, unfortunately, very much greater, and the people were starved because it was impossible to take the food to them. Fortunately, on the present occasion we have a railway which runs right through the heart of the country where the drought has occurred, and we have had unlimited means, so to speak, of taking the food within reach of the distressed districts; and in proportion as the means of distributing food are improved, so will the means of coping with famine be improved. The fact is, that England, as regards its locally produced food supply, is infinitely worse off than any part of the country which is now suffering in India; and the only reason that England does not suffer from famine year by year, is that it is a civilised country, and that the other is a barbarous one. The condition of every country that is in a state of barbarism is one of periodical famine. Of course there are various other things which aggravate these Indian famines, of which the enormous population is one.

The witness withdrew.

Adjourned to to-morrow at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Wednesday, 29th April 1874.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

The Most Hon. The MARQUESS OF LANSDOWNE.	WILLIAM SHARPEY, Esq., M.D., F.R.S.
BERNHARD SAMUELSON, Esq., M.P.	HENRY JOHN STEPHEN SMITH, Esq., M.A., LL.D., F.R.S.

A. Buchan, Esq.

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ALEXANDER BUCHAN, Esq., F.R.S.E., further examined.

14,302. (*Chairman.*) I believe it is about two years ago that you were so good as to give evidence to the Commission respecting the Scottish Meteorological Society: are there any other matters connected with its operations to which you think it desirable to call the attention of the Commission?—Yes, there are a few points which I wish to bring before the Commission.

14,303. We shall be very glad to receive any information which you wish to lay before us?—An inquiry into the relations of the migrations of fishes, particularly those of the herring, to sea temperature, winds, and weather generally was undertaken in 1872 at the suggestion of Lord Tweeddale, President of the Society. The inquiry was remitted to a Committee, Mr. T. Stevenson, C.E., being convener. The first step was to enter into communication with the Fishery Board, from whom were obtained the returns of the fishing from four of the district officers for the six years ending 1872. These were discussed, and the results published early in July 1873. From this preliminary tentative examination there seemed to be a connexion between the migration of herrings and the weather, but it was evident that fuller details were required in order to prosecute the inquiry with success, namely, details as to the daily catch at each place, to the daily number of boats out, and the state of the weather at each fishery district. At the suggestion of the Herring Committee, a letter of instruction was issued by the Fishery Board to all their district officers, calling for this additional information, of which this is a copy:—

"Fishery Board, Scotland, Edinburgh,

"SIR, July 16, 1873.

"THE Meteorological Society of Scotland being desirous to make endeavours to solve points relating to the natural history of the herring, and to ascertain more scientifically and accurately than has yet been done the influences which govern the appearance of the shoals of herrings upon the coast of Scotland, have applied for the co-operation of the Fishery Board in this important national matter with a view to the district officers of the board collecting during the herring fishery with care and certainty the information required by the Meteorological Society. This information consists of—1. Daily record of the state of the weather. 2. Daily record of the quantity of herrings caught. 3. Daily record of the number of boats fishing. You are desired, therefore, to get this information during the herring fishery with as much certainty as you can, and render it to me week by week in your weekly returns of fishing. Should you find the ruled spaces of the return too small to give these particulars in the body of it, you must give them by endorsement on the back of the return; and you must make a complete copy of every return in your weekly report book, using two or more pages for the purpose if necessary. You are to understand that the collecting and rendering of these particulars is not to be allowed to interfere with the performance of your regular duties, but it is considered that in the course of those duties you may without much trouble or difficulty obtain what is here called for and render it. You will acknowledge these instructions upon their reaching you.

"I am, &c.

"B. F. PRIMROSE,

"Secretary."

Arrangements were also made for carrying out observations of sea temperature at the surface, and at the bottom, by Her Majesty's cutter, as the vessel sailed round the various fishing grounds. These observations, which were made six times a day, were of a very elaborate character, and show the sea temperature (surface and bottom), the exact position of the cutter, and depth of the sea at the place.

14,304. Is the Fishery Board a Government authority?—Yes, and they have very readily co-operated with us in this inquiry. Mr. Purdie, one of our observers, took the daily temperature of the sea at St. Andrew's, and Mr. W. Boyd, of Peterhead, observed the maximum and minimum temperature of the sea with thermometers continuously immersed. The instructions of the Fishery Board were very completely carried out, and the observations have been discussed. It is of course premature to draw any positive results, but it is interesting to note that such results as were arrived at by the earlier investigation have been confirmed. What is now required is the accumulation and discussion of a few years of such observations taken according to the plan which has been put in operation by the Committee. If the Committee were in a position to supply thermometers to such of the more intelligent fishermen as would use them we think that the inquiry would thereby be greatly promoted. (The mode of discussion was here detailed, and 35 maps were exhibited, on which were shown in red figures, the average number of crans to each boat, in each district, and, in black figures, the number of boats out, the winds at various stations, thunder and lightning, and the barometric pressure; in short each map is a Meteorological Chart for the evening of the day before the boats arrived; in other words, at the time the boats left the ports. Those are all set down here in their places for each day, so that by a comparison of the maps the migration of the fishes from point to point along the North Sea can be traced from day to day in connexion with the climatic conditions.) At the beginning of the inquiry the Committee were convinced of the necessity of fuller and more extended observations on sea temperature being made, and accordingly steps were taken to have such observations made. Those have been commenced according to a plan devised by Mr. Stevenson, by which the daily temperatures, maximum and minimum, have been taken with thermometers continuously immersed. One of these instruments was erected in May 1873, at the suggestion of the Committee, by the Trustees of Peterhead Harbour, who were themselves at the expense of erecting the necessary apparatus. This was done under the superintendence of Mr. W. Boyd, who began the observations in that month. The apparatus for Light Ships (*showing the same*) consists of a cylindrical copper vessel, with holes pierced in it for the greater part of its length. It is to be swung from the light ship, with a weight attached to keep it perpendicular. A maximum and minimum thermometer, specially made by Casella for the purpose, is fixed inside by means of elastic bands and supports, and its bulb being always immersed in the lower part of the cylinder which is unpierced with holes, the temperature, will not be changed by drawing the apparatus up and letting it down in making the observations. We have since applied to various authorities for observations made in this way, for instance, to the Northern Lighthouse Commissioners,

but there are some difficulties in the way; to the Liverpool Dock Commissioners who have authorised it, and it is at their expense that this instrument has been made; and to the Trinity House, but we were refused, inasmuch as the Meteorological Office had applied to them, for observations of sea temperatures some time in July last; to the Irish Lights, who applied to the Board of Trade for the necessary funds to pay or the instrument, but were refused. It lies with the Council to meet this expense since the observations must be made entirely through private subscriptions of the members, seeing that the Society has no funds for this purpose. To carry out this inquiry a very considerable outlay will be required for the purchase of the apparatus as well as the discussion of observations, which is of a very laborious nature. If thermometers be furnished to fishermen, it will require to be done by individual members of the Council subscribing.

14,305. Have you raised any special fund for this purpose? If I recollect rightly you stated before that the income of your society was scarcely sufficient for the work at that time in hand?—Not a penny of the expenses will come out of the income of the society, but the expense must be met by individual special subscriptions if the work is to be done by the society at all.

14,306. A certain amount of expense, I suppose, has already been incurred in what you have already done?—The expense of my official time.

14,307. But has there been no expense incurred in these maps?—We have them in the office for these and other purposes.

14,308. Then hitherto the inquiry connected with the herring fishery has not entailed any extra annual expense?—Not as yet, but some expense will be incurred, and some members of Council have promised subscriptions.

14,309. But it has thrown some additional trouble upon you?—Yes. And there are also some additional expenses, such as for the apparatus to be ordered for the Irish Lights, which will be paid out of private subscriptions or out of some fund specially raised, unless the Government assists us.

The next question is the establishment of Storm Stations. Those are established with the view of collecting data for the solution of some of the more important meteorological problems, particularly the relation of wind force to barometric gradients Several series of stations are in course of being established, radiating in lines from Edinburgh, at which observations, chiefly barometric and wind, are made only when anything remarkable in the state of the weather or the barometer occurs which strikes the observer as noteworthy. This is the schedule which is to be issued for the purpose of these observations (*delivering in the same*). This inquiry will involve a good deal of expense in the way of reducing the observations, and if we were in a position to supply schoolmasters, clergymen, the smaller class of farmers, or others who might be willing to assist, but who could not be expected to purchase the instruments, we think that we could materially promote one of the most important questions of meteorology, which can only be done successfully through a society with local influence.

14,310. How do you contemplate meeting the expense connected with the establishment of the Storm Stations?—We propose, in the meantime, to secure the services of those who are willing to provide their own instruments, and if any one expresses a wish to aid in the matter, to see if we can raise private subscriptions for the purpose, but of course without some aid from the State the whole of the Society's operations in this direction must be very much hampered. A sum of 30*l.* or 40*l.* a year would be a very great help to procure instruments for the prosecution of this inquiry. In connexion with this subject, returns were obtained from all the Scottish Lighthouses, the Commissioners having, at our suggestion, prepared this schedule (*handing in the same*), which is regularly filled up for the Society. The returns are particularly valuable, especially in connexion with the progress of storms. They record very carefully the fluctuations of the barometer, and the changes in the direction and strength of the wind at the moment of their occurrence. The keepers of the lighthouses being always on the watch, and in positions on the coast which are peculiarly suited for these observations, we think that for the purpose of the examination of storms these are perhaps the most valuable observations that exist, certainly in this country.

14,311. How many stations of this description have you, or are you in communication with?—59. We have not been able to reduce the monthly results, but we have frequently used the observations in special inquiries. We have no funds as yet to reduce and print the results.

14,312. Would the 30*l.* or 40*l.* which you talk of be sufficient to enable you to meet the expense of the reductions?—The 30*l.* or 40*l.* referred to was for the purchase of instruments. For the adequate reductions of these and other observations collected by the Society, two clerks at least are required.

14,313. With reference to the Storm Stations, has the establishment of those stations been undertaken since you were here last year?—Yes; the subject was first proposed at our General Meeting in January last, and it was remitted to Mr. Stevenson and Mr. Hope, of Bordlands, to carry it out. Some time will necessarily be required before the scheme is fairly established, but ultimately we hope to succeed.

The society has established a number of stations in connexion with an inquiry into local climates. At the Bridge of Allan we established two, but unfortunately the observers died within two years after the stations were established, so that it broke down there. We have them established at Aberdour and at Burntisland, in East Lothian, and on Deeside. We have also established several stations on small islands where the influence of the sea is very strongly felt, such as North Unst, Monach, the most westerly point of the Hebrides, Airds, and several other places, and the results we have thereby obtained raise very important questions in meteorology. We find, for instance, that in the month of January the mean temperature of North Unst is 41°·5 which is very nearly that of Ventnor. At Monach, in the west of the Hebrides, the mean temperature in January is 44°; that of Truro is only 43°·7, and of Guernsey 43°·5. This result shows in a forcible manner the extraordinary influence of the sea on the climate of the coast. North Unst and Monach are islands so very small that the influence of the land is scarcely perceptible in its effects on the temperature through solar and terrestrial radiation.

14,314. (*Dr. Sharpey.*) Is not the temperature of the sea higher at the same time?—Yes; but the remarkable result is that the mean temperature at those places is all but identical with that of the sea. At places such as Dunvegan, on the West of Skye which is a much larger island, the mean temperature of January there is about 40°. At Airds, on the coast of Argyll to the north of Oban, much exposed to the currents of the sea, the mean temperature of January is 40°·4; whereas inland on the same parallel of latitude, in the West of Perthshire, it is 38°·5. On the East coast the influence of the sea is also felt, though not in so marked a degree. At St. Andrews, where the observations are made close to the sea near the top of a high cliff, the temperature of January is a degree warmer than it is at a station three miles inland. It is probable that this enormous influence of the sea extends but a very little way inland, perhaps not more than a mile; at least, it is very small further inland.

14,315. Airds is a considerable way inland, is it not?—It is on Loch Linnhe, and the currents which pass and repass there are very strong. It is especially where there are currents, bringing up warmer water from the bottom of the sea, that enormous differences are observed. What the Council propose

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to do in this matter is, to investigate this singular influence of the sea by establishing stations, one close to the shore, one say two miles inland, and two or three intermediate. I may point out here that after I had published the charts of the isothermals of the British Isles, a few years ago, Professor Hennessy of Dublin, sent me the chart I hold in my hand, which he had prepared for Ireland, showing the isothermals, which, it will be observed, are concentric with the coast, and show a mean annual temperature in the interior of Ireland of 47°. The data from which Professor Hennessy constructed this chart were almost wholly obtained from stations near the sea, with one or two in the interior for brief periods. Hence the lines are drawn correctly for the coast, but hypothetically for the interior. For instance, the annual isothermal of 47° passes through Armagh, but from 13 years' observations which we have from Professor Robinson of Armagh, the annual mean is 49°·6. The annual mean of Athlone is given as 47°, but from observations for six or seven years it is 49°·5. Those general results are applied by Professor Hennessy to the question of flax cultivation. When data are adduced in connexion with important objects of culture, it is unnecessary to say that accuracy is of the greatest importance. The real question is how do the isothermals incurve when they approach the coast? an extremely difficult problem, and one that will take a considerable number of years in working out satisfactorily, viz., by the establishment of stations as indicated above. It is only in this way that the peculiar influence of the sea can be investigated, which has such marked effects on animal and vegetable life, as seen in the distribution of plants, the distribution of diseases, and in the benefits obtained from seaside climates.

14,316. (*Chairman.*) This branch of your operations, I presume, is not connected with any great outlay?—We are endeavouring to get our wealthier members to undertake it themselves under our direction; but it could be done more satisfactorily if the Council were in possession of the necessary funds to enable them to make grants of instruments to those who might be willing to undertake the observations.

14,317. Do you find generally that there are a large number of private individuals who take an interest in inquiries of this kind?—Yes.

The next question is the influence of seasons on human mortality, at different ages, as caused by different diseases. The Council has recently taken up this subject, and they have remitted it to Dr. Arthur Mitchell and myself for investigation. I have brought with me several charts, and I will, as briefly as possible, explain to the Commissioners the object we aim at. We have begun with London, because of its large population, and full weekly returns, and have adopted an average of 30 years beginning with 1845. Averages of the temperature, dew point, relative humidity, and rain have been calculated, and I may take the opportunity of mentioning that the returns, both of the Registrar General and of Mr. Glaisher are singularly accurate. Indeed I know of none more accurate in the main than these. (*Here a large number of diagrams were exhibited in order to show the extensive nature of the inquiry, and the important results already arrived at. These diagrams showed the curves of mortality from many of the more marked diseases calculated from the mortality tables of London, Australia, India, &c.*) What I have now stated will indicate generally the course of the inquiry that we have begun,—an inquiry which involves an immense amount of clerks' work in computation, and considerable expense in gathering information, putting it into shape, and publishing it. Such an inquiry as this is best taken up by societies like ours, it being necessary to its successful prosecution that the investigators be familiar both with the principles of meteorology and medicine, and have the assistance of an office staff for the enormous computations which are indispensable.

14,318. How have the expenses of this department of yours been met hitherto?—Hitherto the money outlay has been small. The outlay has chiefly been in computations, which have been undertaken by myself during ex-office hours, and which are too heavy to be continued without assistance. Considerable expense will be incurred in publishing the results from time to time; in collecting information; in establishing special stations to show the influence of local climates on disease, &c.

The next question that I have to bring before the Commission is agriculture. I need scarcely refer to what the society has done for agriculture during the last 18 years. The Marquis of Tweeddale, President of the Society, has largely assisted the society in this direction, by a number of prizes. The first that his lordship gave was for the best essay on the rainfall of Scotland. His lordship learned, when in India, that the opinion amongst the Brahmins was that there is a periodicity in weather changes, and that this period was about 19 years. One main object of this essay was to inquire if there was in the rainfall a periodicity. This question did not receive an answer until a few years ago, when Mr. Lockyer, Mr. Meldrum of Mauritius, Professor Piazzi Smyth, and a number of other writers took it up, and it has been shown that there is a relation between the sun-spot period and rainfall, and probably other meteorological elements. His lordship also gave a prize in connexion with the profitable or unprofitable culture of farm crops. This drew out eight valuable sets of observations, for which his lordship gave prizes amounting to 40*l.* These observations were discussed, from which it was proved that if the mean summer temperature in Scotland by thermometers exposed to the sun is 58°·5, or by protected thermometers 56°, and the rainfall the average, the heat is just sufficient to ripen wheat and barley. This very valuable result could not have been accomplished by the society, unless his lordship had given us 40*l.* to enable us to carry out the inquiry. His lordship also offered a premium of 80*l.* for observations of the temperature of drained and undrained hill pasture and arable land. The results derived from the observations thus obtained were of very great value with reference to the behaviour of the temperature on drained and undrained land respectively, and were discussed in Volume I. of the Society's *Journal*. The following points were discussed: The effect of a sudden fall in the temperature of the air; the effect of a continual fall in the temperature; the effect of a protracted frost; the effect of a sudden rise in the temperature of the air; the effect of a continuous rise of the temperature of the air; the effect of rain; the effect of sleet; and the effects of a thaw. All these points were respectively taken up and discussed, and the results shown. Then there was an essay on prognostics, for which his lordship gave 20*l.* The last prizes that he gave were on underground temperature, by observations made 12 times a day on pressure, the temperature of the air, and the soil, wind and other elements, and some very remarkable results were deduced from them, which have been published in the Society's *Journal* Volume II., page 276, and Volume III., page 214. The April and October observations are not yet discussed, and a part of the results of July and January also are not discussed for want of a sufficient office staff. Some very interesting results were obtained on other matters than those connected with mere drainage and soil temperature.

The next inquiry was undertaken with the view of disclosing the effects of very exceptional weather on different crops in different localities. An elaborate set of special statistics relating to the yield and other qualities of agricultural crops was recently obtained through the Highland and Agricultural Society of Scotland. Schedules were issued to 40 distinguished agriculturists in all parts of Scotland, who gave returns upon all the different crops in their district. These observations we have not yet been able to discuss. All these discussions and inquiries I have referred to have led the Society, especially the President, to con-

sider the effect of solar radiation in connexion with the crops, as perhaps the most important of all to the agriculturist and the meteorologist. I mentioned in my evidence two years ago that Lord Tweeddale had established an apparatus for registering every 10 minutes the pressure, the temperature, and the humidity of the atmosphere, and the rain, specially designed with reference to the relation of solar radiation to the growing crops. These interesting and valuable observations have not yet been discussed. They would be more interesting if we had several such apparatuses in other districts whose climates differ materially from that of Yester in East Lothian where they are placed. In connexion with the subject the Council have instituted other lines of research affecting agriculture. The question of integrating the amount of solar heat is a very important one. It is not pretended to arrive at absolute results, but what the council aim at are comparative results from similar instruments used in different situations. It is done by means of an instrument devised by Mr. Stevenson consisting of a glass ball with a long neck, in which there is a provision for setting the height of the fluid to a particular level, and the out-flow of water during the day is measured, it being filled at 9 in the morning, and then observed at 3 or 4 in the afternoon. It is tentative, but we hope that it will enable us to arrive at what differences there may be in the climates of different parts of Scotland. We know, for instance, that certain crops and fruits can be reared about 700 feet higher on Deeside than they can on any part of the west of Scotland. Oats are reared 1,600 feet above the sea in Deeside and Donside, about Braemar and Strathdon, but at heights in the west several 100 feet lower they are only grown for the sake of the straw. We wish to arrive at what is the cause of this.

The Society undertook some observations in connexion with ozone by means of aspirators. The expense of those aspirators was borne by Lord Tweeddale. A number of other inquiries regarding ozone were suggested, and his lordship recently gave the Society 100*l.* to work out this subject, and this winter, through the Ozone Committee, Professor Andrews of Belfast, delivered an address upon the subject to the Royal Society of Edinburgh. This address is being published in the Society's *Journal*, and the expense connected therewith is defrayed by his lordship. The inquiry is in progress, but so far as this subject is concerned we have the funds to meet all that we require through his lordship.

14,319. Apparently without his assistance a great many of those inquiries could not have been undertaken?—No, we could not have undertaken some of the most valuable work that we have done. The definite conclusions which we have arrived at, for instance, the conclusion with reference to the temperature required for crops I think has influenced considerably the practice of agriculture. Of course, other influences, such as the price of butchers'-meat, have been at work, but the farmers know well that the temperature of the North of Scotland is within 2°·5 or 2°·0 of what is essentially requisite to ripen those crops, and they know that a very little below the average means disaster.

In the evidence which I last submitted to the Commission, I stated that we often supplied information to foreign meteorologists, and that we did this so far as we could, but that it threw a great deal of work upon the Office; since then the American Government, through General Myer, who has charge of the Meteorology of the United States, has proposed a scheme of International Meteorology, by which observations over the northern hemisphere or over the whole globe are to be made exactly at the same instant of time, and our co-operation was asked. We supply them with observations from 14 of our stations, and it is very desirable that we had some more assistance to enable us to help in this inquiry. What the Society would wish to do in connexion with their daily observations is to have the means of publishing a selection from them for distribution amongst foreign meteorologists, just as we receive from these foreign meteorologists, the published observations which their governments enable them to publish.

14,320. (*Dr. Sharpey.*) What would be the expense of that?—I should think about 50*l.* or 60*l.* It would depend entirely upon the number of stations embraced. Many of our stations are in such important positions that we are constantly being asked for copies of the observations. As respects Meteorological Congresses, our Society was enabled to take part in them through the liberality of individual members of the council. We were invited to them; but as the society had no funds for the purpose, individual members of the council contributed, and sent me both to the Conference at Leipzic and to the Congress at Vienna. It is most desirable that the Society were in a position to take part in any such congresses as may be held in the future. I may also mention that the Society has since its origin supplied to the Registrar General for Scotland observations from 55 stations, and up to this time we have received no pay for this work.

14,321. What is the nature of the information which you supply to the Registrar General?—Observations of the barometer, maximum and minimum thermometers, wet and dry bulb thermometers, wind direction and force, rainfall, clouds, temperature of the sea, temperature of wells, ozone, &c.

14,322. (*Chairman.*) Do you know whether it is much of the same nature as the information which is supplied to the Registrar General of England through Mr. Glaisher?—Of much the same nature.

14,323. Are those reduced returns made quarterly, or how?—Weekly and monthly. Professor Smyth has done his part of the work more than well. He has gone *con amore* into it, and done it in a much fuller manner than was required by the agreement.

I had a conversation on meteorology generally with Professor Balfour Stewart, who explained his views to me with reference to the division of meteorology into what he calls Physical and Climatic Meteorology. I communicated the result of the conversation to Lord Tweeddale, and his lordship wrote to me, strongly approving of the view of dividing meteorology into physical and practical or climatic, so that purely physical inquiries are remitted to large, well equipped observatories, such as Greenwich or Kew, and observations of meteorology which bear upon health, agriculture, commerce and other interests to societies such as ours. This division of the subject has special reference to the purposes to which the grants from Government are to be applied by the different bodies. A good deal of the evidence which I have given to-day regarding local climates, the influence of the sea, and of exposure, the relation of different meteorological conditions to the herring question, and the question of storm stations come under the head of practical or climatic meteorology, and can only be effectively worked out by a society that has great local knowledge and influence.

Among questions of a general character, I think one of the most important and imperative is that of solar physics, particularly the observation of sun-spots. We know now, especially from Mr. Meldrum, Mr. Lockyer, and others, that the rainfall of the tropics, and generally of the whole globe, is connected with the sun-spot period. Professor Balfour Stewart stated to me that during the maximum sun-spot period the actinic rays of the sun were feeblest. If this opinion be correct, its bearing on questions affecting health and mortality is evident.

About 10 years ago Professor Poey made a series of valuable observations in Cuba, on the temperature of the sky at different angles from the horizon by means of the thermo-electric pile, and obtained some remarkable results, showing that it was much greater at certain heights than at others. The relation of these results to the whole question of terrestrial radiation is of the greatest importance, and if we had exact and fuller information upon this subject from British and other observatories it would tend greatly to the solution of many questions con-

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nected with terrestrial radiation. He also examined the temperature of clouds of different species and at different heights, and found that the cirrus cloud was the coldest, and that the cumulus, except in certain conditions, was the warmest—thus opening up a line of inquiry which properly falls to be worked out by a physical observatory established for the prosecution of meteorological inquiries.

Our information regarding the vapour of the atmosphere as a radiant and absorbent of heat is very defective, and extensive experiments and observations connected therewith are urgently called for. At present observations on atmospheric vapour are almost universally made by wet and dry bulb thermometers, and the results arrived at regarding the dew-point, the amount of vapour in the atmosphere, relative humidity, &c., are in this country deduced from Glaisher's tables. Now these and all such tables are in an unsatisfactory condition. For Great Britain, with the usual temperature and states of the atmosphere, the tables are fairly good, but in spring in cases of great heat and great drought, the errors are considerable. As regards such hot climates as north-western India, if hygrometric observations made there be reduced by Glaisher's tables, and also by formulæ in accordance with the results obtained by Regnault's recent researches, we obtain from observations of the same air two dew points, which may differ to the extent of 25°·0 from each other. Such being the present state of our hygrometrical tables, it is plain that meteorologists are not in a position to investigate with the requisite accuracy this important element of the atmosphere upon which the whole problem of meteorology turns. It is by the vapour of the atmosphere chiefly that the equilibrium of the atmosphere is disturbed, and it is by the concentration of aqueous vapour over some limited region that hurricanes and storms in all probability originate. Extensive observations on the dew-point with Regnault's hygrometer in connexion with the different hygrometers in use, are required, from which tables may be prepared sufficiently trustworthy and complete for the reduction of all hygrometric observations. Let it be well understood that till this be done, many of the most important problems of meteorology cannot be properly discussed.

14,324. (*Dr. Sharpey.*) To whom would you go for a solution of those questions?—The work cannot be done but at a fully equipped physical meteorological observatory, having at its head a competent scientific man who is provided with funds by the State for carrying on the extensive observations required.

14,325. Then, if I understand you rightly, you would assign to a central establishment engaged in researches in physical meteorology, the determination of those points that you speak of as to the proper methods of inquiry respecting the atmospheric moisture and the like, which might afterwards be applied by local establishments?—Quite so.

14,326. So that physical observatories would supply methods for the work of climatic meteorology?—Yes, and supply us with the requisite instruments for the purpose,—using the word instruments in its broadest sense, as including tables, and so on. I think also that it is most desirable to investigate questions of radiation and absorption through the pure gases of the atmosphere as well as aqueous vapour. As regards anemometers, I believe I am correct in saying that we have at present no velocity anemometer (Robinson's, for instance) whose indications we can value, feeling assured that they are correct, and give truly comparable indications, and which when erected at a station admits of its error being at any time ascertained. This state of things ought to be rectified; and can only be rectified by a properly appointed physical meteorological observatory. When the indications of a pressure anemometer are examined, it is seen that the wind is far from being a steady blowing current, it oscillates from a pressure of, say, 20lbs., to a pressure of 40lbs. almost instantaneously. During storms the chief feature of the wind is its gusty character, and the strength of these sudden gusts no velocity anemometer can measure. Now it is the force of these gusts regarding which correct information is most sought after by seamen, engineers, &c. No observatory that attempts to record wind observations can be considered as completely equipped unless it has a pressure anemometer which can be compared and verified, and its error ascertained at any time. Another important question is the determining of the conditions of a good position for an anemometer, so that the indications will give a tolerable approximation to the real direction and force of the wind over the place. The influence of the land in deflecting the wind from its true course is very remarkable, the deflection from its normal direction amounting in some cases to fully 90 degrees as it rounds the ridge of a hill or is deflected by the contour of the land. Thus at Liverpool the general direction of the wind is west-north-west, instead of west-south-west, the general direction of the wind in that part of Great Britain. With regard to the dragging effect of the land and other objects on the wind, if a wire screen with meshes an inch apart be placed against a wind, flower pots placed on the lee side of it during a storm are in calm. From this it will be easily understood that the velocity of the wind is enormously different at different heights above the ground. The rate of increase in the velocity as we ascend from the ground we are absolutely ignorant of, so that it is at present impossible to attempt, by means of any anemometric observations, to arrive at an approximate indication of the true velocity of the wind over any place. What is imperatively required is experiments by a series of anemometers placed at different heights in the same place, in order to ascertain the dragging effect exercised by the earth's surface upon the wind,—an inquiry that can only be satisfactorily carried out by a physical observatory, owing to the expense. We cannot at present, from any wind observations that have yet been made, draw any conclusions regarding the general rate of movement of the atmosphere. Conclusions of tolerable correctness can only be drawn as regards direction, and no more can be attempted owing to our ignorance with reference to this important question.

Our Society has worked a good deal at the question of the temperature of the soil at depths of 3, 12, and 22 inches. Our thermometers are fixed in the ground. Continental meteorologists use Lamont's method of observing earth temperatures, which consists of a wooden tube, down which the thermometer is sunk, and up which it is drawn when an observation is made, at all depths exceeding 3 inches. A series of experiments in connexion with this subject are called for in order to ascertain the value of each of these methods of observations.

Another important question is the true observation of the air temperature. We are not now in a position to say that any temperature observed by the methods in present use is the true temperature of the air at the time of observation. How to eliminate the effects of radiation of surrounding objects from the temperature observations is one of the most important questions of physical inquiry. It will be necessary that boxes for the thermometers of all sorts as regards material, size, and pattern, be erected, in exactly similar positions, in which temperature observations may be made, and compared with observations made at the same time by Joule's method of observing the true temperature of the air* at all hours of the day and in all seasons of the year, for a series of years. From the results so obtained we should be in a position to say what sort of thermometer box is the best for giving an approximation to the true temperature of the air, and is easily observed with at stations of the second order. In Russia, Switzerland, and some other countries, zinc boxes are used because they are believed to follow more closely the fluctuations of the temperature of the atmosphere. In this country wooden boxes are

* Described by Dr. Joule in a communication to the Philosophical Society of Manchester, 26th Nov. 1867.

used. The Glaisher stand is open to the north, the stand used by our Society is louvre boarded all round; some again have louvre boards on the bottom of the box, some have not, and so on. In Scotland we have from the beginning attempted to secure uniformity in the methods of observation at all our stations; we have insisted upon this in order that the observations at the different stations may be comparable *inter se*, which is all that can at present be secured.

Another important question is that of evaporation, which concerns the drying qualities of the air, and which is so important in connexion with health, and with all questions affecting animal and vegetable life. A little has been done in this direction, but we are still far from being in possession of instruments that give comparable results. The question is one for physical observers to examine and inquire into by means of observations and experiments extending probably over some years.

The extreme desirableness of regularly observing the electricity of the atmosphere has been frequently under consideration by the members of our council, but nothing has been done owing to the great expense attending such inquiries. The subject is so important in many inquiries (with the herring question, for instance, it has a remarkable connexion), that it should be taken up by a physical observatory, with a view of devising some inquiry that could be turned to account at secondary stations.

Another duty of those physical observatories would be to institute observations by which an exact value could be put upon observations like those made at such stations as ours. That could be done by apparatus exactly similar to ours being established in close proximity to the instruments at the physical observatories; in this way much might be done in valuing observations of temperature, humidity, wind, and rain.

There is another matter which our Society has done a good deal in forwarding, and which was recommended to be carried out as far as possible by the late Congress at Vienna, namely, establishing stations in foreign countries, at places of great importance, where there is no likelihood of any local means being taken to establish stations. We have established stations in the Faroe Isles, in Iceland, at Jerusalem, in Cyprus, at Damascus, Beyrout, in Yanina, Nice, Pau, and also in Brazil. At the time that we established those stations there were none in those places or near them. The instruments were supplied to these stations not from the funds of the Society, but through special contributions or otherwise.

14,327. (*Chairman.*) Are you acquainted generally with the operations carried on under the direction of the Meteorological Committee?—Yes, generally.

14,328. Are you prepared to express an opinion as to the value of what has been done under its direction?—I think the barometric observations possess great value; taken all in all they are the fullest that we have.

14,329. Is that work which otherwise would not have been accomplished if the Government had not provided the means for carrying on those observations?—It scarcely could have been accomplished in so complete a manner. Lord Tweeddale has observations of pressure made every 10 minutes by means of a self-recording instrument. Abroad, the observations of pressure are generally made by means of an aneroid barometer, which is self-recording, at stated intervals such as every hour, alongside which there is a standard barometer which is read several times each day, and the readings of the aneroid are corrected by means of these eye observations. That is not so satisfactory a method, but it is cheaper.

14,330. At how many stations are the barometric observations carried on?—There are seven in the United Kingdom, three in England, two in Scotland, and two in Ireland.

14,331. (*Professor Smith.*) Are they all self-registering?—They are all self-registering by means of photography, and they may be considered as self-registering every three minutes, that is to say, the breadth of the line of light is such that it takes about three minutes to pass, so that if we were to suppose a fluctuation extending over a minute it would not be recorded. The wind observations I consider also to be good, qualifying the statement by what I have already said about the present state and position of anemometers. The temperature and hygrometric observations are, so far as the instruments themselves are concerned, good. They show great skill in the devising of the apparatus, but as regards the position of the instruments they are bad. It was essential, in such a system, to place the instruments in positions at each observatory, perfectly comparable with those at the others—comparable both as regards height above the ground, and comparable as regards the buildings to which they were attached. In neither of these points have the conditions been attended to. At Armagh the height is 4 feet above the ground, at Aberdeen it is 41 feet, and the result is that at Aberdeen the daily range of temperature as recorded by the thermometers at a height of 41 feet above the ground is only about two thirds of the amount of the range of the district. That is to say, the thermometer of the Meteorological Committee records a range, speaking roughly, of 10°·0 instead of 15°·0. One of the objects, if not the chief object, of establishing those stations was to give thermometric constants. Now, it is plain that the constants deduced from the observations made by the thermometers of the Meteorological Committee are of no use for our stations, inasmuch as the daily range falls short of the true range of the locality by, in the case of Aberdeen, one third of the whole amount. That I take to be the mistake made in the arrangements at those stations, especially of the station at Aberdeen.

14,332. Has the choice of position been left entirely to the observer at each station?—I do not know. But I should scarcely think so. Of course the Meteorological Committee are responsible for the position adopted.

14,333. Do you know whether this point to which you have alluded has been overlooked by the Meteorological Committee?—It must, I presume, have been overlooked at the time of founding the stations.

14,334. Do you not think that their attention has been called to it, and that they do not consider it of sufficient importance?—I believe they have been aware of it for about three years at least, but no change, so far as I am aware, has yet been made. We have not specific information as to the positions of the thermometers at their telegraphic stations, which are more numerous. They have not published a description of the positions of the thermometers, but it is believed that the arrangements are in some cases faulty, and that uniformity is not attended to; and they have not yet published a single monthly temperature average from any one of those stations. Under the management of the Meteorological Office previous to 1867, many of the thermometers at the telegraphic stations were in bad positions. However, in this, as in some other countries, the exigencies of the telegraphic stations may sometimes render the choice of good positions for the thermometers and the rain gauge difficult. It need scarcely be added that results obtained from instruments placed under different conditions are unsuited for inquiries into the relations of weather to health, agriculture, and other public interests where comparability is the first requisite.

14,335. (*Chairman.*) Are there any other points connected with the operations of the Meteorological Committee to which you would like to call attention, for instance, have you referred to their financial statements?—Yes, I have necessarily had my attention in some measure directed to this point.

14,336. Do you consider that the country gets good results from the 10,000*l.* that is expended?—That adequate value is got is, I think, doubtful. The 10,000*l.* might perhaps be spent in ways that would promote meteorology more effectually.

14,337. Is there any particular point upon which you would wish to make any remark as to the details

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of the expenditure?—I am not sure whether it has been put in evidence by our Society, that during the management by Admiral FitzRoy we were in a very good position for receiving from the Government any instruments we might require, but on the accession of the present Committee we were informed that no more could be given to us on loan, or in any other way.

14,338. By far the largest item in the whole of the expenditure is the expenses at observatories, 2,613*l.*; have you formed any opinion upon that item of expenditure?—The details are not given in the annual reports.

14,339. Are you able to conjecture how the expenditure arises?—There is a skilled photographer required, and I believe the hourly observations are converted into figures at the observatory, from the curves of each day. I suppose that the chief expense consists in remunerating the gentleman at the head of each observatory, who is required to find a photographer and computer. It is a question for consideration how far eye observations, which would cost less, might not furnish the information required. I refer to eye observations such as those that were made for the Russian Government by Kupfer, or those now made at many foreign observatories in connexion with less expensive self-recording instruments.

14,340. Would it in all probability be much less costly?—I think so.

14,341. Is there any branch of their operations, the advantage of which appears to you to be questionable?—I should be inclined to agree in the main with Professor Balfour Stewart, that their attention should be chiefly given to physical researches in connexion with meteorology, and that the investigation of the science in its bearings on health, agriculture, and other practical matters such as those I have already referred to, should be remitted to such societies as ours. If, in prosecuting the practical inquiries which can best be done by societies, there be a tendency on the part of the Office to draft in amongst their observers the observers of other societies, the result would certainly be, if allowed to go on, to extinguish these societies. When observers work for private societies, the work is done cheaply, but when they work for the Government and know that the Government cannot do without their services, it comes naturally to be a matter of considerable expense. It is a question for consideration how far maritime meteorology should be included in the same office as land meteorology.

14,342. Could it in your opinion be possibly undertaken by private societies?—No, it could not be undertaken by private societies, it must be by a Government office. It is a question as to whether it should be undertaken by a distinct office jointly under the Board of Trade and Admiralty

14,343. (*Mr. Samuelson.*) How does that question arise in your mind? What gave rise to that question?—The question was discussed at the Congresses at Leipzic and Vienna. At Leipzic the opinion was expressed that there should be either a separate office for marine observations, or that in the central meteorological office there should be a separate department with a separate head; and at Vienna that marine meteorology might be placed under the general management of the chief Establishment of the country. The question is an important one, but at the same time one of considerable difficulty, the object desired being to enlist to a greater extent than hitherto the services of the Navy, since many questions of ocean meteorology can only be adequately carried out by the Navy. One of the most important practical questions in connexion with ocean meteorology is the determining of constants for the ocean, undoubtedly the most important of which are the daily range of atmospheric pressure over the sea, and the daily range of the temperature of the air resting on the sea. Those are most important questions, and, until we have some approximate solution of them we cannot properly discuss ocean statistics, inasmuch as the observations are made at hours which do not give the mean pressure, temperature, and humidity of the day. And, moreover, since in most cases the observations from which ocean charts must be drawn are so very few, it is clear that until we are able to apply approximate constants, the results obtained will be unsatisfactory. The organising of a system of hourly observations could be carried out more systematically and completely by the Navy than by mercantile vessels.

14,344. (*Chairman.*) Would it be necessary for this purpose to equip and send out certain vessels expressly for the purpose, or do you contemplate it as part of their ordinary duties?—Part of their ordinary duties. I may mention that Professor Wyville Thomson consulted us about sea observations in connexion with the *Challenger*, and the result was that he organised a system of meteorological observations that will partly meet what has been suggested.

14,345. If the views of Dr. Balfour Stewart, in which you have expressed your concurrence were adopted, would any considerable proportion of what is now expended under the head of land meteorology be abandoned by the Meteorological Committee?—There might be a saving as regards inspection of stations, if suitable arrangements could be entered into by the different offices, and probably, also, as regards computation. The work of the Meteorological Office might be re-organised, so that the observations of land meteorology would probably be conducted on a less expensive system.

14,346. Altogether there is nearly 2,330*l.* expended in computations?—Yes, the computations occur thrice in the accounts, under land and ocean meteorology; and the sum appears to be large.

14,347. (*Professor Smith.*) Have any researches in physical meteorology of the kind to which you have been referring been undertaken by the Meteorological Committee?—I am not aware of any.

14,348. Do you know of any improvements in the means of observation or in meteorological instruments that have originated with them?—Yes. I believe they have originated improvements in the system of continuous observations by the photographic process, and in the instrument for recording the rainfall.

14,349. (*Mr. Samuelson.*) Assuming that more were done by the Navy in the way of meteorological observations, would not it still be desirable that the schemes of observations should be settled by the Meteorological Committee, and that the results should be referred to them?—I suppose that would be desirable, but the question is who should control the system.

14,350. You mean whether the Navy would be allowed to accept directions from the Meteorological Department?—That is the practical difficulty, the difficulty of the two departments working harmoniously, and it is to secure the active co-operation both of the Navy and Mercantile services that the question, as to whether there should be two distinct offices, becomes a matter for consideration.

14,351. You have upwards of 100 stations, have you not?—Yes.

14,352. I think you stated in your previous evidence that you did not give any subsidies to these stations? We have never done so. I believe that a few of our members, chiefly landed proprietors, have done so.

14,353. The gentlemen who make those contributions are members, are they not, of your Society?—In all cases.

14,354. What means have you of ascertaining that the regulations which you have laid down in regard to the system upon which the observations should be conducted are carried out?—Partly by inspection, which owing to the want of funds is far from being so efficient as we should wish, and by repeated examination of the schedules. Occasionally members of council, when they are in different parts of the country where the observers are, visit the stations and report regarding the instruments and the method of observing. We feel strongly the want of adequate inspection. As stated in my last evidence (under Qu. 12,394), various

things are done by personal investigation to make up for what we have always admitted to be an inadequately performed part of the Society's work, owing to the expense. Dr. Arthur Mitchell and Mr. Robert Tennant and others of the council have visited several times a number of the outlying stations.

14,355. Have they made any report to you officially, or otherwise?—Yes, they have made reports both written and oral.

14,356. What has been the general result of those reports?—That generally the instruments were correct. From the means taken to check the returns by the construction of charts, serious errors are detected and rectified.

14,357. The error would be obvious?—Yes.

14,358. Supposing that these observations were conducted by a Government department at a much smaller number of stations (say, for the sake of argument, 20 stations instead of 100), do you suppose that the inspection could be conducted without expense?—It could not. It is necessary to take a mercurial barometer (an aneroid being insufficient), standard thermometers, and instruments for comparing rain gauges. A good deal of time is required, say from three to five hours at each station.

14,359. If it were stated by the department that they had a sufficient staff of computers in their office, and that, therefore, no expense would be incurred by their assuming those observations, you would say that they had only looked at one side of the question?—Yes.

14,360. Assuming that the Government department were to state that they could take over the climatic observations, and that they could do so without expense, because they had a staff of computers in the house to whom they would make no extra payment, would you consider that that would be meeting the whole question?—It is a mistake in various ways. If the computation be done without charge, it could only be by other departments of the work of the office suffering. Besides, 20 stations are altogether inadequate. I have given evidence to-day with regard to prosecuting many important meteorological questions of a national character, for which our 100 stations are too few. We not unfrequently find that in attempting to investigate important points which rise up, we have too few stations. I have already expressed my opinion that returns from the telegraphic stations of the Meteorological Office are not generally suited for the requirements of the Registrar General and other public interests. (See Qu. 14,334.)

14,361. That is to say, that observations at a great number of different stations are essential, and that inspection is required at all those stations?—Yes, at all the stations.

14,362. And that inspection could not be carried on without some expense in addition to the expense of the mere office work at head-quarters?—It is quite impossible. One, or certainly not more than two stations a day could be overtaken, owing to the tedious work of comparing instruments carefully. It takes from three to five hours at each station, which with travelling is a good day's work. Inspection means not only comparing instruments, but spending some hours with the observer, inasmuch as in not a few cases he requires further education, and the inspector requires to know what value he puts upon various phenomena, so that there may be comparability among the observations of the different observers.

14,363. How often would you say that each station ought to be visited by an inspector?—At any rate every two years, but if possible every year.

14,364. Does it occur frequently that people get tired of the work of observation, and a change takes place in the observer?—Only in the case of a few of those who have had the work imposed upon them, not from any liking to it, but because their employer required them to do it. In almost all cases the interest of the observer in the work increases, and frequently he undertakes additional observations. Indeed we have every year to refuse a considerable number of applications from persons who express their readiness to observe, provided they are furnished with the requisite instruments.

14,365. Assuming that it is desirable that there should be a certain department for meteorology, what should you say would be the most desirable control for that department? Would you put it under a single head, or under an unpaid committee with a director or an equivalent officer?—Under a paid Committee with a secretary, nominated by the Government and consisting of men who possess the requisite knowledge of the subject, the Committee being, in some respects, similar to a Royal Commission. My opinion is that an unpaid committee is not a suitable body.

14,366. You mean that you want to have a Royal Commission for Meteorology alone?—Perhaps I have not expressed my meaning clearly. I mean that whatever committee is appointed, its members should be paid according to attendance, in the same way, for instance, as bank directors are paid, and therefore feel their responsibility.

14,367. But would you have that paid committee a committee for meteorology alone?—Yes, for meteorology alone. Perhaps the word committee scarcely discloses what I mean; it would more correctly be expressed if I used the phrase a Body of Directors appointed by the Government.

14,368. Would you prefer that to having a single head?—The business of the Scottish Meteorological Society has been conducted very satisfactorily by a council elected from the members; it must, however, be added that the members of council are elected because it is known that they are specially interested in the subject. But the central office for meteorology, which would be wholly, and necessarily liberally supported by the State, should be placed under a Minister of Public Instruction, who would be responsible to the Government for the department.

14,369. In that case would you prefer a Commission or a single head under the Minister of Public Instruction?—Owing to the local knowledge and influence which is so necessary in conducting the work of societies, I should prefer a Council for them, but for the Central Department I am of opinion that it should be placed under a paid body of Directors appointed by and responsible to a Minister of Public Instruction, or the Board of Trade.

14,370. Do you not think that a divided responsibility of the members of a committee or a commission, whether paid or unpaid, is in some respects an evil?—That is a question on which I have some difficulty in expressing an opinion. If I mistake not, it is only in some respects that it is an evil. In the conducting of scientific societies and commercial undertakings, experience leads to the adoption of such a machinery as I indicate. A paid small committee representing physical and practical meterology would be invaluable as responsible advisers to the secretary, whose responsibility, his position, and scientific reputation sufficiently secures.

14,371. But not being certain of that, you would prefer a single head, if you could be certain of obtaining a person thoroughly qualified for the post?—Yes, if such were obtained. But the scheme I recommend would, I think, be safer.

14,372. (*Chairman.*) Are there any other matters upon which you would like to add to your evidence?—No; I am not aware of any.

14,373. In your answer to Mr. Samuelson, just now, I understood you to say that if you discontinued making the returns that you now make to the Astronomer Royal for Scotland, and if the Meteorological Committee took upon themselves to obtain those returns, you think that they could not be obtained without putting the country to considerable expense?—I believe not. Besides, the Scottish Society has a proprietary right in the stations which it has established at so much expense and labour, and with these stations the Meteorological Committee cannot interfere, an arrangement to that effect having been entered into last year between the two bodies with the concurrence of the Government. Our Society is perfectly

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distinct from them, and they are distinct from us. The Meteorological Committee would therefore require to be at considerable expense in founding new stations, and in paying the observers, who could not be expected to observe gratuitously for a Government office.

14,374. Are you in frequent communication with the Meteorological Committee?—We have occasional, not frequent correspondence with the Committee.

14,375. Can you explain what you mean by the sum invested by the Meteorological Society of Scotland?—Large sums of money have been sunk by the Society in establishing the stations, in purchasing instruments, furniture, books, schedules, &c., and otherwise in founding the Society, which possesses upwards of 100 stations, and consists of 560 members, of whom, it is to be observed, 97 are life members, and therefore have a pecuniary interest in the continuance of the society. With regard to 20 stations being sufficient, 70 stations, well distributed, at least, are necessary to represent the general climatic condition of Scotland, not taking into account storm stations, stations for investigating the influence of the sea on the climate, the causes which result in local climates, and such questions as I have brought before the Commission to-day. In this opinion the Registrar General for Scotland concurs, he having considered, in the application to Government some years ago for funds to meet the expense of 17 new stations, that 72 stations were necessary for the purposes of his office.

14,376. (*Mr. Samuelson.*) Are you aware what number of stations are under the Registrar General of England?—I understand there are 47.

14,377. Is there any reason why the number of stations relatively to the area should be greater in Scotland than in England?—Yes. The physical conditions and climate of Scotland are much more varied, and its geographical position with respect to atmospheric pressure, temperature, winds, ocean currents, and other points affecting the meteorology of north-western Europe, is so important, that supposing England represented by 60 stations, Scotland with its adjoining islands would require at least 100 stations to be as well represented. Besides, different parts of England are still in many points very imperfectly represented. Wales, for instance, which is so very important in connexion with the meteorology of the British Isles, has only one station on the whole of its west slope. Then, excepting the station at Gloucester, the whole valley of the Severn is unrepresented.

14,378. Is it the case in Scotland that the stations have been established upon any scientific system?—We have endeavoured to establish our stations on a scientific system, and this has been done so far as our circumstances rendered it possible.

14,379. The possibility of finding observers, for instance?—Yes, the possibility of finding observers in suitable localities; we have, however, repeatedly refused applications because it was considered the stations already in the district were sufficient. One point that we have given a great deal of attention to is local climate; for the purpose of investigating which, we have been induced to establish perhaps more special stations than otherwise we should have done. It is known, for instance, that the country to the west of the Spey has a vegetation totally distinct from that on the east side of the river, showing two climates very different from each other in many respects, a difference which is impressed upon the whole vegetation and agricultural produce of the two districts. It would be an extremely important problem to determine by statistics the meteorological differences between the two districts.

14,380. To know how much is due to the climate?—Yes. The temperature of the north-west part of Aberdeenshire is certainly different in several respects from that of any other part of Scotland, and the growth of trees is also markedly different.

The witness withdrew.

Adjourned to Tuesday next at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Tuesday, 5th May 1874.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

The Most Honble. the Marquess of LANSDOWNE.	THOMAS HENRY HUXLEY, Esq., LL.D., Sec. R.S.
BERNHARD SAMUELSON, Esq., M.P.	HENRY JOHN STEPHEN SMITH, Esq., M.A., LL.D., F.R.S.
WILLIAM SHARPEY, Esq., M.D., F.R.S.	

R. H. Scott, Esq., M.A., F.R.S.

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ROBERT H. SCOTT, Esq., M.A., F.R.S., further examined.

14,381. (*Chairman.*) Have you a large stock of instruments at the Meteorological Office?—Yes, a very considerable stock; the amount is given in each of the annual reports. We have a large stock for the Navy, and a considerable number for the Mercantile Marine. We have to keep a sufficient stock to keep the Navy continually supplied, and the actual value of this may be some 3,000*l.* or 4,000*l.*, speaking generally.

14,382. Are a considerable number of new instruments required every year?—A considerable number are damaged on service, and we do all that we possibly can to repair instruments, and do not purchase entirely new ones if we can make the old ones do, *i.e.*, if they can be repaired satisfactorily.

14,383. Are your instruments employed for any other purposes besides those which you have already referred to?—They are solely used in the service of the Office. We do not lend to private persons except in one or two cases, so that they are entirely used in the service of the Office.

14,384. Is a proper history kept of each instrument?—There is a history of the varying service which each instrument has been engaged on, and the number of times that it has been verified. Those particulars are all kept in books, so that we can trace all the instruments which have ever been in the Office.

14,385. Do you refer to each particular instrument?—Yes, each individual instrument. I may illustrate the importance of this by saying that recently we have had the greatest possible difficulty in tracing the instruments which Sir James Ross used in his Antarctic Voyage, because at that time there was no history of the instruments. Things have been kept since 1864 precisely as I have said. Each individual instrument is known by its distinguishing number.

14,386. What improvements have been introduced into the instruments from time to time?—We have found that the instrument makers can make their instruments with much more accuracy, and they make better instruments than they did before the Office commenced to work, and this has tended to the gradual introduction of a better class of instruments for general use. The first thing which the Office did under Admiral FitzRoy was to request the Kew Committee of the British Association to devise barometers, thermometers, and hydrometers for use on

shipboard; the barometer has since been introduced in certain Foreign Navies, and it is called the Kew marine barometer. Then there have been also special barometers made, at Admiral FitzRoy's suggestion, for use on board ships of war, because the firing of heavy guns will break ordinary barometers, and these "gun barometers" are specially fitted for use on board men of war. In all instruments every improvement which seems likely to be of value has been, at all events, tried, and if it is found satisfactory has been adopted.

14,387. Have many of those improvements of which you speak been recommended by the members of the Meteorological Committee?—Not particularly by the members of the Meteorological Committee, but some of them have been suggested by the instrument makers, and there have been suggestions from various sources. I cannot at present think of anything which has been actually suggested as an improvement since I have been connected with the Office, except the addition of a fuller vernier to the gun barometer, and the alteration of rain gauges so as to serve for collecting and recording snow, but most certainly there were improvements introduced by the Meteorological Department under Admiral Fitz-Roy in the matter of barometers, aneroids, porcelain in lieu of metal for thermometer scales, deep-sea thermometers and maximum and minimum thermometers for use in H.M.'s ships (in the chronometer rooms).

14,388. What measures are adopted as to the verifications of the instruments?—All the instruments are verified at Kew before they are received for service, and on return from service they are not re-verified at Kew, unless they have been in the hands of an instrument maker. If they have passed out of the hands of the Office into those of the instrument makers, and any alteration has been made in them, they are sent back to Kew, but if they are simply returned from the ship to us we compare them with our standards, and if they agree as well as before they went to sea they are not sent to Kew again.

14,389. Do you know whether similar care is exercised in other establishments of the same nature abroad?—I should say decidedly not. They are now commencing to use the same care, as they are applying to England for the same modes of testing the instruments. All maritime barometers, for instance, must be tested in the vacuometer to find the range of pressure, and the only vacuometers in existence, as far as I know, have been those made in England. There is one at present going out for this work to Berlin, for the Prussian Navy. But the difference between this office and all other offices with which I am acquainted is, that all the instruments from which the observations are obtained which we use in our discussions belong to the office, and we do not use observations made by private instruments, unless we have got the verifications of those instruments, and that case has not yet arisen to any great extent. Perhaps I might be allowed to amend one answer which I gave before, as to the Members of the Committee introducing alterations. Professor Miller made a suggestion about the improvement of the deep-sea thermometers; it was a re-invention of something which had been done before, but at all events it was original on his part, and that was done in the year 1869.

14,390. What has been the origin of the self-recording instruments in use at the observatories?—On a former occasion I spoke of a general conference held at the British Association meeting in 1845, and the great question there was whether or not people could agree on uniform hours of observation. As they could not do that the English representatives there, namely, Sir Edward Sabine, Sir John Herschel, and other English gentlemen who were there, determined that they would introduce a set of instruments which should be independent of the hours of observation, so that you could get continuous records; and ever since that year, 1845, the continuous records at Kew and Greenwich have been gradually perfected and brought to their present state. The chief persons who had to do with the invention of these instruments were Mr. Charles Brooke, F.R.S., and Sir Francis Ronalds, who has recently died. Several improvements have been due to Mr. Beckley the mechanician at Kew, &c.

14,391. Are the self-recording instruments found to be perfectly satisfactory at present?—Not perfectly satisfactory, for several reasons. One reason is, that the time scale is not sufficiently long. If you look at the photographic record for one day given in the First Annual Report you will see that if it could be extended over a much longer space, so as to afford, say two inches for each hour, it would be much more minute. We do not get records of sudden squalls, or any of those sort of things. The time scale only allowing 0·35 in. for each hour, it is found that anything very transient might pass without being recorded, and a lengthened time scale might be more advantageous. There are various difficulties which have only been discovered since we have had so much practice, various defects of photography, and defects as to the shrinkage of paper, &c., whilst there is also a difficulty in this process that it is only suitable for application in a well populated country, because of the difficulty of keeping up photography, &c. But these instruments seem to be, on the whole, more satisfactory than any other self-recording intruments which are at present in existence.

14,392. Are you from time to time still introducing improvements?—Yes, we are decidedly introducing gradual improvements in the management of those instruments.

14,393. Does their use entail any special precautions which may in some measure affect the observations?—In certain cases decidedly. For instance, for the thermometer it is absolutely necessary that an instrument which costs about 100*l.* should be well protected, and should be in a stable building; but the fact of having it in a building which would be safe against thieves, and against damage of various kinds, would naturally affect the perfect accuracy of the temperature, and we do not find that those thermometers give the absolute extremes of temperature; they do not give such great cold or such great heat as instruments more fairly exposed would do; but, on the whole, they act exceedingly well. A criticism has been frequently made against us that we have not built special buildings, and because we have adapted our thermometers to the floors of the different houses. At Aberdeen we could not get a floor which would do for placing the thermograph at a less distance from the ground than forty feet. We should not wish it to be more than twelve feet in any case, but as it is we cannot afford to build buildings for the thermometers, and we have to take the existing buildings and do the best we can. Similar cases have arisen in three or four instances, but especially at Falmouth and Aberdeen.

14,394. You have not erected buildings yourselves, have you, in any instance?—At Falmouth we have not erected the building, but the building that is supplied to us was erected for us. We have not erected any other buildings. At Valencia we have fitted a dwelling-house as an observatory, and at Aberdeen the Board of Works have allowed us to use a part of the buildings of King's College.

14,395. If you had to provide buildings, that would in all respects meet your wishes, would it entail considerable cost?—It would entail a considerable additional cost.

14,396. Can you mention the sort of sum that it would require to provide a building in every way fitted for the purpose?—I am not prepared to give an estimate; it is so very dependent upon the place where you have to build it, and the materials which you can build with; and the idea of building special observatories was far beyond anything that was ever contemplated. The original endeavour was to attach our observatories to existing establishments, astro-

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nomical observatories of some sort or other, and that in most cases we have succeeded in doing.

14,397. What have you at Aberdeen?—At Aberdeen we have got an existing establishment, but not an existing observatory. There is no regular astronomical observatory there; there is simply a telescope for teaching astronomy.

14,398. Do you pay rent for the use of buildings?—We do not pay rent excepting at Valencia, where the Committee have taken a house. We had to take a house and garden there; but in all other places we use existing buildings. At Falmouth the Royal Cornwall Polytechnic Society pays a special rent for the building which we have as an observatory. In all the other cases there is no rent paid.

14,399. With respect to the ocean, do you issue regular instructions for the observations?—Yes. We have slightly altered the instructions which Admiral FitzRoy issued, but we issue regular directions to observers for taking all observations.

14,400. What was the result of the Brussels Conference with respect to ocean observations?—That an abstract log for recording observations was devised by the representatives of the different nations which were represented at Brussels, and they all agreed to take observations in accordance with that log, and to issue an uniform scheme of instructions. The idea at that time was, speaking generally, that the observations were to be sent to Lieutenant Maury to America to be discussed.

14,401. Has the plan which was then adopted been generally acted upon since?—I should not like to say that it has absolutely not been acted upon, but it has hardly been acted upon at all. In fact I am at present issuing, or rather shall issue to-morrow, a circular to all the governments that were represented at Brussels, to inquire the extent to which they have acted on the resolutions of this Brussels Conference. Practically speaking, this country has been the only country that has worked really on the plan. The Dutch very soon set themselves free from the literal rules laid down at Brussels. They have worked exceedingly well at maritime meteorology since, but not exactly on the plan of the Brussels Conference. This country has adhered more closely to the Brussels Conference; as for other nations, there has been hardly any work at all done. For the United States, the operations of the Naval Observatory, which had been almost exclusively meteorological between 1851 and 1861, were re-directed to astronomy on the outbreak of the war, so that little meteorological work has been done there since. Practically the Brussels Conference led to the foundation of the Meteorological Department of the Board of Trade, and was the first attempt to establish an uniform plan of operations at sea.*

14,402. Is there at present an idea of holding a new Maritime Conference?—A sub-committee, consisting of five gentlemen, of whom I am one, has been appointed to organize such a conference, and it is intended to hold such a private conference this autumn either in London or at Utrecht, in order to see in what position we are, and whether there are sufficient grounds for summoning an official conference.*

14,403. Have you any expectation of co-operation from other countries?—Yes, of very extensive co-operation.

14,404. By whom has this committee been appointed?—By the Permanent Committee of the Vienna Congress. The gentlemen who form that committee are Professor Buys-Ballot of Holland, Professor Mohn of Norway, Captain Mouchez of France, M. Neumayer of Berlin, and myself.

14,405. How are the marine observations dealt with?—When a log comes in it is first examined very carefully, and the Marine Superintendent, Captain Toynbee, carries on a correspondence with the gentleman who kept the log, asking various questions so as to render it as complete as possible. It is then handed over for discussion, and the observations which require correction, such as the barometer for temperature, and for elevation above the sea level, are corrected for such portions of the sea as are likely to be required for any special investigation. We do not take the log and at once correct everything throughout. We simply correct the portion which we are likely to use immediately. These observations are conveyed to us in a certain form, and they are used according as they may be wanted for the investigation.

14,406. A plan was proposed by the Committee of Inquiry in 1866; has that plan been followed?—No, it was found not practicable. The plan which they proposed was that all the observations for any definite day, or any definite set of observations for definite hours, should be put upon a separate card, with the idea that those cards could then be sifted and handled so that any cards bearing upon the same subject could be thrown together. But we have found that it was better, instead of using these loose cards which we tried, to have simply a large book, with certain columns agreeing with the log. In this book, each opening corresponds to one month and to a definite small portion of the sea, one single-square degree. We find that by having the books bound they are more manageable than loose cards, and are less likely to get astray.

14,407. How is the discussion conducted?—A definite area of the sea is taken, and all the data books for it are consulted. Those books are called data books into which the extracts are made. They are then dealt with and treated in order to see what we can find out from them, and if there is a sufficiency of material they are further investigated to the most minute particulars, such as the daily march of the meteorological elements, the barometer and thermometer for that region, if there is a sufficiency of material to justify such discussions. The whole of the material in the office for that area is discussed at one time. It is not one single element that is discussed, neglecting all the rest. The material, as far as we can say so, is exhausted for that district.

14,408. Is there a difficulty in preparing accurate charts of large areas?—It is excessively difficult. To give the Commission an idea of this I might hand in a certain chart which is to be found in the Report for 1872, page 7, and you will observe the numbered squares therein: at present we have extracted the whole of the observations for those squares. For the whole area of those numbered squares there are 125,000 observations, and for the little shaded square in the centre there are 75,000 observations. If, therefore, the results for the whole area were shown on a single chart, this portion would give its weight to the whole of the results. This chart, which I have brought, will show the Commission more strikingly even than that how very limited the distribution of observations is. This is a chart (*producing the same*) which shows for a single month (February) all the observations taken in three years for the sea temperature, near the Cape of Good Hope. It shows that all the observations run in a certain stream, and in certain portions there are no observations whatever, and, therefore, if you attempt to give the mean all over the whole of this area, you entirely ignore those places where there are none at all. There is this serious difficulty in any dealing with observations, that the observations run along the tracks of ships, and you cannot get observations elsewhere.

14,409. Over how long a period do those 75,000 observations that you have just spoken of extend?—Since about the year 1856. I cannot say precisely when they first began, because there are some old logs which have been received from private sources, which date from former times. These have come in and have been used for some observations, but not for all. They have been used for wind observations, but not for the barometer. So that it is not quite easy to say exactly, but the observations began to come in about the year 1856.

14,410. For large areas do you consider that those charts that you have been able to prepare are prac-

[* See Supplementary Evidence in Appendix III., p. 6.]

tically useful?—We have hardly prepared any charts for large areas: such charts are hardly useful for sailors, because anybody who really wants a chart makes a very minute inspection. We are at present publishing monthly charts for that single-square area to which I have referred above, entirely neglecting the remainder, which we are working up subsequently. But the difficulty of publishing charts for a large area is that you necessarily neglect a great number of minor peculiarities which may make all the difference to a captain about his making his voyage or not. The large Pilot Charts of the Admiralty are for three months at a time, and for a very much larger area than one ten degrees square; but for practical sailing these can hardly be used.

14,411. To what extent are the results obtained abroad utilized by the office?—Whenever we find good charts which are capable of being reproduced at comparatively small expense we reproduce them, as, for instance, the Dutch charts of the temperature of the South Atlantic and of a portion of the North Atlantic have been reproduced, not combined with our information, but reproduced alongside of our information. A paper on the form of cyclones by Mr. Meldrum of Mauritius; a paper on the winds of the North Atlantic by Herr von Freeden of Hamburg; and a Dutch paper on the passage by the Suez Canal to the Straits of Sunda, have all been reproduced as the most important papers on maritime meteorology which have been published of late years. They are issued for English sailors and published as translations, the Committee assuming no responsibility about them excepting that they are translations.

14,412. Do you think that there is a reasonable hope of carrying out the ideas of the Committee of Inquiry as to completing the subject of ocean meteorology in 15 years?—It is perfectly impossible. We have been now seven years at work, and in that time we have thoroughly examined all the materials in the office, and have produced various results as I shall explain subsequently, but as to the special mode of inquiry proposed by the Commission in their Report we have matter prepared for the entire district shown in the chart in our Report for 1870, before referred to, but are as yet only actually publishing monthly charts for this one small square, but of course this is an exceptionally troublesome square from the mass of information in it. But the idea of the Committee of Inquiry was that large charts giving the results in a very general way should be published, whilst the Meteorological Committee have looked more for minuteness in the results which they have sought to attain.

14,413. Do you propose to deal any further with that particular square?—Not with that particular square. The whole of it will be published next month. Now we are dealing with certain squares round it; we have dealt with that square in the first instance for every single degree, and for every month. That was thought to be too cumbrous, and so we are publishing monthly charts for every two-degrees square, giving 25 sub-squares for the district, that is 10 degrees each way. The squares all round will not by any possibility bear such minute treatment as that, because there is not material enough for it. There are only one or two portions of the sea, the entrance to the Channel perhaps, and the point of the Cape of Good Hope, where we could get material enough for such a minute discussion as we have carried out. Almost every ship, that goes south of the Equator, passes through that square. She must do so, both going and returning. It is the crossing point for every track, and it is a place where there are calms and variable winds, so that the duration of the voyage in a great measure depends on the winds that are met there.

14,414. Do you consider it better to publish separate charts for each element, or to enter the whole information for a given district on one chart?—Captain Toynbee and I are of opinion (and the Committee have confirmed our decision) that it is better to publish all the information for one district at once, because the number of charts would be so enormously multiplied if the other plan were followed, and the turning over from one chart to another would be exceedingly troublesome. We find that the different subjects illustrate each other, as for instance, the way in which the surface currents are caused by the winds, all such points as these come out if you show the wind and the current on the same chart. But there is a great difference of opinion between ourselves and the Dutch, the two offices who publish the most charts at present. The Dutch publish one subject on each chart, whereas we publish the different subjects on the same chart. Our opinion is in favour of our own method, but it is a question which is not by any means decided.

14,415. Has the Dutch system any advantages in certain respects?—It is more simple undoubtedly; but I find fault with the Dutch system for the same reason that I have already mentioned to the Commission, as an objection to general charts of large area, that they will give the mean temperatures for the parallels of latitude when all the meridians of longitude are not represented in the observations.

14,416. What charts were issued by the Office when it was under Admiral FitzRoy?—He first commenced to reproduce Maury's charts in a form for English sailors. He issued a set of wind charts which were simply conversions of Maury's Pilot Charts, but gave the data graphically instead of numerically. Maury's Pilot Charts differed from his wind and current charts, as the observations in the latter had been published in the way that I have shown in the chart I have just exhibited to the Commission, by giving each of the actual observations and putting it down where it was taken. In the Pilot Charts, Maury, and Admiral FitzRoy after him, in the Board of Trade Wind Charts, threw all those observations into the middle of the square. In addition to these, Admiral FitzRoy published some special wind charts for the Black Sea immediately after the Crimean war, and commenced publishing special monthly wind charts combining his own observations with Maury's for the North Atlantic and giving also currents, temperature, magnetic variation, &c., but he only published four in the year, one in each quarter. The great difference between those wind charts and any other wind charts that have hitherto been published, excepting what we are publishing now, was this, that Admiral FitzRoy began to refer to the mean force of the wind, whilst Maury only gave the direction of the wind. There are no such things as wind charts in existence excepting those few of Admiral FitzRoy's which show the force of the wind; they usually simply give the direction.

14,417. What charts have been issued under the Meteorological Committee?—The first were the monthly charts of the surface temperature of the South Atlantic; then there were monthly charts of the meteorology of the sea near Cape Horn. There were monthly charts of the currents and surface temperature of the North Atlantic for each month for 2° half-squares, with a general current chart. The whole of those were discussed from materials collected by Admiral FitzRoy, and whenever possible we published together with our own data the most important of the Dutch results, and for the currents Maury's and Rennell's materials, so as to give everything. Daily charts of the weather in the North Atlantic for certain days in February 1870, and the time the S.S. "City of Boston" was lost were also published. The last publication has been a discussion of the work done during Sir James Ross's Antarctic Expedition, which was investigated partly with reference to the transit of Venus, and which has just appeared; and the publication is now in progress of those charts of which I have been just speaking, of this square in the middle of the Atlantic.

14,418. Have you any additions to make to what you have already stated about the 10-degrees square?—Not very much; merely that we have gone to much more minuteness than 10 degrees. The idea which was apparently originally contemplated by the Commission of Inquiry was that the mean for 10 degrees

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squares was sufficient; but we consider that there should be at least 100 means instead of one for that same district, if there be observations enough, in order to investigate the subject properly.

14,419. Have you anything to state about "Fragmentary Papers"?—Yes; this is a very important question, because the Commission of Inquiry stated their opinion at page 17, "That no original observations, no fragmentary papers on meteorology, be henceforth issued;" but it has been found necessary to work at fragmentary papers, as, for instance, at this discussion of the meteorology of the Antarctic Ocean, which is decidedly fragmentary. Moreover, we have had a special application from the Astronomer Royal to investigate the meteorology of Kerguelen Island for the month of December, so as to be ready to furnish the information to the expedition which is just sailing next month. We have also found that for certain districts there was more material than for other districts, and that it would be worth while to publish such results as we could for a district of which we knew anything, rather than wait, perhaps for a great many years, before we were able to publish results for a larger area. I may say, particularly, that besides Kerguelen Island we have published a discussion for one very small district of Vancouver Island. During the hydrographic survey of Vancouver Island a large mass of materials was collected for that district. There is practically nothing from the sea all round it, but we had some information for four or five years for that particular district, and we all thought that it was advisable to publish such results rather than to keep them locked up in the office. Some of them have been published in papers submitted to scientific societies; not all published by the office, but still the publication is admitted to be by the authority of the Office.

14,420. Did the Committee of Inquiry distinctly report that the publication of such papers was inadvisable?—They used the words which I have quoted. Admiral FitzRoy commenced by publishing fragmentary meteorological notices, and he published a paper on the meteorology of New Zealand, and observations made in various other places, in his first number, with very little attempt at discussion. We ourselves considered that a paper about Vancouver Island would be decidedly fragmentary, and therefore would be contravening the recommendation of the Committee.

14,421. Do they give any reason for their opinion with respect to fragmentary papers?—No.

14,422. They do not state that they consider that it would dissipate the attention of the Committee from more important work?—It was not a recommendation actually to the Committee, it was a recommendation to the Department. The Committee was not in existence at the time the Commission sat, but the Committee have considered that this report of the Commission might certainly be dealt with in a liberal spirit.

14,423. With respect to land work, will you describe the method of observation at the observatories?—The method is, that continuous records are taken photographically, and mechanically in the case of wind, by means of instruments at these observatories. The reading for every hour is measured at the observatory, and the curves and measurements are sent up to the central observatory to be examined, so that the observatories are simply responsible for keeping their instruments going, and for furnishing copies of the hourly readings obtained therefrom, with a simple daily journal of the weather, &c.

14,424. What are the functions of the central Observatory?—In the first place they commenced by the testing of all the instruments sent down to the observatories, and the teaching of the observers; but now its duties are to receive all the records weekly, to examine them and send them up monthly to the office in London. The whole question of the accuracy of the outlying observatories in keeping up their work and measuring their records is left by the Office to be settled between Kew and the observatories, the Office simply dealing with the subsequent discussion. If we have any question to ask about the observations, we in the first instance ask the Kew Observatory about it.

14,425. Is that the principal function of the central Observatory?—As soon as we receive a set of records which are presumed to be correct, and they have been tested and posted to us with the signature of Kew, then we proceed to deal with them. Kew is in fact simply responsible for the control of those seven observatories including itself.

14,426. Are there any other functions of the central Observatory to which you wish to call the attention of the Commission?—Nothing beyond what I have already mentioned on a former occasion as to our work of a general kind.

14,427. How are the curves reproduced for publication?—A member of the Committee, Mr. Francis Galton, has invented a certain pantagraph, by means of which the automatic record is compressed to one third of its length, leaving its height the same. This instrument has been specially invented by Mr. Galton for us. It was then further reduced by an ordinary pantagraph, made by Wagner of Berlin, and engraved on copper. The whole of the records for one day are engraved on a zinc plate by Mr. Galton's pantagraph. They are reduced one third in their length, and on page 54 of the Report of 1867 you will see a specimen of the final result which we produce. The zinc plate at its true size is represented at pages 26 and 27 of the Report for 1870. It contains the record of one day for one observatory, while the final result for all the seven observatories for five days for all the elements is shown at page 54, as I have just said.

14,428. Do you know any other mode of obtaining mean results from your photographic curves besides the numerical calculation of hourly measurements?—There is the use of this instrument, with which I do not know whether the Commission are acquainted or not—Amsler's planimeter. We have recently found that by measuring the area of a curve by means of this instrument, and then determining what the mean ordinate of that curve would be, which can be done very speedily, we can get the result for a day in about ten minutes. If we could take the means from our published plates, the economy of time would be enormous. I hope in a few days to lay a communication on this subject before the Royal Society. The amount of accuracy is exceedingly great, so that when you have got the photographic record, you can by measuring it get a result which does not differ in any case more than two or three tenths of a degree from the result obtained by taking the mean of 24 hourly observations. This instrument is very extensively used by engineers for taking out areas and taking out quantities. Mr. Francis Galton suggested that we should use it, and we have commenced to use it; it has not been authorised and we have not begun to publish such results, but preliminary investigations show that they agree nearly exactly with those obtained in the usual way; if such measurements were admissible we should hardly measure any of our tabulations at all, or give any hourly readings at all; we should only give the mean results. We should simply take the photographs and measure them off at once, but hourly readings are wanted for other purposes. It would be a prodigious saving of time if these instruments could be introduced.

14,429. (*Professor Smith.*) You would measure the area for every 24 hours?—Yes. (*The witness described the use of the planimeter.*)

14,430. Is it strictly correct, or is it an approximation?—It is as correct as it possibly can be. The person who is the best authority on the subject is Mr. F. J. Bramwell, C.E., F.R.S. The instrument can hardly be made quick enough to supply the demand for it, it is so accurate. It is the first time that it has been tried in this country on anything of this kind, but engineers use it very much. I have here the actual figures which show the amount of accuracy

which we have obtained on the first trial, and which I intend to submit to the Royal Society.

14,431. (*Chairman.*) What numerical discussions are carried out in the office?—The numerical discussions are to obtain five-day and monthly means for pressure and temperature (dry and wet bulb). Means for the wind are not yet published, as that must be discussed in a different way. We have also daily means for the elements mentioned, but those are not published. We have not been able to carry out all the original proposals made by Sir Edward Sabine in his various notes laid before the Royal Society in the 15th volume of the Proceedings, to which I have referred before. But such discussions as we are carrying out have been distinctly proposed by Sir Edward Sabine, and they have been literally carried out. They do not include at present the hourly value for each month. That will be a subsequent discussion. What I mean is that we shall calculate the mean for to-day, but we are not now calculating the 31 means at 1 o'clock for the month of May, so as to show the hourly mean for each month. That will be subsequently discussed when we arrive at the end of a certain lustrum of five years, about which I spoke on the last day.

14,432. Has any wish been expressed for the issue of more minute particulars of the curves than their mere reproduction?—We have received recently a memorial signed by about 30 gentlemen, asking that the actual hourly tabulations should be placed at their disposal. Several gentlemen have asked for such things before, but it came forward signed by several well-known gentlemen, including Dr. Joule and several others, and simply asked that everything which is furnished to us by the observatories should be given to the public, or should be accessible to the public without calling on everybody to pay for the actual copying of such information as he required. The Commission must understand that our position at present is this, that anything which is in the office, no matter whether fully discussed or partially discussed, or not discussed at all, can be obtained by anybody who chooses to pay the price of copying it, but that stipulation is absolutely prohibitory to a great number of investigators.*

14,433. What readiness has been evinced by those who ask for such information to pay for it?—Very slight indeed. 32 men signed the memorial, and only five of them have agreed to pay a subscription which would bear no proportion to the extra expense in clerks' time which they are imposing on the Office.

14,434. What sort of amount would that be?—1*l.* a year.

14,435. Do you mean that all the information that they ask for could be supplied for 1*l.* a year?—We supply daily weather charts, the subscription for which is 1*l.* a year; we look to have some subscription which would cover the cost of postage, &c. of those hourly readings, simply in order that we should recover some portion of the cost. It will throw heavy work on our clerks and cost a good deal of money; but we have only received altogether 14 subscribers for those charts, and of those only five are gentlemen who signed the memorial.

14,436. Are you producing those tables at present?—We are preparing to produce them; the forms are not ready yet, but we shall produce them as soon as possible, and issue a very limited number.

14,437. What is the special value of the reproductions of the curves?—Those reproductions of which I have spoken are for tracing the history of the weather, and showing the way in which the various phenomena pass over the several observatories. The idea which was originally contemplated when we first started was, that each meteorologist could take one of those curves and could take any reading that he wanted by measuring it off, on the side scale given on the plate, but that entailed too much labour, so that now the plan is to furnish them in addition with the actual measurements which we have taken for every hour. These continuous records are perfectly invaluable for anyone tracing the progress of weather, but for physical discussions the measurements of the curves, that is the hourly values, are also required.

14,438. Is there a want of funds for a more complete treatment of the subject of land meteorology?—A very serious want of funds. As I mentioned before, for any serious discussion like that of the hourly values for all the elements for five years we are not provided with a sufficiency of funds; in fact the amount of our staff for land meteorology would be sufficient to discuss the results for one observatory, but not for seven. It is in that sort of way that the original provision of clerks who were to discuss the work was quite insufficient, the amount of materials being so enormous.

14,439. What you would consider a complete treatment would require a very much larger expenditure?—Very much larger expenditure.

14,440. Can you at all give the Commission any idea of what would be required according to your view?—I should say that a skilled scientific calculator, and a staff of four or five clerks, would certainly be wanted, and that the expense of that could not be less than 1,000*l.* or 1,500*l.* a year. Our actual expenditure on clerks is about 2,800*l.* a year for the whole staff, of which 800*l.* is for land meteorology; but we should want much more money in order to provide for a higher class of scientific work than is at present available for land meteorology, in order to discuss everything that every one might want to determine, or even the meteorological conditions for each of our observatories, with the same degree of minuteness, not actually as is done at Greenwich, because I think that perhaps too much may be done there, but certainly on the same sort of scale as at Greenwich. Practically there is hardly any experience of the amount of work that is required in order to have such discussions, because no institution except the Radcliffe has ever attempted in this country to discuss readings for every 24 hours, excepting in the one investigation which the Astronomer Royal is now carrying out, of the photographic records of temperature for 20 years. I might say that an estimate of about 1,200*l.* a year would be the least that would be required for everything that is demanded to be carried out by us.

14,441. Will you describe the general features of the system of weather telegraphy?—There are a number of reporting stations, 29 in these islands, directly under the orders of the office, and paid by the office, and in addition we receive information from 22 foreign stations by way of exchange with the different organizations in the several countries. Our stations are all supplied with instruments by the office, and are inspected regularly, as I have already explained, and then they furnish to us those observations. Then in addition to that we have got a number of stations, nearly 130 I believe, at which signals are exhibited. In this chart, which I may produce, the red stations are the stations which report to us, and the black stations are the stations where our warnings are put up, and the crosses on the chart are our observatories. The blue ones are stations which have a partially self-recording outfit, and the red stations all over Europe are stations from which we get reports every morning.

14,442. Are the foreign stations supplied with your instruments?—No, they are supplied by their separate governments. A list of those stations is on this chart (*handing in the same*).

14,443. Does your system differ from those existing in other countries?—Very seriously. The observers are very much more under the control of the office than they are abroad. They are directly paid by us, and we are able to remove them from their meteorological duty of reporting, whereas in other countries it is the employés of the telegraphic stations who furnish the reports, that is to say the telegraphic observers.

14,444. Do you know what proportion the cost of your system bears to that of the chief Signal Office at

* [See Supplementary Evidence in Appendix III., p. 6.]

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Washington?—According to our last Annual Report the cost of our telegraphy, including the salaries of most of the clerks employed in it, was 2,762*l.*, whilst by the last Annual Report of the American Signal Office, the estimate of expenses, exclusive of salaries, is 50,000*l.* The salaries are all charged to the military vote. It should, of course, be remembered that we are dealing with very different areas. The whole system in the United States is on a totally different scale. There the telegraph is stopped for a certain portion of the time each day for the transmission of those reports, and all the post offices disseminate the information. In fact there is no comparison between the modes of carrying on the work.

14,445. Do you know whether the results obtained by the Signal Office at Washington are of very great value?—They certainly are of exceedingly high value. With such an organization as they have they can, of course, carry on much more elaborate discussions than is possible with us. General Myer has three gentlemen, one of them Professor Cleveland Abbe, formerly the head of the Cincinnati Observatory, who are his assistants, and in addition he has the chiefs of the various secondary stations through the country, so that altogether he has a great deal more scientific power available for discussion than is elsewhere the case, but that the results he obtains are exceedingly good there is no doubt.

14,446. Do you mean, strictly speaking, that all salaries are excluded, or only the salaries of the heads?—All salaries. I will read the actual words:—"For "manufacture, purchase, or repair of meteorological "and other necessary instruments, for telegraphing "reports, for expenses of storm signals announcing "probable approach and force of storms through-"out the United States, for the benefit of commerce "and agriculture, for instrument shelters, for hire, "furniture and expenses of offices maintained for pub-"lic use in cities, or post-receiving reports, for maps "and bulletins to be displayed in chambers of com-"merce and boards of trade rooms, for books and "stationery, and for incidental expenses not other-"wise provided for, 250,000 dollars." There is no provision whatever for a single salary. In fact there is no balance sheet.

14,447. You know nothing about the details of how the money is spent?—They furnish no information as to that, but I believe that the whole thing is a military organization, and the pay is all on the vote for the army.

14,448. What relations exist with foreign countries as to the exchange of information?—We receive observations from all foreign countries with which we care to be in communication; for instance, France, Holland, Norway, Sweden, Denmark, and the town of Hamburg, a regular exchange, to a certain extent, of station for station. The Norwegians send us three reports, and we send three reports every day; the Danes send us two, and the Swedes send us four, and they only get the same reports as go to Norway, but it is a system of reasonable exchange. We have an exchange with two separate organizations in France, and the French furnish us with the Spanish reports. This all refers to a daily exchange, and in addition to that we send to each other special messages in case of storms, and that means that this office sends at least 20 warnings to foreign countries for one which it receives, because we lie, so to speak, in the Atlantic. We let each other know specially when there is anything of importance to remark beyond what is shown in the regular reports, by sending special telegrams to each other.

14,449. A correspondence between the Meteorological Office and the French Ministère de la Marine was presented to the House of Commons in 1868; does that correspondence indicate closer relations between that office and your own than exist elsewhere?—It indicates most remarkably the peculiar relations which exist, because the meteorological service of the Ministère de la Marine may be said to be managed in connexion with the Meteorological Office in London. The French naval authorities will have nothing to do with their own Observatoire. The correspondence shows that they furnish us information from stations which report directly to us, and that the warnings which are issued to the coasts of France are those which are sent to Paris from the London office, and they only extend to the coast of France from Dunkerque to Nantes. Only recently the Préfet of the Fourth Arrondissement at Rochefort asked for leave to warn the coast of the Bay of Biscay, and the Ministère de la Marine, instead of asking the Observatoire if they would sanction it, wrote to ask the Meteorological Committee if they would sanction it. The duty of warning the coasts of France through the Ministère de la Marine rests with the London office, but it has been repeatedly stated to France that the Committee are only too anxious to give up this duty the instant that the French think fit to undertake it themselves. In money matters the French Government is exceedingly liberal to us, and our relations are most cordial and friendly, both with the Observatoire and with the Ministère de la Marine.

14,450. A system of synchronous observations has recently been established; will you be so good as to explain the system to the Commission?—The chief Signal Officer of the United States, General Myer, came to the Congress of Vienna, and he proposed that at all our stations synchronous observations should be taken at a definite epoch of Greenwich time, or a definite epoch of Washington time, but that each country should observe at the hour which is given by its own longitude, so that we should have absolutely simultaneous observations. For instance, the daily weather reports and observations which we deal with are taken in London at 8 o'clock, whilst they are taken at 7 o'clock, or even before that, at Stockholm. We cannot get actually observations at the same moment. Different nations, particularly the United States, ourselves, and the Russians, have agreed to undertake to furnish observations at a definite epoch of time, and those observations are all copied. I keep copies of our own, and we send copies to the United States at Washington, where they are being discussed, but this has only commenced since the beginning of this year.

14,451. You are not at present able to say how far it is likely to succeed?—It seems exceedingly likely to succeed here. We have a number of gentlemen volunteering to join; we had something like 60 men to commence with, but I do not expect that anything like that number will continue, because it involves being at home every day at a definite hour, a quarter to 1 o'clock.

14,452. Does that mean Greenwich time?—Yes, for these islands, but it is about 7 o'clock Washington time; the night hours come in the middle of the Pacific.

14,453. Are there any observers who have undertaken to observe on the ocean?—Not officially on the ocean; but there are observing stations started in the Sandwich Islands, and there are instruments at Tahiti that we might possibly get observations from, but the Chinese observations and those from Kamschatka would be taken at night.

14,454. Have any attempts of a similar nature been made previously?—The first attempt was made by Admiral FitzRoy in his very first report, for 1857. The first thing that Admiral FitzRoy stated was his wish that such observations should be collected to be used in charting the weather. Then, in the year 1861, M. Le Verrier commenced an organization for a certain amount of work, and M. Le Verrier's proposal was that France should take the Atlantic Ocean, while England should take the Indian Ocean and Russia and America should take Asia and the Pacific and America. This was hardly fair, so to speak, because the only place from which satisfactory results could be published was the Atlantic, and the French could furnish no quota of observations from the Indian Ocean or from the Pacific, whilst they would receive everything from other places. They commenced, and published for a year and nine months, for a part of

the year 1864 and for the year 1865, a book of daily charts called the "Atlas des Mouvements Généraux de l'Atmosphère," but that has been suspended; it was suspended as soon as M. Le Verrier left the Observatory. Since he has returned to the observatory they have talked about recommencing this work, but have not done anything. Then in addition to that, by carrying out to a great extent Le Verrier's idea, there are these daily charts for the Indian Ocean, of which I submit one, which have been commenced by Mr. Meldrum of the Meteorological Society of the Mauritius, which are at present in process of publication. These are produced by taking ships' logs and interpolating the observations for the hours that you require. Such are the attempts which have been made hitherto. With regard to the French, I may say that M. Le Verrier proposed a set of gold medals to be given to captains who gave the best observations, but the Meteorological Committee declined to receive any medals, because of the jealousy that might be excited. Medals were given at first, but since the Committee came into operation, although we have furnished information, we have refused to receive any medals.

14,455. Do you think that the system which is just established is more likely to be successful?—It certainly is received with a great deal more readiness than the other; it deals only in a secondary way with observations at sea.

14,456. Has support been promised to it from several different nations as well as individual observers?—It has been, in the first place, from those nations which I have named. I think almost all the civilised nations have agreed to it. All nations of any consequence were represented at Vienna excepting France, and France has given in its adhesion. Everybody has, to the extent of their power, joined, but it is not until a matter has been worked for two or three years that you see whether it has really got vitality in it.

14,457. Daily charts of weather are published by your Office, have you any remarks to make upon this subject?—The only remarks that I have to make are as regards the way in which we distribute them, and the pecuniary arrangements about the daily weather reports. We issue altogether about 530 reports every day, and of these a considerable number are supplied free to small fishing stations, at which they are exhibited for the use of the public, and a certain number of others are supplied to the chief public offices, and some are supplied free to people who give us observations, while we receive in subscriptions, at the rate of 1*l.* a year, 355*l.*, (the sum received last year); but the price at which we issue the charts, barely leaves any margin over the cost of wrappers and postage. We have an issue of upwards of 530 copies every day, and the amount that we have received is about 350*l.*, and that 350*l.*, as I say, pretty nearly covers the whole of the expense of wrappers and postage. I may also say in connexion with this that we are endeavouring to produce charts which can be published in the daily newspapers, and the process seems to be very promising.

14,458. What was the Report of the Committee of Inquiry on Admiral FitzRoy's system of warnings?—That the results were not sufficiently satisfactory. The per-centage of failures was so large that they recommended that the forecasts, by which he used to foretell the weather for three days in advance, should be entirely discontinued. The report was so far unfavourable to the practice of warnings as carried out under Admiral FitzRoy, that the Treasury, in its letter of the 30th November, recommended their discontinuance. The Royal Society first proposed not to take up the warnings, but simply to take the scientific part of the duty of the office; as they considered that the warnings were practical work, and that that was not to be taken up by them. The Treasury said, "It "appears to my Lords that if the other branches of "the Meteorological Department are to be transferred "to the Royal Society, a very strong case ought to "be made out for the utility of these warnings before "they could consent to retaining, under the superintendence of the Board of Trade, or of establishing "under some other government department, a separate staff for the mere purpose of continuing them, "and they are not disposed, with the information at "present before them, to sanction any expenditure on "that account." It was simply, as the Royal Society stated, that the report of the Commission was not favourable to the warnings, so that they declined all responsibility connected with them; and when first appointing the Committee they said that they would appoint a Committee which should not undertake storm warnings.

14,459. Were the tests that were applied on that occasion convincing to your mind?—Not at all thoroughly so. This deals with rather a difficult matter. The idea which appears to have been in the minds of the Commission was that a storm announced would be felt at every place on the coast which was warned, no matter whether that place was sheltered or not. Say a place like Scarborough; they took the reports of their man at Scarborough to know whether the warning had been justified at all or not. In fact they considered,—I might almost say they considered,—that every case of non-occurrence of a storm on any portion of the coast was a failure, whereas we consider that any case of occurrence on any portion of the coast is a success. It is a question as to the men employed to check the warnings. We found that the way in which they tested the warnings by taking the reports of the Receivers of Wreck was not satisfactory, because when we took reports from the coastguard men afterwards, who have even better opportunities of judging of the weather than Receivers of Wreck, we found that they disagreed with each other. I speak in the former case about the opinion of the Commissioners because of course I was not in the office, and had nothing whatever to do with the subject. I have since been testing my own warnings, and it has struck me that the test applied by the Commission was hardly a satisfactory test.

14,460. How far was the system appreciated by the maritime public of this country and by foreign countries?—It was very much liked in this country. There were a number of memorials sent in in 1867, praying for a restitution of the warnings. As for the French, at the very time of the publication of this unfavourable report by the Commission, the French Ministère de la Marine commissioned an old naval officer, Captain De Rostaing, to test the warnings, and he reported that they were right in 89 per cent. of the cases. He gave too favourable a report on the opposite side, so that testing with about the same amount of materials two gentlemen arrived at totally different results. But as a stronger proof of the general approval of the system, a system similar to that of Admiral FitzRoy, was established in Portugal, in Italy, and also in New South Wales, very soon after, or almost simultaneously with the temporary discontinuance of the system in England.

14,461. What was the system first established under the Committee?—They were given to understand that the grant would not be continued unless they consented to add storm warnings to the duties which they had originally undertaken. They then said that they would telegraph the fact of the existence of a storm, but they would not announce what sort of a storm it would be; they would announce in a telegram as much as they knew about it, but they would not attempt to do anything like prophesying. They used truly to say that the telegraph is the only means of obtaining information of the gale, and they cannot themselves go further than what the telegraph conveyed. This system was established at the beginning of the year 1868.

14,462. What results were obtained under that system?—The results as we have tested them have been that in 1872 about 60 per cent. of the warnings have been followed by gales, and they have been in time for gales, and about 80 per cent. have been

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followed by a change of wind which to a certain extent justified the warnings. In fact in three out of five cases the warnings of gales, and in four out of five the warnings of strong winds, have been right.

14,463. How far have the signals been tested?—They have been tested in the first instance by our continuous records of the wind at all places where we could get them, and by the telegraph reports which we get from our stations, with any other reports which we could get generally. We tried to test them by means of the coastguard, and by means of official reports, but we found that the coastguard, being in coves and sheltered places, did not know what wind was blowing at sea. Although wishing to report on it they were not in a position to do so, and as we found that one and another made records which disagreed with each other, and that in certain cases the records from lighthouses were more trustworthy, we have endeavoured to get any information we could from the coast by putting up anemometers in exposed situations and getting observations taken at coast stations.

14,464. Has that been done to a tolerably satisfactory extent. Are you satisfied with it?—We are to a certain extent satisfied with it.

14,465. Have any modifications been subsequently introduced into your system?—Recently we have almost re-introduced Admiral FitzRoy's system. We now issue announcements of the direction and the force of the wind. We use Admiral FitzRoy's signals, the drum and cone, and the only difference between our system and his is that he sometimes used to hoist a drum which said "dangerous winds from nearly opposite quarters," and did not say which wind would come first, whereas we always say which wind will come first. We never hoist the drum alone, we always give an indication of the direction first. That system has been introduced since the middle of March last, two months ago. We have obtained certain results from our experience of six years, and then we have announced our readiness to make the change.

14,466. This change, of course, was made with the consent and approval of the Meteorological Committee?—Yes, everything is done by the Meteorological Committee. In fact, as I have mentioned, everything is referred to the Committee, and the whole action is to be found on their minutes.

14,467. What action has been taken as to the publication of forecasts?—The Committee are anxious that we should announce forecasts, that is, that we should announce in the afternoon paper what weather there is going to be to-morrow. That is what Admiral FitzRoy used to do, and he used to do it for three days in advance. Ever since the beginning of December last we have been regularly issuing those forecasts to the Committee, but never issuing them to the public. In fact the actual clerk who does that work is no more desirous of publicity than I am in the matter, and we are trying whether or not we can get sufficiently good results.

14,468. Is there anything in the position of the United Kingdom which renders it peculiarly difficult to form an opinion as to coming weather for our own coasts?—Most decidedly. The fact is that we are entirely exposed to the westward. We have no stations outside us to the westward, and while I can give intelligence from our system of every storm, or at least almost every storm, that goes to Denmark, or to the coast of Germany, I can do very little for our own west coasts, because we have to wait till a storm strikes us and till we are quite certain about it. We have got a more exposed coast than anyone excepting the Norwegians. The north coast of Norway, from about the parallel of 60 degrees, in fact is more exposed than we are, but we have no possibility of getting intelligence till the storm reaches our outposts.

14,469. Is there any interruption to the service of reports?—We cannot get any observations on Sundays, or even if we did get observations, we could not re-issue them. The post office people all leave at about 10 on Sundays, and we should not be ready to issue our warnings or to telegraph our information down to the coast till about 11, and the offices are all closed on that day during a very long time. We are perfectly ready to begin the work here if we could do anything with it, but the information would necessarily lie in the office till Monday.

14,470. Is the information sufficient in quantity, quality, or frequency?—Not nearly for what we want. The United States get three observations a day. They get three telegrams of the state of the wind at three different hours, at each eight-hourly interval, and we only get one at most stations. For the afternoon report we want extra information, but that all means extra money. And in the same way as regards the quality, if we could get continuous self-recording instruments, we could get a better record of the actual movement of the mercury in the barometer at the moment of observation. When a man gets up in a morning he wants to know what has happened for the last three or four hours; that all implies additional money, and our photographic instruments will do nothing for us in that respect, because they require two days for the records to be developed. You see nothing on the paper until it is developed. You must have mechanical instruments for this purpose.

14,471. Can you point out to the Commission some of the most important requisites for an improved service?—Additional information as regards the commencement of a gale, the instant that the wind begins to rise or to change, especially the changes which occur at outlying stations, and which may not be exactly felt as soon at our telegraph reporting station. For instance, take Cape Clear, the wind might begin at Cape Clear some two hours before it reached Cork. Cork is our nearest station, as the gale might not affect Valencia if the thing commenced just down at the south of Cork. So that extra reports, of a simple character, of the wind would be exceedingly valuable. There is a plan devised by Mr. De la Rue for erecting small anemometers which shall ring bells, whenever they begin to move at a certain velocity, and we think that possibly at stations like a lighthouse, hardly at an island station, but on an outlying headland, we might at a moderately small expense get information of the actual commencement of a gale. Supposing I saw what the reports were this morning, I should know nothing more until 3 o'clock; the afternoon reports are only just beginning to come in at the present moment (2.30 p.m.), and there may be a gale which has commenced which was not serious enough for the man to send a special telegram, as he is ordered to do, but still the fact of the velocity having risen would give indications to us of what was going on. The idea would be that we might have automatic records of the wind transmitted to the telegraph stations by wire, and giving a signal there which would be very simple.

14,472. Has any suggestion been made for the more speedy receipt of information from the outposts?—A suggestion of this nature, which is that a simple telegram should be sent by wire to the central station.

14,473. Would that involve complicated telegrams?—No, not complicated; but it would involve an interference with the commercial telegrams, which is a serious difficulty.

14,474. Practically, then, it would be difficult to carry into effect?—We think it must be. At first objections would be raised; it would simply be a question of a demand for more money.

14,475. What systems are in practice abroad?—There are various systems of telegraphy; but we are hoping for uniformity. In fact, the Director of the Russian service, Professor Wild, and myself have devised by the direction of the Vienna Congress a code for such telegrams, and we hope to get it introduced, so as to get greater uniformity. At present I might say that the French stations do not report the rainfall, which we want to get. The Russians do not report certain things which we

report, from the difficulty of getting good instruments to the outlying stations in Russia.

14,476. Does the office lend barometers for public use in poor fishing villages?—A very considerable number; in fact, any place which can show that it is a port for small craft, and is poor, can get an instrument from us on condition of exhibiting it. But if a place is in any way wealthy, or if there is a wealthy landlord near it, we see what we can get him to do to put it up. There are about 300 public barometers round the coast, of which upwards of 100 belong to our office. I think every lifeboat station has a barometer from the Lifeboat Institution, not from us; but they are all the same pattern. The Duke of Northumberland also erected several on the coast of the North of England. We find that they are exceedingly liked in most cases.

14,477. Do you look after any of those barometers?—Yes, whenever I am near them; whenever I go round the coast, if I get within a mile or two of a fishery barometer station I would go to it. I would not go out of my way and take a long journey, but if a few hours would do it I should go to it.

14,478. Have they been neglected in some cases?—In some cases they have been. The Scotch ones are managed through the Fishery Board, and they look after them. In some cases we have recalled them because we found them neglected; but in most cases they are very much liked. They are mostly put up outside the Sailors' Homes or in public places where the people take a pride in them.

14,479. Do you also supply forms for registration?—Yes.

14,480. And are those made use of?—In a good number of cases they are; with most of them we supply those daily weather charts, if the people ask for them, and we supply the Barometer Manual, and various books with our instruments that we send; they are very simple publications which ordinary fishermen are likely to understand, and are sent for free distribution.

14,481. Is the subject of the weather studied to any considerable extent?—We have no funds for any thorough discussions of the history of storms and the character of storms. We have very little means for doing it. Our discussion has been simply a sort of chronicle of the weather, simply a history for two or three days of one particular storm, but not as to the origin and genesis of the storm. In fact, investigations into Atlantic weather would be the only thing which would throw a light on our own weather; but it is certainly a weak point of the office that we have not got sufficient staff to go on with it. There is a staff for the weather telegraphy and the preparation of the daily weather reports, going on from day to day, testing the accuracy of the warnings and detail work of that character.

14,482. Do you think that with a larger staff and with a larger amount of funds you could do much more in the direction of studying the weather?—Yes, undoubtedly.

14,483. Would you require additional buildings for your accommodation?—No, not additional buildings. The accommodation upon the three flats that we have in the house that we rent is sufficient. There has been one very interesting investigation into the Atlantic weather, published by Captain Toynbee, at the time that the steamer, the "City of Boston," disappeared, and most elaborate charts for eleven days have been published. We are at present collecting information to publish a similar discussion if we can of the weather during the time of the storm of last August, the great storm on the coast of Nova Scotia; but we want to see if we can get information, if the information is in existence, because everybody says that there is information in existence for the discussion of cyclones, and asks why it is not discussed. The answer that we could make to that is, that the information *is not in existence*, and that there is nothing like a sufficiency of materials.

14,484. What is your opinion as to the need of an experimental observatory?—Decidedly there is a very serious want of an experimental observatory for all sorts of experiments, such as the best mode of exposing the thermometers, the best kind of anemometers, &c.,&c. Physical experiments connected with meteorology are most seriously wanted. The experiments of that nature which are carried on are only on a limited scale. There is one set of experiments carried on, by permission of the Board of Works and Doctor Hooker, at the Pagoda in Kew Gardens, on the effect of height on the thermometers by exposing them at different heights in the different storeys of the Pagoda, and that is paid for by the Meteorological Committee. I have received a grant from the Government Grant Committee to test certain kinds of anemometers; these operations are all on a small scale, but for regular investigations on an extensive scale funds are certainly wanted.

14,485. Is anything of the kind done at Kew?—To a certain extent, but very little. The money of Kew is for definite purposes. The money from the Gassiot donation has to be expended on the keeping of continuous observations, chiefly of magnetism. Mr. Gassiot's money produces about 500*l.* a year. The money from the Meteorological Office is 650*l.* a year, which is wanted for our regular work, for the work at the central observatory. The testing of the instruments pays for itself, so that there is only a very small margin for any real experimental testing. The Kew Committee lay down the work very definitely, but if extra money is supplied the work can be done. For instance, if anyone pays for work it can be done at Kew. The Indian Grand Trigonometrical Survey have sent Captain Heaviside to test pendulums there at the expense of the Indian Government, but there are no funds at Kew for originating such things.

14,486. What is your own relation to the observatory at Kew?—I am simply the secretary to the Committee. The Committee is composed of the members of the Meteorological Committee. I simply manage their minutes, and am honorary secretary, and am not paid at all.

14,487. Practically the Committees are composed of exactly the same persons?—Yes, the same persons.

14,488. What is your opinion as to the proper functions of a central establishment for meteorology?—I think that it should discuss the materials, and present the results in such a form that physicists can deal with them, but that it should not itself aim at arriving at anything but mean results; that it should not commence investigations into theoretical subjects, because that is the real difficulty. It is very difficult for an office which is responsible to Parliament to keep itself at all within bounds if it begins theoretical discussions. And besides that, it should superintend all the work through the country, but it should not itself begin to discuss and go too much into theories. I think that questions of general meteorological speculations can hardly be carried on at such an office, if it is responsible for the work done, because you have to produce definite results.

14,489. Did I rightly understand you to say that you have to furnish materials?—Yes. We have to furnish materials, and we are always ready to answer questions.

14,490. (*Dr. Sharpey.*) Is the cost of the instruments supplied to the Navy charged to the grant of the Meteorological Office?—Entirely; and, as I stated on the last day, in the first estimate there was a sum of 570*l.* for the supply to the Navy, but after that year it was not included. It is a portion of our work to supply the Navy. All the old instruments which belonged to the Navy from all the dockyards and every place were sent in to us. The whole management of the meteorological service of the Navy is transferred to the Meteorological Office.

14,491. (*Professor Smith.*) On referring to the Report for 1870, I noticed that the greater part of the expenses of the land meteorology fall under the headings of expenses incurred at the observatories;

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those are chiefly your seven fixed stations, are they not?—Yes, the seven fixed stations.

14,492. How does that money go at the different observatories. Is it in payment of salaries?—We do not ask any questions. I mean, we say, *e.g.* to Professor Grant, at Glasgow, we will give you 250*l.* and a stock of instruments; you must furnish us with the returns, and you may pay your assistant, or do whatever you like with the money. The arrangement is with the different gentlemen, Professor Thomson at Aberdeen, and Professor Grant at Glasgow, but with the College at Stonyhurst, with the Royal Cornwall Polytechnic Institution at Falmouth, and with the Kew Committee, to do a definite amount of work for a definite pay. In Ireland it is different. Dr. Robinson says:—"I will do the work without any pay if you "will pay me all that I am out of pocket," and, therefore, we pay his assistants, and at Valencia everybody is paid by us.

14,493. Do you not receive from the Radcliffe Observatory at Oxford nearly as much information for a very much smaller payment as you receive from any one of those seven stations?—No; we only receive from the Radcliffe Observatory one set of observations taken at 8 o'clock in the morning.

14,494. And what do you receive from the other stations?—A great number of observations, taken at 24 different hours during the day, with the continuous records. We simply get one single set of readings from the Radcliffe Observatory. They have the continuous instruments, but they do not send us observations from them. In fact, the Radcliffe Observatory is not in connexion with us. The assistant is allowed to undertake the work of reporting to me. The Radcliffe Observatory is in no sense an observatory for the Office. It is a station for telegraphic reports, and I think the amount of payment is simply 5*s.* per week. We simply call the Radcliffe Observatory a telegraph station.

14,495. (*Dr. Sharpey.*) That is the case with the other stations which you call telegraph stations, I suppose; you get information from them at the same rate?—Yes, at the same rate and the same amount of information precisely at 8 o'clock, and at certain stations we get it also at 2 o'clock in the afternoon.

14,496. (*Chairman.*) Is there any further point upon which you would wish to make any additions to your evidence?—The only thing that I would venture to ask the Commission would be that as there is a good deal of responsibility attached to my position at the Office, if, in the evidence of anyone else there is any question connected with the office, which, in your opinion, would want explanation, or which bears on our action, I might be allowed an opportunity of being re-examined.

The witness withdrew.

JAMES GLAISHER, Esq., F.R.S., examined.

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14,497. (*Chairman.*) I believe you are chief of the Meteorological Department of the Royal Observatory at Greenwich?—I am.

14,498. Is there any special name attached to your office?—Superintendent of the Magnetical and Meteorological Department.

14,499. I believe you have for many years undertaken to compile certain meteorological returns for the use of the Registrar General?—I have.

14,500. Will you be so good as to explain the nature of the system which you have organised for that purpose?—With great pleasure. Perhaps I may state how my first connexion with the Registrar General commenced. The Registrar General had published the mean temperature at York as being five degrees higher than the mean temperature at London; in consequence of which I wrote to him, telling him of the physical impossibility of such being the case, and he then told me that he had no one in his office who could reduce the observations, and no one who could judge whether they were correct or no. Having been educated as an astronomer, and having had the meteorological department placed in my hands, I had been desirous of ascertaining the general accuracy of meteorological instruments in general use. For that purpose I had gone all over England, Ireland, and Scotland to see the best observers who were taking observations, and I found that of the thermometers the most accurate were three-tenths of a degree wrong at 32, and three degrees wrong at 90, in both cases reading too high, and that barometers were very frequently a quarter of an inch in error. Mr. Sheepshanks in the years 1840 and 1841 brought out his standard thermometer, which is still the standard, and I endeavoured to bring into general use instruments very nearly free from errors. The instrument makers then worked with me, and the consequence was, that at the time the Registrar General spoke to me I knew a large number of persons who I thought would take observations; and, knowing a good number of Cambridge men, I thought that clergymen would unite with me, and would help in establishing a system of truthful observations. Thereupon I travelled over the country and induced some 50 or 60 gentlemen of education and position to engage in the toilsome work of daily observations, and they have done so for these 30 years. I feel it a great pleasure and pride to think that I have successfully organised a system which had always previously failed. That system I have continued from that time to the present. I have had assistance from noblemen; for instance, the Earl of Leicester has always returned observations to me, and Mr. Whitbread has given me every assistance. So have several other persons, and I have been enabled for 30 years to collect observations, and furnish the results to the Registrar General. Those observations came then, and now come, to me. I have brought a sheet of observations for January, February, and March, from Dr. Hoskins of Guernsey, my most southern station (*producing a chart*). As the Commission will see, this is a sheet for Guernsey for a month. The observations come to me at the end of every month, and on the 15th day following the third month the results must be in the hands of the printer. I take Greenwich as the standard, as it has photographic registrations. Then when I have the returns I take all in or near the latitude of Greenwich, and compare the heights and look at every reading of the barometer. I then look and see whether the temperatures given during the day are larger or smaller than the maximum or minimum readings of the same day. By these means I check them to a very large extent (*explaining the sheet to the Commission*). The Registrar General publishing within a month after the close of every quarter necessitates my being ready for him, so that I have within 15 days after the quarter to send the results to him, and I have invariably done so without failure for 30 years. (*The witness produced several tables, and explained to the Commission the mode of preparing the returns for the Registrar General.*) By the means which I take it is almost impossible for me to let any great error go out to the world. The value of these tables depends on their accuracy or their inaccuracy. I keep other tables for thunderstorms in every month, for solar haloes, for lunar haloes, and indeed for all the different phenomena, which are collected together and checked in the same way. When these are done and examined by two persons they are sent to the printer. In any case of discordance I immediately write to the observer, and if my writing is not sufficient to cause the error to be corrected, I publish it as such in one of the quarterly reports, which I find to be the most effective way of obtaining the correction. By these means, as an old computer, and as one who has been well trained to calculation, I believe that I have produced tables upon the whole as accurate

as any in the world. But I cannot say that absolute accuracy is attained even in the Greenwich observations, on which no time or trouble is spared; there is not a volume nor a sheet that passes me that is correct. When I receive a revise I find errors in it that did not exist in the proof, and when that revise goes to the printer after I have corrected it, it is often printed wrongly by a slip in the figures. Therefore, as typographical errors in all probability will remain, I believe it to be impossible to be quite free from error.

14,501. Are the observations taken entirely gratuitously at the different stations with which you have connected yourself throughout the country?—Entirely gratuitously.

14,502. Have you furnished in any cases the instruments that are made use of?—In some cases I have given instruments to gentlemen with small incomes; but I have given them out of my own pocket. As a rule I have not done so, and I do not wish it to be known that I have ever done so, because then other observers would want the instruments supplied to them; and, indeed, I believe that were once the Government or anyone to supply instruments, there would be such a demand that the system would break down entirely, and more than that the observers would want to be paid. In Ireland particularly, where having been engaged on the Trigonometrical Survey, I knew a good many people, I thought that I should be successful; but Irish gentlemen would not take any observations unless I furnished them with instruments, and then they would not use them without I paid them for taking the observations. Were 50 or 60 or 70 gentlemen to be paid, the amount of money required would be very great.

14,503. If they were paid in proportion to the work done, you think that the cost would be very great?—Very large indeed.

14,504. Could you state on the average what each station would be likely to cost, supposing that the work done at it was paid for?—The Meteorological Office has six stations, and you know what each of them costs. Each of the observers is paid 250*l.* a year, I believe.

14,505. Do your observers do as much as each of those under the Meteorological Office?—They do not do so much, simply because at the Meteorological Office stations they have self-recording instruments and photographic registration, and therefore more attention is required than my observers would give. I tell my observers, if they can only take one observation a day to take it, at or about the hour of breakfast, as being the most convenient time; and after some time, if they commence with one, they will generally take two. In the case of gentlemen I always wish them to train some one person in their establishment in whom they could place confidence. In many instances they employ Scotch gardeners, who are generally very intelligent men, to take the observations. All the observations at Cardington have been made by a Scotch gardener as carefully as I or Mr. Whitbread himself could make them. I have been at Cardington many times, and I have seen the observations being taken. My plan has been to go round to the stations, and read the instruments with the observers.

14,506. At all events the cost would be very considerable if the system of paying for those observations were once established?—I think it would be very large. Take a mere set of instruments, a barometer, a thermometer, a dry and wet bulb thermometer, a minimum and maximum thermometer, a maximum solar radiation thermometer, and a minimum terrestrial radiation thermometer, an anemometer, a rain gauge, and so on, these cannot all be bought for less than 20 guineas, and, besides, if gentlemen pay for their own instruments they are careful in their use. I think if Government were to pay for instruments, observers might be less careful in their use, and I think some voluntary observers would give up if Government were to interfere.

14,507. Why would they object, do not they do it because they take an interest in the subject?—Most of them take an interest in the subject, because it is my desire to find gentlemen who do take an interest in it.

14,508. Do not you think that under any system they would be willing to furnish information, owing to the interest that they take in the subject, without expecting any remuneration for it?—Some would, doubtless.

14,509. Does the management of the system entail upon yourself a considerable amount of expense and labour?—Owing to the constant correspondence I must have two assistants, and I have to train them, so that when I am away they shall be able to proceed with the work. I always endeavour to come back before the time of printing to examine it and see it. The Government allows me 150*l.* now towards the expenses to which I am subjected, but for many years I did the work free of all expense. Then I received 50*l.*, then 100*l.*, and then 150*l.* per annum.

14,510. Are you in the habit of travelling to any of those stations?—Yes; not so frequently now because I know the character of my observers. I know from their returns and I know by all that occurs that there is no occasion for me now to travel so frequently as I used to do.

14,511. Does your number of stations continue about permanent?—Yes.

14,512. Occasionally on the death of an observer who has had charge of a station have you found much difficulty in finding a successor?—No. There were two deaths last year, but I have Ramsgate and Leicester for the first time this year, and they will make up the loss of two last year. I like a change of stations because I thus get observations from another part of the country. I could increase my stations now, but I do not want to increase them beyond the number I can deal with.

14,513. Is the whole country tolerably well represented?—Yes, tolerably well.

14,514. Do you include Ireland?—No, I do not. I have only one station in Ireland. I was terribly disappointed with regard to Ireland. My stations are Guernsey, Helston, Truro, Portsmouth, Brighton, in the South, and so on, extending up to North Shields in the North. In Scotland I had several observers. I have Aberdeen still, but that is the only one. The Scottish Meteorological Society and the Registrar General of Scotland attend to them now, so that I am confined to England.

14,515. Have you any opinion as to whether, supposing you were to discontinue the duties that you have conducted for so many years, the Meteorological Office would be able to carry on the same work?—I think that the Meteorological Office or any Government office would have a difficulty. The Meteorological Office at the present moment has not the stations. The six stations that they have I would not accept the observations from. When I was at Aberdeen I found the thermometer 48 feet above the ground and close to a stone wall. When I was at Weymouth I found the thermometers badly placed, and even at Kew, where one would think all would be perfect, the thermometers are 10 feet above the ground. Now I lay it down as an absolute necessity that the thermometer shall be 4 feet above the ground, which is just the height of the mouths of men and women, and I obtain that uniform height all over the country, because unless there is an uniformity in the position of the instruments it is impossible that there should not be continual differences due to other than local causes.

14,516. The Meteorological Office, we understand, are alive to the necessity and importance of having the thermometer at the same height, but they find a practical difficulty in carrying it into effect?—Yes, to a great extent I have the same, but still I have the instruments placed as nearly as possible under the same circumstances. If I have to deal with a house in a courtyard surrounded by a wall, I may place the instruments in the centre and make the best of what it

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may be; but with respect to placing thermometers 48 feet above the ground to compare with results at other stations at 4, 6, or 8 or 10 feet high, I say it is impossible to compare the results together.

14,517. Do we understand that all your instruments are precisely under the same circumstances as to height from the ground?—As near as it is possible. I cannot have them identical, but I insist upon their being as nearly as possible under the self-same circumstances. It is imperatively necessary for the investigations which I have to conduct, that is to say for the Statistical Office, that the different results given should be due to local causes. That is the problem which I have to solve.

14,518. Supposing that the Meteorological Office were to undertake the duties which you at present take upon yourself, would it be necessary, in your opinion, for them to abandon any part of their present operations?—It seems to me that if the Meteorological Office attack land observations, large as their sum is, a great portion of it would be absorbed, and that they would have to lessen their work unless you were to increase very much their present allowance. Sea meteorology is that which an individual cannot attack. Sea meteorology is what we want; we want the physics of the globe. Meteorology is not yet a science, it can only be called collecting facts, and those facts now are becoming very numerous, affording data for the mathematician to use, but he is at fault for want of knowledge of the physics of the globe. We know a little of the meteorology of the sea about those tracts which the steamers make. Maury did a great deal with the little means at his command, and that which the Government must do, and which nobody else can do, is to get the physics of the globe, and until that is attained we must remain pretty nearly in the state in which we are now. Local societies and local people can investigate the climate of their districts, and do it well, and that is very important, but we cannot do individually the physics of the globe. It is proper that the Government should help in solving that problem, and what we want is a director who is a good physicist; a man who is a good mathematician, who knows how to use the results which are brought to his notice.

14,519. Would you leave land meteorology chiefly to private observers?—I would indeed, because they will do it, and do it well. They will supply sufficient information with regard to climate, and so on, and the public will have the results; but that which the Government should do is that which a man cannot approach. Whatever I have attempted with regard to the sea I have given up as beyond my power. It requires the Government to come in and attack the physics of the globe, and to get observations—just what the Government are going to do with regard to the transit of Venus. The observers will have instruments to take hourly observations with during their voyages, which will add greatly to our knowledge, because they will be passing over tracts of the ocean not usually traversed.

14,520. Would you think it right that the Government should encourage private observers, or would you leave them entirely to their own unaided efforts?—I think that the Government had better leave them entirely alone.

14,521. And not give them any assistance in any shape?—I think they had better be left entirely alone. Once give assistance, and you will check private and individual effort. My observation is based upon a long experience in that respect.

14,522. Perhaps you are aware that the Meteorological Society of Scotland do not at present take the same view, but would like a little help from the Government?—I founded the Meteorological Society of England myself, and for 25 years I was its secretary or president, and never once during that time would I allow any application to be made to the Government for help. If you do give Government aid to societies you emasculate them, you take from them their energy. The society of Scotland is a little different, because it proposes, at the request of Lord Tweeddale, certain specific investigations such as that connected with the herring fishery, a very important matter; and if a grant be made by the Government for that special object, doubtless good results will follow. But my experience with respect to societies, and I have been connected with a good many, is that Government had better not aid or control any of them. If they will not work by themselves, if the members will not subscribe sufficiently for their objects, they had better be left to die.

14,523. You are decidedly of opinion that everything that is desirable as regards extending our knowledge of land meteorology might be left to private observers?—Yes, I think so.

14,524. As a consequence of that opinion, do you hold that the operation of the Meteorological Office as regards land observations is not of very great value or importance?—I think that its operation is of no great importance, but I think it is of very high importance for the sea. I am only saying now what Admiral Beaufort said to me when Admiral FitzRoy was appointed, and in which I agreed. He said, It is of the very highest importance at sea, as no man can grapple with it. What we want is sea meteorology, and connected with ocean meteorology are the physical investigations of the globe, and that must be done by Government.

14,525. Do you hold that if the land operations of the Meteorological Committee were given up, meteorological science would not suffer in consequence?—I do not think it would; but there is one great good thing that these six stations of the Meteorological Office will do if they are well worked. They are placed here in a line, and they have got hourly observations, and in consequence of their photographic registration they will determine very shortly the diurnal range in those six parallels of latitude with a considerable degree of accuracy, and having determined the diurnal range due to any one latitude, this will become an excellent guide for observations made in or near that latitude, and will enable local observers to reduce their observations to practical results. If the diurnal range be accurately determined, observers need only take observations at 9, 10, or 11 o'clock, and in the afternoon at 3, 4, or 5 o'clock, as they would know the corrections to apply to those means, so as to deduce true values for 24 hours. It will add very much to the power of local observers. I am now engaged in reducing 20 years' photographic observations that have been made at Greenwich, and I believe that among other determinations that of the diurnal range will be one of great importance.

14,526. That could not have been obtained, could it, except through the Meteorological Office?—The photographic observations at Greenwich have no connexion with the Meteorological Office.

14,527. (*Professor Huxley.*) Did I rightly understand you to say in reply to the noble chairman, that with the exception which you have just mentioned, the observations taken at the six stations of the Meteorological Office are absolutely of no value whatever?—I did not say that. I spoke of their no great value, and one valuable thing that I would mention is, that you will have the mean temperatures under the circumstances under which they have been taken in those six observatories very well determined.

14,528. I think I understood you to say that meteorological science will suffer no loss if those six stations were abolished?—When once the diurnal range is determined I do not think it will suffer any loss by their cessation.

14,529. Then it comes in point of fact to the statement that all observations, except those particular ones to which you have referred, are of no good?—I do not say that. I say that from them you will have a good determination of the mean temperature of those stations, which is valuable, and possibly a good determination of the hygrometrical states. Do not let me depreciate them. Their chief value, as I hold, con-

sists in a good determination of the diurnal range for the elements in those positions, and having determined these, it is quite sufficient to apply them as corrections all over the country.

14,530. (*Professor Smith.*) Except at such stations where public money was given you could not have photographic observations, could you?—No.

14,531. You could not expect volunteer observers to take photographic observations?—No. Certainly you cannot expect volunteer observers to do that.

14,532. What is your opinion of the importance of photographic observations made at fixed stations on land for the progress of meteorology?—At a few fixed stations I value them much. At many stations I should not value them, for I think that observations by the eye, &c., of all local causes are sufficient for the advancement of science, and would give quite as much information as we need. I believe that we obtain from many of our stations all the principal investigations of the elements, equal in value to those from the six stations, and with much more ease.

14,533. (*Professor Huxley.*) Of course at some time or other, although I hope the period will be very far distant, your own activity in this matter will probably come to an end?—Yes, certainly.

14,534. You would be very sorry, would you not, to see this system discontinued?—Indeed I should be.

14,535. It may be difficult to find a second representative, or an equivalent to yourself, who would do all this work voluntarily. In what way would you suggest that it might be continued?—I am getting old it is true, but still at the same time so long as I should be able I should like to continue that which I have founded and worked out myself; but as that time approaches I should have to speak to the Registrar General to see whether I could not get some one in his office, first of all. You are touching upon a matter about which I have not really thought very much; but I should be very happy if you have any series of questions to send to me to furnish you with answers in writing.

14,536. It would be obvious that that is a point of view from which the Government is very likely to regard the whole matter, because the question at present is between your own voluntary efforts and the action of a Government office, and of course the Government must necessarily look to the possibility (let us hope that it may be 20 or 30 years hence) when you will discontinue that work; still if the work is to go on it must be done by somebody, and unless there should be some volunteer who is willing to make the same sacrifices that you have done, of course the alternative is that the work would fall into the hands of some Government office, whether the Registrar General's or some other; but you do not seem to contemplate with much horror the possibility of its going into the Registrar General's office?—I have been so long connected with that office, and I see the officials there so apt with their figures, and so correct in their work generally, that I have no great horror of its passing into the Registrar General's office. It would be merely collecting so many facts.

14,537. Do you think that those local observers, with whom you have established those relations, would supply information to the Registrar General's office?—I am doubtful of that. I have been training them in a great measure to become accustomed to do so in order that the transition might seem to be but small. As you will observe, instead of having my name printed on the back of those papers which used always to be sent to me with my name on them, I have accustomed the observers to send them to the Registrar General's office in the manner which you will see by looking at the papers. Until very recently my name was printed on the back of the quarterly reports.

14,538. So that in point of fact at this present time the observations do go as it were to a Government office?—Yes, a large number of them. Connected with this I have weekly reports which I send to the Registrar General, and another to the Registrar General of Edinburgh, and there are several other reports, some annual.

14,539. (*Chairman.*) With respect to photographic observations, I am not quite sure whether you expressed an opinion that their permanence is not a matter of importance, but that in the course of a few years they might be discontinued without any disadvantage?—Yes; I think it is better that they should be discontinued at the six stations, because they will have done their work.

14,540. (*Dr. Sharpey.*) Did I understand you rightly, that the weekly reports are reports of the observations at Greenwich?—Not only from Greenwich. I have on every Saturday night or Monday morning a return sent to me from about 14 large towns in the country, and the results are sent by messenger every Monday morning to the Registrar General.

14,541. Are those 14 large towns part of the 49 stations that you have established?—There are some other stations; they are not the same.

14,542. Not private stations?—Yes, private stations.

14,543. Is there anything paid in those large towns for those returns?—No; I merely ask my friends to give them to me.

14,544. It is a friendly act?—Yes; the principle on which I collect observations is that the sending them is a friendly act to myself. I know that the Fellows of the Royal Society will do anything for me if I ask them. I know that of Oxford or Cambridge men; if I ever want an observer, I have only to write to them on the subject, and I generally get volunteers who will give me the observations that I want. I have a large correspondence with meteorologists, both here and on the continent, and I think I can get almost from any part of the country any information I may wish.

14,545. My reason for asking is, that the Astronomer Royal, in a letter which he caused to be written to the Government, states that weekly observations were furnished from Greenwich free of expense?—Yes, they are furnished from Greenwich free of expense.

14,546. You furnish them to him, and he supplies them to the Registrar General?—No; we have supplied from Greenwich from about the year 1843 a weekly return to the Registrar General, based only upon the Greenwich observations. Then when the Registrar General publishes, as he has done lately, the weekly statistics of any new town, I write to somebody that I know to send me week by week information of the meteorological conditions to publish with his returns.

14,547. That is in addition, is it not, to the returns from Greenwich?—Yes, that is in addition to the Greenwich returns. The Greenwich return has always been sent from the observatory at Greenwich to the Registrar General free of all expense, as it necessarily would be from one Government office to another Government office. The comparison of the reports is one of those things that tie me there on a Monday morning until I can write out the report. The Registrar General sends down at 1 o'clock every Monday, and by this time I must have it ready.

14,548. (*Chairman.*) Are there any other points upon which you think it desirable to give your opinion to the Commission in connexion with this subject?—No. I was not quite well aware when the letter from the secretary came to me as to the nature of the evidence that you required, nor indeed when I came to-day was I aware of the nature of it.

14,549. It was in consequence of the correspondence which had taken place that we asked you to come.—I should be very happy to give any information to the Commission. If it occurs to you that you think my experience of any value, I shall be very glad to give it at any time that you might wish. I should like, as I have said before, if the Commission could use its great influence to get the physical meteorology of the globe undertaken by the Government, because it must

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be done by the Government if at all, and we are stuck fast in a great measure until we get information from parts of the earth where we have now no observations.

14,550. Are there any branches of meteorology to which you think the Government ought to apply itself which are not at present included in the operations of the Meteorological Committee?—I think that the extension of sea meteorology might very well be undertaken.

14,551. What measures would you recommend to be taken that are not taken at present. Would it be anything of a different nature from what is at present done?—No. At present we get information mainly from those parts of the sea which are the tracks of steamers or the tracks of other vessels, and we get it constantly repeated; but that which we want is, so far as the Government can afford it to us, the opportunity of getting useful observations on parts of the earth's surface of which we are at present ignorant.

14,552. Do you think that expeditions ought to be sent out expressly for that purpose?—I think that is rather too expensive. I would suggest that we should avail ourselves of every opportunity of getting observations wherever expeditions are sent.

14,553. Have any opportunities of that kind been neglected?—I do not know that any have been.

The witness withdrew.

Adjourned.

No. 6, Old Palace Yard, Westminster, Tuesday, 12th May 1874.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

Sir JAMES PHILLIPS KAY-SHUTTLEWORTH, Bart.
WILLIAM SHARPEY, Esq., M.D., F.R.S.
THOMAS HENRY HUXLEY, Esq., LL.D., Sec. R.S.
GEORGE GABRIEL STOKES, Esq., M.A., LL.D., Sec. R.S.
HENRY JOHN STEPHEN SMITH, Esq., M.A., LL.D., F.R.S.

Deputation from a Committee appointed to promote the Extension, &c. of the University of Edinburgh.

12 May 1874.

A Deputation from a Committee of the general public appointed to promote the extension and improvement of the buildings of the University of Edinburgh,—consisting of Principal Sir ALEXANDER GRANT, Bart., Professor WILSON, Professor TURNER, and Mr. R. BRUCE JOHNSTON, Secretary, and accompanied by the Right Hon. LYON PLAYFAIR, C.B., M.P., waited upon the Commission.

(*Chairman.*) We have already received a good deal of evidence with respect to the wants of the University of Edinburgh, but as we understand that in the meanwhile the subject has been further considered in the University, and public opinion may possibly have assumed a more definite shape than at the time the witnesses from the University were examined, we shall be very glad to hear any statements that you may have to make upon the subject.

(*Sir Alexander Grant.*) My Lord Duke, we attend as a deputation from a Committee, of the public in general, that has been formed in Edinburgh to endeavour to remove the great disabilities which at present exist in the University of Edinburgh. A statement has been drawn up of the objects which this Committee has in view. That statement contains, of course, matter which is external to your Grace's Commission, that is to say, the giving of the University a hall and other things besides scientific buildings. I will limit myself to one or two extracts from the appeal which has been drawn up, and which will be entirely confined to the scientific wants of the University.

The facts of the matter are these: 100 years ago, or thereabouts, the buildings of the University were found to be utterly inadequate; and the people of Edinburgh felt that, and then they took a similar action to what they are taking now, and they caused meetings to be held, the matter to be inquired into, and a public subscription to be collected. The public subscription gradually amounted to the sum of 30,000*l.*, and the Government supplemented that by the sum of 129,000*l.*, and out of that money, 159,000*l.*, the present College buildings of Edinburgh were erected. They were only finished I think about the year 1810, or, at all events, within the first 20 years of the present century. The cost of the site and buildings did not completely expend the sum, because the Commissioners who were appointed by the Government to superintend and arrange for the buildings at the time bought for the purpose more land than was built over. That superfluous land lay to the west of the present College buildings, and afterwards, when the Industrial or Science and Art Museum came to be erected in Edinburgh, the land which had thus been bought for the University was handed over by the Town Council, who were then the patrons of the University, to the Government for the purpose of building this Museum upon it. And thus the Science and Art Museum of Edinburgh is built to a certain extent on land which properly belonged to the University of Edinburgh, and which would certainly have been used by the University at the present moment if it were still in our possession. I may add that the building of that Museum necessarily, to a considerable extent, impeded the use of the parts of the University buildings which lie on that side. The lights was entirely excluded, and one face of the building was darkened, and, in fact, a considerable part of that building has been thrown out of use. That was the history of the present buildings, which were finished early in the present century.

The number of students for which the buildings were originally asked was between 600 and 700, and the number of professors was then 21. At present the number of students is far over 1,900, and the number of professors is 35, and two additional professors have been appointed or are on the eve of being appointed, and they will require additional accommodation.

But apart from the insufficiency of space which is thus indicated, we have had our attention long directed to a change which has taken place in the manner of scientific teaching, that is to say, that since those buildings were erected the whole subject of Practical Chemistry has been added to the course of study. I believe that the study of Practical Chemistry was first introduced into the Medical Curriculum in the University of Edinburgh, but the accommodation is totally inadequate for conducting such a study. The same may be said of the teaching of Anatomy, about which my friend, Professor Turner, will be able to give your Grace some further information. But it is well known that since the buildings were erected, there has been a considerable change in the idea of the way in which Anatomy should be taught; so that now complete practical instruction in it is thought necessary for every Anatomical Student. But the dissecting rooms at the disposal of the professor are absolutely in every way inadequate for such teaching. The same may be said of the course of teaching of Natural Philosophy, for which there is no proper laboratory in the present University. The chairs of Materia Medica, the Institutes

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of Medicine, Natural History, and Pathology, all require great additional accommodation, especially in the way of laboratories and room for scientific specimens for exhibition. At present, hardly any class room is enjoyed by one professor alone. They all have to be used twice over in the daytime by professors of different subjects. Necessarily, great inconvenience arises from this, the proper ventilation of the rooms is rendered more difficult, and anything like a permanent exhibition of specimens and diagrams is, of course, rendered very difficult also.

On these and many other grounds, the friends of the University of Edinburgh took up the matter some time ago. The late Sir David Baxter took great interest in the subject, and he bequeathed us a sum of 20,000*l.* towards making new buildings for the University. A Committee was then appointed, public meetings were held, and including the sum bequeathed by Sir David Baxter, which was reduced by the legacy duty to 18,000*l.*, we have already, by appeals to the public, and through the munificence of individuals, raised the whole sum of 60,000*l.* We have now promised, and we have in fact at our disposal, more than 60,000*l.* The deputation came to London to endeavour to raise some of the additional 40,000*l.*, which will be required to make up the large sum which, under the circumstances, we have ventured to ask from the liberality of the general public.

We have as yet, of course, made nothing but the vaguest estimate of what will be required, but estimating it in a vague way, we think that about 150,000*l.* or 160,000*l.* will be required for what we propose. And this is a summary of our proposals: 1st, to purchase the site of Park Place, Teviot Row. These are localities in the immediate vicinity of the new Infirmary, and that was the reason why this site was chosen. They are also not far removed, perhaps 300 yards, from the University. Of course, had the land which I before referred to been still in the possession of the University, and not been handed over to the Museum, part of that outlay might have been obviated; but we have already expended 33,000*l.* on the purchase of a site. The *second* proposal is to erect on this site, in the immediate vicinity of the new Royal Infirmary, complete class rooms, theatres, laboratories, and museums, with the latest scientific improvements, for the Medical Faculty of the University of Edinburgh. Then, having thus removed the whole of the Medical Faculty from the present College buildings, we propose, *thirdly*, to reorganize the existing class rooms of the College, and to improve them in direct adaptation to the wants of the several professors in the Faculties of Arts, Law, and Theology. The *next* proposal may still be considered to come within the scope of your Grace's Commission, and that is, that we consider it necessary to provide increased and more convenient accommodation for the University Library. The *fifth* proposal is, perhaps, not one which your Grace would feel so much interest in, although it is of the highest necessity for the University, namely, to erect an University hall for the conferring of degrees, and the holding of examinations, and for all public ceremonials. The *sixth* proposal is to improve to some extent the north front of the present College building. These, my Lord Duke, are the proposals which we have in view, and we trust that we shall get evidence of the feeling of the public, that those proposals are good and necessary, by the fact that they will subscribe for them no less than 100,000*l.*; and we trust that your Grace may be able to recommend that the Government will on its part provide what else may be necessary for giving the University proper buildings for scientific instruction.

(*Chairman.*) I imagine that your views of what is required have become somewhat more extended since the time when some of your professors gave evidence to the Commission two years ago. I think at that time it was thought that all that was required was new buildings for teaching Anatomy and Chemistry, and that every other department might be provided for in the existing buildings. I think I understand from what Sir Alexander Grant has now said, that the wants of the University are more extensive than that.

(*Sir Alexander Grant.*) Certainly, we feel very strongly that we want more than that.

(*The Right Hon. Lyon Playfair.*) Perhaps your Grace will allow me, as an old professor of a scientific subject, that of Chemistry, to mention how this necessity has arisen. There has been a great disposition in Edinburgh, and in fact in almost all teaching institutions, to develope much more the practical laboratories connected with the institutions. The accommodation for the laboratories of Physics, Chemistry, Physiology, and Anatomy, has become utterly unadapted to the wants of modern science. And the reason that it was supposed it would be a convenient thing to take the Medical Faculty out to the new proposed site is that the Infirmary is the natural laboratory of the medical profession, and it would be desirable to take along with that the laboratories, which now exist in a very imperfect form, of Chemistry, of Physiology, of Materia Medica, and of practical instruction in Anatomy, and then to develope in the present College an efficient laboratory of Physics. The main object which the promoters of this subscription have in view is to develope the teaching of science in all directions in the University. And thus it is with a view of having laboratories of research and laboratories of instruction that this movement is mainly taking place; and from the expenditure which has been made on laboratories in other directions, both on the Continent and in this country, we feel that the sum of 150,000*l.* to develope the efficient practical teaching of the University is not greater than would be required if we are to put the University of Edinburgh in an equal position with modern Universities in this respect. The main purpose is to develope the practical teaching through the laboratories of the University.

(*Chairman.*) Your view is to raise 100,000*l.* from private sources, and ask Government for 50,000*l.* more?

(*Mr. Lyon Playfair.*) Yes, that is it.

(*Chairman.*) Would that include the provision of apparatus?

(*Mr. Lyon Playfair.*) I am afraid it would not include the provision of apparatus, nor would it include the increased expenditure which would be incurred for assistants, and the various expenses that are incurred by such large buildings; but at the same time I think we may hope for private munificence to aid us in those respects as soon as the wants are clearly made known to the public, if we get the material aid of the Government in our buildings.

(*Chairman.*) We are to understand that your application to the Government will simply be for this 50,000*l.*, and nothing more whatever.

(*Sir Alexander Grant.*) We hardly limit ourselves to that. We hope that the Government will do all that is required to put the scientific teaching upon a thoroughly efficient foundation.

(*Chairman.*) You do not ask for an annual grant of any kind?

(*Sir Alexander Grant.*) That is not the nature of our proposal.

(*Chairman.*) I think that at present the Government provide something like 1,300*l.* or 1,400*l.* towards the stipends of certain professors?

(*Professor Turner.*) I do not remember the exact sum, but the particulars are stated in my evidence as given two years ago.

(*Mr. Lyon Playfair.*) I think it might be as well to mention to your Grace that in the Act of Union, when the Scotch Parliament was merged, the people of Scotland took great care to insert in the Act that the protection of the Scotch Universities became an Imperial duty; we consider, therefore, that we have a fair claim upon the Government, as it was particularly stipulated that the Universities of Scotland should become an object of Imperial care as soon as the transference took place.

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(*Professor Turner.*) Perhaps your Grace would allow me to say that this scheme for the extension of our University buildings is not to be mixed up with the requirements of the University as regards additional grants for assistants and for apparatus. The additional grants for assistants and apparatus would require an annual expenditure and an annual allowance from the Government: but our wants on these points I submitted to the Commission in my former evidence. The scheme which we now submit to your Grace is for the investment of a certain sum of money in stone and lime.

(*Dr. Sharpey.*) Not as an equipment of laboratories, providing apparatus and fittings?

(*Professor Turner.*) Yes, fittings certainly, but not apparatus.

(*Professor Wilson.*) Our present material would be transferred to the new buildings. I may mention that of late years our numbers have been increasing with a gradual ratio. For the last four or five years our increase has been between 80 and 100 every year, and I hope it will continue so. We have nearly 2,000 now, and therefore we have to provide for increasing wants and increasing accommodation.

(*Dr. Sharpey.*) Of course, as you have already remarked, the whole system of teaching science has been greatly extended by the extension of the practical teaching; that of course requires further accommodation?

(*Professor Wilson.*) We are really now crowded to the utmost extent—we cannot strain our accommodation any more. We have got two new Chairs to provide for speedily, and I do not know how we shall accommodate them, because our class-rooms are already incumbered with three, and one even with four, professors, which is excessively bad for the students as well as for the professors.

(*Chairman.*) I think the Professor of Geology complained very much that he was obliged to lecture immediately after the room had been used for another purpose.

(*Professor Wilson.*) Yes, we cannot arrange the professors' classes according to anything like an affinity of subjects.

(*Mr. Lyon Playfair.*) Every scientific class has recently attempted, as far as the resources of the University would go, which are very limited, to connect practical teaching with the work of the class. Even Geology is now to a certain extent taught practically. The mineralogical part is not nearly so practical as it could be if we had proper space, and the means of studying the minerals; but geological excursions are regularly made. Botany, of course, is taught practically, and there is also a great disposition to teach every science practically in the University, if we had only the means to do it.

(*Professor Turner.*) During the past six months a most valuable mineralogical collection has been given to the University which belonged to the late Mr. Brown, of Lanfine, who had one of the best private mineralogical collections in the country; but we have really no proper place to show it in. It cannot be used for teaching purposes for the simple want of space to put the cases in.

(*Dr. Sharpey.*) Does not that go into the Industrial Museum?

(*Professor Turner.*) No, it is given expressly to the University.

(*Professor Smith.*) Are you of opinion that if you remove the medical classes and the medical lecture-rooms to the new site, you will have room on the old site for all the purposes to which you have referred?

(*Sir Alexander Grant.*) I think we should, for the adequate teaching of the other Faculties of Arts, Law, and Theology. We should have to provide an examination hall somewhere. At present the only place where we can possibly hold an examination is in the library hall of the University, which is a place filled with valuable and extremely rare books, and busts of former professors, and of persons connected with the University; and it is a very great inconvenience that this handsome hall should be invaded many times a year by the examinations of 300 or 400 students at a time. You can very well understand that it disfigures the appearance of the hall; it produces a great deal of dust, and people who wish to give their treasures to the University are considerably deterred by seeing the hall in this position.

(*Mr. Lyon Playfair.*) The chief laboratory which would be left in the old buildings is the Laboratory of Physics, and considering the little money that has been spent upon that, it has been spent very judiciously. We have an excellent collection of physical apparatus. We have been lately attempting to get a good working Physical Laboratory; even now there are a considerable number of people working in it under very disadvantageous circumstances. But one is ashamed to allow any stranger to see our collection of instruments. They are all piled one up above the other, and so crowded together that the professor can scarcely move through his laboratory. The Professor of Physics would chiefly be the one who would be accommodated by the relief in space through taking the other laboratories away. The whole of Chemistry, and also the whole of Physiology and Anatomy, would go to the new buildings.

(*Professor Wilson.*) Both this session and last session the Professor of Physics was obliged to refuse certainly an equal number to those that he was able to admit of students wishing to go into the practical laboratory, simply because there was no possibility of accommodating them.

(*Dr. Sharpey.*) Do you contemplate moving the anatomical museum?

(*Professor Turner.*) We do contemplate moving the anatomical museum. We have a very fine collection of specimens of comparative anatomy, which, as far as regards teaching purposes, are at the present time almost unavailable, because the museum space is so crowded with specimens that there is not room for the students to move to and fro with safety to the preparations.

(*Professor Smith.*) As it is clearly admitted that increased laboratories would imply increased annual expenses, especially for the payment of demonstrators, I should be glad to know whether the gentlemen from Edinburgh really consider that it would be possible for them, without an annual grant from the Government, from the resources of the University itself, to supply those additional annual expenses?

(*Sir Alexander Grant.*) We have a general fund from the University, which consists chiefly of fees for graduations and for matriculation, and we administer that fund in supplying as well as we can the current expenses of the University; I may say with regard to that fund that we live in faith, and as we have hitherto been spared anything like insolvency, we trust that in the future we may, by some means or other, whether by private assistance or by grants from the Government, be able to continue in the same course, but we have not entered on that question. The public has offered to make this effort of providing materials—buildings for us, but as to the best employment of them afterwards, we have not yet entered into that question.

(*Mr. Lyon Playfair.*) I think that the Principal could very safely say that the present amount of the general fund of the University is not sufficient to meet the expenses of the new laboratories, and that resources of some kind must be found, whether they are from the Government or from private generosity, as the general fund is not sufficient at present.

(*Professor Huxley.*) I should like to ask whether the arrangements in the new chemical laboratory, which as I understand is going into the new buildings, are made with regard to the wants of the medical students chiefly, or whether there is ample provision there for a general chemical course.

(*Professor Turner.*) It is intended to make ample provision for all classes of students. Of course our medical students, being so numerous, constitute the principal attenders on the class of Practical Chemistry,

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but their course of Chemistry is a special one, and for their special instruction a special room will have to be provided. But, in addition, it is intended to provide a general laboratory with the most improved fittings and arrangements for all students of Chemistry, whatever their intended profession may be.

(*Professor Huxley.*) And will the physical laboratory which will be left in the old buildings be similarly provided with accommodation for thorough physical pursuits?

(*Professor Turner.*) The rooms adjacent to the small physical laboratory are my anatomical rooms, which Professor Huxley is acquainted with; and they are so situated that Professor Tait feels that there would be no difficulty in fitting them up for his purpose. My rooms are on the same floor as his apartments, and it would be an easy matter to make a doorway of communication between his present apartments and my rooms, and to fit up the rooms now occupied by me for his purposes.

(*Professor Huxley.*) Can the solidity be given to the floor which is requisite for the physical laboratory?

(*Professor Turner.*) I have no doubt as to that. The building is a solid substantial building.

(*Professor Huxley.*) There is now, I think, a science degree given by the University of Edinburgh?

(*Professor Turner.*) The University has given a science degree for several years.

(*Professor Huxley.*) And those arrangements will enable the students to pursue their studies with reference to that degree?

(*Professor Turner.*) Yes.

(*Mr. Lyon Playfair.*) Professor Huxley raises a very important issue in his questions. The chemical laboratory, as Professor Turner has explained, consists of two parts, one for the training practically of medical men in such subjects as testing, which chiefly come under their notice; but the other laboratory, which is a laboratory of investigation and of general training in chemistry, consists almost entirely of non-medical students, and of course in the new buildings it must be kept in view that the main laboratory of instruction and research is much more adapted to non-medical students than to medical students.

(*Professor Turner.*) We have that clearly before us.

(*Dr. Sharpey.*) Can the expense of assistants in any way be provided through the fees of the students?

(*Professor Turner.*) Only by withdrawing from the incomes of the professors.

(*Dr. Sharpey.*) I mean by adding to the fees of the students; has that occurred at all?

(*Professor Turner.*) The question of adding to the present fees has been mooted, but it might be doubtful whether it would be a wise course to resort to.

(*Mr. Lyon Playfair.*) Practically, the fees are much lower than they are in London or in England generally; but whether the students of Scotland are able to pay any larger fees is doubtful; and it would be a great question whether it would be advisable to raise considerably the fees for practical instruction.

(*Dr. Sharpey.*) Of course it would be a great deal better if provision for assistants were obtained in another way; there is no doubt about that.

(*Professor Wilson.*) But we do pay small salaries to a great many assistants out of the General University Fund. Whenever we happen to have a little surplus at the end of the year, we devote it to the most useful purposes, and one of those purposes has been the payment of certain assistants.

(*Mr. Lyon Playfair.*) We have now only to thank your Grace and the Commission for the kind attention which you have given us.

The Deputation withdrew.

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APPENDICES.

APPENDIX I.

The Botanical Collections at Kew and at the British Museum.

Communication from Mr. Carruthers.

British Museum,
My Lord Duke, 29th March 1875.

As Dr. Hooker and Messrs. Bentham and Ball were requested by the Commissioners to explain statements made in the communication I had the honour to submit, and as they apparently corrected or contradicted the said statements, I expected that I should also have been invited by the Commissioners for explanations of their statements.

I regret I had not such an opportunity before the Commissioners prepared their Report, as these explanations would have modified some of the statements, as of fact, contained therein; but, as I conceive they ought to be in possession of those who will be called upon to take action on the Commissioners' Evidence and Reports, I communicate them in order that they may be included in the next publication of the Commission.

I am, &c.,
To His Grace (Signed) Wm. Carruthers.
The Duke of Devonshire, K.G., F.R.S.
&c. &c. &c.

Referring to the communications of Dr. Hooker and Messrs. Bentham and Ball printed on pages 26 to 29 of the *Fourth Report of the Royal Commission on Scientific Instruction and the Advancement of Science*, I beg to submit the following statements:—

I. As to Dr. Hooker's Statement regarding the Herbarium at Kew before the appointment of Sir W. J. Hooker, to the following effect:—"From what I recollect myself, "and from what Sir W. J. Hooker told me, I believe that "it was, for the period, extensive, that it was arranged "chiefly according to countries, and was in part, at any "rate, classified and well named," l. c. p. 26; I assert, from data which I shall adduce as I proceed, the following facts:—There were two Herbaria: 1, the private one of Mr. Aiton, which was kept at his own house; and, 2, the Herbarium collected by Bowie and Cunningham, which was accommodated in a room in the Gardens. 1. Mr. Aiton's Herbarium consisted of (*a*) garden specimens, (*b*) a small alpine collection made by Schlescher in Switzerland, and (*c*) a small series of British plants collected by Teesdale. This Herbarium was retained by Mr. Aiton when his connection with Kew Gardens ceased, and was sold by Foster and Son in 1851 with his other effects. I have the catalogue of this sale in my possession. 2. The Bowie and Cunningham Herbarium was collected by these botanists in their joint or separate expeditions as "Botanical Collectors to His Majesty." Some years after Sir W. J. Hooker became Director of Kew Gardens, this Herbarium was sent to the British Museum, and was placed in a cabinet, where it remained untouched until some time after I was appointed Keeper of the Botanical Department. I am, therefore, able, from my own knowledge, to speak of this Herbarium. It was arranged in three sections, South American, African, and Australian. I am intimately acquainted with the African portion, which is being incorporated with the general Herbarium, and I have carefully examined a large portion of the South American and Australian portions, and I am able to say that the whole was very imperfectly named and only approximately classified, and that it never could have been of any use in naming plants in the Gardens. But I have further the testimony of Mr. John Smith, who, according to the *Report* of Dr. Lindley, quoted in the *Fourth Report* of the Commissioners, was responsible for the names of the Garden plants, that he received no assistance whatever in this work, either from the small Herbarium of Bowie and Cunningham in the gardens, or the private Herbarium of Mr. Aiton, kept in his own house. I regret that my suggestion that Mr. Smith should be examined was not adopted by the Commission, as his testimony would have been most important in regard to matters of fact, to which he alone can speak from personal knowledge.

From facts which have come to my knowledge since I wrote the paper printed in the first volume of the Evidence taken before the Commissioners, I wish to modify the statement therein made that "no Herbarium of any kind, "I believe, existed at the Gardens during their (the "Aitons) time." (Appendix XV., Vol. I., p. 45.) I was aware of the private Herbarium in Aiton's house when I wrote this, but not of the collections of Bowie and Cunningham accommodated in the Gardens. As they were, however, of no use for garden purposes, the argument of my paper is unaffected by this modification.

II. Mr. Bentham calls in question my personal experience of the Botanical Museum and Herbarium at Kew, because he has no recollection of seeing me there. If Mr. Jackson or Professor Oliver had borne this testimony, it would have been to the purpose. They are the officers in charge of these establishments, and their testimony, which would have been somewhat different from that of Mr. Bentham, would have been of value. I would, however, say further, that whether Mr. Bentham's memory or observation is at fault I cannot tell, but I have had the pleasure of seeing him at the Herbarium at Kew.

Mr. Bentham ventures to correct my statement, made, as he thinks, from ignorance of the Kew Collections, that Sir W. J. Hooker had no "*public* Herbarium at Kew till 1855," by stating that he used "his own *private* Herbarium?" My statement was based on the Official Reports for 1853 and 1854 of Sir W. J. Hooker to the First Commissioner of Her Majesty's Works, in the former of which he says, "Kew had hitherto possessed "no Herbarium or Hortus Siccus, the invariable accom-"paniment of every Botanic Garden abroad, and no "Library save the small practical one for the use of the "gardeners, but by gifts it is endowed by both;" referring to the bequest of Dr. Broomfield's, and the gift of Mr. Bentham's Herbarium and Library. And in the latter he says, "till 1853 our Garden was utterly destitute of the two former appendages," viz., Herbarium and Library.

Mr. Bentham may have presented his Herbarium for the use of Scientific Botanists, but Sir W. J. Hooker, as the above extracts and other Reports testify, accepted it as an appendage to the National Botanic Gardens for "naming, arranging, and ticketing the specimens."

In reference to Mr. Bentham's correction of the date when his Herbarium and Library were presented, I have to say that the year given by me was obtained from the Official Report of the late Sir W. J. Hooker for the year 1855.

III. Mr. Ball calls in question my right to state that "everything that became National property in 1827 is still "in the Collection," unless I have verified, specimen by specimen, the tens of thousands of specimens in the Museum. Were this the only possible premise on which my assertion could be based, Mr. Ball would be justified; but I had other and more satisfactory data, which I am ready to state and substantiate at any time.

I venture to submit that Mr. Ball should not be allowed to print such charges as are contained in his letter of 28th November 1872, without being required to substantiate them. I deny that there is any foundation of truth for these statements; and until he specifies some of the "large "accumulations of collections" that "were extensively

Appendix II. to Fourth Report, p. 28.

"attacked by insects," I have a right to believe that such assertions have no more foundation than the equally sweeping accusation against the Museum made in his Evidence in chief [Qu. 7229]. In that instance, when I demanded from him the case on which his assertion was founded, he informed me that "from inquiries made "within the last two days, I am led to believe that the "impression under which I spoke was incorrect." Instead of withdrawing this admitted erroneous statement, he tries to strengthen his position by making further equally objectionable and baseless assertions.

I venture to express the belief that whatever action is taken on the Evidence and Reports of the Commissioners will be based on the facts adduced in evidence, and not on the opinions of partisans whose strong assertions have not been and cannot be supported by facts.

WILLIAM CARRUTHERS.

29th March 1875.

APPENDIX II.

CORRESPONDENCE between the TREASURY and the REGISTRAR GENERAL, relative to certain METEOROLOGICAL RETURNS furnished to him by MR. GLAISHER.

1543.

SIR, Whitehall, February 26, 1874.

I AM directed by Mr. Secretary Cross to transmit to you, herewith, a copy of a letter received from the Treasury, with enclosed correspondence between that Department and the Registrar General, as to the employment of Mr. John [James] Glaisher in compiling certain Meteorological Returns; and I am to request that, in laying the same before the "Aid to Science Commissioners," you will draw their special attention to the grant made to the Committee appointed by the Royal Society to conduct Meteorological Observations and Experiments on behalf of the Government. (See Civil Service Estimates, Class IV., Vote 6.)

I am, &c.

The Secretary to the Aid to Science Commission. A. F. O. LIDDELL.

Copy of 29,391/68, enclosure, and Treasury reply.
Copy of 13,998/72 and reply.
Copy of 14,808/72 of 17,867/72 and enclosures, with reply.
Copy of 18,248/72 and reply, and of 2,209/73, and enclosures and reply.

1543/151. Treasury Chambers.

SIR, February 24, 1874.

I AM directed by the Lords Commissioners of Her Majesty's Treasury to transmit to you copies of the enclosed correspondence between this Board and the Registrar General, as to the employment of Mr. John [James] Glaisher in compiling certain Meteorological Returns, and I am to request that you will move the Secretary of State to cause them to be transmitted to the "Aid to Science Commission," with a view of drawing their special attention to the grant made to the Committee appointed by the Royal Society to conduct Meteorological Observations and Experiments on behalf of the Government. (See Civil Service Estimates, Class IV., Vote 6.)

I am, &c.

(Signed) WILLIAM LAW.

The Hon. A. F. O. Liddell.

SIR, December 28, 1867.

UPON more than one occasion I have brought under the notice of the Lords Commissioners of Her Majesty's Treasury the advantage I derive from the labours of Mr. Glaisher in obtaining the results of Meteorological Observations from different parts of England and Wales.

They are published in my Weekly, Quarterly, and Annual Returns; 57 publications every year.

The interest of these returns in the eyes of many of the public is greatly increased by making known the results of these numerous observations, deduced by so scientific a man as Mr. Glaisher.

But his labour is *enormous*, as is evinced by the two specimens of my Weekly and Quarterly Returns, which I now enclose for their Lordships' inspection (see pages 402 and 403 and 408 of Weekly, and pages 6 and 18 to 26 of Quarterly).

I also now enclose a copy of a letter I have lately received from Mr. Glaisher, and I will thank you to ask their Lordships' sanction to my paying in future to Mr. Glaisher out of the funds voted by Parliament for the contingencies of this Office 200*l.* 0*s.* 0*d.* per annum, instead of 100*l.* 0*s.* 0*d.*, the first of such payments to be made at the end of this current year.

I have, &c.

(Signed) GEORGE GRAHAM,

To the Secretary, Registrar General.
Treasury, Whitehall.

MY DEAR SIR, Blackheath, August 15, 1867.

SINCE the year 1844 I have at the end of every quarter forwarded to you the results of carefully made Meteorological Observations collected from different parts of the country.

A sum of 50*l.* was allowed for several years towards the expense of reducing the observations and the deduction of results.

Two years since, on the addition of weekly returns for several large towns, the annual sum was increased to 100*l.*, but these returns necessitate my employing a competent computer to deduce the results, and to proceed with the work during my absence.

The work of necessity occupies a good deal of my time, for which I am not remunerated; may I ask you to increase, if you can, the annual allowance to 200*l.*

I am, &c.

The Registrar General. (Signed) JAMES GLAISHER.

20,391. Treasury Chambers,

SIR, February 7, 1868.

WITH reference to your letter of the 28th of December last, I am directed by the Lords Commissioners of Her Majesty's Treasury to state that the subject of Meteorology generally, and Meteorological Observations, has been placed in the charge of a Committee of the Royal Society, and that a sum of 10,000*l.* is to be inserted in the Estimates, with the view of enabling them to carry out the objects assigned to them, in communication with the Board of Trade.

My Lords are inclined to think that the arrangements for reducing the Meteorological Observations for the purpose of publication in your Returns might be transferred to the Committee of the Royal Society, and form a part of their business, and my Lords suggest that you should place yourself in communication with the Committee, and make a further report to this Board.

In the meantime, however, my Lords would be sorry that the public should be deprived of your publications with the deductions of Mr. Glaisher, and they will not object to his remuneration being increased from the present rate of 100*l.* a year to the rate of 150*l.* a year, to be paid out of the contingencies of your Office, until it can be ascertained whether any arrangement can be made with the Meteorological Department.

I have, &c.

(Signed) GEO. A. HAMILTON.

The Registrar General.

1160. Exchequer and Audit Department,
Somerset House, London, W.C.

SIR, August 30, 1872.

I AM directed by the Comptroller and Auditor General, with reference to the second paragraph of a letter addressed by the Lords Commissioners of Her Majesty's Treasury to the Registrar General, on the 7th February 1868, to transmit for their Lordship's consideration a copy of a letter dated 10th August 1872, sent by the Registrar General to this Department, relative to his continued employment of Mr. Glaisher upon Meteorological Observations.

I have, &c.

(Signed) C. MALLET.

R. R. W. Lingen, Esq., C.B.

1092. General Register Office, Somerset House,

SIR, August 10, 1872.

As requested in your letter of 25th July, I now transmit copies of the correspondence between the Lords of the Treasury and myself respecting Meteorological Reports furnished to me by Mr. Glaisher.

I have had no correspondence on the subject with the Meteorological Society that I can recollect, nor have I acted upon the suggestion made by the Lords of the Treasury, on 7th February 1868, that I should communicate with the Royal Society, being unwilling that the public should be deprived of the deductions, of Mr. Glaisher to which they have been accustomed for many years in my Weekly, my Quarterly, my Annual Reports, 57 in number annually, and being certain that the Royal Society would not furnish me with Meteorological Observations so complete and so punctual as I invariably, without delay, receive from Mr. Glaisher.

I have, &c.

(Signed) GEORGE GRAHAM,

To the Secretary, Registrar General.
Exchequer and Audit Department,
Somerset House.

13,926. Treasury Chambers,
September 16, 1872.

Sir,

In forwarding to you the enclosed copies of correspondence for such further explanation as you may wish to offer, I am directed by the Lords Commissioners of Her Majesty's Treasury to express to you the surprise with which my Lords learn that you read their letter of February 7th, 1868, relative to the payment of Mr. Glaisher, for the preparation of Meteorological Records, as conveying more than a provisional and limited authority, and I am directed by their Lordships to acquaint you that the reasons which you have at present alleged appear to them to be insufficient to justify you in having continued to retain that gentleman's services without further express reference to this Board.

My Lords have not yet replied to the Comptroller and Auditor General as to the discharge of your account for these payments, and as the time is approaching at which the Estimates for 1873–4 have to be prepared, my Lords will be glad to receive also (as soon as possible) a statement of any fresh reasons you may wish to offer against the removal, after the end of the current financial year, of this charge from the votes in supply.

I am, &c.
(Signed) Chas. W. Stronge,
pro Sec.

The Registrar General.

13,926.

September 21, 1872.

Sir,

In reply to your letter of 16th inst., I regret to own that inadvertently I have omitted to act upon the suggestion of the Lords Commissioners of Her Majesty's Treasury, conveyed to me in your letter of 7th February 1868.

I hasten to protest that I must not be considered guilty of anything so heinous as wilfully and designedly disobeying their Lordships instructions.

I did not, in written letters recorded in official ledgers at that time, communicate with the Royal Society, but from personal inquiries I satisfied myself that that learned body could not give the same particulars that I receive from the Royal Observatory at Greenwich, with the same regularity for immediate publication; and I am sorry to say I accidentally omitted to make that report to their Lordships. To me, personally, it was of course immaterial whether the particulars were furnished by the Royal Society or from the Royal Observatory at Greenwich.

I have now written to the Royal Society, and will inform their Lordships when I receive their reply.

I imagine that their Lordships do not wish to see the Meteorological Returns abridged, which for so many years I have been in the habit of publishing, the value of which was fully pointed out in my letter to you of 21st December 1864.

I have, &c.
(Signed) George Graham,
Registrar General.

To the Secretary, Treasury.

November 9, 1872.

Sir,

I will thank you to inform the Lords Commissioners of Her Majesty's Treasury that, in accordance with the wish I understood to be expressed by their Lordships, I have asked the Royal Society whether they could furnish me with the information and Reports on Meteorological subjects now supplied to me weekly, quarterly, and yearly, by Mr. Glaisher of the Royal Observatory at Greenwich, seeing that 10,000*l.* per annum is received from the public by the Meteorological Committee of the Royal Society.

I have received a reply, a copy of which I now enclose, and I shall be glad to receive instructions from their Lordships as to any further steps they desire me to take in this matter.

I have, &c.
(Signed) George Graham,
Registrar General.

To the Secretary,
Treasury, Whitehall.

The Royal Society, Burlington House.
November 6, 1872.

Sir,

In reply to the inquiry contained in your letter of the 18th September 1872, I am directed by the President and Council of the Royal Society to explain that the weekly Meteorological Returns transmitted to your Office from the Royal Observatory, Greenwich, are supplied by the Astronomer Royal, and free of expense.

In case of any other information being desired from the Meteorological Committee, the President and Council suggest that application be made to the Board of Trade, under which Department the Committee acts.

I have, &c.
(Signed) W. Sharpey, M.D.,
Secretary R.S.

G. Graham, Esq.,
Registrar General.

17,087. Treasury Chambers.
November 19, 1872.

Sir,

I am directed by the Lords Commissioners of Her Majesty's Treasury to acquaint you, for the information of the Lords of the Committee of Council for Trade, that for some years past an annual payment has been made through the Registrar General to Mr. Glaisher, one of the Assistants to the Astronomer Royal, on account of the preparation, by him, of certain tables of Meteorological Observations, which are published by the Registrar General with his Reports.

My Lords have received from the Registrar General a copy of a letter from the Royal Society (a copy of which is herewith enclosed), dated 6th November 1872, from which it appears that some misapprehension exists as to the terms on which these Returns are supplied, and bearing in mind the arrangement made in 1866, by which the sum of 10,000*l.* was placed on the Estimates in order to provide for Scientific Meteorological Observations, &c., to be undertaken by a Committee appointed by the Royal Society at the request of the Government, my Lords would be glad if their Lordships of the Committee of Council for Trade would cause a communication to be addressed to the Committee of the Royal Society with a view to ascertain whether the tables now furnished by Mr. Glaisher might not be supplied to the Registrar General by that Committee without incurring any charge beyond the 10,000*l.* a year they now receive.

I am to transmit copies of the Registrar General's Returns with Mr. Glaisher's tables appended.

I am, &c.
(Signed) Wm. Law.

T. H. Farrer, Esq.

Meteorology.

Board of Trade, Whitehall Gardens.
November 29, 1872.

Sir,

I am directed by the Board of Trade to acknowledge the receipt of your letter of the 19th instant (17,087) inquiring whether certain tables of Meteorological Observations, now furnished by Mr. Glaisher, might not be supplied to the Registrar General of Births, Deaths, and Marriages by the Meteorological Committee of the Royal Society, without incurring any charge beyond the 10,000*l.* a year they now receive.

Before taking the matter into further consideration, this Board would be glad if the Lords Commissioners of Her Majesty's Treasury would cause them to be informed specifically what particulars the Registrar General would require, also in what forms and at what periods these particulars would have to be furnished.

The Meteorological Committee have certain stations, observatories, telegraphic and others, from which they obtain reports, and it would be of importance to know whether the Registrar General would be satisfied with these, or if he thinks it necessary that reports should still be obtained from Mr. Glaisher's present stations, whether he can guarantee that the Committee would in future be able to obtain information from Mr. Glaisher's present stations.

Having regard to them, I am to suggest that it might be desirable that the Registrar General of Births, Deaths, and Marriages should be instructed to place himself in direct communication with the Meteorological Committee, who are ready to render all the help in their power.

I have, &c.
(Signed) W. R. Malcolm.

The Secretary, Treasury.

18,248. Treasury Chambers.
December 7, 1872.

Sir,

With reference to the correspondence which has taken place on the subject of the tables of Meteorological Observations supplied to you hitherto by Mr. Glaisher, one of the Assistants to the Astronomer Royal, for publication with your Reports, I am desired by the Lords Commissioners of Her Majesty's Treasury to transmit to you the enclosed copy of a letter which their Lordships have received from the Board of Trade on the subject, and I am to request that you will place yourself in communication with the Meteorological Committee of the Royal Society, in accordance with the suggestion contained in the last paragraph of that letter, and report the result to this Board.

I am, &c.
(Signed) William Law.

The Registrar General.

February 6, 1873.

Sir,

I will thank you to lay before the Lords Commissioners of Her Majesty's Treasury the copies and extracts of a letter dated 7th January 1873, addressed to me by the Meteorological Committee of the Royal Society, and of a letter, dated 3rd February, which I have received from Mr. Glaisher, to whom I showed the first-named letter.

I think, beyond all doubt, the Committee would not be able to furnish with necessary regularity the observations for publication on specified days in the same fulness as they have for many years been received by me here without fail.

This would be so painful to Mr. Glaisher that, as their Lordships dislike giving him 150*l.* per annum, he offers to continue furnishing these Returns *gratuitously*.

I think their Lordships will hardly consent to such an arrangement proposed by this gentleman, so zealous in his calling.

I take the liberty of suggesting that their Lordships should recommend the Committee to give to Mr. Glaisher annually 150*l.* out of the immense sum placed every year at their disposal for like purposes.

I have, &c.
(Signed) GEORGE GRAHAM,
Registrar General.

To the Secretary,
Treasury, Whitehall.

Meteorological Office,
116, Victoria Street, London, S.W.
January 7, 1873.

SIR,

I AM instructed by the Meteorological Committee to inform you, in reply to your letter of the 17th ultimo, that having examined the list of stations from whence Meteorological Reports are printed in your various Returns, they are of opinion that there would be no difficulty in their supplying you with information of a similar character to that now published by you, without any additional charge to the Government beyond their annual grant.

Several private observers whose names appear in the Returns, already supply observations to this Office, and the Committee think it probable that a larger proportion of the remainder would do so if requested.

In order that you may be acquainted with the amount of information the Committee are now in a position to supply, I am instructed to send you the map herewith enclosed, on which I have marked in red the stations from which the Committee receive reliable daily observations. The number of these stations could be increased.

The Committee having a staff competent to discuss the Returns, would be most happy to meet the wishes of the Treasury by supplying such Returns free of charge.

I am instructed to point out to you, that they could not undertake to pay any sum of money out of the grant, with the management of which they are intrusted, for work to be carried on by any gentleman not under the entire control of, and in direct communication with the Committee.

I have, &c.
(Signed) ROBERT H. SCOTT,
Director.

G. Graham, Esq.,
Registrar General,
Somerset House, W.C.

Blackheath, February 3, 1873.

MY DEAR SIR,

I THANK you for affording me an opportunity of perusing the correspondence that has taken place with reference to the meteorological matter supplied by me to you for publication in your Quarterly Reports, and for which in recent years I have received the sum of 150*l.* per annum.

I have supplied this information for the last 28 years, and in relation to the discussion that has occurred, I desire to place on record the history of the matter as far as I am concerned.

Previously to the year 1844, you published the results of a few observations, the accuracy of which you stated you had no means of determining, and you added that you had no one in your Office who could assist you in the reduction of the observations to useful and practical results.

I travelled at my own expense over the country, and induced 40 to 50 gentlemen of education to incur the expense of instruments, and to supply themselves with new ones where broken, also at their own expense, as well as to devote their time to taking the observations. Every attempt to collect a corps of observers previously had failed.

From the year 1844 I supplied the information to you adapted to your wants, at first without receiving any grant, then 50*l.* was granted, afterwards 100*l.*, and lately 150*l.* annually towards the expenses. It seems to be considered that 10,000*l.* paid for the Meteorological Office ought to cover all meteorological expenses, and in this I entirely agree. I go further and say that 10,000*l.* appears to me an extravagant sum to spend annually on Meteorology, even if it were properly devoted to the advance of the science. When the Royal Observatory at Greenwich, an institution that is charged with duties of a far higher scientific and national importance, and undertakes far more laborious work, is maintained at much less cost. I think advisedly and as an old meteorologist who has devoted more than 40 years of his life to the advance of the science, when I say that I can see no results that are obtained by the Meteorological Office that in any way represent the value of the money expended on them, and I am so clearly convinced of the inability of the Office to collect and properly reduce the information that it has been a pleasure to me to undertake and build up in accordance with the varied needs of your Office, and the advance of Science, for more than a quarter of a century, that rather than the work should be continued under the direction of others not competent to carry it on, I would willingly supply the matter to you, as for some years I did, free of expense.

The original foundation of the meteorological stations and the continued supply of observations I have received, together with the confidence and goodwill the observers have invariably shown towards me, have been a great source of pride to me, and I have never regarded the preparation of the matter I have forwarded to you for so many years in the light of work done for money.

I bore, as I have stated, the expense of the reduction of the observations, the labour and expense of correspondence, travelling expenses in visiting the stations, for a long time myself, and if necessary I am prepared to do so again.

The amount I received was devoted to paying expenses, and I have always considered, even in recent years when I have received 150*l.*, that my own services were given almost gratuitously.

With regard to the Meteorological Office supplying the information hitherto collected by myself, it could of course be done if the Office had as many stations with careful observers, as well scattered over the country as mine are, but in point of fact nothing of the kind is the case: the Office, at great cost, maintains six elaborate meteorological stations in England, Ireland, and Scotland, situated almost in a straight line (as near as possible), furnished with self-registering instruments, but placed differently in each. Now for the purpose for which the Meteorological matter is printed in your Returns, six stations would be useless, and the self-registration would give no additional value.

Mr. Scott, the Director of the Meteorogical Office, states that a good many observers who now forward reports to me would do so to that Office if requested, and it is not unlikely that a considerable number of the gentlemen who contribute information to me might, if asked to do so, send copies also to any Government Department; but setting aside the question of how far Mr. Scott, as the head of a Government Office, is morally justified in tampering with my corps of observers, the majority of whom were induced to take observations at my personal request, I do not believe any Government Department could afford to perform the work under a very considerable expense, and for this reason: I have been repeatedly asked by my observers whether I supplied the instruments, or whether any public body could supply them, and have invariably replied that I had no fund for such a purpose, and that they must bear the expenses themselves. Some would-be observers have then declined, but others I have induced to undertake the expense. Now I am certain that observers would not bear the cost of their own instruments; not to mention the devotion of their own time to supply information gratuitously to any Government office, particularly when that office had a very large sum of money at its disposal.

With regard to the great waste of public money, which I in common with most meteorologists, consider takes place by the Meteorological Office, I trust that if the Lords of the Treasury see fit to withhold the grant I have received, they may also consider whether it is not desirable that a considerable reduction may also be made in the amount annually devoted to Meteorology, which not only seems to me excessive, but likewise calculated to bring the science into disrepute, from the small return that is received for the money, due, as I consider, to its misappplication. I wish to except Sea Meteorology, the results from which I am of opinion are valuable, and for which *alone* the Office was founded.

I should not have felt called upon to express an opinion on the management of the Meteorological Office, only as its Director states that he can perform the work that I have hitherto done, I feel it due to myself to distinctly state why I desire the work begun by me, and continued during a great part of my life, should not be handed over to those in whom I could place no confidence, and, so long as I am able, I desire to continue, with or without a grant, the series of reports of which I was the founder, and in which I have reason to know every member of the medical profession places confidence.

I have not entered into more detail with regard to my objection to entrust work to the Meteorological Office, though I am ready to do so if required.

But I cannot close without expressing my opinion that no head of a Meteorological Office will inspire confidence who is not an observer himself, and contrasting the amount of information I have collected and afforded, for a sum never exceeding 150*l.*, with the work performed by the Office for a grant of 10,000*l.*

I am, &c.
(Signed) JAMES GLAISHER.

The Registrar General.

2200. Treasury Chambers,
April 2, 1873.

SIR,

THE Lords Commissioners of Her Majesty's Treasury have had before them your letter of the 6th ultimo [February], and its enclosures, with respect to the supply to you by Mr. Glaisher, of the Royal Observatory, of Meteorological matter for the purpose of printing with your Reports.

I am to acquaint you that their Lordships are pleased to sanction the employment of Mr. Glaisher up to the present time at the salary, viz., 150*l.* per annum, but this sanction is limited to the year ending 31st March 1874.

A copy of this letter has been sent to the Comptroller and Auditor General with reference to his letter of the 30th August last, calling their Lordships' attention to Mr. Glaisher's continued employment, copy of which was sent you with the letter of this Board of the 14th [16] September last.

I am, &c.
(Signed) WILLIAM LAW.

The Registrar General.

APPENDIX III.

THE METEOROLOGICAL OFFICE.

COMMUNICATION from the DIRECTOR.

Royal Commission on Scientific Instruction
and the Advancement of Science,
6, Old Palace Yard, S.W.,
Feby. 27, 1875.

SIR,

WITH reference to your letter to Professor Smith, proposing to give further Evidence respecting additional work carried on by the Meteorological Office, I am directed by His Grace, the Chairman of this Commission, to say that any further information which you wish to place before the Commissioners may be conveyed in the form of a written communication.

I have, &c.,
J. NORMAN LOCKYER,
Secretary.

R. H. Scott, Esq., F.R.S.

Meteorological Office,
116, Victoria Street, London, S.W.,
27 February 1875.

SIR,

I HAVE the honour to acknowledge the receipt of your letter of this day, and to inform you, in reply, that I shall submit a brief statement to you, in accordance with the kind permission of His Grace the Chairman of the Commission.

This statement will not have reference so much to "additional work carried on at the Meteorological Office," as to the action of the Permanent Committee of the Vienna Congress in the development of uniformity of operations in the different European countries.

I have, &c.,
ROBERT H. SCOTT,
Director.

Norman Lockyer, Esq., F.R.S., Secretary,
Royal Commission on Scientific
Instruction, &c.

Meteorological Office,
116, Victoria Street, London, S.W.,
March 11, 1875.

SIR,

IN accordance with the kind permission from His Grace the Chairman of the Science Commission, conveyed to me in your letter of the 27th ult., I beg to enclose a memorandum containing some evidence supplementary to that already tendered by me to the Commission.

I have the honour to be
Your obedient servant,
ROBERT H. SCOTT,
Director.

J. N. Lockyer, Esq., F.R.S.

SUPPLEMENTARY EVIDENCE for the ROYAL COMMISSION ON SCIENTIFIC INSTRUCTION and the ADVANCEMENT OF SCIENCE.

Qu. 13,925. Arrangements have been concluded between the Meteorological Society and the Meteorological Office, and have come into effect on the 1st January 1875. The principal features of these arrangements are that the Observers belonging to these two organizations are supplied with an uniform schedule for recording their observations, and that the Society undertakes to furnish to the Office monthly returns from certain selected stations for publication with the returns from its own stations, in consideration of a certain payment, which will probably average about 50*l.* per annum.

An invitation has been issued to the Scottish Meteorological Society to co-operate with the Office on similar terms, and the Meteorological Committee are not without some hope that this proposal may be accepted.

Qu. 13,933. The Trinity House and the Commissioners of Irish Lights have undertaken to have observations of sea temperature taken at certain lightships and at one lighthouse. The Commissioners of Northern Lights have declined to co-operate on the ground of having no lightships.

The Committee have been requested by the "Commission Zur Wissenschaftlichen Untersuchung der Deutschen Meere" to organize a series of observations on the Western Coasts of the North Sea, similar to that organized under its own auspices on the German shores.

The Committee have not felt themselves in a position to undertake so complete an investigation, as much of the enquiry would be of a biological character, and, therefore, foreign to their own sphere of operations.

Qu. 13,939. In virtue of the arrangements mentioned under Qu. 13,925, the Office is prepared, if necessary, to supply returns of trustworthy character from January 1st, 1875, from at least 36 stations distributed over Great Britain and Ireland, and there is no doubt that this list could be largely increased to meet the requirements of the Registrar-General, if such stations as the Royal Observatory, Greenwich, the Radcliffe Observatory, Oxford, the Bidston Observatory, Birkenhead, were requested to continue to send to the Meteorological Office their returns as soon as the Registrar-General ceased to receive them directly.

Qu. 13,961. The Permanent Committee of the Vienna Congress held a meeting at Utrecht this year, and adopted certain measures tending towards the attainment of greater uniformity in climatological enquiry than has hitherto obtained.

The chief of these measures has been the recommendation that at a certain number of stations in each country observations of a similar nature should be taken and should be published on an uniform system, so as to be capable of being bound up together. These observations are to be published in full, and a form has also been devised for the publication of yearly *résumés* from all stations.

The number of stations suggested for each country is as follows:—

Norway	10
Sweden	10
Denmark, with Iceland and Färoe	6
Great Britain and Ireland	15
Russia in Europe	50
Russia in Asia	100
Netherlands	2
Belgium	2
Germany	12
France	12
Austria and Hungary	15
Turkey	10
Switzerland	5
Italy	12
Spain, Portugal (and Azores)	12
Greece	3

The Permanent Committee have reason to hope that this proposal will be accepted by *all* the nations of Europe with one or two exceptions, among which France should be mentioned, inasmuch as she was not represented at the Congress of Vienna.

Qu. 13,962. I have been elected Secretary to the Permanent Committee.

Qu. 14,402. The Maritime Conference mentioned was held in September 1874 at the Meteorological Office. It was of a private, *i.e.* non-official, character, and was attended by the following gentlemen:—

Austria	R. Müller	Director of the Imperial Royal Hydrographic Office at Pola.
Belgium	F. van Rysselberghe	Navigation School, Ostend.
Bengal	H. F. Blanford	Secretary Meteorological Committee, Calcutta.
China	J. D. Campbell	Inspectorate General of Chinese Maritime Customs, London.
Denmark	Capt. N. Hoffmeyer	Director of the Royal Danish Meteorological Institute, Copenhagen.
France	A. Delamarche	Ingénieur Hydrographe, Ministry of Marine, Paris.
„	C. Sainte Claire Deville	Inspector of French Meteorological Stations, Paris.
Germany	W. H. v. Freeden	Director of the "Deutsche Seewarte" at Hamburg.
„	H. A. Meyer	Commissioner for Investigating the German Seas, Kiel.
„	G. Neumayer	Hydrographer, Berlin.
„	Capt. Stempel	Imperial Navy.
Great Britain	R. J. Mann, M.D.	President of the Meteorological Society, London.
„	Rear-Adm. M. F. Nolloth	Representative of the Admiralty.
„	R. H. Scott, F.R.S.	Director of the Meteorological Office, London. Hon. Secretary to the Sub-Committee.
„	Capt. H. Toynbee	Marine Superintendent, Meteorological Office. (Representative of the Board of Trade.)
Holland	H. Buys Ballot	Director of the Royal Meteorological Institute of the Netherlands, Utrecht.
„	Lieut. J. E. Cornelissen	Marine Superintendent, Utrecht (Royal Dutch Navy).
Italy	Capt. N. Canevaro	Naval Attaché to the Royal Italian Legation, London (Royal Italian Navy).
Norway	H. Mohn	Director of the Royal Norwegian Meteorological Institute at Christiania.
Portugal	J. C. de Brito Capello	Director of Nautical and Meteorological Observations, Observatory of the Polytechnic School, Lisbon.
Russia	A. Moritz	Director of the Observatory at Tiflis.
„	Capt. M. Rikatcheff	Central Physical Observatory, St. Petersburg (Imperial Navy).
Spain	Capt. H. Montojo	Spanish Navy.
„	Capt. C. Pujazon	Director of the Marine Observatory, San Fernando (Spanish Navy).

Every nation in Europe, except Greece, Sweden, and Turkey, was represented. The United States, however, took no part in the Conference.

The Report of the Conference has now appeared, and contains the replies from the various nations respecting the working of the Brussels Conference referred to by me under Qu. 14,401.

The result of the deliberations was to approve, on the whole, of the Brussels Resolutions, and to recommend for general adoption a plan of observation and record almost identical with that in use in our own Office.

Qu. 14,432. The Permanent Committee have supported the request for copies of the Hourly Tabulations from our automatic records, and the Committee have undertaken to issue them for the year 1875 as well as for 1874, but the subscribers have been extremely few.

ROBERT H. SCOTT.

APPENDIX IV.

RESOLUTIONS passed at the LAST MEETING of the COMMISSION.

[Extracted from the Minutes.]

"At this, the final meeting of the Royal Commission on Scientific Instruction and the Advancement of Science, the following Resolutions were carried unanimously:

"I. That the Commissioners desire, before separating, to place on record their high sense of the value of Mr. J. Norman Lockyer's services as Secretary to the Commission.

"The labours of the Commission have extended over a period of more than five years, during which Mr. Lockyer has been constantly engaged in procuring and arranging for the Commissioners information upon various and important subjects connected with Science.

"The Commissioners would refer more especially to Mr. Lockyer's exertions as Assistant-Commissioner for enquiring into Scientific Teaching in Public Schools.

"The Commissioners consider that they have been very fortunate in obtaining the services of a Secretary who combined eminence in scientific enquiry with experience of the business of the Public Departments.

"The Commissioners desire, in conclusion, to express a hope that, on the termination of the Commission, some arrangement may be made by which the services of Mr. Lockyer, in the promotion of Science, may be secured to the country.

"II. That the above Resolution be printed in the Appendix, and that His Grace the Chairman of the Commission be requested to lay it before the Prime Minister and the Lord President of the Council."

ANALYSES

OF THE

EVIDENCE CONTAINED IN THIS VOLUME.

ANALYSES OF THE EVIDENCE

RESPECTING

METEOROLOGY.

SCOTT, ROBERT H., Esq., M.A., F.R.S. (Index of his Evidence.)

Accommodation for Science Purposes.
Meteorological Office is not located in a public building; it utilizes existing buildings for observational purposes, 13,886, 14,011–14,014, 14,393–14,398, 14,483.

Admiralty.
Meteorological Office is constantly consulted by Admiralty Court, 13,948.

Army Medical Department.
Army Medical Department is being organized in conjunction with Meteorological Office, 13,950.

Austria.
Meteorological Congress at Vienna; permanent committee appointed, 13,958–13,963.
Allowance in Austria for meteorological observations, 14,020 (App. B.)

Board of Trade.
Meteorological Office was originally under Board of Trade; it should be so again, 13,861–13,874, 13,904, 13,978.

British Association.
Grants given by British Association for rainfall observations, 13,940–13,947.

Brussels.
Brussels Conference proposed a uniform system for ocean observations; English only adhere to it, 14,400, 14,401.

Colonies.
Meteorological organizations exist in India, New South Wales, New Zealand, &c., 13,952–13,955.

France.
French Meteorological Department; no proper organization; connexion with London Meteorological Office, 13,957, 14,449, 14,454–14,456.

FitzRoy, Admiral.
Admiral FitzRoy; formerly head of Meteorological Department; his publication of fragmentary notices; his signals still used, 13,863, 13,864, 13,906, 13,932, 14,386, 14,387, 14,420, 14,454, 14,458, 14,465, 14,467.

Government.
Relation of Government to Meteorological Office; disclaims connexion; gives an annual vote, 13,861–13,874, 13,904–13,906.

Grants for Science Purposes. See *Income and Expenditure.*

Greenwich.
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Temperature Every day 1 year from 1814 — 1856 in London

(Glaisher)

ON

THE DETERMINATION

OF

THE MEAN TEMPERATURE

OF EVERY DAY IN THE YEAR,

FROM ALL

THE THERMOMETRICAL OBSERVATIONS

TAKEN AT

THE ROYAL OBSERVATORY, GREENWICH;

FROM THE YEAR 1814 TO THE END OF 1856.

By JAMES GLAISHER, Esq., F.R.S.

[*From the* Report of the Meteorological Society *for* 1857.]

LONDON:
TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.
1858.

Previous to the year 1807 no readings of meteorological instruments were taken at the Royal Observatory, Greenwich, with the exception of those necessary for the calculation of refraction in the reduction of astronomical observations. From the year 1807 to the end of the year 1813, readings for meteorological purposes were taken, but they consisted only of a single reading of the barometer and thermometer daily. From January 1814, a more extensive series was commenced, which consisted of the reading of the barometer and thermometer, direction of the wind, amount of cloud, and general remarks, all of which were taken two, three, or four times daily; together with the readings of a maximum and minimum thermometer. These observations have been carefully preserved in the archives of the Royal Observatory, but no use has been made of any of them taken before the year 1841.

I have reduced and discussed all the thermometrical observations taken at the Royal Observatory, from January 1st, 1814, to December 31st, 1856, the results of which I have now the honour of laying before the Society. The barometrical observations taken at Greenwich previous to the year 1841 are of little value, they having all been made by the instrument in use for the observations to calculate refraction, and which, though good enough for this purpose, is certainly not adapted for meteorological observations; this circumstance is one, however, of little importance, since the fine series of barometrical observations taken at the Apartments of the Royal Society is more than sufficient to supply the defect.

The purpose to which I have applied the observations in this paper, is the determination of mean daily temperatures, which has been performed in the following manner:—

The first process has been to copy out from the MS. observations, day by day, all the readings of that day, including those of the maximum and minimum thermometers. The correctness of this transcription was examined.

The next process has been to see that all the thermometrical readings in the day were less than the maximum, and greater than the minimum, and to note all discordant readings.

The third was to examine all discordant readings; for this purpose the Greenwich volumes of 'Astronomical Observations' were

consulted for readings taken at about the same times; the Philosophical Transactions, and any contemporaneous observations to be met with.

The fourth process was to take the mean of all the observations of the free thermometer taken daily.

Next, to deduce from these means true mean daily values by the application of the correction as calculated from my Tables of diurnal range published in the Philosophical Transactions for the year 1848; depending upon the time at which the observations were taken at the different periods.

The first period extended from January 1814 to September 1822, during which time the observations were taken at 8 A.M., at noon, and at 10 P.M., and the corrections applied to the monthly means were as follows:—

January, −0°·1; February, −0°·1; March, −0°·1; April, −0°·5; May, −0°·9; June, −1°·2; July, −1°·0; August, −0°·8; September, −0°·5; October, −0°·5; November, −0°·3; and December, −0°·4.

The second period extended from October 1822 to March 1831, during which time the observations were taken four times daily, namely at 8 A.M., at noon, at 4 P.M., and at 10 P.M.; the corrections applied were as follows:—

January, −0°·5; February, −0°·8; March, −1°·2; April, −2°·1; May, −2°·2; June, −2°·8; July, −2°·2; August, −2°·0; September, −1°·8; October, −1°·1; November, −0°·7; and December, −0°·6.

The third period extended from April 1831 to September 1835, when the observations were taken at 9 A.M., noon, 3 P.M., and 6 P.M., and the following corrections were applied to the means:—

January, −1°·1; February, −1°·7; March, −3°·0; April, −4°·7; May, −4°·8; June, −5°·7; July, −4°·6; August, −4°·3; September, −4°·0; October, −2°·4; November, −1°·5; and December, −0°·9.

The fourth period extended from October 1835 to March 1836; the observations were taken at 9 A.M., noon, 2 P.M., and 6 P.M., and the corrections for these times were as follows:—

January, −1°·2; February, −1°·8; March, −3°·1; April, −4°·6; May, −4°·9; June, −5°·7; July, −4°·7; August, −4°·5; September, −4°·6; October, −2°·7; November, −1°·7; and December, −1°·0.

The fifth period extended from April 1836 to December 1840; the observations were taken at 9 A.M., noon, and at 2 P.M.; the corrections applied were as follows:—

January, −1°·4; February, −2°·1; March, −3°·5; April, −5°·0; May, −5°·5; June, −6° 1; July, −5°·0; August, −5°·3; September, −4°·6; October, −3°·3; November, −2°·1; and December, −1°·2.

The sixth period extended from January 1840 to December 1847, and the observations were taken bi-hourly (excepting on Sundays, Good Fridays, and Christmas Days, on which days, two, three, or more were taken), the simple mean of these twelve observations daily being taken to represent the true mean daily temperatures.

The daily temperature of Sundays, Good Fridays, and Christmas Days, during this period, have been determined by two different methods; first, by applying those corrections to the means of the observations due to the times at which they are taken; and secondly, to the mean of the maximum and minimum; that correction was applied which was formed by taking the difference between the monthly mean of all the maximum and minimum readings, and the true mean of the month: these two results were then combined, according to the number of observations on which they were deduced.

The seventh and last period extended from January 1848 to the end of December 1856, during which period observations were taken daily at 9 A.M., noon, 3 P.M., and 9 P.M., to the means of which the following corrections were applied:—

January, −0°·9; February, −1°·3; March, −2°·2; April, −3°·4; May, −3°·4; June, −4°·1; July, −3°·2; August, −3°·2; September, −2°·9; October, −1°·9; November, −1°·2; December, −0°·7.

The sixth process has been to take the arithmetical mean between the maximum and minimum readings daily, diminished by the corrections due to each month.

The next process was to compare the results deduced from the observations of the free thermometer with that found from the maximum and minimum thermometer, with a view by their combination to determine an adopted mean daily value; but it was discovered that the results till 1841, deduced from the observations of the maximum and minimum thermometer, were so frequently discordant, that none of the observations made by this instrument (one of Six's construction) could be used. Their errors did not seem to be errors of observation, but to arise from an error in the instrument itself. Therefore all the results in this paper till the year 1841 are based upon the other observations only.

The last process was to combine the results formed by the two methods together, according to the number of observations on which each was based; and in this way the numbers in the following Tables were formed.

TABLE I.—Mean Temperature of every day in the Month of January, as deduced from the Observations taken on that day, at the Royal Observatory, Greenwich, in the years 1814 to 1856.

Days of the Month.	1814.	1815.	1816.	1817.	1818.	1819.	1820.	1821.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	Mean of 43 years.
Jan.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	24·7	34·6	37·2	44·6	27·4	51·6	19·9	28·6	19·6	29·9	46·0	30·8	35·5	45·5	44·0	41·8	51·6	35·5	27·5	34·5	39·2	40·5	28·6	39·5	43·9	40·9	49·6	40·5	33·7	33·6	37·3	37·8	41·6	30·5	34·0	30·7	32·3	51·8	31·8	49·1	26·7	48·7	39·1	36·9
2	27·9	33·6	27·2	40·3	38·1	32·9	34·4	33·9	33·2	39·4	45·5	41·5	35·0	32·4	38·3	37·5	31·0	34·4	30·9	44·0	36·5	38·7	22·1	24·9	44·3	43·6	47·6	39·1	34·2	32·8	30·6	34·8	35·3	39·0	43·8	24·6	33·6	49·9	36·4	48·9	24·8	47·7	42·7	35·9
3	29·2	31·2	33·2	38·3	33·6	34·2	29·9	28·4	36·2	41·3	37·4	41·5	31·6	22·1	41·6	36·6	33·9	34·3	27·9	39·0	45·5	36·0	31·6	36·3	41·6	43·9	42·6	30·7	30·8	30·1	29·9	34·7	35·9	34·5	48·2	25·4	37·6	44·8	40·4	43·7	23·7	46·6	45·4	33·8
4	29·9	31·1	31·6	48·9	39·6	33·6	24·6	26·9	36·6	37·3	33·5	43·8	34·1	23·0	36·9	39·3	33·9	36·1	28·7	33·5	40·8	39·7	45·6	36·3	41·6	40·9	33·9	29·7	29·5	38·1	45·2	40·7	37·4	40·0	42·8	32·7	45·4	42·7	40·6	47·0	31·4	44·0	42·7	36·8
5	30·9	30·2	36·9	38·2	40·3	33·9	22·6	30·6	34·7	39·1	37·2	34·6	34·1	27·6	38·7	33·0	35·0	36·5	28·4	31·0	45·3	33·2	46·3	35·6	31·3	37·9	34·3	29·8	31·9	36·3	30·6	41·9	38·5	38·0	41·2	32·7	34·0	39·9	37·2	45·2	32·4	44·6	44·4	35·9
6	31·2	30·9	43·2	40·2	34·3	42·9	31·2	37·6	34·7	41·3	36·0	32·0	36·0	31·1	32·8	31·0	32·3	32·1	34·4	34·0	45·7	26·8	44·6	46·3	33·6	41·2	31·9	26·1	33·3	36·6	46·7	45·4	42·4	39·6	34·7	31·6	31·0	38·5	41·9	42·5	32·7	48·3	43·3	36·8
7	31·9	29·3	36·6	33·3	43·2	41·9	30·2	35·4	35·1	37·3	34·7	43·0	37·9	41·8	31·9	33·9	36·9	26·5	36·4	31·5	40·0	22·3	35·3	40·3	33·4	44·3	25·9	17·4	30·2	42·7	39·9	44·0	45·8	39·0	35·6	31·0	30·1	42·8	45·4	46·5	39·7	47·1	41·9	36·2
8	27·3	31·6	43·9	28·6	37·9	37·9	24·9	38·6	36·2	33·3	35·0	36·6	29·3	48·5	33·0	31·4	32·9	28·1	36·1	32·2	43·5	29·2	37·8	34·8	27·6	33·9	22·9	22·2	29·1	37·3	37·0	33·0	41·8	33·2	35·5	37·8	30·3	45·1	44·0	42·2	41·8	45·1	39·1	34·9
9	24·9	31·6	44·2	29·6	42·7	49·6	25·7	38·2	38·7	26·8	41·2	39·3	23·9	41·5	29·2	33·4	33·9	35·4	38·9	31·0	38·5	40·2	29·3	45·6	30·9	33·0	32·3	20·9	27·5	36·8	34·8	32·4	41·8	31·0	32·2	41·2	31·8	38·4	36·1	42·7	36·8	45·5	34·2	34·9
10	19·6	40·9	43·3	26·6	48·3	47·6	23·7	40·9	38·6	30·0	43·1	37·5	25·6	43·0	27·4	33·0	33·8	37·0	45·2	27·7	40·2	38·5	32·0	46·6	22·6	31·7	31·6	24·6	28·7	38·5	40·5	39·9	37·4	27·2	31·4	45·0	31·0	44·8	34·8	47·0	36·8	33·2	34·2	35·6
11	22·6	36·6	43·6	30·9	44·1	41·2	28·6	40·9	43·6	27·0	37·1	38·3	28·0	36·3	33·4	30·1	32·0	35·3	44·0	30·7	44·7	47·7	31·6	31·3	21·0	38·2	28·3	34·3	31·9	33·6	40·1	46·8	39·1	29·8	31·6	37·2	29·2	48·2	47·1	45·3	34·9	33·2	30·7	35·5
12	21·6	33·2	39·9	33·6	50·7	41·9	22·2	47·6	45·2	27·5	30·9	35·1	23·9	34·6	39·3	34·0	26·9	36·3	42·0	33·0	47·7	46·7	30·6	33·3	26·8	43·6	29·3	34·1	32·3	31·1	40·4	43·0	33·7	34·6	37·2	34·0	28·7	48·1	47·8	49·7	36·2	36·7	31·5	35·9
13	24·9	33·9	36·9	34·6	46·6	38·9	18·7	46·2	45·6	25·3	28·4	36·1	21·9	38·8	42·0	33·9	29·9	35·9	38·4	37·7	48·0	39·8	33·6	46·6	20·9	45·1	33·9	33·0	31·5	38·2	39·7	42·4	40·0	33·7	42·9	40·3	28·3	46·6	42·6	44·8	38·4	37·2	31·4	36·8
14	21·0	16·2	37·6	33·7	45·6	49·6	22·6	39·6	42·4	23·0	28·0	40·5	19·5	43·0	39·2	33·9	27·0	34·8	34·2	39·0	46·7	45·0	44·9	35·6	22·4	43·2	39·6	33·0	33·6	35·9	35·1	41·0	41·8	33·8	39·1	49·3	28·0	43·8	47·0	41·4	37·8	33·9	29·8	36·2
15	22·7	34·6	37·3	30·9	50·7	43·6	14·6	38·9	37·2	22·5	32·4	38·0	18·4	35·0	33·8	33·8	31·0	31·0	28·7	37·0	43·3	43·7	38·3	34·4	16·2	37·7	41·9	33·3	32·5	33·8	31·5	40·7	45·1	38·9	37·8	39·1	25·5	45·4	49·6	43·9	36·4	30·5	33·2	34·8
16	28·2	30·6	38·6	34·1	49·4	37·7	23·9	44·6	31·1	29·5	32·1	41·5	18·9	44·1	33·6	28·0	26·8	32·0	30·4	37·0	48·0	48·7	34·8	39·9	25·5	34·2	40·6	41·7	34·8	35·7	30·5	41·7	44·4	30·6	31·3	42·9	29·7	43·9	47·8	40·4	42·2	33·4	39·4	36·1
17	22·9	34·9	36·2	41·2	38·6	45·2	31·9	42·2	38·7	28·9	29·5	36·1	25·5	36·0	45·5	27·3	22·3	40·0	37·7	37·5	47·5	34·8	33·1	37·9	27·8	31·3	38·1	44·6	35·9	38·1	38·4	37·7	44·9	28·0	39·9	50·1	33·1	45·9	42·3	38·8	46·5	26·3	43·3	36·7
18	29·6	32·2	36·2	42·4	37·6	37·9	30·4	47·6	38·2	25·5	35·6	41·8	37·3	32·5	51·2	25·4	18·1	40·5	34·5	35·5	44·8	31·4	37·3	35·9	21·3	28·9	36·9	43·9	30·2	44·2	41·5	41·0	40·5	29·5	33·7	46·9	32·7	41·3	37·5	37·5	45·0	28·2	47·4	36·7
19	30·6	26·2	37·2	42·2	33·6	37·2	41·4	45·6	42·9	23·4	38·4	35·0	38·3	29·5	48·3	25·0	22·5	44·8	32·4	41·5	43·9	36·8	32·6	34·8	17·0	43·6	43·8	34·0	30·8	38·9	42·4	40·0	48·0	30·1	33·2	49·9	40·6	44·0	40·5	43·7	35·5	32·1	46·2	36·7
20	28·9	25·2	33·6	44·9	37·2	37·2	30·7	44·9	45·9	22·5	40·6	39·0	36·0	29·0	48·0	26·3	32·5	41·8	34·4	33·2	40·7	29·2	38·3	32·7	10·7	40·0	41·3	31·3	30·8	38·0	37·9	37·8	44·7	31·2	30·3	47·8	38·8	41·8	45·6	49·6	44·4	29·0	45·9	36·2
21	22·2	31·2	39·6	35·9	39·6	36·2	34·1	33·6	41·6	29·6	41·9	38·0	37·3	24·8	41·9	25·8	32·8	44·3	39·4	30·5	47·2	25·5	36·6	37·3	24·0	46·6	48·9	31·3	32·3	34·9	36·5	34·5	48·8	34·6	30·7	47·8	28·5	45·8	45·2	44·2	45·3	22·7	47·2	36·6
22	24·0	29·6	39·1	45·6	39·3	42·6	22·6	38·6	42·9	24·6	43·4	36·3	34·1	24·6	48·3	23·9	33·4	47·1	39·7	28·2	47·7	34·5	42·6	42·8	38·6	33·6	46·3	36·4	33·7	37·2	39·2	38·4	51·4	34·0	30·7	44·2	32·2	40·1	43·4	38·9	43·1	26·3	37·9	37·5
23	24·9	29·6	38·6	49·2	35·6	38·6	33·7	35·9	42·6	22·9	42·6	36·3	35·1	25·3	46·5	21·1	32·3	42·5	38·9	26·2	51·8	38·7	50·1	48·4	33·1	34·9	47·9	38·6	31·4	43·0	37·6	43·4	47·9	37·9	30·1	47·3	36·4	40·0	39·5	38·6	43·0	29·3	46·2	37·3
24	25·2	20·9	38·2	47·9	39·6	42·2	39·2	38·6	45·2	23·8	42·9	35·9	29·5	48·4	42·1	34·2	32·0	38·7	30·8	50·7	43·2	43·1	47·6	25·2	38·3	49·9	31·6	28·3	44·2	35·8	41·8	47·1	45·5	31·1	48·4	34·0	31·7	40·7	37·9	42·1	32·0	47·3	37·7
25	27·7	25·7	37·2	48·4	37·9	40·3	42·2	36·9	44·2	23·9	32·4	38·3	32·4	26·2	45·0	22·2	34·0	29·4	42·3	29·2	44·7	40·0	40·2	44·3	24·8	41·3	39·3	32·1	35·1	44·4	38·0	41·2	50·5	41·2	30·5	49·6	45·4	37·1	44·5	37·4	39·5	33·9	43·3	37·7
26	31·7	27·6	35·1	44·9	47·9	40·6	45·6	37·7	41·2	27·3	28·9	35·3	31·6	27·3	42·9	37·0	34·0	27·5	38·2	34·7	51·0	45·0	42·3	39·2	26·4	33·6	44·8	41·7	37·5	47·4	42·2	39·3	48·0	42·0	25·1	44·1	43·5	36·5	44·4	36·2	43·4	31·5	43·8	38·8
27	32·9	29·9	36·1	44·2	40·7	42·9	48·2	35·6	38·2	33·3	46·1	48·0	37·3	29·0	41·5	37·7	34·5	31·8	33·7	38·5	47·5	41·0	41·6	36·1	26·7	30·1	38·6	44·5	38·1	50·7	42·6	37·7	47·2	46·5	26·5	39·5	33·2	41·0	42·7	36·0	42·3	28·5	40·5	38·4
28	33·7	34·9	30·6	42·7	37·9	43·9	41·6	31·9	43·3	43·8	39·9	37·5	34·0	35·8	38·0	36·0	33·5	31·4	29·9	38·2	48·5	38·5	44·9	32·9	28·8	30·9	45·3	37·9	38·1	52·3	45·5	33·3	46·8	40·7	21·0	39·2	41·4	43·5	36·4	39·2	43·4	30·7	35·1	37·9
29	34·7	38·9	28·9	45·3	38·6	38·2	39·2	34·2	39·2	46·6	38·9	33·6	34·3	41·8	40·8	32·5	31·9	29·0	30·2	37·2	33·2	48·0	39·8	33·3	38·6	32·6	41·9	37·3	34·3	49·6	45·8	31·0	47·1	36·4	37·1	38·9	43·8	49·2	38·7	38·4	41·2	30·5	31·2	37·7
30	34·5	35·6	25·6	43·9	41·6	38·3	41·2	44·2	32·4	43·3	35·1	41·6	40·7	36·7	38·3	34·2	32·5	33·8	39·7	35·2	38·7	43·0	37·6	36·7	32·8	26·1	34·9	37·3	36·4	48·6	45·8	30·2	46·8	35·9	43·4	38·2	35·3	41·2	44·5	39·1	49·3	29·8	31·5	37·9
31	29·9	38·6	24·9	41·9	35·1	38·2	41·9	42·2	36·2	38·6	35·6	46·3	42·7	43·3	41·2	34·1	20·0	29·6	39·4	32·7	42·2	38·5	39·8	43·6	32·1	29·6	43·6	35·5	41·2	45·5	35·7	31·0	50·2	35·2	36·2	39·4	36·6	39·0	43·5	38·5	48·9	27·2	32·1	37·6

The Mean Temperature of the coldest day in January in the years 1814 to 1856 was 10°·7, and it took place on the 20th day in the year 1838.
The Mean Temperature of the hottest day in January in the years 1814 to 1856 was 52°·7, and it took place on the 24th day in the year 1834.
The difference between these numbers is 42°·0, and it represents the extreme difference between the Mean Temperature of two days in the month of January in 43 years.
The day of the month whose Mean Temperature has been subjected to the greatest difference was the 20th; in the year 1838 its Mean Temperature was 10°·7; and in the year 1853 it was 49°·6: the difference between these numbers is 38°·9.
The day of the month whose Mean Temperature has been subjected to the least difference was the 6th; in the year 1841 its Mean Temperature was 26°·1; and in the year 1855 it was 48°·3: the difference between these numbers is 22°·2.

TABLE II.—Mean Temperature of every day in the Month of February, as deduced from the Observations taken on that day, at the Royal Observatory, Greenwich, in the years 1814 to 1856.

Days of the Month.	1814.	1815.	1816.	1817.	1818.	1819.	1820.	1821.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	Mean of 43 years.
Feb.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	30·8	42·2	25·1	40·9	34·6	32·9	34·9	45·9	41·2	38·8	34·8	43·8	40·7	40·2	47·5	29·2	22·0	31·0	42·6	33·5	36·0	44·8	39·0	39·6	28·9	32·9	42·9	27·2	39·2	42·3	31·0	32·4	45·3	32·8	33·2	32·3	50·8	37·6	51·5	32·6	44·6	29·8	32·6	37·0
2	34·1	38·6	32·9	39·9	36·9	31·9	35·1	44·6	48·2	39·1	34·5	39·0	45·2	34·5	44·2	27·0	17·0	32·5	41·3	45·8	36·5	48·0	39·0	41·9	29·4	30·6	42·4	25·9	42·4	44·7	31·6	30·5	42·8	32·8	38·5	45·4	52·2	36·2	50·0	33·8	38·2	26·1	32·0	37·1
3	27·6	42·3	42·6	39·1	30·9	32·2	33·1	41·2	42·5	38·8	37·8	43·7	48·5	39·0	39·5	26·7	19·2	35·1	36·1	44·2	39·0	46·0	34·2	41·6	29·2	35·6	42·6	19·2	42·1	37·4	33·7	35·8	46·7	32·6	40·5	45·4	47·2	38·6	43·2	36·8	32·9	32·8	34·9	37·2
4	22·0	46·6	40·3	40·6	30·2	37·6	33·9	41·6	40·2	32·6	44·0	29·6	44·0	33·0	47·3	35·5	25·7	36·0	47·1	48·5	39·8	44·0	34·7	33·2	29·4	37·2	42·2	24·4	35·2	31·3	29·4	36·0	43·4	33·7	43·7	48·2	42·3	37·2	46·2	37·0	36·0	35·2	35·2	37·5
5	29·1	42·3	35·9	40·3	34·4	42·9	40·6	31·2	45·2	39·5	40·0	35·2	43·7	33·7	47·2	39·7	19·0	33·7	46·1	49·8	42·0	45·3	34·9	35·0	28·6	40·2	40·6	24·8	33·4	31·2	30·8	37·4	42·0	34·6	50·7	46·0	45·7	44·4	51·6	36·4	43·9	30·2	41·6	38·5
6	36·8	41·3	36·6	48·2	31·2	45·9	41·6	34·9	36·6	29·7	39·0	33·7	49·6	32·7	49·0	39·0	18·7	32·5	44·9	44·3	39·8	37·0	41·2	31·6	28·4	38·6	40·2	25·5	33·5	32·9	32·5	33·2	41·6	43·0	50·4	44·1	42·2	39·9	44·5	37·3	51·1	33·1	45·3	38·6
7	36·5	44·9	38·6	46·6	32·7	41·2	46·6	37·2	45·9	32·7	37·6	46·5	47·6	42·3	34·0	45·7	41·5	38·0	47·5	38·8	46·5	34·5	45·5	42·4	34·6	39·7	47·6	46·6	22·2	34·5	33·1	39·0	28·6	46·4	28·5	49·0	42·0	40·4	41·8	42·2	38·8	47·3	31·4	49·7	39·9
8	38·8	46·1	19·7	46·2	32·7	39·6	42·9	36·2	46·9	35·2	47·5	38·8	43·2	29·6	40·5	36·0	45·5	50·7	40·7	47·3	33·5	40·8	40·5	39·2	44·2	47·1	39·2	26·1	38·8	35·7	35·5	28·9	37·9	24·6	45·6	45·2	47·3	45·3	49·4	33·5	40·8	29·5	50·2	39·5
9	38·8	39·2	12·6	44·6	37·9	46·2	42·9	32·6	46·9	39·7	47·8	38·2	34·6	28·7	42·8	38·7	41·2	35·0	43·8	40·5	37·5	34·8	46·2	44·2	40·8	48·9	39·6	25·7	43·5	37·0	35·4	27·3	38·9	23·9	45·6	42·0	47·5	40·5	40·6	36·4	38·4	27·9	50·3	38·9
10	42·5	41·6	22·6	47·2	29·4	45·9	41·9	38·6	47·2	43·6	47·7	41·5	38·1	30·0	32·5	37·2	34·7	51·7	35·6	45·8	35·5	32·3	44·2	46·6	30·9	41·6	45·9	27·7	46·5	35·3	34·6	29·2	31·1	27·1	42·9	47·8	42·2	39·2	38·1	34·3	37·0	25·0	49·4	38·5
11	42·5	46·9	29·2	36·6	33·4	46·1	40·2	34·6	43·2	47·7	40·0	39·0	34·7	30·0	30·6	42·5	37·6	49·2	36·3	46·8	41·3	36·5	35·5	46·2	31·6	40·9	42·9	36·3	27·9	36·7	31·4	24·5	34·8	29·8	41·6	40·9	42·5	38·5	36·7	32·4	35·4	25·8	46·7	38·2
12	42·1	45·2	25·3	39·9	32·6	42·9	40·7	35·2	38·9	43·2	43·5	36·7	42·2	33·2	28·5	42·2	38·3	48·2	35·1	45·3	39·0	41·3	40·5	41·9	27·0	43·6	45·2	43·5	29·1	37·9	30·4	19·2	36·4	23·4	46·4	35·6	39·8	40·5	34·3	30·7	35·8	29·3	48·0	37·9
13	42·5	44·9	29·6	44·6	31·7	37·9	39·2	33·6	40·2	39·2	40·2	35·0	41·7	33·3	29·6	43·0	36·0	47·0	37·1	45·5	38·8	39·8	34·2	47·6	26·6	39·6	42·9	43·8	44·2	32·8	26·0	30·3	42·1	24·8	48·0	35·4	35·6	41·5	35·0	30·7	31·6	25·5	48·1	37·6
14	38·1	44·2	32·2	39·2	38·9	32·6	35·9	33·6	43·1	40·2	39·5	36·1	44·1	32·6	38·3	42·5	32·0	44·7	34·6	42·5	41·3	44·8	42·7	43·9	27·2	47·2	34·9	50·0	41·6	28·9	31·6	37·5	42·1	32·7	50·3	42·6	42·3	40·5	37·5	30·1	32·4	24·5	47·5	38·1
15	32·5	44·2	17·6	42·2	31·9	37·7	30·9	32·7	46·6	36·5	37·0	38·7	46·7	31·7	34·2	43·0	33·7	41·0	27·8	37·8	39·5	46·2	42·2	42·2	27·2	39·6	38·2	44·5	44·6	24·2	42·3	34·9	37·6	48·0	45·1	48·8	33·0	36·7	43·1	28·4	33·9	26·5	46·3	38·6
16	32·8	47·6	38·0	39·3	41·3	43·6	27·7	32·9	41·4	36·6	34·0	41·7	46·2	26·1	31·5	44·1	31·2	44·2	33·3	37·8	38·5	41·8	38·9	49·6	27·9	38·9	44·2	45·1	43·6	27·9	38·8	35·3	41·6	42·0	37·2	39·7	45·6	35·1	45·5	31·7	35·4	24·5	45·1	38·2
17	31·5	42·3	34·6	48·6	42·9	...	25·6	30·6	43·6	33·3	35·5	44·7	42·0	25·3	31·2	44·7	29·8	41·7	36·8	38·5	47·8	40·0	31·9	44·6	28·2	36·1	43·9	40·6	40·8	29·8	39·8	33·5	43·4	48·3	37·6	42·2	45·9	35·9	52·3	30·3	41·9	21·8	37·7	37·1
18	27·8	39·6	33·6	49·2	46·9	44·3	27·9	33·2	45·9	39·5	38·7	44·7	39·0	24·2	36·7	35·5	33·2	40·5	39·1	42·5	42·3	42·8	32·4	45·6	33·8	33·6	37·2	45·1	35·4	32·2	40·7	34·0	42·8	49·3	34·4	43·0	48·2	48·9	49·0	28·8	34·5	21·1	34·2	38·2
19	36·5	44·9	40·2	40·6	42·6	44·2	31·9	31·6	42·6	40·7	40·7	44·6	48·5	23·7	39·0	46·3	35·7	42·2	34·3	40·9	45·0	41·8	30·9	41·1	32·9	33·6	31·2	44·8	34·0	34·5	41·7	39·2	42·5	44·9	41·3	45·8	47·8	48·9	34·4	28·7	34·5	25·3	34·7	38·1
20	27·5	47·2	43·9	41·2	36·6	40·3	30·4	31·9	41·7	37·2	39·5	46·0	44·5	32·0	41·2	44·5	30·2	36·5	36·0	39·3	43·1	40·3	27·4	40·9	33·6	34·2	29·6	45·0	34·5	36·7	33·1	26·2	43·5	43·5	39·7	45·9	48·0	46·2	31·9	30·2	42·6	25·8	34·4	37·7
21	26·8	48·9	40·6	38·6	43·3	42·9	30·7	37·2	37·2	44·0	37·5	39·0	43·0	33·3	42·5	46·0	36·7	36·1	37·1	41·3	42·3	38·0	31·8	47·6	33·6	35·6	29·2	41·1	38·8	42·3	33·4	31·8	48·6	42·2	39·2	43·0	46·1	42·7	34·6	31·9	41·1	24·8	33·0	38·7
22	28·8	48·6	43·2	41·9	35·6	38·9	38·6	33·9	38·6	41·0	42·7	39·7	49·0	32·4	42·2	42·2	35·5	36·2	35·6	39·5	39·5	42·8	38·4	42·2	31·9	44·6	29·2	39·2	44·7	44·2	31·8	31·7	50·4	45·2	46·3	50·7	49·1	39·8	35·6	32·8	41·4	26·8	34·9	39·4
23	26·1	44·9	43·2	41·9	35·2	39·1	45·9	32·2	41·6	43·1	39·5	37·0	42·0	31·6	38·7	35·2	49·0	36·5	34·6	38·3	39·5	43·5	36·9	45·2	31·6	45·2	28·8	37·8	44·2	45·7	33·3	36·4	51·8	39·7	45·5	47·0	45·6	39·5	36·4	35·5	42·1	30·2	40·4	39·7
24	25·5	46·9	45·2	41·9	39·2	31·9	37·8	29·2	47·9	43·5	39·7	36·5	37·8	32·1	43·2	35·7	50·5	39·7	32·6	36·8	49·0	37·8	38·2	38·9	39·2	39·1	29·6	36·2	42·9	38·1	39·9	37·5	53·4	31·5	48·6	42·3	40·0	34·1	37·3	33·3	41·4	34·2	42·3	39·1
25	24·2	46·6	45·9	45·2	48·6	31·9	35·1	37·9	48·9	39·5	39·2	35·6	47·0	35·0	30·5	37·1	49·7	42·2	30·6	43·6	41·5	45·3	30·9	34·6	43·5	37·2	33·2	38·9	38·4	34·5	40·7	36·8	50·6	33·7	48·3	43·6	42·3	41·4	37·3	33·8	44·2	42·3	40·3	40·1
26	26·5	44·9	38·9	42·2	35·7	34·4	33·4	30·6	46·6	35·4	36·2	35·5	40·7	43·0	30·7	38·0	50·2	43·2	36·5	45·2	44·5	43·5	32·9	33·4	35·7	34·6	33·2	41·6	37·2	35·0	41·0	43·6	50·1	32·2	46·2	40·5	44·3	38·2	37·8	37·2	41·3	36·8	47·8	39·4
27	27·1	39·2	41·9	45·9	40·6	38·7	30·9	25·6	37·2	36·0	36·7	38·3	45·0	49·0	31·7	37·7	31·0	45·7	36·6	42·3	50·0	43·6	32·9	34·9	34·9	40·9	32·9	37·3	37·5	37·2	32·7	39·6	52·1	30·6	47·9	38·5	41·7	37·1	39·2	32·7	41·9	35·0	48·7	39·5
28	33·8	35·2	35·9	45·6	43·4	38·3	39·2	30·9	36·5	36·7	38·0	36·1	48·2	44·5	46·5	31·0	48·7	39·2	33·0	40·5	44·3	39·5	35·4	36·9	44·2	40·2	34·9	36·7	41·4	38·2	38·8	34·4	50·4	30·4	47·4	41·4	37·4	38·2	41·9	33·5	43·9	40·9	44·1	39·6
29	..	..	29·2	..	..	..	30·6	..	..	..	38·7	..	..	..	48·7	..	..	..	35·9	..	..	..	34·9	..	..	..	35·6	..	..	..	41·3	..	..	45·0	..	..	..	37·7	..	..	..	..	43·8	..

The Mean Temperature of the coldest day in February in the years 1814 to 1856 was 12°·6, and it took place on the 9th day in the year 1816.
The Mean Temperature of the hottest day in February in the years 1814 to 1856 was 55°·0, and it took place on the 9th day in the year 1831.
The difference between these numbers is 42°·4, and it represents the extreme difference between the Mean Temperature of two days in the month of February in 43 years.
The day of the month whose Mean Temperature has been subjected to the greatest difference was the 9th; in the year 1816 its Mean Temperature was 12°·6; and in the year 1831 it was 55°·0: the difference between these numbers is 42°·4.
The day of the month whose Mean Temperature has been subjected to the least difference was the 20th; in the year 1845 its Mean Temperature was 26°·2; and in the year 1830 it was 48°·0: the difference between these numbers is 21°·8.

TABLE III.—Mean Temperature of every day in the Month of March, as deduced from the Observations taken on that day, at the Royal Observatory, Greenwich, in the years 1814 to 1856.

Days of the Month.	1814.	1815.	1816.	1817.	1818.	1819.	1820.	1821.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	Mean of 43 years.
Mar.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	39·3	42·9	32·6	44·9	40·6	36·6	38·2	39·6	37·9	35·8	38·3	38·4	47·8	49·7	42·8	29·3	47·8	37·3	37·5	39·9	49·5	32·0	38·2	31·5	42·2	42·2	33·9	38·6	45·8	34·2	40·4	33·2	47·9	38·2	40·3	41·1	45·7	36·4	40·0	31·6	40·4	43·4	39·9	39·7
2	33·3	40·2	38·2	42·3	41·6	40·6	32·1	43·2	45·6	40·1	30·2	40·9	48·3	48·5	43·1	32·9	47·3	48·0	40·0	42·1	51·1	35·8	42·4	33·5	40·8	46·8	33·5	39·2	44·2	33·4	41·6	35·4	49·8	39·5	41·2	44·7	47·7	37·6	38·9	35·4	43·2	45·3	41·9	40·7
3	34·8	41·2	36·9	41·6	43·6	36·6	29·7	50·9	45·6	46·6	35·3	35·7	44·6	48·5	41·6	34·1	45·1	49·1	37·3	46·7	47·5	41·0	43·5	33·5	41·8	44·3	36·8	42·5	51·2	32·8	39·9	33·4	50·5	37·9	41·2	46·9	47·0	36·1	35·2	34·5	38·8	47·9	40·2	41·0
4	31·8	47·2	37·7	37·9	40·9	39·1	30·2	49·6	43·6	40·3	32·3	35·3	48·3	49·2	44·2	36·2	34·8	50·7	41·7	46·1	47·3	39·0	42·5	37·2	42·1	35·5	32·8	38·2	44·1	34·3	38·1	37·2	49·6	36·5	38·8	50·4	38·5	41·6	34·8	35·6	37·4	41·7	36·8	39·9
5	31·1	47·2	37·6	37·9	41·3	41·6	27·6	32·6	47·9	38·6	45·1	35·6	41·6	31·3	36·8	37·7	37·7	47·8	40·3	42·3	50·3	37·5	45·2	38·2	37·5	30·0	34·2	43·0	41·8	34·3	34·4	26·3	45·6	39·6	39·9	47·1	38·4	42·3	33·9	43·9	35·4	41·1	38·5	39·0
6	29·6	44·7	40·6	37·3	40·9	41·9	28·6	38·1	48·2	32·8	46·1	38·4	41·6	44·8	31·4	40·2	39·1	42·8	39·6	37·6	44·5	42·5	46·5	37·2	45·2	27·0	34·2	44·8	40·7	36·8	32·8	24·5	44·7	37·4	39·9	46·8	44·9	38·8	36·3	47·8	34·0	39·1	39·2	39·5
7	29·5	43·2	43·3	34·9	43·2	40·3	30·9	46·6	42·2	29·7	49·1	41·6	50·8	42·6	35·6	40·6	35·1	42·5	39·3	36·8	48·8	41·0	42·4	37·5	41·5	36·5	35·8	51·4	43·1	33·8	35·9	31·5	45·5	36·3	38·3	47·2	42·8	39·6	40·2	46·9	36·7	37·0	35·9	39·7
8	28·5	43·9	37·9	35·6	39·9	38·4	31·9	47·3	41·9	32·8	48·8	41·8	49·6	42·6	48·1	40·6	39·3	45·0	38·3	32·8	50·3	36·0	43·2	38·5	39·8	28·1	30·2	51·2	48·6	34·9	36·8	32·7	40·2	41·6	39·6	39·5	41·6	39·9	41·2	44·0	49·3	35·4	35·3	39·8
9	28·3	39·2	35·2	38·6	34·8	38·0	34·9	47·2	48·2	35·1	43·3	47·2	56·3	33·8	49·8	41·8	43·1	43·9	35·8	31·3	53·7	41·8	38·2	42·2	35·8	27·8	33·8	45·8	40·9	34·3	45·8	34·7	40·8	36·6	49·8	34·2	45·3	40·2	42·7	42·0	54·5	31·9	38·7	40·3
10	29·0	36·9	33·2	37·3	35·2	40·6	25·9	49·6	48·7	38·1	40·1	49·3	54·2	37·1	48·4	39·3	44·8	39·5	31·9	35·5	48·8	35·2	41·9	42·2	39·2	28·2	42·8	47·5	40·9	37·4	40·9	37·1	42·9	30·2	43·3	36·1	44·4	38·3	38·3	45·5	47·3	27·7	40·0	39·9
11	32·6	36·6	44·2	43·6	36·2	43·6	36·9	45·9	40·6	41·3	40·3	46·8	42·3	50·1	46·3	35·1	51·6	44·9	33·6	34·2	45·5	45·0	44·8	40·2	37·2	35·2	39·2	45·8	45·9	39·7	45·0	34·7	45·7	37·8	40·6	37·2	40·6	40·0	37·8	42·2	49·2	31·2	36·8	40·8
12	31·3	39·2	48·6	47·9	35·7	45·9	37·2	44·6	38·2	40·1	37·7	44·3	39·6	48·6	49·1	35·6	49·3	41·6	38·3	35·8	47·8	47·5	45·4	35·2	37·5	35·8	42·2	48·7	44·8	43·9	38·6	30·6	44·1	37·8	38·7	47·5	41·2	38·8	40·1	44·1	49·3	32·2	35·3	41·4
13	32·3	41·9	47·2	49·6	35·9	45·2	40·2	45·9	44·2	44·6	36·3	39·2	37·6	50·8	52·1	36·7	46·2	42·6	40·0	32·2	42·8	40·5	45·8	35·2	40·8	43·2	41·8	45·9	45·8	45·8	38·0	22·1	44·5	39·9	38·7	48·8	44·4	45·1	39·8	48·8	52·1	40·2	34·9	41·8
14	30·0	40·3	45·8	41·6	37·9	40·9	48·9	41·6	51·9	45·3	38·6	32·6	42·1	44·6	52·8	34·6	42·7	41·1	46·0	27·8	41·8	47·2	42·9	37·2	51·2	47·5	41·8	44·2	45·1	49·2	38·5	23·2	49·3	36·9	40·8	42·9	41·9	44·3	39·7	40·4	49·0	36·8	35·7	41·8
15	29·0	43·9	44·9	48·9	42·2	41·9	51·6	38·6	52·9	38·6	43·6	32·7	44·2	41·8	50·1	30·8	42·8	41·0	39·1	37·5	43·6	40·0	42·9	34·5	41·0	44·8	40·0	47·5	49·5	47·2	43·6	26·8	49·6	44·5	42·7	48·2	37·7	38·8	37·8	41·1	47·9	37·6	33·1	41·5
16	31·1	50·6	38·6	38·6	39·6	50·2	43·4	40·2	50·2	37·5	48·6	32·6	37·3	40·6	54·3	31·8	40·1	51·0	40·0	40·0	44·1	42·8	39·7	34·5	45·8	45·8	39·8	49·6	49·1	48·5	43·0	25·2	47·1	50·2	39·5	48·2	36·4	42·6	43·6	36·6	48·6	43·6	42·3	42·3
17	31·7	47·9	37·6	36·6	45·2	41·9	41·1	41·6	51·9	42·8	48·8	29·4	38·1	42·2	51·1	35·8	50·6	51·0	44·8	...	40·5	45·6	47·4	33·5	38·2	38·8	37·8	48·7	48·3	48·3	37·5	28·5	39·6	51·2	37·9	47·8	31·4	40·4	40·8	39·2	42·4	42·8	39·6	41·5
18	29·0	47·2	41·9	39·9	45·2	38·2	39·9	41·6	47·6	43·3	48·6	32·6	38·6	36·8	48·6	44·6	52·1	41·8	40·2	35·0	37·8	39·9	52·9	36·2	38·0	31·5	38·5	47·7	45·8	48·9	38·2	30·3	36·1	48·4	43·3	40·3	35·3	43·9	38·1	38·5	41·0	42·1	43·8	41·0
19	28·5	47·9	42·6	41·6	46·2	44·2	38·6	39·6	54·6	31·8	48·3	35·2	41·1	39·3	45·3	52·3	49·6	43·9	43·3	37·8	38·3	36·2	52·7	37·7	40·2	34·5	40·5	45·8	41·2	45·9	41·1	34·3	33·8	49·1	42·1	42·3	42·8	46·2	39·7	31·7	40·3	44·0	46·7	41·7
20	34·3	49·3	38·6	30·6	45·2	41·9	37·7	40·2	52·6	34·3	44·8	38·1	41·3	49·8	45·3	51·8	45·6	45·4	44·8	35·5	41·0	47·5	58·0	34·8	46·3	41·2	39·5	44·4	41·3	50·2	39·4	32·8	34·7	49·6	42·3	41·4	40·5	48·6	43·7	34·3	38·7	42·4	43·6	42·5
21	38·6	49·9	40·6	31·2	41·9	39·9	39·9	39·9	50·2	47·0	44·1	39·1	40·8	47·3	43·6	47·1	49·1	48·0	47·0	35·0	40·3	45·0	47·4	37·2	41·5	45·2	35·2	48·3	40·4	52·1	36·0	33·9	37·9	46·9	39·6	41·8	38·9	48·2	47·4	34·8	40·6	37·5	48·0	42·0
22	44·5	49·6	40·6	29·6	45·6	39·9	44·2	39·2	45·9	48·5	39·1	36·8	38·4	49·3	39·6	47·3	48·1	44·7	47·5	35·5	44·8	41·0	47·2	31·5	35·2	41·8	35·3	48·9	38·8	55·2	41·4	42·3	43·8	45·4	45·8	37·7	39·9	45·3	54·2	34·3	40·6	33·5	41·8	42·3
23	44·6	48·9	39·9	35·2	43·6	43·6	45·2	41·9	47·6	37·0	38·3	38·3	35·4	49·6	38·3	42·7	45·6	39·9	48·5	32·8	43·3	41·5	46·2	38·2	32·5	49·2	34·5	47·6	35·7	51·1	42·3	45·6	43·7	45·3	51·3	40·4	36·5	45·5	51·3	31·9	42·3	34·3	39·8	41·9
24	42·3	48·6	39·6	45·9	40·2	47·2	41·2	42·9	44·6	41·0	40·8	37·8	36·1	47·3	39·3	38·6	50·8	35·7	37·0	35·0	42·3	39·5	41·5	39·0	39·5	48·7	31·2	47·7	38·0	52·2	41·5	45·4	42·8	45·0	48·4	36·2	34·4	44·7	46·3	31·7	40·3	31·7	37·7	41·3
25	46·0	44·2	37·7	44·9	41·0	45·2	36·7	41·9	42·7	40·0	40·3	40·8	35·9	43·8	38·6	34·6	51·2	39·4	39·9	37·0	37·8	38·6	44·2	32·2	41·2	43·8	34·8	48·7	44·0	45·0	42·5	44·4	42·3	41·7	44·0	33·4	32·9	45·0	39·7	32·2	39·7	34·5	37·9	40·6
26	44·3	46·9	38·9	45·6	38·7	44·9	42·6	42·6	47·6	38·0	43·1	43·1	31·8	38·6	38·3	39·3	56·3	47·2	42·3	35·2	37·8	36·6	40·2	37·4	46·5	41·2	31·8	52·1	42·5	41·4	49·3	46·6	45·3	49·4	46·1	36·8	31·2	44·7	40·2	33·9	46·0	35·5	36·8	41·7
27	46·0	47·2	37·9	36·9	38·6	48·6	49·2	42·2	50·9	37·0	39·6	42·6	35·3	43·3	44·3	38·6	54·1	51·9	45·5	38·5	47·9	43·8	38·5	31·2	45·5	47·2	34·5	46·5	43·2	38·0	51·2	31·1	43·3	49·1	48·7	38·9	35·4	47·4	37·7	39·4	42·9	38·1	40·4	43·0
28	47·6	51·6	35·9	42·6	41·4	47·6	48·6	41·9	56·2	44·0	35·3	44·1	48·3	47·6	37·6	42·1	50·8	48·7	41·3	41·8	45·2	39·5	39·5	39·5	44·5	42·8	35·5	45·6	50·1	41·1	48·6	49·2	41·7	45·3	47·6	39·1	34·5	49·0	39·8	39·9	42·1	36·4	35·9	43·5
29	46·3	51·9	36·9	49·9	40·9	47·9	49·2	41·6	48·2	41·0	38·1	42·1	40·6	41·6	37·8	42·3	55·8	46·0	40·8	46·5	43·9	42·6	40·2	43·2	43·8	40·0	39·2	49·0	51·1	41·0	44·4	45·0	41·8	37·6	49·0	41·8	38·7	47·5	46·9	38·5	48·0	36·4	35·6	45·3
30	44·6	47·9	36·9	50·6	40·8	51·2	49·9	41·2	47·9	49·0	40·3	40·3	38·1	40·6	36·3	42·6	49·1	41·6	45·8	43·8	49·5	42·0	44·5	38·8	50·2	38·8	43·8	46·9	50·0	47·1	44·4	43·3	42·5	37·4	51·6	41·6	43·9	44·8	50·1	44·0	47·1	37·5	37·4	44·2
31	47·0	58·6	38·6	43·9	39·2	43·6	50·9	42·9	38·9	48·0	31·8	41·8	38·1	42·1	37·8	38·8	45·8	41·1	45·3	45·8	40·8	47·6	43·2	35·2	45·5	41·0	43·2	46·1	49·8	50·9	44·2	46·4	45·8	35·0	52·7	48·0	45·9	42·7	45·3	47·6	47·4	37·0	42·3	43·8

The Mean Temperature of the coldest day in March in the years 1814 to 1856 was 22°·1, and it took place on the 13th day in the year 1845.
The Mean Temperature of the hottest day in March in the years 1814 to 1856 was 58°·6, and it took place on the 31st day in the year 1815.
The difference between these numbers is 36°·5, and it represents the extreme difference between the Mean Temperature of two days in the month of March in 43 years.
The day of the month whose Mean Temperature has been subjected to the greatest difference was the 16th; in the year 1845 its Mean Temperature was 25°·2; and in the year 1828 it was 54°·3: the difference between these numbers is 29°·1.
The day of the month whose Mean Temperature has been subjected to the least difference was the 29th; in the year 1856 its Mean Temperature was 35°·6; and in the year 1830 it was 53°·8: the difference between these numbers is 18°·2.

TABLE IV.—Mean Temperature of every day in the Month of April, as deduced from the Observations taken on that day, at the Royal Observatory, Greenwich, in the years 1814 to 1856.

Days of the Month.	1814.	1815.	1816.	1817.	1818.	1819.	1820.	1821.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	Mean of 43 years.
April.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	47·3	38·2	38·2	44·2	41·5	52·5	49·2	41·8	41·2	52·2	38·4	38·9	41·4	42·9	40·2	35·9	34·9	46·8	47·1	45·5	42·5	34·7	27·8	38·4	33·0	37·4	40·7	45·4	44·2	51·9	48·7	38·9	50·0	38·7	57·0	47·1	50·8	44·5	44·9	47·6	51·4	36·2	50·3	43·8
2	47·3	49·2	37·8	43·8	40·2	53·2	53·6	49·5	41·8	45·2	38·4	41·3	47·9	48·4	41·4	34·7	35·0	38·0	47·3	49·2	41·8	38·4	36·0	34·3	33·0	32·4	43·7	45·7	48·6	52·4	51·9	43·0	50·9	34·5	61·8	43·4	52·6	44·6	39·9	46·6	49·0	32·7	53·2	44·3
3	43·8	46·2	35·2	44·2	39·5	51·5	52·2	43·8	45·2	45·2	37·2	48·4	51·4	50·4	37·7	37·4	33·7	41·6	50·6	48·0	45·5	35·1	36·2	38·7	34·7	28·9	41·0	42·5	36·9	53·0	52·8	50·2	46·3	36·6	60·7	42·1	50·3	44·7	41·6	46·0	48·0	40·3	48·3	44·2
4	43·7	47·2	38·5	43·2	38·5	48·2	47·3	44·2	45·8	45·2	38·7	50·9	51·2	51·2	36·4	41·4	33·9	43·6	50·6	49·3	44·7	45·0	37·1	35·0	41·7	29·5	37·0	42·8	38·9	49·2	53·1	48·3	45·4	38·8	61·5	44·2	50·1	43·5	39·7	51·6	46·2	41·7	47·8	44·4
5	45·7	47·5	36·5	40·8	41·5	46·2	58·5	41·8	46·2	45·2	39·4	45·4	51·4	53·2	41·5	46·7	34·8	43·3	55·1	45·7	46·7	43·2	42·0	36·4	48·7	29·7	43·2	45·3	39·0	48·9	49·9	41·0	48·6	43·2	52·4	47·4	49·9	39·5	47·2	51·0	50·7	41·3	45·3	44·9
6	46·0	51·5	41·8	40·8	46·2	46·2	44·7	42·2	44·2	38·2	40·5	45·2	50·5	57·4	41·9	45·9	42·7	47·5	47·8	54·7	50·2	49·5	41·4	35·2	51·0	34·0	45·0	45·5	40·8	49·3	48·2	41·0	44·7	46·6	45·9	49·1	47·8	37·4	45·0	52·0	50·5	50·9	42·3	45·5
7	46·3	54·5	40·5	41·2	43·2	52·2	39·8	50·8	44·2	37·2	39·9	41·7	53·2	51·9	40·4	43·2	46·7	53·2	42·8	45·2	47·2	51·2	41·3	34·0	50·0	35·7	41·0	43·8	44·7	53·1	49·9	40·4	42·8	49·9	44·0	46·3	54·4	38·6	42·3	48·9	51·0	50·0	45·3	45·7
8	45·3	50·2	37·3	43·5	54·5	50·8	44·2	56·2	39·5	41·7	42·5	45·2	54·4	52·4	43·4	45·2	54·4	42·6	45·0	45·7	42·1	53·4	43·7	35·0	50·3	34·4	36·4	43·7	43·3	49·1	46·2	40·9	45·3	51·4	39·5	47·1	53·1	42·8	44·6	41·8	53·9	44·0	46·0	45·6
9	45·7	54·5	37·8	39·9	50·5	47·8	40·2	52·2	38·2	40·9	42·2	50·4	54·2	51·9	46·7	40·2	54·4	51·6	45·1	46·0	38·4	51·1	39·4	31·7	39·0	35·0	39·7	44·1	39·5	39·3	52·6	52·6	45·3	46·6	39·0	44·1	46·6	38·9	42·4	40·2	50·8	46·7	45·1	44·4
10	47·0	46·2	46·2	33·2	48·8	47·2	46·2	54·5	38·2	40·7	37·0	53·4	48·7	50·7	46·7	42·9	47·9	51·2	45·6	45·4	38·7	48·5	45·8	30·4	51·4	46·0	44·4	42·1	39·6	37·4	54·0	40·2	45·9	45·8	39·6	45·1	49·2	41·2	46·5	46·6	43·3	45·6	49·9	44·7
11	47·3	52·5	41·5	34·2	46·2	42·6	48·2	50·5	41·8	41·4	35·2	54·2	52·7	50·7	47·9	46·7	47·4	51·3	45·6	48·7	35·7	42·5	39·4	31·7	54·4	38·4	45·0	37·8	40·2	36·5	49·5	39·8	49·5	44·2	43·4	38·2	49·0	41·1	48·7	47·8	47·2	45·5	50·2	44·4
12	51·3	54·8	41·2	43·5	37·2	45·8	49·5	46·8	42·2	38·4	37·7	51·2	46·7	50·2	54·9	50·7	49·4	52·7	41·6	43·0	35·7	44·2	46·7	33·9	45·4	39·0	47·6	39·1	38·9	35·4	49·1	44·7	51·5	53·9	50·4	38·3	48·2	42·1	45·1	45·8	48·0	50·1	51·1	45·2
13	57·0	53·2	38·5	45·5	42·5	48·2	47·5	44·2	50·5	41·7	40·4	45·4	48·2	48·2	49·4	48·2	47·9	56·8	46·6	42·5	39·7	48·7	46·7	31·4	42·1	39·0	50·7	44·7	38·2	38·5	50·1	40·6	52·5	44·4	48·6	40·1	46·2	41·8	50·2	39·1	49·8	48·2	52·9	45·0
14	57·3	57·2	51·5	49·9	45·8	48·8	47·5	45·2	51·5	44·6	41·7	54·2	54·4	46·7	51·7	49·7	49·4	48·5	50·1	52·2	41·5	51·7	45·0	36·9	42·4	45·6	48·7	48·4	41·7	39·6	52·6	44·9	50·7	41·6	44·5	42·5	47·4	41·2	52·7	42·3	47·1	50·4	46·8	46·4
15	58·7	59·5	38·5	50·9	44·2	48·5	45·8	41·5	51·8	42·4	42·3	54·2	53·7	48·9	49·5	47·9	52·3	48·7	47·2	49·0	43·7	45·4	49·0	37·6	47·2	45·7	55·0	44·5	41·7	51·3	51·1	41·7	50·0	40·5	43·3	39·9	48·0	42·7	45·9	42·5	49·9	53·3	46·5	46·3
16	55·7	40·8	41·8	44·2	48·5	48·8	51·5	44·2	46·8	47·2	40·4	54·9	49·4	46·2	48·9	45·2	54·9	52·7	51·6	52·7	44·2	43·5	45·0	34·2	34·7	50·4	53·7	48·7	41·4	52·3	52·8	45·2	51·9	37·8	48·3	41·4	46·4	41·2	41·5	47·0	50·2	56·9	43·8	46·1
17	51·7	42·8	42·8	37·2	48·5	46·7	55·8	44·8	46·2	54·2	40·7	43·0	45·4	44·7	50·7	47·4	52·7	47·7	47·8	51·8	47·0	44·2	43·1	38·0	44·4	44·7	47·7	48·1	52·3	53·9	47·3	49·8	37·5	49·7	34·8	51·5	52·8	45·6	49·6	45·5	51·9	41·8	45·6
18	53·7	41·2	45·5	39·9	41·8	47·5	52·2	47·5	45·2	42·7	43·7	46·9	47·7	44·7	50·7	48·4	51·2	48·3	52·6	39·2	48·2	40·7	44·7	34·7	33·0	48·4	48·4	48·2	43·6	50·7	49·8	44·6	47·2	40·1	48·9	37·6	51·4	53·3	44·0	51·8	50·6	42·9	46·5	45·7
19	54·0	42·5	42·2	43·8	41·1	50·2	54·2	49·8	46·2	39·7	47·4	42·4	50·7	45·2	48·0	44·4	48·7	48·2	46·3	41·5	50·2	40·2	49·4	41·0	33·2	45·4	47·7	47·3	45·4	48·3	50·8	47·9	42·5	44·5	50·2	32·4	48·0	51·0	39·7	48·3	52·2	47·2	42·6	46·0
20	53·7	44·3	44·2	45·2	41·8	53·5	51·8	53·5	46·8	40·4	50·4	48·9	49·7	43·4	46·9	44·6	46·7	47·8	46·8	47·5	44·5	49·0	49·4	45·4	33·9	42·7	51·0	44·2	46·6	55·2	55·3	50·8	43·4	46·1	49·8	37·0	49·5	51·7	44·3	44·0	39·9	49·6	43·9	47·4
21	50·7	41·2	44·5	43·2	45·8	49·5	51·5	51·5	50·2	44·9	53·4	51·7	54·4	43·7	43·3	48·7	49·9	47·8	48·6	47·8	46·5	48·2	49·0	38·7	38·4	45·2	52·7	44·2	45·9	53·3	57·0	46·6	42·3	44·8	49·2	36·8	50·9	53·5	46·8	41·8	38·2	41·9	46·1	47·6
22	45·7	40·0	50·8	41·5	48·5	47·8	51·2	49·8	48·8	46·9	53·7	52·2	55·9	39·2	42·2	44·4	53·2	50·8	52·0	50·7	47·2	50·2	52·7	38·0	47·8	51·0	55·0	43·3	50·7	49·0	55·8	48·2	45·0	44·7	47·4	41·4	46·1	49·0	51·2	44·1	45·4	39·9	46·6	48·0
23	47·3	40·5	56·5	38·8	48·5	45·8	49·5	53·5	48·5	48·2	50·4	52·4	45·7	38·4	46·9	49·4	50·7	52·9	54·1	54·7	46·7	47·2	46·9	43·1	48·7	46·4	57·7	49·7	56·6	46·6	55·2	51·0	45·6	43·7	49·9	44·7	44·8	51·5	51·3	41·8	40·0	43·8	46·3	48·1
24	45·0	41·8	54·2	41·5	46·2	46·8	49·5	53·5	51·2	43·4	50·4	52·7	44·2	37·4	50·9	45·2	52·7	48·3	46·3	49·5	44·2	49·7	45·0	46·0	45·0	40·7	59·4	47·2	58·6	45·7	52·0	52·6	47·2	45·2	44·6	43·0	44·2	50·6	44·4	39·6	39·5	48·6	46·7	47·4
25	42·7	43·8	50·8	39·5	50·5	44·8	46·2	63·2	49·2	49·9	51·4	53·2	43·3	40·7	50·9	37·9	49·4	53·1	43·6	44·2	46·7	43·7	46·1	46·0	39·0	41·0	61·4	48·3	55·2	41·3	53·0	55·7	49·5	48·2	41·1	49·1	47·4	47·1	44·4	53·1	40·5	40·6	38·0	48·9
26	44·0	44·5	50·5	46·7	55·8	49·8	51·2	63·2	49·2	45·7	53·9	50·9	45·2	42·4	48·7	42·9	53·9	55·1	37·1	53·5	45·2	38·2	45·4	50·4	41·0	42·4	54·0	37·7	51·3	45·0	57·9	53·4	41·4	48·4	41·9	48·0	49·0	46·2	50·6	41·6	46·8	45·4	53·6	47·9
27	43·7	46·8	50·8	40·5	55·5	41·2	40·2	59·2	51·8	42·2	53·2	50·9	39·9	47·2	51·7	43·4	54·3	53·2	45·8	51·9	51·2	39·2	38·6	46·7	39·2	48·7	61·0	63·5	50·2	44·9	51·7	50·9	41·5	52·7	45·7	48·1	45·0	40·6	42·5	45·4	46·4	45·2	40·2	47·4
28	45·3	51·3	52·8	45·8	50·5	46·2	40·2	56·8	54·8	44·7	53·2	51·2	38·4	51·7	56·9	43·2	58·7	49·8	44·1	53·3	54·7	44·0	43·0	48·0	39·4	48·1	61·0	60·3	53·2	46·1	50·8	52·9	46·4	49·8	42·3	47·1	44·2	40·6	49·8	45·8	44·7	44·7	43·2	48·2
29	50·0	44·8	57·5	46·8	49·5	45·8	45·2	52·2	52·8	45·4	60·7	53·2	38·4	60·4	61·2	47·9	60·4	50·6	55·3	54·7	54·0	38·2	35·4	45·7	38·2	50·0	61·7	56·7	52·2	49·6	45·2	55·1	45·0	46·8	44·4	51·9	45·7	42·3	52·2	41·3	43·3	43·2	41·7	48·9
30	52·3	44·6	53·2	42·5	50·2	46·5	46·2	48·5	55·5	48·7	57·7	50·7	42·7	60·5	55·7	40·2	61·4	53·5	49·6	49·0	51·2	43·5	38·4	52·5	44·4	56·7	58·4	54·2	56·5	52·4	51·0	54·2	49·0	45·0	49·2	53·6	45·9	43·9	53·8	50·6	45·4	44·0	42·3	49·7

The Mean Temperature of the coldest day in April in the years 1814 to 1856 was 27°·8, and it took place on the 1st day in the year 1836.
The Mean Temperature of the hottest day in April in the years 1814 to 1856 was 63°·2, and it took place on the 25th and 26th days in the year 1821.
The difference between these numbers is 35°·4, and it represents the extreme difference between the Mean Temperature of two days in the month of April in 43 years.
The day of the month whose Mean Temperature has been subjected to the greatest difference was the 3rd; in the year 1839 its Mean Temperature was 28°·9; and in the year 1848 it was 60°·7: the difference between these numbers is 31°·8*.
The day of the month whose Mean Temperature has been subjected to the least difference was the 22nd; in the year 1837 its Mean Temperature was 38°·0; and in the year 1826 it was 55°·9: the difference between these numbers is 17°·9.

* Also the 4th in the year 1839: Mean Temperature 29°·5; and in the year 1848 it was 61°·3: the difference between these numbers is 31°·8.

TABLE V.—Mean Temperature of every day in the Month of May, as deduced from the Observations taken on that day, at the Royal Observatory, Greenwich, in the years 1814 to 1856.

Days of the Month.	1814.	1815.	1816.	1817.	1818.	1819.	1820.	1821.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	Mean of 43 years.
May	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	51·4	55·4	48·8	41·1	49·1	51·8	47·1	48·1	50·8	53·3	57·9	53·1	42·3	62·8	52·8	49·8	54·3	53·1	48·7	49·0	54·7	48·7	40·5	52·2	48·2	59·2	49·8	56·4	54·7	57·4	52·8	56·5	51·8	48·2	48·4	49·4	42·5	45·6	48·7	52·6	49·2	42·4	40·4	50·3
2	52·4	57·4	50·4	42·8	54·4	56·1	49·8	54·1	49·8	57·1	51·6	53·6	47·6	54·6	50·1	51·6	52·8	50·2	53·0	48·2	55·2	49·8	43·3	53·5	59·8	59·2	55·8	55·7	52·5	55·3	53·5	53·3	56·7	50·6	51·1	53·2	44·4	46·0	41·3	51·5	49·3	47·8	40·3	51·3
3	48·8	53·4	49·4	47·8	56·4	60·8	46·4	56·8	54·1	55·8	44·4	53·3	42·8	59·1	53·1	52·1	53·1	53·7	56·2	57·0	58·0	43·3	45·5	56·2	56·8	50·8	59·3	46·7	51·8	49·3	51·6	50·7	58·7	45·7	54·7	57·7	46·7	40·3	44·1	50·2	50·9	48·4	40·7	50·9
4	45·7	54·1	47·4	49·4	53·4	56·1	44·6	59·8	57·4	44·6	48·2	58·9	41·2	55·8	52·3	49·8	53·6	50·7	46·3	65·7	60·3	46·2	46·8	45·8	57·8	57·8	54·5	55·3	52·6	53·8	51·7	48·0	55·4	45·8	57·3	61·3	49·1	40·2	45·1	49·1	51·4	40·8	43·8	51·5
5	48·4	55·4	47·1	50·8	54·8	55·8	43·6	58·4	58·1	55·1	52·6	62·1	42·6	54·2	49·1	54·8	60·3	44·7	51·2	59·1	57·5	51·2	44·8	46·5	54·8	52·0	57·8	55·3	52·1	53·9	57·7	44·9	55·4	48·7	57·6	59·6	48·8	41·2	46·9	50·2	48·2	43·5	40·6	51·8
6	51·1	53·1	50·1	49·4	53·4	55·4	47·4	52·1	60·4	60·6	53·3	64·3	39·8	52·1	49·6	54·8	66·1	59·7	57·5	58·2	58·2	52·2	49·8	45·5	57·1	56·5	56·2	54·6	52·1	47·1	56·3	43·3	54·1	49·8	60·4	50·7	42·8	44·5	47·4	43·4	47·9	50·0	43·6	51·9
7	50·7	55·1	50·1	47·8	53·4	58·1	51·1	53·8	55·1	63·8	57·1	57·1	45·3	45·6	50·1	50·3	66·3	45·0	62·0	56·7	60·3	51·7	49·5	45·5	59·2	53·8	58·8	54·3	51·0	44·7	58·8	42·6	51·7	54·1	63·3	45·3	44·7	47·8	53·0	38·0	52·4	50·7	42·1	52·3
8	51·4	57·4	48·4	54·1	54·4	59·4	56·1	53·8	46·4	53·1	56·8	54·3	49·8	45·3	48·6	54·8	58·3	44·0	55·5	56·2	63·0	56·0	48·8	45·5	63·2	58·2	60·2	52·0	50·1	43·0	58·8	41·1	55·0	52·2	61·4	43·8	44·3	49·7	59·0	40·1	47·8	45·4	43·2	52·1
9	45·4	58·1	45·8	45·6	51·9	60·1	57·4	52·4	47·1	53·1	54·1	54·8	49·7	43·6	49·3	55·8	50·1	46·3	43·5	62·5	61·2	59·2	47·8	38·2	61·2	47·8	59·2	52·3	47·2	47·6	60·7	46·5	57·4	53·0	59·4	43·0	45·5	52·0	56·3	41·9	45·0	45·5	44·7	51·0
10	43·2	55·4	41·4	49·1	51·1	58·4	56·4	51·2	48·4	55·3	53·3	53·2	50·2	48·8	51·6	57·2	47·2	47·2	41·7	58·0	56·2	54·3	49·8	38·2	47·5	44·2	59·0	55·7	48·1	49·3	53·7	46·5	54·3	57·9	61·1	42·2	48·8	56·3	52·9	43·0	47·8	51·9	52·2	50·9
11	42·4	59·8	39·4	47·8	56·8	57·1	53·6	56·8	50·8	53·8	47·1	53·8	49·8	48·6	54·8	55·6	45·6	49·8	46·7	62·2	57·3	52·2	53·8	41·5	47·5	45·2	47·5	58·7	56·1	49·8	56·1	49·3	53·3	55·2	63·7	46·3	52·1	56·2	48·8	45·5	49·0	47·4	56·4	51·6
12	43·4	55·1	38·1	46·8	50·8	57·8	55·8	54·8	47·1	54·1	46·3	53·3	46·2	47·3	52·8	54·6	46·8	54·0	42·5	67·3	59·2	55·0	57·8	42·8	51·3	44·0	53·2	54·3	47·6	53·8	57·1	49·2	53·4	55·4	65·1	47·2	52·6	51·8	50·9	47·1	53·0	44·4	50·7	51·3
13	48·4	51·4	40·8	46·4	51·1	54·4	55·1	46·4	48·1	53·8	43·8	47·1	50·6	48·2	55·1	53·8	46·1	51·5	58·6	63·4	51·3	52·0	57·8	40·8	47·6	48·1	51·8	52·8	53·9	55·3	57·8	49·9	51·0	56·4	64·9	54·6	50·3	48·4	53·5	48·5	54·2	41·2	53·0	51·0
14	43·1	52·1	43·8	44·8	49·4	52·4	55·4	47·4	51·8	50·1	44·3	50·1	47·2	46·6	56·2	57·6	49·8	45·3	44·5	63·4	53·7	44·0	58·2	41·8	41·5	54·5	59·7	51·9	54·8	52·7	59·5	50·8	51·2	59·2	66·1	54·5	46·4	48·2	53·1	51·0	54·7	43·5	49·3	50·6
15	45·8	57·1	50·8	48·4	51·4	54·1	54·4	43·8	55·1	55·6	42·8	49·8	48·6	50·6	57·2	57·3	54·6	48·6	47·4	72·4	60·5	49·0	57·8	45·2	46·2	42·2	49·8	55·9	55·2	53·6	51·0	51·3	49·0	56·3	66·2	51·3	43·7	50·7	53·6	50·4	55·5	42·0	48·8	51·9
16	45·4	54·6	55·1	49·2	56·4	56·2	49·8	48·1	55·1	54·8	44·3	48·1	53·6	57·3	59·6	53·8	58·8	54·0	49·7	68·0	60·5	51·7	59·5	45·8	45·2	40·2	49·5	54·1	55·5	53·6	53·5	52·6	50·4	58·5	67·7	55·8	46·0	52·7	59·3	57·3	50·7	45·1	50·1	53·1
17	48·8	56·5	55·4	54·4	58·1	57·8	52·1	50·8	61·1	54·3	48·6	52·1	58·3	57·1	59·6	55·3	62·8	57·3	45·5	72·2	53·7	54·3	59·5	54·5	49·3	49·5	51·9	54·4	52·1	50·5	47·2	49·6	47·4	57·5	60·8	53·9	52·2	50·5	54·0	55·8	52·0	48·5	50·2	54·0
18	54·7	59·1	45·4	59·4	54·8	58·8	51·1	49·1	61·4	55·3	49·1	49·6	61·2	58·1	54·1	54·3	61·6	59·5	50·7	59·5	57·3	61·2	58·8	48·2	46·5	52·2	51·5	53·9	50·3	46·9	45·7	58·0	50·9	58·0	54·6	55·7	53·2	50·3	59·2	58·1	47·3	49·6	48·6	53·5
19	55·1	58·1	47·4	45·4	48·4	57·6	52·8	51·4	60·8	57·3	48·3	50·8	58·6	59·8	54·6	57·2	58·8	55·6	55·5	55·3	54·5	57·7	51·5	41·5	50·8	55·4	42·8	50·8	50·8	50·1	46·4	47·1	51·8	56·6	54·2	54·2	54·9	49·8	54·9	59·5	49·0	54·1	51·9	55·0
20	55·1	59·4	48·1	44·4	50·1	56·1	54·8	47·1	63·6	60·1	43·6	54·1	55·1	59·3	56·1	59·8	58·3	60·2	55·7	58·2	54·0	56·4	56·2	39·8	53·8	59·2	46·2	53·1	52·2	52·1	50·9	46·6	52·7	57·1	55·3	51·5	53·9	50·3	58·3	52·5	54·1	56·0	53·9	* 53·9
21	50·4	47·8	48·8	43·8	48·4	54·2	57·4	48·4	63·9	55·3	47·6	55·6	57·6	61·3	55·1	57·1	55·6	56·0	59·0	60·5	57·7	52·0	55·5	43·7	55·8	55·5	43·8	55·0	53·7	53·4	51·0	46·2	51·8	58·0	57·8	57·7	60·0	53·9	51·2	52·8	54·2	46·0	56·7	53·7
22	46·7	47·1	55·4	44·8	48·1	56·1	60·1	46·4	57·4	55·8	45·2	58·6	59·3	56·4	52·3	56·7	57·6	54·7	58·2	60·7	55·0	55·7	49·5	40·4	49·8	42·2	46·2	57·9	54·3	53·6	54·7	49·1	56·8	61·1	60·7	52·8	53·1	60·0	58·3	55·9	53·6	49·9	53·2	51·1
23	48·7	51·8	51·8	46·2	49·1	57·4	60·8	42·8	55·8	53·3	49·4	61·8	55·8	57·8	55·1	61·8	58·1	60·5	59·5	62·2	59·0	56·2	51·5	44·0	48·8	46·5	58·8	58·7	55·4	54·8	54·3	48·0	57·7	56·2	57·9	57·1	57·4	52·4	54·3	59·2	51·3	50·0	53·4	54·4
24	41·4	53·1	49·8	47·8	52·1	55·1	63·1	43·1	56·8	56·3	49·8	60·6	53·8	49·6	56·2	55·3	59·1	61·5	60·0	63·2	61·2	60·3	49·2	53·2	46·2	38·2	59·3	60·1	52·6	56·2	54·6	48·2	59·0	62·5	60·3	59·6	54·5	54·3	54·8	59·8	51·0	58·9	53·7	54·8
25	40·7	58·8	51·8	49·4	53·4	51·2	53·8	47·4	55·4	59·1	51·6	58·3	52·3	50·2	57·6	50·3	60·6	66·1	61·2	66·2	51·3	53·5	50·5	53·2	51·2	42·5	55·5	61·4	52·7	56·2	51·0	48·6	60·1	56·4	62·1	60·9	54·6	58·9	53·2	60·4	50·2	61·7	53·5	54·9
26	47·7	60·4	49·8	51·4	56·8	53·1	56·1	40·1	55·1	56·6	56·1	54·2	57·1	54·8	58·8	54·1	56·3	56·0	61·0	57·8	54·0	50·7	52·6	55·9	49·8	44·0	53·5	66·2	55·9	54·8	46·9	49·7	57·1	57·2	62·9	58·4	55·3	51·1	49·9	63·2	51·3	65·3	57·5	54·8
27	50·7	57·8	50·4	53·8	53·1	52·1	52·1	44·8	55·1	58·3	57·1	46·8	58·6	56·6	57·8	56·8	52·3	53·5	56·0	54·0	56·5	50·5	54·2	55·8	50·3	53·2	54·5	68·6	58·5	55·1	46·7	51·8	56·5	63·2	56·1	62·4	55·5	51·3	49·1	64·7	49·0	61·5	58·6	55·0
28	51·7	60·9	55·4	55·1	53·8	49·1	54·1	46·4	59·8	60·2	66·1	46·8	57·6	57·6	56·1	58·3	50·3	55·5	63·2	44·5	52·5	52·0	54·2	54·4	51·5	51·2	60·8	66·9	57·0	52·3	50·2	51·5	55·5	72·2	59·1	52·6	55·6	56·9	50·6	54·6	52·5	51·3	56·3	55·4
29	54·7	59·4	59·1	46·2	51·4	46·8	50·4	48·8	61·1	55·1	59·3	51·3	49·8	58·3	58·3	56·3	54·3	51·7	57·7	56·0	51·7	50·0	55·2	58·8	57·2	52·5	56·2	60·9	58·2	47·3	49·7	51·4	56·5	63·8	64·3	58·4	59·9	59·8	46·8	51·3	48·6	45·7	53·1	54·6
30	54·1	57·4	56·8	45·1	48·4	60·4	51·1	49·1	60·8	67·1	58·1	49·6	50·8	60·2	59·8	54·3	54·1	52·5	62·2	54·5	57·5	48·2	56·2	51·8	59·2	56·5	61·5	66·1	59·8	51·6	51·4	54·0	57·9	57·3	59·9	61·9	57·4	58·2	48·2	54·4	52·8	43·7	48·4	57·2
31	56·7	58·4	56·1	47·8	59·1	60·1	51·4	52·4	64·4	61·2	59·6	49·6	53·1	58·1	58·1	55·1	54·1	56·0	52·2	59·1	57·0	50·3	57·8	54·2	60·5	55·8	61·9	63·2	58·4	58·4	51·8	54·2	63·4	63·9	55·3	64·3	60·9	58·9	50·0	50·8	54·8	45·4	46·0	56·2

The Mean Temperature of the coldest day in May in the years 1814 to 1856 was 36°·2, and it took place on the 3rd day in the year 1832.
The Mean Temperature of the hottest day in May in the years 1814 to 1856 was 72°·4, and it took place on the 15th day in the year 1833.
The difference between these numbers is 36°·2, and it represents the extreme difference between the Mean Temperature of two days in the month of May in 43 years.
The day of the month whose Mean Temperature has been subjected to the greatest difference was the 15th; in the year 1855 its Mean Temperature was 42°·0; and in the year 1833 it was 72°·4: the difference between these numbers is 30°·4.
The day of the month whose Mean Temperature has been subjected to the least difference was the 2nd; in the year 1856 its Mean Temperature was 40°·3; and in the year 1838 it was 59°·8: the difference between these numbers is 19°·5.

TABLE VI.—Mean Temperature of every day in the Month of June, as deduced from the Observations taken on that day, at the Royal Observatory, Greenwich, in the years 1814 to 1856.

Days of the Month.	1814.	1815.	1816.	1817.	1818.	1819.	1820.	1821.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	Mean of 43 years.
June.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	48·4	53·8	57·1	48·5	67·5	58·7	50·6	59·1	64·8	64·0	57·7	58·8	58·7	55·0	57·7	55·0	54·5	59·3	51·6	61·8	63·3	49·3	54·0	59·2	57·6	58·9	66·9	59·7	61·4	59·9	56·0	56·6	61·6	63·2	51·2	59·9	61·1	54·8	52·2	50·0	55·1	48·0	49·8	56·8
2	50·0	58·8	61·5	51·5	66·0	59·1	50·8	61·5	64·8	62·5	58·5	55·2	57·5	55·5	57·0	61·2	59·3	58·3	57·1	63·6	68·9	56·2	57·6	49·6	57·2	52·7	49·6	60·8	60·8	57·1	57·3	62·8	62·2	62·8	53·8	63·3	59·6	58·5	53·8	50·7	51·5	50·0	57·5	57·5
3	50·4	63·8	55·5	54·1	66·5	58·2	50·5	58·8	66·3	53·1	52·0	54·6	56·7	55·5	57·0	66·5	56·6	58·2	58·1	55·1	62·8	59·6	59·6	47·2	56·7	51·6	51·9	61·4	59·8	56·7	54·0	60·6	64·4	63·3	51·6	62·2	60·9	60·8	51·8	54·2	51·0	53·2	55·9	60·2
4	48·4	59·8	55·8	53·1	67·8	59·3	47·8	56·1	66·8	51·0	54·2	50·8	58·0	54·2	53·8	62·5	52·0	57·4	54·6	56·3	60·0	53·3	58·6	49·6	56·6	52·9	55·2	56·4	54·1	52·3	51·4	58·5	66·2	57·9	58·1	68·6	63·5	50·9	58·7	56·3	54·3	58·1	55·3	57·0
5	46·0	59·1	51·1	53·8	68·1	56·8	53·8	57·8	68·5	50·0	54·2	57·1	57·7	51·5	53·5	53·5	55·7	60·2	58·3	60·1	55·6	54·6	54·1	59·9	55·9	58·2	55·2	56·4	64·1	52·3	61·4	58·5	66·2	57·9	58·1	68·6	63·5	50·9	58·7	56·3	54·3	58·1	55·3	57·0
6	46·0	55·1	46·1	56·1	66·1	55·8	49·5	57·8	69·1	53·5	57·0	54·1	59·3	50·0	52·2	47·3	58·5	48·9	58·6	61·1	57·1	64·6	57·3	55·6	45·9	59·6	59·9	54·0	64·3	51·0	59·8	59·3	68·5	53·6	59·4	56·8	54·5	56·5	58·2	57·1	50·2	71·4	52·9	56·5
7	45·0	55·5	48·8	63·5	65·8	56·1	54·1	56·1	61·8	55·7	59·5	59·1	59·1	50·0	51·5	49·5	55·3	49·3	53·1	62·0	59·6	65·1	54·6	50·2	50·1	58·6	60·9	50·8	66·1	55·9	62·0	55·9	66·7	52·3	56·6	57·3	57·4	62·5	58·2	65·0	52·7	58·1	60·4	57·4
8	49·4	58·9	48·1	55·8	66·6	56·5	53·1	52·1	61·8	57·0	59·2	61·6	59·0	55·7	57·4	51·7	55·2	57·0	58·6	59·3	58·7	59·1	60·2	51·8	45·9	58·9	60·9	50·8	66·1	55·9	62·0	55·9	66·7	52·3	56·9	58·3	57·3	57·4	60·5	58·2	65·0	52·7	58·1	60·4
9	50·7	59·8	43·5	54·1	64·6	58·5	51·8	48·1	70·1	53·7	58·0	60·6	63·5	60·7	58·1	58·5	50·5	59·9	56·6	58·0	64·1	69·3	58·3	54·6	58·9	60·5	59·2	50·4	63·9	56·7	61·6	56·7	64·0	55·1	56·9	58·3	59·1	55·1	56·9	59·8	53·6	55·1	61·5	58·0
10	53·4	59·5	46·1	53·8	67·5	57·1	47·8	45·5	72·1	52·7	50·0	63·8	64·8	58·2	59·2	56·5	50·2	56·7	51·8	68·1	59·0	71·8	58·0	58·6	57·5	60·9	60·6	55·7	65·2	52·9	61·8	60·3	62·9	52·8	55·9	59·3	62·9	49·6	50·8	61·2	55·8	57·5	61·5	57·3
11	52·7	61·2	50·6	56·2	69·8	56·5	49·5	49·1	65·3	54·5	49·5	66·2	65·0	59·0	62·3	55·5	56·7	59·5	56·8	58·8	54·3	72·1	61·6	56·9	58·9	60·2	62·9	50·0	68·7	52·2	61·5	62·7	67·5	54·9	58·1	50·3	67·5	53·9	51·2	68·0	54·3	59·0	59·5	58·5
12	55·7	54·1	56·1	51·8	73·5	52·1	50·5	48·8	59·8	57·0	53·0	68·2	67·2	60·0	58·2	62·5	57·5	59·5	62·8	54·6	54·3	71·6	57·3	56·9	54·2	66·9	63·2	48·6	70·6	53·0	64·6	66·3	69·9	57·3	58·7	50·0	58·9	55·1	49·3	58·3	56·5	57·6	59·0	58·7
13	55·7	55·6	57·8	56·5	76·1	57·8	52·6	49·1	59·1	51·2	56·2	69·2	69·6	59·0	61·2	66·0	55·0	57·9	64·1	51·3	54·8	56·2	61·6	66·9	51·2	70·9	59·9	57·3	66·7	51·9	67·7	68·5	67·4	58·3	54·6	54·8	57·1	58·9	53·7	52·5	52·6	58·6	59·2	59·0
14	67·7	59·8	53·1	53·5	71·2	59·2	52·0	51·1	67·1	58·7	57·2	66·0	68·3	63·5	62·2	67·7	59·0	63·3	62·1	52·6	61·1	55·7	68·2	65·6	57·6	54·9	64·5	56·8	68·3	59·2	61·7	67·8	66·7	57·5	59·2	54·2	52·2	56·6	53·2	58·8	58·7	52·2	52·9	59·7
15	63·4	60·1	53·8	53·1	67·3	59·8	59·2	55·1	61·8	56·7	55·2	62·3	66·7	61·2	62·7	64·6	48·0	61·5	56·1	55·3	60·7	67·1	69·6	65·9	58·9	55·2	62·9	56·0	63·2	60·5	58·9	66·6	69·4	54·4	66·5	57·3	48·5	54·5	55·7	60·7	54·0	54·1	55·4	59·1
16	57·0	63·5	48·8	55·5	68·8	52·8	52·8	53·1	60·3	52·7	57·2	64·0	56·8	59·2	62·2	54·2	53·5	60·1	59·3	58·1	56·1	65·1	63·9	66·2	62·6	57·9	64·9	56·0	62·0	60·8	58·4	66·3	69·4	53·7	63·1	57·6	53·6	58·5	54·8	61·1	55·2	49·5	58·6	58·7
17	54·4	61·5	54·5	58·1	68·1	57·5	55·5	52·8	57·1	59·0	52·2	59·2	63·0	65·7	64·5	55·7	50·0	58·4	46·6	58·0	55·3	66·1	64·6	63·6	62·5	62·9	59·6	58·6	59·8	59·1	60·2	64·6	68·2	57·3	63·2	54·9	55·8	56·1	55·3	62·3	56·5	49·8	56·3	58·7
18	55·0	60·1	56·1	66·2	69·8	52·8	54·5	53·1	58·8	48·7	52·2	58·5	67·2	62·7	59·0	55·7	55·0	59·3	64·3	59·1	57·0	58·1	62·9	61·0	65·9	72·6	55·6	62·4	57·3	58·6	58·9	59·2	68·8	54·8	58·7	58·5	61·5	54·0	54·1	56·7	56·1	48·2	57·9	58·6
19	56·4	55·8	57·8	70·5	65·8	65·8	54·5	54·8	64·5	53·5	53·2	59·0	61·7	59·7	64·2	61·5	52·7	60·8	64·6	61·1	61·3	56·2	60·5	62·6	57·2	62·9	54·6	58·5	60·0	54·6	54·4	59·1	70·2	58·4	55·2	54·5	62·1	61·2	57·4	55·8	56·1	51·5	52·3	59·1
20	51·4	62·5	60·5	71·1	69·5	57·3	52·5	51·5	57·8	58·2	55·5	58·7	60·5	58·7	62·7	66·0	54·7	61·1	62·8	58·8	68·6	57·8	56·2	60·9	67·9	58·9	64·9	57·6	55·1	62·8	52·6	58·7	61·7	71·2	58·4	56·9	57·7	66·1	64·9	58·4	52·9	53·7	50·7	54·2	59·2
21	50·4	60·3	59·5	75·8	64·1	57·5	54·1	51·1	56·1	53·2	57·5	59·0	61·7	55·5	58·0	63·5	57·0	63·8	57·9	61·6	73·8	57·7	57·9	64·9	58·6	63·9	62·1	59·8	60·3	58·3	63·8	62·1	63·2	58·6	62·8	62·4	68·3	68·4	57·2	52·7	55·3	54·6	54·5	59·9
22	49·7	61·5	59·5	68·8	61·5	58·2	60·6	50·6	63·5	48·7	58·2	56·0	60·2	54·5	60·0	59·7	49·5	63·4	57·9	57·6	62·7	61·8	58·9	63·2	54·9	55·2	58·9	57·2	62·1	58·5	60·5	63·3	72·8	58·9	63·4	59·2	68·0	58·2	55·3	55·0	61·3	58·5	57·0	59·4
23	49·4	58·1	59·5	68·1	62·8	60·2	61·5	50·5	63·8	49·5	55·5	58·7	62·3	56·0	60·0	66·0	53·2	64·1	61·6	53·6	62·1	53·8	57·9	66·2	60·6	59·5	54·3	55·8	62·2	57·8	71·3	60·1	58·6	57·4	61·9	61·1	67·7	54·4	60·3	59·3	64·5	58·7	59·2	60·8
24	49·7	59·2	54·1	67·8	65·5	55·8	67·5	51·5	67·5	54·7	51·7	64·0	57·7	57·5	65·2	65·5	61·2	58·3	58·3	58·0	60·6	48·8	58·2	66·2	61·7	60·2	49·6	57·6	62·2	57·8	71·3	60·1	58·6	57·4	62·0	60·7	69·4	57·8	59·2	64·8	63·7	58·7	59·7	60·9
25	48·1	55·5	60·1	65·5	67·1	59·8	72·5	55·6	67·2	55·8	54·5	62·5	66·7	57·5	65·2	65·5	61·2	55·3	54·3	57·1	60·6	45·1	58·0	64·7	67·2	62·1	51·2	59·4	60·1	56·1	57·0	58·1	57·9	58·9	56·1	61·2	69·1	63·4	60·8	61·0	67·3	58·2	65·8	61·5
26	49·4	58·5	59·5	65·5	68·1	57·3	73·1	54·8	68·5	59·0	59·2	57·0	71·7	59·2	67·5	65·0	65·7	52·1	55·1	58·6	63·1	47·1	59·9	63·6	51·9	61·2	52·9	60·4	59·2	57·5	56·2	58·6	57·9	60·2	57·9	63·0	66·8	67·3	60·7	58·0	59·4	62·7	68·6	61·9
27	50·7	51·8	54·1	67·8	74·8	56·5	72·8	55·5	61·1	59·2	51·7	55·5	71·0	59·5	67·7	64·5	66·5	55·8	59·8	55·3	53·6	47·6	61·6	57·6	59·2	59·2	59·9	59·4	60·7	64·2	53·8	58·7	57·3	63·0	64·6	59·8	56·3	59·6	66·8	58·6	63·7	56·7	65·8	64·3
28	55·7	59·3	61·5	59·5	68·8	54·1	73·8	55·5	65·0	59·0	63·0	57·5	74·2	58·5	68·0	63·7	63·7	51·8	62·1	64·3	58·6	52·1	71·9	57·9	61·5	55·2	55·7	58·6	64·2	53·8	58·7	57·3	63·0	64·6	59·8	56·3	59·6	66·8	58·6	63·7	56·7	65·8	64·3	61·5
29	58·4	61·3	60·1	64·1	67·8	58·8	63·3	60·1	58·8	57·7	63·2	54·4	70·3	61·7	66·0	53·2	61·2	53·1	66·8	61·3	60·7	55·6	61·2	60·9	57·6	48·7	61·9	55·8	66·1	53·9	63·5	55·6	64·5	63·6	59·1	58·3	57·9	65·0	58·6	60·6	56·2	65·3	58·8	61·5
30	58·4	60·3	61·3	59·8	69·5	57·1	59·1	61·8	59·8	59·7	58·7	56·4	70·6	61·7	67·0	61·7	60·7	55·7	61·3	60·7	60·3	58·6	66·2	67·9	60·6	47·7	61·9	56·5	66·9	55·7	56·7	64·0	58·9	61·2	61·6	57·1	55·3	57·2	64·3	60·0	59·2	57·0	65·3	61·8

The Mean Temperature of the coldest day in June in the years 1814 to 1856 was 45°·0, and it took place on the 7th day in the year 1814.
The Mean Temperature of the hottest day in June in the years 1814 to 1856 was 76°·1, and it took place on the 13th day in the year 1818.
The difference between these numbers is 31°·1, and it represents the extreme difference between the Mean Temperature of two days in the month of June in 43 years.
The day of the month whose Mean Temperature has been subjected to the greatest difference was the 25th; in the year 1835 its Mean Temperature was 45°·1; and in the year 1820 it was 71°·5: the difference between these numbers is 26°·4.
The day of the month whose Mean Temperature has been subjected to the least difference was the 16th; in the year 1850 its Mean Temperature was 52°·6; and in the year 1846 it was 69°·4: the difference between these numbers is 16°·8.

TABLE VII.—Mean Temperature of every day in the Month of July, as deduced from the Observations taken on that day, at the Royal Observatory, Greenwich, in the years 1814 to 1856.

Days of the Month.	1814.	1815.	1816.	1817.	1818.	1819.	1820.	1821.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	Mean of 43 years.
July	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	60·0	64·3	58·0	55·7	64·3	58·0	54·0	60·0	57·7	59·6	62·3	53·6	69·1	62·3	67·6	58·1	61·9	58·9	67·0	59·7	57·7	61·2	73·3	58·3	62·3	53·0	59·3	58·2	57·6	59·9	61·0	59·9	61·3	60·4	52·3	60·9	60·9	66·2	59·3	55·1	53·8	62·1	57·7	60·0
2	56·3	52·7	58·7	58·0	62·3	60·0	55·7	51·0	62·3	59·6	62·8	60·3	71·8	60·8	69·1	58·8	59·8	63·7	64·7	54·4	62·7	65·9	73·0	57·1	65·0	56·7	57·7	62·1	58·1	61·6	58·4	58·1	66·1	57·9	55·6	62·4	60·0	69·4	60·0	58·0	57·8	64·8	56·5	60·6
3	61·6	57·0	57·3	59·0	64·3	64·3	55·7	51·0	62·8	57·6	60·3	62·8	71·7	60·2	72·1	58·3	60·3	61·0	59·2	54·4	63·6	64·7	68·1	67·7	57·0	60·3	54·3	65·9	56·5	66·0	58·9	67·4	66·5	59·4	59·3	62·6	60·7	58·2	64·7	59·4	60·0	67·0	56·2	61·3
4	60·6	61·3	55·0	57·0	63·5	73·3	54·2	53·7	65·7	53·6	59·2	65·1	74·3	63·3	68·6	58·1	60·6	66·0	67·2	61·2	64·2	64·9	74·7	64·7	60·4	64·0	59·0	60·0	64·2	64·8	60·0	61·4	70·6	64·0	60·0	58·6	59·7	57·4	68·0	61·3	59·5	63·9	61·8	62·3
5	62·9	60·0	52·3	58·0	63·0	67·3	51·7	57·7	62·7	61·6	60·6	62·3	73·9	61·8	67·1	56·6	59·6	66·4	66·2	64·9	63·9	61·3	76·7	64·7	63·0	66·7	60·3	62·2	60·1	71·5	57·5	62·3	74·3	65·8	66·1	61·2	59·0	59·5	75·6	61·8	55·2	60·4	61·2	63·2
6	62·9	59·7	58·7	58·0	66·7	60·0	54·7	54·7	59·7	60·6	58·3	58·3	72·3	63·4	62·8	61·2	61·6	69·7	66·4	63·2	65·6	61·7	70·0	67·7	66·3	67·3	57·0	61·5	58·1	71·5	57·3	63·8	59·5	63·6	74·0	62·7	59·6	59·6	73·5	62·5	55·2	61·8	63·2	62·7
7	62·9	54·7	57·3	57·3	68·0	61·7	56·3	52·0	62·3	58·6	60·8	54·8	73·2	67·3	65·8	59·2	60·3	64·4	65·7	58·5	65·7	60·9	63·0	62·7	60·7	66·6	55·7	58·8	55·8	59·5	59·9	71·6	59·2	64·6	66·2	70·6	57·4	63·0	69·8	69·3	54·5	59·2	58·6	62·6
8	59·3	56·7	57·0	57·0	64·0	59·3	56·0	54·0	60·0	59·6	64·7	57·6	72·6	67·1	70·6	61·3	59·6	64·2	62·8	58·9	64·3	62·0	63·7	67·7	62·1	62·6	60·0	56·9	58·3	56·5	60·9	62·4	59·6	61·7	59·5	71·4	56·4	61·2	67·9	68·4	58·3	64·2	48·0	60·9
9	60·9	57·0	58·0	61·0	63·3	60·3	57·0	58·3	61·7	58·6	61·1	58·2	71·7	67·3	60·6	58·1	55·8	63·4	66·4	54·6	63·4	58·4	68·7	58·6	65·3	61·6	57·0	56·3	58·4	59·3	61·8	60·4	62·1	63·2	57·7	67·3	56·7	58·7	70·9	62·7	58·2	63·4	53·0	61·0
10	59·6	59·7	55·7	63·8	64·0	60·0	60·0	58·0	64·7	62·1	64·3	64·3	67·3	66·6	60·2	60·6	57·3	60·4	65·4	59·7	61·9	54·4	71·8	63·7	67·0	61·7	58·7	58·2	59·6	60·2	60·3	67·8	60·3	67·8	61·5	65·5	58·0	54·9	70·5	58·4	58·3	67·3	57·8	61·8
11	61·6	62·3	59·0	61·3	65·3	61·7	57·7	57·0	63·7	63·6	65·3	66·3	67·1	62·3	65·3	59·7	59·2	62·9	64·9	59·2	63·4	58·7	72·3	64·7	68·7	66·7	55·7	51·7	65·8	57·3	65·1	58·1	59·0	70·8	61·0	64·9	59·7	56·1	63·4	64·7	55·5	57·5	61·6	62·0
12	60·6	67·3	58·3	58·7	64·3	63·7	59·7	54·3	58·7	63·6	66·5	69·6	66·8	62·8	60·1	61·8	58·1	62·4	65·9	58·4	69·9	61·6	64·3	61·0	67·0	63·0	57·3	54·7	62·9	62·1	59·3	55·1	63·8	73·3	64·7	66·1	63·6	63·8	64·5	61·9	51·0	65·3	61·1	62·2
13	58·6	66·0	57·7	59·7	65·0	61·7	57·7	57·3	58·7	58·6	69·8	70·6	64·8	63·1	55·6	62·3	59·3	60·0	68·0	51·2	65·6	59·2	62·7	63·3	69·7	62·3	53·2	54·8	63·9	60·9	59·7	59·0	68·7	72·8	68·8	67·3	62·8	61·8	67·2	61·3	58·9	67·5	58·4	62·0
14	55·3	61·7	58·3	57·0	68·3	58·3	60·7	58·0	59·7	58·6	73·3	71·3	65·8	60·8	57·1	61·1	61·8	60·3	62·8	59·1	65·7	60·4	63·0	63·3	62·0	60·0	59·3	54·5	61·7	61·7	59·7	58·7	69·4	72·8	69·7	65·2	62·2	61·5	67·5	59·9	56·1	66·6	60·1	62·3
15	60·6	66·0	57·7	55·5	67·7	56·0	63·3	55·7	62·3	55·6	65·8	79·1	66·1	61·3	59·0	64·1	64·6	62·2	59·5	62·4	67·2	62·9	58·7	66·3	62·0	60·3	61·7	54·2	63·1	64·8	61·7	55·0	64·4	69·9	61·5	61·4	70·4	59·4	72·0	55·4	59·7	63·2	63·3	62·4
16	55·8	61·6	54·3	53·3	72·0	58·3	65·3	58·0	61·3	52·6	67·3	74·1	60·8	61·3	61·3	60·1	60·1	61·2	63·9	61·7	59·7	64·9	59·0	61·5	62·3	62·7	67·3	56·7	60·3	66·3	56·7	58·0	63·1	69·4	61·6	67·3	73·6	58·1	69·8	55·2	62·3	59·3	58·2	61·7
17	58·0	66·6	55·7	58·7	67·0	60·3	61·3	60·3	61·7	53·6	63·8	73·9	63·8	62·3	63·6	58·3	58·8	61·2	70·2	60·7	76·7	66·2	61·6	62·3	64·7	65·3	60·7	59·4	60·5	68·7	56·9	61·3	62·3	62·7	65·3	62·6	69·4	54·9	66·7	59·3	60·8	57·6	59·2	62·6
18	60·3	61·0	52·3	54·0	69·3	63·7	57·7	61·7	67·7	58·2	64·3	78·2	66·6	64·3	64·8	62·1	58·3	61·3	57·9	68·9	62·9	70·4	58·0	64·0	60·3	64·7	58·7	57·1	65·6	63·2	58·6	62·8	61·2	62·5	65·8	59·1	61·9	57·2	62·5	58·0	61·8	62·8	57·3	62·0
19	61·3	55·7	57·7	55·0	70·3	65·3	59·3	66·3	63·3	54·7	62·3	78·6	63·8	61·8	61·3	59·1	60·0	61·4	55·2	63·2	53·9	63·6	61·3	64·7	64·3	61·3	62·0	60·2	63·3	57·3	54·9	61·7	61·2	60·4	61·1	58·9	61·1	58·1	65·0	60·9	61·0	54·9	64·5	61·2
20	64·3	54·3	60·7	58·0	66·3	64·7	64·0	61·3	63·3	68·6	63·8	70·8	61·6	59·6	60·8	60·6	60·1	60·3	57·9	60·4	60·5	69·9	67·7	59·7	61·3	63·0	59·3	57·5	58·9	55·4	58·8	56·6	62·6	65·0	60·4	57·5	60·1	63·0	64·5	59·1	63·3	59·0	62·1	61·4
21	62·6	55·7	60·7	62·2	68·0	53·3	61·7	60·7	64·7	58·6	64·6	64·1	59·8	59·8	60·6	63·1	63·8	61·7	54·1	65·5	58·7	69·4	53·7	60·7	55·3	60·2	62·3	57·5	55·8	59·4	62·4	61·8	62·8	65·7	60·6	58·9	67·6	62·2	66·9	60·6	65·0	60·4	62·9	61·2
22	61·9	58·0	57·7	58·7	68·3	58·7	60·3	60·7	62·3	55·6	63·8	63·6	60·1	59·5	60·6	62·6	66·1	57·9	55·2	57·7	61·7	64·7	55·3	62·7	56·1	61·3	60·7	58·9	58·4	59·6	67·5	61·4	61·2	64·0	62·6	61·3	68·2	61·6	65·8	60·2	68·2	61·5	65·5	60·5
23	64·3	59·0	58·3	58·3	72·7	60·3	56·0	57·7	63·7	58·6	66·7	58·2	53·2	66·3	62·3	61·8	66·8	58·4	56·4	56·8	66·4	67·2	58·3	66·1	55·7	62·3	55·7	55·1	59·2	54·9	69·2	58·4	65·3	60·9	63·2	57·0	72·3	59·6	63·7	61·5	68·3	65·7	68·2	61·4
24	60·6	61·0	58·7	59·0	79·2	65·3	63·3	60·7	63·7	60·7	65·6	60·1	61·3	66·3	61·2	67·3	66·2	64·2	59·7	56·4	62·9	67·9	57·0	61·7	54·0	62·3	59·0	55·3	61·3	54·2	68·9	58·7	60·7	62·6	59·6	55·3	62·6	55·7	66·6	60·5	69·3	61·6	64·2	61·0
25	66·9	61·8	57·0	58·3	70·7	62·7	60·7	61·0	62·0	56·6	63·8	61·6	62·6	62·6	62·2	63·6	70·6	63·7	60·7	59·2	64·4	66·0	55·0	65·3	54·0	64·3	61·0	60·7	61·7	56·2	70·7	60·1	60·2	59·8	58·7	57·5	59·7	59·6	64·8	60·5	73·0	57·8	64·7	61·9
26	64·9	57·0	59·7	57·0	72·0	64·3	61·7	58·3	61·3	56·2	64·3	59·8	61·6	63·6	61·6	55·1	73·1	64·9	62·4	62·4	62·9	64·6	62·0	70·0	58·0	60·7	54·6	60·0	60·3	62·4	65·1	61·5	59·9	61·7	62·7	57·6	59·8	58·7	65·5	58·8	60·2	56·2	62·1	61·5
27	68·9	55·0	59·0	57·7	69·3	62·0	64·3	59·3	63·3	51·6	59·3	63·3	61·3	65·6	60·1	57·1	70·3	66·9	59·0	67·9	59·7	70·7	69·0	74·0	56·3	55·7	58·7	61·3	59·4	61·6	65·4	57·7	61·5	64·8	60·3	61·7	57·8	61·4	67·1	62·1	61·2	60·8	58·6	62·1
28	74·6	59·7	55·3	54·7	61·7	61·3	66·0	59·3	63·3	59·6	61·1	65·3	63·1	67·6	58·1	60·6	71·1	65·7	60·2	65·6	65·9	73·2	68·7	66·7	59·3	57·7	61·7	59·8	62·5	59·9	66·5	58·3	69·9	65·1	63·1	62·0	58·5	60·5	65·8	60·5	60·4	61·3	62·6	62·8
29	64·6	63·3	58·0	59·0	67·0	65·0	67·3	60·3	60·7	57·6	61·8	64·3	66·2	73·9	53·8	59·8	72·3	66·9	60·0	65·2	69·4	67·2	61·0	61·0	57·0	59·0	62·7	55·0	57·3	61·3	62·7	54·7	69·4	69·6	61·6	58·9	62·6	64·3	66·3	60·7	60·1	63·7	65·3	62·6
30	63·6	62·7	54·3	58·0	68·3	69·0	69·0	60·7	56·7	59·6	62·8	64·1	70·8	66·1	53·8	58·6	76·1	68·4	61·9	66·7	67·1	69·4	58·3	61·3	54·7	58·3	64·0	55·2	56·0	59·4	58·6	55·3	73·6	67·3	62·8	61·4	60·6	61·8	63·6	59·0	63·4	64·2	58·5	62·4
31	64·6	58·3	55·7	55·7	68·0	71·5	71·6	65·0	55·3	59·6	61·6	70·7	74·8	63·3	55·6	56·3	69·6	67·9	57·3	56·7	59·4	64·9	55·2	64·7	59·3	54·3	57·3	55·6	62·0	58·7	60·2	58·8	74·2	66·9	62·6	61·0	65·1	60·3	67·0	60·5	63·7	60·9	71·9	62·3

The Mean Temperature of the coldest day in July in the years 1814 to 1856 was 47°·7, and it took place on the 20th day in the year 1836.
The Mean Temperature of the hottest day in July in the years 1814 to 1856 was 79°·2, and it took place on the 24th day in the year 1818.
The difference between these numbers is 31°·5, and it represents the extreme difference between the Mean Temperature of two days in the month of July in 43 years.
The day of the month whose Mean Temperature has been subjected to the greatest difference was the 18th; in the year 1816 its Mean Temperature was 52°·3; and in the year 1825 it was 78°·2; the difference between these numbers is 25°·9.
The day of the month whose Mean Temperature has been subjected to the least difference was the 10th; in the year 1835 its Mean Temperature was 54°·4; and in the year 1852 it was 70°·5; the difference between these numbers is 16°·1.

TABLE VIII.—Mean Temperature of every day in the Month of August, as deduced from the Observations taken on that day, at the Royal Observatory, Greenwich, in the years 1814 to 1856.

Days of the Month.	1814.	1815.	1816.	1817.	1818.	1819.	1820.	1821.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	Mean of 43 years.
Aug.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	61·6	57·9	55·5	54·9	60·5	58·9	60·2	61·9	56·5	60·1	57·8	75·3	69·0	61·0	61·5	59·5	66·8	65·0	60·5	57·2	68·0	67·0	60·7	57·7	64·4	58·4	62·0	54·0	60·0	58·6	52·3	58·1	71·2	69·1	58·3	60·3	60·6	68·3	70·8	61·4	61·2	62·3	71·9	63·3
2	64·3	61·2	55·9	56·9	59·9	61·2	63·9	64·2	54·2	60·8	59·8	67·5	70·3	71·0	60·8	62·0	64·5	64·2	67·2	54·5	67·0	65·5	56·7	64·4	63·0	61·0	63·9	58·5	60·6	57·7	58·3	56·0	66·0	68·5	59·6	62·5	60·0	66·1	67·7	63·4	60·8	63·7	74·2	62·5
3	66·3	61·5	56·5	57·2	63·2	62·2	67·5	62·9	56·9	62·9	64·0	65·8	66·8	62·8	59·3	59·8	63·0	70·3	60·7	56·2	63·1	61·2	64·0	62·3	61·7	68·4	67·7	62·0	66·8	59·1	57·7	56·8	64·1	61·6	56·8	55·9	60·8	66·6	61·0	62·7	55·5	61·7	72·4	62·3
4	61·6	67·7	56·9	58·5	63·4	61·2	64·9	66·9	58·9	60·3	62·8	67·3	66·0	62·8	60·3	56·8	67·2	66·7	62·0	56·2	62·3	66·5	64·0	63·0	63·0	63·7	68·0	61·0	67·8	56·9	61·9	60·5	63·9	60·9	59·4	56·5	64·3	67·7	59·6	63·0	51·3	60·6	68·1	62·5
5	62·1	64·2	58·9	58·9	74·2	61·2	61·2	69·3	59·2	57·3	60·5	62·8	63·3	60·8	60·5	59·0	63·0	65·2	57·6	58·0	64·2	67·7	63·4	57·4	58·5	58·7	65·7	60·3	67·9	59·2	59·2	61·5	66·3	61·9	60·5	58·4	68·8	62·2	61·7	59·3	53·4	60·6	65·8	61·8
6	61·6	56·2	57·5	59·9	74·5	66·2	58·5	66·2	60·5	54·0	58·3	63·0	66·0	60·3	60·9	63·3	60·3	65·7	61·7	57·7	64·0	61·5	59·0	57·2	57·7	64·4	68·7	59·8	62·5	59·4	62·2	60·7	71·8	61·3	60·0	62·3	63·2	58·0	59·8	60·9	56·7	59·3	65·1	61·6
7	60·0	56·5	57·2	64·2	64·9	66·5	60·2	60·5	61·2	55·3	60·0	65·0	68·0	59·5	64·8	65·3	60·0	66·7	64·7	55·7	59·7	61·5	58·9	60·4	57·0	57·7	69·4	61·5	65·0	60·8	57·4	57·0	68·2	61·2	58·9	67·7	64·2	65·1	62·3	59·6	56·1	63·4	67·0	61·8
8	60·6	61·2	60·2	58·5	68·0	62·5	61·5	61·9	63·9	54·5	60·8	63·8	68·3	60·5	62·6	63·8	62·3	65·7	65·0	59·2	61·7	60·0	61·7	60·4	55·7	58·4	67·0	57·5	64·5	67·1	58·0	58·1	64·5	60·6	55·4	70·8	64·4	68·3	62·2	62·2	59·9	61·4	61·9	62·1
9	58·3	58·9	57·9	58·2	67·9	67·2	61·5	58·9	63·2	58·2	64·5	60·8	67·0	61·8	60·9	67·3	63·8	67·0	67·5	62·7	61·7	59·5	59·7	62·7	60·7	63·4	63·0	57·3	68·9	68·0	58·0	58·9	61·2	57·2	58·4	66·6	61·0	61·1	59·1	61·2	61·9	58·8	64·3	61·9
10	59·6	61·7	58·5	58·5	63·9	64·5	62·2	58·5	64·0	58·5	62·3	59·5	63·5	63·8	60·5	59·9	60·8	63·5	69·2	58·7	62·5	72·7	63·4	66·0	64·0	60·0	71·4	57·8	73·2	59·2	57·2	55·1	62·6	57·2	58·2	67·4	63·5	58·7	61·0	61·9	61·5	60·1	69·3	62·2
11	59·0	58·2	59·2	58·9	63·9	67·2	64·9	59·2	63·9	63·8	65·5	59·8	60·5	59·0	59·5	61·9	63·5	65·7	69·5	61·5	66·7	74·9	61·4	66·7	66·4	58·8	60·7	58·3	62·3	58·5	55·9	58·0	63·1	64·5	58·6	68·9	62·0	60·2	58·1	63·0	60·3	63·7	72·1	62·5
12	59·6	57·7	57·2	57·9	61·5	67·2	61·9	59·2	63·9	67·3	62·3	62·3	61·3	55·5	59·0	63·8	62·3	65·0	65·7	56·2	69·0	68·3	59·4	63·0	63·4	54·4	61·4	54·4	63·8	62·3	60·2	57·4	62·5	72·1	60·2	65·5	57·9	69·3	54·3	59·8	62·4	59·9	67·4	61·8
13	61·6	60·3	59·9	57·0	62·9	68·2	61·5	59·5	62·9	67·0	61·3	61·3	63·8	58·3	59·3	66·2	55·8	65·7	62·0	54·6	70·0	61·2	64·0	62·1	61·7	55·0	61·4	56·0	65·4	61·5	58·3	55·6	60·2	66·8	58·3	61·1	62·9	69·8	62·0	60·4	66·7	59·2	68·3	61·9
14	57·9	65·9	58·2	60·5	60·0	63·2	64·2	58·9	64·9	58·7	59·2	60·5	63·8	64·3	55·0	61·8	58·5	63·5	64·2	58·2	60·6	61·2	63·1	62·7	58·4	62·4	56·0	59·6	68·1	66·0	55·0	55·2	59·3	62·3	54·8	61·1	61·6	64·4	61·4	59·0	64·2	59·9	64·4	61·1
15	56·6	64·5	57·9	59·2	61·2	67·2	63·5	59·5	59·9	58·3	58·0	59·5	65·3	64·0	54·3	52·5	57·8	67·0	66·7	58·0	63·7	62·7	62·0	66·7	58·7	58·7	58·0	58·7	69·8	67·4	58·1	54·7	62·9	65·2	57·4	61·2	60·5	65·7	60·1	57·3	58·6	63·3	64·9	60·9
16	55·9	65·2	57·5	58·2	59·5	67·2	66·2	67·9	58·5	58·3	59·5	62·3	64·3	60·0	58·8	54·2	55·3	63·2	65·5	55·5	66·6	66·5	58·0	65·7	62·4	61·7	60·0	61·3	69·1	65·7	59·2	52·5	59·1	62·5	61·9	58·1	66·6	65·9	60·8	58·9	56·3	65·3	62·5	61·1
17	55·9	59·2	55·9	54·2	60·5	66·9	64·9	64·5	66·5	58·0	60·5	63·8	64·5	57·3	62·0	55·0	53·3	62·0	62·5	56·7	66·1	66·0	64·4	74·4	58·4	58·0	54·7	63·2	66·1	65·9	60·3	53·7	61·0	65·3	59·7	57·5	66·5	65·9	65·7	60·4	54·6	64·2	59·8	61·0
18	59·3	61·5	54·5	57·9	60·5	63·9	62·5	61·9	66·5	61·8	59·0	60·3	71·5	58·0	58·5	57·2	52·5	55·0	63·2	58·7	63·2	63·9	63·4	66·7	61·6	56·6	54·0	61·3	74·3	68·2	57·9	57·4	60·6	65·2	60·2	57·9	64·2	57·7	63·1	57·4	53·6	65·4	57·4	61·0
19	57·6	55·5	55·2	60·9	57·2	62·9	58·5	63·9	66·2	61·8	59·3	56·5	69·1	58·0	60·0	58·5	53·3	62·5	62·1	59·0	62·5	68·5	56·7	71·7	63·0	59·7	60·0	61·5	66·5	70·3	58·3	58·9	60·2	64·5	60·4	60·2	58·2	59·0	61·1	64·0	63·3	64·4	57·8	61·0
20	54·3	57·7	54·5	58·9	57·5	62·5	55·2	63·1	67·2	61·0	62·0	59·8	73·3	55·8	61·5	55·8	51·8	57·0	62·0	60·1	64·0	68·0	53·7	69·5	62·4	47·0	65·0	65·4	63·5	59·4	64·5	55·4	59·5	61·9	58·2	61·5	57·4	65·4	58·4	64·5	64·8	60·9	59·3	60·5
21	59·9	57·2	58·9	58·5	59·9	64·5	58·9	66·9	70·5	57·0	61·2	67·5	65·8	60·4	61·3	55·5	58·1	59·2	63·3	64·2	60·7	71·0	55·4	63·7	60·7	49·2	68·4	62·6	63·4	57·7	56·7	55·3	62·0	63·0	57·8	64·1	50·9	67·8	63·7	62·7	62·6	63·2	59·0	60·9
22	59·9	61·2	56·5	59·2	58·0	64·9	62·2	71·9	60·8	58·5	63·5	65·0	67·0	55·5	56·0	58·8	56·8	60·0	61·2	57·7	59·7	65·0	58·0	65·0	57·4	58·4	62·4	57·0	67·4	55·6	56·7	55·9	61·3	59·1	58·0	63·4	51·8	68·2	61·7	62·1	60·4	62·5	58·6	60·0
23	64·3	64·9	58·2	53·8	57·2	67·9	54·2	65·2	62·7	62·8	59·3	64·3	66·3	60·0	57·3	63·3	61·3	66·0	62·7	57·2	58·2	61·9	57·4	63·4	53·4	64·4	61·5	58·1	67·3	56·9	57·5	57·9	61·3	55·2	58·7	62·2	57·9	63·5	61·1	57·0	58·2	64·5	53·0	60·5
24	57·3	65·9	59·2	54·9	59·5	68·2	57·5	67·9	61·2	61·3	57·3	62·9	64·0	56·6	57·3	54·8	61·5	65·5	59·0	58·0	57·5	64·7	54·2	56·0	55·0	63·7	60·0	53·6	61·9	59·0	58·8	60·2	62·2	56·3	55·0	63·3	58·9	61·0	62·2	56·8	65·5	64·0	59·4	60·1
25	58·3	67·9	56·2	53·9	61·2	66·5	60·2	68·9	58·2	69·5	62·0	63·0	71·5	52·7	66·0	55·3	59·3	59·2	59·2	53·8	52·3	56·7	57·4	58·0	56·4	62·9	62·7	56·7	63·5	60·8	58·6	59·2	58·8	60·9	56·3	65·9	59·1	60·3	65·0	57·6	59·2	60·4	60·2	60·3
26	56·6	65·5	54·9	53·2	61·9	64·2	59·2	62·5	59·2	62·0	62·8	65·4	66·3	51·8	63·0	60·0	59·3	63·0	56·7	57·5	54·7	52·6	56·0	60·4	59·3	62·7	62·7	65·2	65·6	62·3	56·8	59·4	60·8	62·0	61·8	66·7	61·6	56·6	64·1	56·5	59·9	59·8	60·2	60·2
27	53·9	66·2	54·5	56·5	61·2	63·5	56·6	58·5	59·9	61·8	61·3	56·5	61·3	56·8	61·0	56·0	59·3	63·2	54·7	57·5	54·0	58·2	59·7	57·8	60·7	55·4	60·4	60·9	64·3	58·4	56·5	55·7	61·7	62·9	63·7	60·2	59·6	61·1	66·5	56·3	62·2	57·2	64·3	60·3
28	53·6	62·2	53·5	57·2	61·9	65·2	54·2	56·2	60·5	63·8	61·5	60·5	66·8	55·0	64·3	51·3	55·3	59·2	56·2	61·5	55·0	60·0	57·3	57·7	63·4	53·7	62·4	62·6	64·1	60·4	53·8	57·7	65·4	64·6	63·8	63·3	58·0	54·4	64·7	58·0	70·7	66·3	61·0	60·2
29	56·3	57·9	53·9	57·5	65·9	64·9	56·2	56·9	58·2	64·5	68·8	61·8	71·0	55·8	63·0	58·0	56·3	61·0	49·3	62·7	59·2	60·5	56·4	52·7	59·0	62·7	61·4	64·2	63·9	63·4	56·4	57·0	62·6	60·6	60·5	64·6	53·5	49·4	63·1	58·7	67·4	62·1	61·3	60·0
30	57·6	59·2	54·5	58·2	64·5	62·4	55·2	57·5	60·3	63·3	69·8	70·6	58·0	62·5	54·8	53·3	57·0	66·2	52·0	57·0	59·5	62·5	59·0	49·3	50·0	59·7	70·0	64·1	62·0	64·4	56·6	51·9	64·2	57·2	59·1	66·2	53·0	52·3	61·5	57·6	69·3	60·0	60·9	59·8
31	62·9	60·9	51·5	54·5	60·5	53·0	53·5	64·9	56·2	58·8	65·0	69·0	63·3	57·3	59·0	57·5	56·3	61·5	54·0	43·2	..	57·0	62·7	52·4	58·0	53·7	63·7	61·9	54·6	65·0	58·6	52·6	63·6	57·1	54·9	64·9	53·6	54·3	58·9	56·7	62·1	61·5	62·3	58·4

The Mean Temperature of the coldest day in August in the years 1814 to 1856 was 43°·2, and it took place on the 31st day in the year 1833.
The Mean Temperature of the hottest day in August in the years 1814 to 1856 was 75°·3, and it took place on the 1st day in the year 1825.
The difference between these numbers is 32°·1, and it represents the extreme difference between the Mean Temperature of two days in the month of August in 43 years.
The day of the month whose Mean Temperature has been subjected to the greatest difference was the 20th; in the year 1839 its Mean Temperature was 47°·0; and in the year 1826 it was 73°·3: the difference between these numbers is 26°·3.
The day of the month whose Mean Temperature has been subjected to the least difference was the 9th; in the year 1848 its Mean Temperature was 56°·4; and in the year 1842 it was 68°·9: the difference between these numbers is 12°·5.

TABLE IX.—Mean Temperature of every day in the Month of September, as deduced from the Observations taken on that day, at the Royal Observatory, Greenwich, in the years 1814 to 1856.

Days of the Month.	1814.	1815.	1816.	1817.	1818.	1819.	1820.	1821.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	Mean of 43 years.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Sept.																																													
1	60·2	61·8	44·5	54·8	67·5	51·8	55·2	60·5	58·5	60·2	71·7	67·2	63·7	58·7	60·2	56·0	59·0	50·0	57·0	51·8	59·2	59·9	60·1	50·4	59·7	59·1	67·4	55·1	58·5	67·1	60·2	57·5	59·4	56·6	56·6	62·3	57·0	64·6	61·2	58·1	58·3	57·3	57·9	58·9
2	58·5	59·8	45·5	59·2	61·8	58·2	55·2	61·8	60·5	62·5	73·5	64·7	59·2	58·7	57·5	57·5	59·2	50·3	58·5	49·7	55·9	58·9	58·1	53·4	57·2	53·4	67·7	55·8	68·4	67·4	59·6	56·3	61·9	53·8	58·2	60·8	61·5	65·0	63·4	52·6	60·2	54·9	55·3	58·9
3	56·8	61·5	46·8	64·8	64·2	64·5	56·2	65·2	61·5	58·0	70·5	62·7	63·0	59·2	60·5	54·2	58·0	52·5	57·5	50·4	58·7	61·7	55·7	52·8	59·7	58·7	55·4	61·9	62·9	64·8	60·9	54·7	59·9	51·7	61·1	61·3	57·5	64·4	64·3	52·5	60·8	57·1	55·9	59·2
4	56·2	60·5	49·8	60·2	68·2	63·5	55·2	65·8	62·5	63·3	69·7	54·0	63·0	58·5	58·7	54·0	57·2	58·5	56·8	48·9	61·7	65·9	60·3	50·7	60·7	56·7	57·4	50·0	59·4	61·3	64·0	52·4	59·7	49·3	62·5	66·0	56·0	60·7	64·7	56·0	62·2	60·3	57·5	57·8
5	51·8	53·5	49·2	59·8	64·2	58·2	55·8	60·5	63·2	61·8	61·5	54·7	59·2	59·5	56·7	59·5	58·2	64·3	55·3	50·9	62·7	61·2	53·3	55·4	65·4	60·1	56·4	48·8	60·6	56·2	64·1	53·1	65·3	50·8	68·1	65·9	55·0	58·0	63·6	57·8	58·8	55·2	54·6	58·4
6	56·8	50·8	49·5	60·5	58·8	56·2	54·5	68·2	62·2	57·2	62·7	55·0	60·7	57·2	59·7	57·7	57·2	60·5	59·0	54·1	58·0	66·5	52·7	52·4	56·1	58·7	56·0	47·9	59·8	60·0	63·5	53·8	68·4	51·3	60·8	65·7	53·6	56·8	61·8	58·1	58·8	51·9	58·7	57·9
7	51·2	48·8	50·8	57·5	56·5	64·5	56·2	64·8	56·5	55·5	61·7	58·5	54·2	56·1	61·2	55·7	56·1	56·5	59·0	57·2	57·6	61·4	49·8	52·4	61·1	59·7	59·4	52·0	59·9	63·7	63·9	55·5	64·9	53·0	57·3	59·9	54·6	56·9	57·7	52·6	59·0	56·3	57·7	57·7
8	55·8	53·5	56·5	60·5	53·5	64·2	59·2	58·5	59·8	52·2	58·0	58·5	59·3	58·0	61·5	55·7	57·2	55·0	58·3	55·8	58·9	58·4	55·2	54·4	47·1	60·9	56·4	58·1	57·9	62·4	62·7	56·4	64·1	58·1	58·0	58·9	53·4	58·2	60·6	53·9	57·2	56·5	57·1	57·8
9	54·8	57·2	56·2	58·2	52·5	63·2	57·8	60·8	58·2	50·7	58·7	62·2	54·3	59·7	63·7	58·5	56·2	48·2	59·5	55·7	55·7	51·4	55·5	61·1	49·6	64·4	57·7	60·4	59·3	65·4	58·8	56·4	65·7	56·4	59·7	57·9	52·5	56·5	61·4	56·1	57·3	55·0	58·1	57·6
10	51·2	59·5	56·8	58·2	50·2	62·5	59·2	58·5	53·2	54·1	60·7	63·2	55·2	60·7	61·2	61·5	54·0	52·0	56·5	53·7	55·7	55·4	47·4	60·0	48·7	61·1	57·4	63·2	56·8	61·9	57·9	56·6	64·0	58·5	57·5	60·7	56·1	57·3	60·9	58·1	55·0	55·3	63·5	57·7
11	53·3	61·8	54·3	57·3	50·2	60·2	61·2	56·2	63·2	56·7	60·7	65·2	54·8	64·2	63·6	54·5	53·2	53·3	56·0	54·7	58·9	50·2	47·0	61·4	49·7	66·7	55·7	61·0	55·2	61·6	55·3	55·8	65·2	59·6	51·6	57·6	56·1	56·6	58·6	57·4	55·6	57·6	61·3	57·5
12	59·8	57·2	54·8	57·5	55·5	56·8	61·8	60·2	52·5	60·0	58·0	63·1	56·7	57·2	60·5	52·5	52·7	56·0	56·2	51·7	56·9	52·4	49·7	56·1	55·7	56·1	50·1	68·7	57·6	63·1	57·4	57·0	65·2	57·9	47·3	50·7	57·5	55·7	57·6	61·3	62·3	58·9	59·2	57·0
13	50·8	65·8	57·2	56·9	52·8	55·8	57·5	56·8	53·2	65·5	60·0	62·5	56·2	56·5	59·7	53·7	52·7	57·5	57·0	54·5	55·7	53·8	50·9	57·2	58·7	53·1	52·6	66·1	56·7	58·8	58·5	54·7	61·4	57·9	49·9	54·6	55·5	58·2	57·4	52·8	62·1	58·3	54·1	56·8
14	50·5	64·8	60·5	57·8	58·8	61·8	60·5	55·2	51·5	69·5	58·0	62·1	57·0	58·7	52·0	51·0	54·0	58·0	51·8	59·2	53·6	59·7	51·5	51·9	59·1	57·0	50·4	66·4	60·9	60·6	60·2	60·6	61·3	58·5	51·3	58·7	56·1	56·2	54·7	55·8	60·8	54·7	54·3	57·3
15	51·5	67·2	61·5	61·8	59·5	66·2	59·5	57·8	56·3	59·7	58·5	61·8	52·2	62·0	52·2	48·7	57·5	54·3	52·3	54·5	54·7	59·4	53·2	50·4	58·1	59·5	46·4	63·2	60·4	64·9	62·8	50·3	61·4	58·1	52·5	57·3	57·1	57·2	52·9	55·8	61·0	52·5	57·0	57·1
16	52·5	64·5	60·5	61·5	50·2	48·8	56·5	63·5	58·8	57·1	61·5	64·0	54·2	63·2	49·2	49·2	58·0	53·8	54·5	53·9	57·9	55·4	50·5	52·4	57·5	56·1	47·7	58·7	57·5	65·8	64·8	55·1	63·7	58·4	54·7	60·5	58·9	58·2	52·2	59·3	64·8	59·2	57·7	57·3
17	54·9	57·8	56·5	59·2	49·5	52·8	57·2	61·2	60·5	56·7	61·8	64·7	58·7	60·5	52·3	49·7	51·5	55·0	56·8	55·2	66·4	55·4	52·0	61·4	59·4	55·1	49·4	51·5	61·9	65·6	62·7	61·6	65·3	53·1	55·9	56·5	57·6	58·4	52·0	61·5	63·0	55·0	57·3	57·4
18	58·2	65·2	56·2	57·2	54·8	56·2	48·5	62·5	57·2	51·5	63·6	61·5	58·7	60·2	54·0	53·7	53·5	60·0	54·5	50·7	63·4	55·9	52·5	62·7	56·2	50·7	48·1	55·0	55·2	66·0	54·4	57·7	57·4	49·7	52·4	51·0	58·4	57·0	53·4	57·2	58·9	60·3	52·8	58·4
19	54·9	59·8	53·2	57·2	61·2	51·2	45·2	57·2	56·2	53·5	56·6	64·7	62·7	51·0	55·2	51·2	57·5	57·8	47·3	50·4	65·7	58·4	49·2	65·1	52·1	51·4	47·1	54·9	54·9	65·9	59·7	52·4	54·6	48·8	52·4	54·8	58·0	57·9	54·3	57·9	61·8	60·8	49·5	55·4
20	64·9	54·2	53·0	56·2	59·8	49·5	49·2	54·5	54·5	54·0	55·9	63·7	58·0	48·2	55·2	50·7	53·8	55·8	51·3	53·9	64·9	59·9	50·6	62·1	55·4	53·4	46·6	61·8	50·3	61·5	53·7	53·0	58·5	55·0	58·0	52·7	60·7	56·2	58·0	53·5	57·6	60·6	47·5	55·5
21	60·5	49·2	53·5	56·8	58·5	51·2	47·2	61·5	54·5	54·5	53·2	63·2	54·2	54·7	55·7	53·0	50·0	56·5	53·8	53·9	61·5	52·4	44·0	59·1	47·2	46·4	52·4	60·1	51·3	60·7	52·5	56·5	58·4	53·0	57·9	54·9	58·3	55·2	49·0	53·9	53·2	61·2	51·0	54·5
22	56·5	60·5	57·2	52·8	60·2	51·8	48·8	61·2	56·2	50·0	58·7	58·5	48·2	53·5	59·5	54·0	51·2	53·0	55·8	55·0	56·9	60·9	49·0	58·7	50·4	53·4	45·4	59·4	49·0	59·4	51·5	52·8	60·9	60·3	61·7	59·7	57·6	57·7	52·7	57·8	50·5	59·9	54·7	55·4
23	53·8	49·8	53·5	54·2	59·2	56·2	59·0	59·5	56·5	50·7	57·7	56·7	51·5	52·2	59·2	54·2	53·5	54·5	57·1	55·9	53·2	59·4	57·2	53·7	47·6	50·4	48·4	55·9	50·4	57·9	53·0	47·1	60·9	59·2	59·7	55·3	56·1	58·7	54·0	53·2	54·9	62·5	54·5	55·1
24	60·2	54·8	55·8	54·5	53·8	57·5	55·5	56·5	55·2	59·2	57·7	64·5	58·5	54·3	61·2	53·0	49·1	58·5	61·0	54·4	52·4	58·9	58·6	54·0	48·4	55·4	50·4	54·8	53·3	55·7	54·1	44·3	59·2	54·8	56·2	58·2	58·0	59·2	52·7	49·0	59·5	53·5	53·6	55·7
25	61·2	51·5	56·8	59·2	56·8	56·8	47·8	57·5	53·2	59·5	53·2	65·2	60·2	55·0	62·8	51·0	51·5	57·8	62·5	54·9	53·4	52·8	59·3	50·4	47·7	59·4	44·7	56·2	55·3	52·4	50·9	51·7	57·9	55·2	60·6	57·6	57·3	55·6	58·1	52·3	52·8	53·7	52·7	55·3
26	60·2	59·2	53·8	53·8	54·2	55·8	45·3	62·5	50·2	60·2	63·8	59·7	61·2	59·0	63·7	52·0	50·7	56·8	60·6	56·4	56·4	54·0	62·4	50·6	50·4	56·1	51·4	55·8	54·6	48·6	50·5	50·9	57·8	50·3	57·1	56·1	55·5	47·1	52·2	49·5	53·0	50·7	52·6	54·7
27	57·5	51·8	54·2	51·2	56·5	60·2	48·2	56·5	49·8	47·7	61·3	55·2	61·5	60·7	55·2	55·2	53·5	58·5	58·3	51·9	59·0	50·6	58·4	52·1	47·1	51·7	53·3	58·1	51·3	45·4	51·1	53·4	58·7	46·8	57·4	62·2	56·5	50·4	54·9	52·1	55·3	54·2	51·1	53·8
28	54·5	48·2	55·2	47·8	60·5	57·2	54·5	58·2	50·8	45·7	49·7	53·0	61·7	58·7	58·7	47·5	58·7	60·3	59·8	53·7	57·6	50·6	58·7	54·1	49·2	54·1	52·4	60·5	51·5	46·0	52·3	53·0	53·0	48·2	55·3	59·5	55·7	49·6	54·0	58·7	58·4	61·5	51·1	54·1
29	52·2	57·5	55·8	48·8	60·2	58·5	50·2	55·2	51·5	48·2	49·5	52·5	61·2	56·7	59·0	46·5	50·7	60·0	62·0	52·6	55·7	53·0	52·4	51·4	53·2	50·9	49·1	58·9	51·6	47·3	49·3	49·3	51·0	52·5	54·2	59·8	55·0	51·0	54·0	53·3	55·0	60·2	53·0	53·5
30	57·2	51·8	50·5	49·0	58·2	60·5	53·2	51·5	50·2	48·0	60·5	51·5	61·7	58·0	57·0	44·7	48·2	60·5	57·6	50·9	51·7	50·7	47·1	56·4	55·6	48·7	48·1	57·3	49·3	57·3	46·7	52·1	49·7	53·5	56·2	57·7	52·1	53·3	50·6	51·2	54·9	59·2	53·8	53·5

The Mean Temperature of the coldest day in September in the years 1814 to 1856 was 40°·7, and it took place on the 28th day in the year 1824.
The Mean Temperature of the hottest day in September in the years 1814 to 1856 was 73°·5, and it took place on the 2nd day in the year 1824.
The difference between these numbers is 32°·8, and it represents the extreme difference between the Mean Temperature of two days in the month of September in 43 years.
The day of the month whose Mean Temperature has been subjected to the greatest difference was the 2nd; in the year 1816 its Mean Temperature was 45°·5; and in the year 1824 it was 73°·5; the difference between these numbers is 28°·0.
The day of the month whose Mean Temperature has been subjected to the least difference was the 23rd; in the year 1845 its Mean Temperature was 47°·1; and in the year 1855 it was 62°·5; the difference between these numbers is 15°·4.

TABLE X.—Mean Temperature of every day in the Month of October, as deduced from the Observations taken on that day, at the Royal Observatory, Greenwich, in the years 1814 to 1856.

Days of the Month.	1814.	1815.	1816.	1817.	1818.	1819.	1820.	1821.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	Mean of 43 years.
Oct.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	50·7	53·2	53·5	46·5	57·5	63·8	49·8	56·2	55·4	44·2	55·7	60·4	58·2	57·7	52·9	52·9	54·7	60·4	58·9	50·9	52·6	52·4	49·4	56·2	49·0	51·4	52·4	54·6	49·8	62·3	53·9	51·1	54·2	55·6	56·0	52·6	51·6	55·1	49·3	49·5	51·7	56·6	54·1	53·8
2	49·3	48·5	55·2	57·7	56·9	60·3	49·2	51·5	59·2	42·4	55·2	61·4	53·9	55·4	51·0	53·9	58·2	58·9	59·4	50·4	53·1	53·3	45·6	61·7	55·4	56·7	51·0	52·1	45·3	59·2	58·4	59·8	57·8	53·8	57·0	48·3	50·7	51·1	50·6	45·7	51·3	54·1	56·5	53·5
3	46·0	51·5	50·5	39·9	57·8	59·5	47·3	61·2	61·7	48·4	56·4	60·7	52·3	58·9	49·4	54·6	57·7	58·4	57·1	48·8	51·9	51·4	44·6	61·7	53·0	49·0	45·4	48·3	49·1	57·5	59·0	61·5	55·1	53·6	57·3	52·5	51·2	55·5	50·2	44·7	54·9	54·0	58·6	53·4
4	47·6	54·2	57·8	45·2	53·5	55·2	49·8	59·8	60·9	50·2	57·9	58·7	48·7	54·2	54·7	53·2	56·7	58·1	58·6	52·1	58·6	52·7	45·0	61·7	50·7	54·4	49·7	54·0	47·4	59·5	55·6	55·0	51·6	52·8	62·3	51·0	52·9	57·1	50·3	48·4	50·7	58·1	59·7	54·0
5	48·7	54·2	59·2	43·8	50·5	45·8	50·2	50·2	59·9	53·2	56·9	60·4	44·2	55·7	57·2	50·9	49·4	55·4	55·1	52·1	64·5	51·2	46·0	57·4	47·4	47·4	47·4	52·3	42·5	58·9	55·8	45·8	58·6	50·9	62·5	50·0	51·4	58·8	51·9	51·5	60·6	55·4	57·2	52·9
6	46·0	51·2	59·2	43·8	46·8	50·5	50·8	54·2	51·7	58·9	59·4	61·9	42·5	54·2	53·2	46·4	50·2	59·9	51·4	54·9	60·5	54·7	50·4	57·7	49·4	48·9	47·5	50·7	48·1	59·8	49·3	44·6	56·3	51·7	63·2	46·6	52·2	53·8	44·7	45·5	51·5	56·3	54·1	52·2
7	46·0	46·2	57·3	48·2	44·5	55·5	51·2	57·2	53·7	54·4	59·7	57·7	50·5	52·9	52·4	57·4	51·9	60·4	52·1	52·8	60·1	50·4	56·0	55·0	51·0	52·4	45·0	50·9	51·5	59·5	46·9	48·9	55·8	54·4	61·7	55·2	54·6	51·8	48·3	51·8	51·6	55·2	53·8	52·7
8	42·6	48·8	58·2	47·8	44·2	60·2	49·5	53·2	53·3	49·3	58·2	57·9	56·3	53·2	52·7	59·7	51·9	54·6	50·4	51·1	57·9	50·6	52·4	55·9	49·0	51·0	49·2	50·1	51·8	54·9	45·3	49·6	53·6	52·1	59·1	47·1	52·5	51·2	39·8	53·3	54·4	54·5	53·8	51·7
9	41·3	46·9	55·8	45·3	48·3	59·2	48·8	47·5	57·2	47·8	55·9	58·9	48·2	53·4	51·4	58·7	51·4	54·1	50·6	49·7	59·4	50·0	55·0	49·7	51·0	59·7	43·7	48·7	50·3	49·0	55·4	46·2	58·1	55·8	55·9	42·4	48·2	50·8	41·7	51·6	58·7	52·3	51·8	51·0
10	38·0	48·2	54·8	48·2	56·2	62·5	48·0	49·8	49·3	50·9	49·7	59·2	57·0	52·4	55·7	46·1	50·7	55·6	59·6	50·9	52·1	46·0	54·7	54·7	48·0	57·7	44·0	50·2	52·6	47·4	55·8	47·0	58·1	57·0	52·7	44·4	48·2	61·2	46·1	50·0	55·8	48·4	53·5	51·8
11	46·6	49·2	52·8	44·5	59·8	62·2	47·5	49·2	54·2	46·3	51·7	57·9	60·7	48·2	53·2	51·4	51·2	57·9	60·9	49·9	48·6	45·3	53·4	57·4	53·4	59·0	47·5	53·7	51·2	54·4	53·1	49·1	55·1	57·9	50·4	47·4	44·3	58·7	50·3	51·9	51·4	51·6	54·5	52·4
12	50·3	47·2	52·2	41·8	50·5	53·2	42·8	48·8	57·9	48·2	48·4	58·2	60·3	49·2	55·2	51·9	50·4	56·5	58·6	49·2	52·2	52·5	51·4	55·7	42·6	52·0	47·7	49·2	50·5	45·7	55·0	46·9	50·7	58·9	48·8	46·6	45·2	60·4	48·1	52·1	46·5	55·8	50·5	50·9
13	53·8	53·5	51·2	42·7	56·2	57·8	43·3	48·5	55·9	47·7	59·2	56·4	59·7	43·7	52·9	51·2	49·4	58·6	51·4	46·8	55·6	54·6	54·7	48·4	56·0	51·2	44·4	48·9	49·8	41·2	57·7	51·5	48·5	56·1	50·0	43·6	43·8	57·7	47·5	52·8	41·3	50·6	54·3	50·3
14	58·3	51·8	50·7	43·7	59·5	53·5	49·5	48·8	44·4	44·3	42·2	55·4	55·4	50·9	52·2	46·4	44·7	59·1	50·1	54·7	59·6	50·4	52·4	46·7	40·6	52·7	46·7	57·3	48·0	41·6	52·3	52·2	48·0	51·4	48·0	42·8	46·4	55·3	48·2	54·1	48·3	48·3	52·8	50·2
15	53·3	51·8	48·5	43·5	58·5	50·8	55·5	46·2	44·4	46·2	38·4	49·7	59·2	55·2	49·7	39·9	42·2	56·4	48·2	52·3	46·2	48·2	53·1	54·4	46·8	49·4	47·6	46·4	53·2	50·7	58·3	52·4	53·7	49·3	51·2	45·8	44·0	44·7	51·3	49·3	51·4	50·0	45·8	51·6	49·2
16	49·0	53·8	46·8	42·3	60·2	48·5	46·8	42·5	49·5	45·3	36·9	48·9	55·2	55·7	50·3	48·9	42·8	52·1	52·6	45·1	52·1	52·1	51·0	48·7	54·7	49·0	47·0	50·8	51·7	35·8	48·4	52·6	53·0	53·0	49·2	45·9	49·2	46·5	47·3	45·4	47·2	47·6	52·2	48·9
17	49·3	51·2	44·8	38·8	56·9	42·0	48·3	45·3	47·7	45·9	38·4	49·9	47·4	50·9	55·7	51·9	48·9	55·4	49·6	49·9	48·1	50·1	54·6	48·4	52·4	45·7	49·7	51·2	49·7	40·8	48·5	50·8	52·7	52·6	45·7	56·1	51·5	45·9	47·1	47·2	44·0	54·1	53·1	48·8
18	51·0	52·5	43·8	40·9	55·5	42·9	45·8	48·8	43·2	50·7	41·9	46·7	54·4	55·2	45·7	54·2	49·9	54·6	52·1	44·9	45·2	49·3	57·0	53·7	45·7	48·7	49·7	49·2	48·4	39·9	44·6	55·3	51·9	55·8	38·0	59·7	54·2	52·1	48·8	44·9	45·3	49·3	50·8	49·2
19	46·3	56·5	50·2	48·7	55·2	43·5	46·2	49·2	51·4	51·7	50·9	47·9	57·2	51·9	41·7	56·3	58·7	56·6	51·9	44·9	47·2	42·0	54·0	49·0	54·0	47·0	49·4	45·3	40·4	36·4	45·5	55·6	53·7	57·9	44·7	59·5	53·1	58·1	43·8	47·0	42·0	52·2	49·9	49·9
20	43·6	56·2	44·8	42·2	51·5	51·5	44·5	49·5	53·0	54·7	51·7	38·4	57·7	54·7	44·0	54·9	58·2	55·1	43·4	38·9	55·4	41·0	46·4	54·7	52·0	48·9	45·7	46·4	36·2	40·2	49·3	51·3	50·7	50·6	45·9	59·1	47·1	58·3	48·7	47·6	48·7	55·7	52·3	49·4
21	45·0	50·5	44·5	43·8	46·2	36·5	42·2	46·8	54·3	53·8	49·7	39·2	60·3	54·7	49·9	50·2	59·7	53·6	47·1	54·7	47·1	40·5	48·0	51·4	55·7	52·0	44·0	40·7	35·6	46·4	45·6	45·9	50·0	51·6	43·4	50·9	43·8	56·4	51·1	50·5	48·6	56·9	53·7	48·7
22	52·6	49·2	44·5	41·9	47·8	35·5	44·8	46·9	51·8	49·8	53·2	43·7	60·7	53·9	57·9	48·4	60·2	51·9	49·8	55·8	49·6	44·3	47·4	52·9	56·4	50·4	46·4	40·9	39·0	47·3	45·3	47·0	46·6	49·9	50·2	52·4	42·8	51·7	55·9	57·6	49·2	55·1	53·9	49·3
23	47·3	55·2	38·2	44·3	48·2	39·9	46·2	47·5	48·8	47·5	54·9	40·0	58·7	52·7	49·2	41·2	52·9	54·9	48·4	51·4	48·9	41·3	47·3	54·4	52·7	49·4	44·0	49·9	42·0	50·9	43·0	45·5	45·4	55·0	53·3	58·1	41·8	53·2	52·1	57·9	46·0	55·8	53·8	49·1
24	43·6	50·8	46·5	41·5	47·3	39·3	45·8	41·8	55·9	47·7	55·4	49·4	57·4	52·4	43·2	45·3	53·9	52·1	46·9	56·1	36·9	47·1	48·4	46·7	53·0	46·0	42·7	46·0	38·7	53·6	48·6	48·7	48·2	46·0	51·8	57·4	38·6	53·9	49·4	56·4	44·0	48·2	48·4	48·1
25	45·0	48·5	41·5	43·0	50·3	35·2	45·5	48·5	55·7	41·6	56·7	40·4	50·9	54·2	45·7	43·9	54·7	55·1	45·4	54·4	41·4	45·9	46·4	40·4	50·7	44·4	40·7	43·8	40·5	45·4	48·0	43·1	45·8	44·1	51·1	56·9	40·7	50·0	45·2	56·1	42·4	48·1	46·7	47·0
26	42·0	46·9	43·5	43·2	44·5	37·5	41·5	51·8	54·4	45·9	51·9	37·8	44·2	54·2	45·7	42·9	43·2	54·1	45·9	54·6	42·0	46·0	48·7	44·4	53·7	45·0	39·4	42·8	37·7	38·0	46·1	37·9	44·0	45·1	50·3	54·0	41·1	49·9	43·7	56·0	42·6	48·4	42·0	45·7
27	44·0	45·2	50·5	43·2	50·0	34·5	46·8	55·5	47·9	48·5	51·2	41·9	47·7	53·2	46·2	40·2	44·7	52·1	48·4	53·9	48·6	42·4	44·4	47·7	49·0	42·7	44·7	46·6	42·9	41·1	46·2	46·4	41·2	50·1	52·6	55·6	40·2	51·3	41·0	57·5	42·6	41·1	44·6	46·7
28	46·6	44·2	50·5	40·5	54·3	35·8	42·5	53·2	44·4	51·6	51·8	51·7	44·7	46·2	44·4	43·7	54·9	59·9	48·1	54·8	48·1	40·0	36·7	48·0	52·8	41·0	41·4	46·3	41·4	45·1	41·6	50·4	39·4	52·7	49·6	54·2	43·6	48·4	46·0	55·8	47·4	47·9	44·0	46·9
29	45·0	47·3	47·8	39·2	53·2	37·2	44·2	42·2	52·4	43·9	49·9	51·2	50·7	41·2	44·7	39·2	46·2	49·4	51·1	54·6	45·4	51·4	38·4	43·4	49·0	39·4	42·4	46·5	38·8	41·6	45·0	49·1	45·7	55·5	48·0	50·6	40·1	48·8	41·0	48·5	47·5	45·5	37·6	45·4
30	44·0	46·8	48·2	48·7	51·2	43·2	44·2	44·5	58·7	43·2	43·9	52·7	51·7	43·0	39·5	48·2	40·9	48·1	46·9	51·7	48·6	45·3	50·8	48·0	44·4	40·7	44·4	46·0	42·4	53·0	44·0	52·4	47·9	51·5	48·1	51·1	43·1	43·5	52·6	46·7	54·2	49·5	46·2	46·6
31	47·8	42·9	46·5	48·2	52·5	46·9	44·8	49·8	56·4	40·2	48·2	47·9	48·4	45·7	45·0	40·9	53·7	51·1	46·1	56·1	50·1	49·0	51·4	42·7	37·4	34·7	47·0	47·3	47·1	50·1	45·9	50·4	41·8	52·2	44·5	46·7	47·6	42·2	54·6	46·9	57·0	45·9	52·2	48·2

The Mean Temperature of the coldest day in October in the years 1814 to 1856 was 28°·4, and it took place on the 29th day in the year 1836.
The Mean Temperature of the hottest day in October in the years 1814 to 1856 was 64°·5, and it took place on the 5th day in the year 1834.
The difference between these numbers is 36°·1, and it represents the extreme difference between the Mean Temperature of two days in the month of October in 43 years.
The day of the month whose Mean Temperature has been subjected to the greatest difference was the 29th; in the year 1836 its Mean Temperature was 28°·4; and in the year 1847 it was 55°·5: the difference between these numbers is 27°·1.
The day of the month whose Mean Temperature has been subjected to the least difference was the 4th; in the year 1836 its Mean Temperature was 45°·0; and in the year 1837 it was 62°·3: the difference between these numbers is 17°·3.

Table XI.—Mean Temperature of every day in the Month of November, as deduced from the Observations taken on that day, at the Royal Observatory, Greenwich, in the years 1814 to 1856.

Days of the Month.	1814.	1815.	1816.	1817.	1818.	1819.	1820.	1821.	1822.	1823.	1824.	1825.	1826.	1827.	1828.
Nov.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	48.0	42.7	44.0	40.5	51.0	44.5	41.1	57.7	56.3	39.8	52.3	51.9	45.8	40.3	48.5
2	43.4	43.0	41.4	50.4	52.7	41.0	38.7	59.7	55.8	34.5	54.5	47.8	43.3	45.8	40.6
3	41.1	37.7	44.0	52.4	55.4	39.9	33.1	54.0	54.5	43.8	45.8	47.3	47.0	44.0	44.5
4	39.1	34.7	46.0	50.0	52.0	45.9	35.1	41.0	46.3	49.0	42.3	39.9	45.1	50.0	41.5
5	41.1	43.4	46.7	50.0	54.4	49.0	36.4	37.2	51.0	47.5	38.5	41.3	44.3	50.8	40.0
6	38.4	46.0	44.7	52.5	54.4	46.4	48.7	36.7	51.5	51.0	38.3	47.8	39.5	51.5	45.1
7	41.4	44.7	35.7	54.0	49.4	43.4	51.4	42.4	48.0	51.0	52.6	36.8	34.3	45.5	40.5
8	39.4	45.0	29.0	51.0	45.4	37.7	50.1	42.4	45.8	48.3	52.0	41.3	34.8	45.0	34.3
9	41.4	50.7	42.4	47.7	45.4	37.0	45.7	40.2	41.0	39.3	44.3	41.3	35.8	48.3	36.8
10	34.4	50.4	32.4	50.4	47.4	45.4	44.7	47.4	48.5	37.8	55.0	40.8	38.8	49.0	36.5
11	36.4	51.0	34.5	48.5	49.4	43.2	41.1	54.7	47.2	36.6	55.5	38.0	49.8	50.3	29.4
12	47.0	52.4	43.7	51.7	44.0	40.7	38.2	48.7	51.3	30.0	45.3	31.8	46.0	42.5	28.8
13	44.0	45.0	49.7	44.4	52.0	43.0	35.1	50.4	42.3	34.0	51.0	29.3	42.3	53.3	42.0
14	44.7	37.4	39.5	51.0	52.6	42.0	35.7	55.0	44.8	38.8	47.9	39.4	40.5	40.8	45.0
15	47.0	34.0	31.9	52.0	47.0	44.0	35.1	58.0	44.5	45.3	39.0	37.3	38.6	43.0	45.3
16	46.7	33.0	33.9	51.0	52.0	38.9	32.9	54.4	38.5	42.0	44.9	35.8	36.8	44.3	50.3
17	45.7	30.0	31.4	55.4	45.7	41.5	37.1	51.0	44.3	38.0	52.0	43.1	42.0	44.5	47.0
18	44.7	29.0	43.7	50.9	41.7	37.7	33.1	47.4	51.0	42.3	51.3	44.8	42.5	45.5	41.0
19	43.7	28.9	42.4	40.7	45.7	34.7	39.1	49.4	51.8	44.3	46.3	39.1	42.8	47.8	44.6
20	39.1	33.0	46.7	40.7	39.7	36.0	46.1	46.4	52.8	47.3	46.5	39.0	42.8	44.0	48.6
21	36.4	36.0	39.0	46.7	38.7	37.9	48.1	45.5	46.3	46.3	47.0	47.6	42.7	36.5	50.0
22	29.4	30.4	32.4	41.7	36.7	31.9	45.9	48.0	47.3	45.0	45.5	38.9	40.5	28.3	49.8
23	30.0	30.4	29.0	45.0	49.4	30.2	42.6	47.4	48.5	45.9	48.5	40.0	42.0	24.6	44.5
24	31.0	34.4	23.4	43.4	47.4	30.7	41.2	44.7	48.0	47.0	44.5	49.1	42.6	28.1	45.5
25	44.4	33.0	34.7	36.5	41.4	31.2	44.4	47.0	48.3	47.3	42.5	40.3	34.1	35.9	50.8
26	44.0	32.4	41.0	46.5	51.0	35.4	46.7	51.7	48.3	45.8	34.5	46.9	27.7	40.9	52.0
27	39.1	32.7	40.0	48.0	52.0	33.7	39.6	40.7	45.0	45.3	39.3	41.8	29.8	37.3	47.8
28	35.2	31.5	40.7	46.4	52.0	34.7	37.1	45.7	44.8	47.0	49.8	49.8	41.4	40.5	54.4
29	43.7	29.0	37.0	50.7	53.7	49.9	38.9	51.7	38.5	50.0	45.3	42.3	48.1	43.5	52.5
30	41.2	41.4	33.0	52.4	51.4	49.4	37.7	46.7	38.5	52.5	48.8	34.8	43.7	46.5	50.8

Days of the Month.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.
Nov.	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	34.0	53.5	52.5	52.8	55.0	51.7	42.5	35.9	52.8	45.2	39.6	49.4	46.0	44.5
2	41.5	52.5	49.4	53.5	49.7	52.2	39.7	49.2	42.9	40.6	39.9	50.6	46.2	45.1
3	46.0	52.5	41.5	50.0	46.9	49.7	44.4	46.6	42.2	39.6	45.9	50.9	47.4	40.9
4	47.1	49.0	41.5	52.0	42.2	52.2	40.6	42.9	40.9	47.9	48.6	49.2	45.0	37.0
5	47.0	50.5	47.3	37.4	46.6	57.7	52.1	42.2	43.9	44.2	45.2	48.9	45.8	39.6
6	47.8	55.8	45.5	42.5	52.2	57.5	50.1	37.0	38.6	41.2	44.6	45.2	46.6	36.3
7	41.0	46.5	44.8	39.7	39.0	55.5	49.9	36.2	33.6	50.6	47.6	46.6	47.0	41.6
8	39.8	40.3	45.9	38.3	38.3	48.0	42.9	33.6	30.2	48.9	48.6	46.4	43.7	40.6
9	44.6	38.5	38.8	37.0	36.2	49.9	38.2	46.9	35.6	44.6	49.2	47.6	44.1	43.0
10	47.1	49.0	36.0	43.5	47.9	42.7	33.9	50.2	47.2	40.2	51.4	43.9	49.7	46.9
11	43.3	47.0	50.5	44.1	47.5	44.6	37.9	48.2	48.9	36.8	47.2	44.6	47.1	48.8
12	53.4	40.3	51.3	39.3	41.9	38.7	39.9	39.9	44.3	39.6	49.2	41.6	45.4	49.8
13	44.8	45.3	45.5	38.3	42.0	38.0	37.7	48.5	39.9	38.6	45.9	49.6	40.9	49.4
14	45.3	49.5	38.4	47.8	34.8	40.7	35.9	41.2	44.1	36.6	48.9	44.6	34.6	45.6
15	45.9	48.0	35.0	44.4	36.0	41.7	46.0	38.6	37.6	40.6	50.2	41.4	32.6	44.3
16	34.8	51.0	36.4	44.4	40.0	42.9	38.9	47.2	34.6	40.9	51.2	56.9	30.5	42.4
17	34.4	43.8	31.3	40.8	50.9	43.7	40.0	43.6	35.2	39.6	49.6	45.6	31.0	39.3
18	35.5	40.5	30.3	38.5	49.5	44.0	48.7	38.2	33.2	42.2	51.2	36.9	33.8	37.5
19	29.0	34.5	39.0	42.8	48.1	35.0	37.0	35.9	41.5	36.4	47.6	39.9	41.7	44.3
20	26.1	43.8	35.5	44.8	42.2	36.0	44.9	37.9	43.6	36.2	43.6	35.6	41.4	45.8
21	29.1	47.3	52.5	43.8	44.5	38.1	49.5	31.2	41.6	36.1	40.9	40.9	45.8	39.1
22	35.5	44.3	53.1	44.4	51.5	43.0	43.6	36.2	50.9	43.6	40.9	39.5	51.8	36.3
23	37.8	41.0	53.5	45.5	48.5	39.9	51.4	41.9	49.9	39.2	34.9	38.6	40.8	40.6
24	34.9	33.3	49.3	48.5	40.8	40.7	49.4	37.6	44.2	34.7	40.6	49.6	37.5	44.1
25	30.3	33.5	50.5	45.5	37.2	38.2	48.4	31.6	36.9	30.0	50.2	40.2	35.7	42.8
26	35.0	36.9	45.8	43.5	34.5	35.1	52.4	39.6	36.0	28.9	38.6	34.6	34.6	42.5
27	36.6	34.5	36.1	39.8	37.5	38.5	48.9	48.5	37.6	31.2	30.2	32.2	46.5	43.5
28	38.3	42.8	35.5	39.5	46.5	41.0	47.4	55.6	39.9	42.6	38.2	26.6	48.4	48.4
29	39.5	42.6	32.3	41.0	43.0	45.5	46.3	51.2	34.2	44.9	41.9	36.9	51.9	44.8
30	38.0	40.6	37.3	40.5	40.2	43.9	50.7	44.6	43.9	47.6	40.9	47.5	51.2	43.4

Days of the Month.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	Mean of 43 years.
Nov.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	42.8	45.9	44.4	47.7	56.0	46.2	48.7	53.5	45.2	57.2	51.6	43.9	37.5	49.4	47.3
2	42.8	48.9	44.7	50.3	50.5	45.1	50.0	56.0	43.9	56.8	52.3	51.4	37.4	50.7	47.2
3	49.6	40.4	41.0	53.6	46.7	46.2	51.0	52.5	36.7	53.2	49.7	44.6	39.8	44.8	46.0
4	50.1	41.0	36.7	53.0	46.4	35.9	50.9	51.0	35.2	50.3	47.8	44.3	42.3	43.1	45.0
5	46.7	40.2	45.6	53.3	49.8	40.6	46.8	51.1	37.2	56.2	46.5	48.3	39.6	42.5	46.0
6	48.1	41.2	53.3	42.5	53.6	47.1	43.7	50.8	41.4	51.2	52.5	42.2	50.2	37.7	46.2
7	51.2	44.9	52.9	41.7	55.5	41.0	47.3	50.5	42.9	56.9	51.4	42.1	49.4	42.8	45.6
8	42.0	48.1	53.9	43.0	57.2	37.1	56.5	47.8	42.5	58.3	48.4	43.6	45.7	42.4	44.0
9	34.5	47.4	51.7	41.7	46.9	35.2	53.6	47.9	42.9	55.9	41.1	37.3	46.3	41.9	43.1
10	41.2	43.6	47.9	42.7	46.2	38.3	52.6	53.7	43.5	47.8	42.8	37.7	48.4	38.5	44.5
11	38.2	42.2	45.7	44.2	51.5	42.8	50.5	53.1	42.7	48.2	40.3	44.2	49.6	36.7	44.9
12	37.3	50.1	46.0	45.0	50.3	42.8	45.9	50.8	40.9	46.7	43.6	40.0	46.4	39.1	44.5
13	34.8	51.9	42.2	45.2	46.9	41.8	50.9	40.6	40.7	44.7	43.3	39.6	42.8	39.4	43.4
14	37.8	48.5	42.1	45.7	47.2	42.7	45.7	38.8	39.4	48.7	39.9	37.1	40.1	38.3	42.5
15	36.1	34.2	44.5	42.4	54.3	36.5	42.1	38.4	31.3	52.8	37.4	43.1	34.3	36.2	42.0
16	39.2	52.7	47.7	40.8	48.5	38.5	42.0	48.3	34.8	53.0	38.8	43.9	35.3	35.1	42.5
17	41.3	51.9	44.3	46.8	39.4	46.9	39.3	43.2	31.7	50.0	34.0	42.5	41.3	34.9	42.0
18	45.5	50.7	49.5	50.0	35.7	45.2	47.0	45.2	34.1	45.1	35.6	40.4	44.4	41.0	42.3
19	48.0	49.7	51.8	50.9	32.1	40.3	47.6	50.2	30.8	45.8	40.2	39.6	40.1	42.1	41.8
20	45.9	48.9	46.9	50.5	34.3	51.4	41.9	46.9	35.2	49.9	41.4	37.7	39.1	46.7	42.4
21	52.2	38.1	42.1	48.0	42.4	47.0	42.8	43.4	38.8	50.8	37.6	38.6	38.1	46.4	42.6
22	51.2	38.9	38.3	44.1	44.7	50.1	38.3	48.7	40.4	45.4	34.2	35.7	37.2	49.8	42.1
23	46.0	40.6	34.7	47.3	49.2	47.4	44.5	49.6	37.0	39.6	29.9	33.8	37.8	51.7	40.5
24	38.8	37.4	35.8	53.9	46.2	40.6	40.8	51.0	39.9	45.8	35.7	34.5	38.9	48.8	41.3
25	41.9	40.3	41.2	51.4	49.7	41.1	34.2	46.7	35.1	42.5	37.9	35.8	37.4	34.6	40.3
26	46.0	36.1	50.6	45.7	44.1	51.6	32.3	41.3	32.1	52.0	40.4	33.2	37.4	35.0	40.9
27	52.1	34.8	51.2	39.2	45.2	47.4	29.2	38.8	36.3	44.3	37.8	28.5	41.3	40.7	40.0
28	49.4	38.4	49.6	37.0	44.9	49.2	26.1	36.1	36.0	43.5	40.4	33.1	42.0	35.2	42.0
29	46.3	39.1	48.1	32.9	40.8	53.6	35.2	35.7	33.9	35.7	40.6	44.4	40.7	29.3	42.4
30	42.2	36.8	42.1	29.9	52.0	43.5	44.3	33.8	34.5	38.0	48.6	40.8	39.2	38.5	42.6

The Mean Temperature of the coldest day in November in the years 1814 to 1856 was 23°·4, and it took place on the 24th day in the year 1816.
The Mean Temperature of the hottest day in November in the years 1814 to 1856 was 59°·7, and it took place on the 2nd day in the year 1821.
The difference between these numbers is 36°·3, and it represents the extreme difference between the Mean Temperature of two days in the month of November in 43 years.
The day of the month whose Mean Temperature has been subjected to the greatest difference was the 24th; in the year 1816 its Mean Temperature was 23°·4; and in the year 1846 it was 53°·9: the difference between these numbers is 30°·5.
The day of the month whose Mean Temperature has been subjected to the least difference was the 4th; in the year 1820 its Mean Temperature was 35°·1; and in the year 1846 it was 53°·0: the difference between these numbers is 17°·9.

TABLE XII.—Mean Temperature of every day in the Month of December, as deduced from the Observations taken on that day, at the Royal Observatory, Greenwich, in the years 1814 to 1856.

Days of the Month.	1814.	1815.	1816.	1817.	1818.	1819.	1820.	1821.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	Mean of 43 years.
Dec.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
1	34·6	49·6	33·3	58·3	45·6	44·2	38·6	43·9	44·4	49·0	39·2	33·4	39·1	49·2	41·6	38·0	39·9	43·6	54·2	51·9	45·9	49·8	40·8	43·5	48·1	38·3	52·5	47·0	49·7	45·8	35·5	46·0	28·9	45·3	40·3	40·0	38·9	33·6	40·6	41·5	42·3	38·4	29·2	42·4
2	33·6	46·9	35·2	43·6	42·6	45·2	38·9	42·2	38·1	47·7	40·6	43·4	42·9	44·2	34·4	40·0	36·7	44·4	47·9	44·9	47·4	44·3	49·1	33·8	52·9	37·5	45·1	47·7	51·9	40·6	36·0	45·7	33·0	47·9	39·6	47·9	42·3	37·7	44·2	35·4	40·3	39·1	27·7	41·8
3	31·1	45·2	35·7	35·2	47·1	36·9	43·6	47·7	36·9	45·1	35·2	40·9	38·6	44·0	45·1	40·2	37·0	42·6	42·2	45·9	45·4	47·3	49·1	32·5	45·8	35·2	38·8	49·1	47·9	42·2	35·2	38·1	33·3	53·9	42·8	39·6	40·5	37·9	42·1	38·0	45·9	33·2	31·3	40·8
4	31·1	41·9	39·3	33·1	45·6	42·9	30·6	42·9	38·9	43·6	38·6	36·4	36·1	51·2	50·4	42·2	37·7	41·3	43·1	52·2	47·4	42·3	50·8	30·1	43·5	31·5	33·2	45·9	47·9	46·3	34·3	38·3	32·6	47·2	48·4	33·0	46·3	35·8	51·8	38·4	45·2	40·1	31·9	41·5
5	30·3	42·2	39·6	45·2	45·6	38·9	49·9	43·6	41·9	38·2	35·9	39·2	37·9	51·4	45·6	45·1	37·4	45·4	38·4	44·7	44·2	41·3	50·8	30·1	43·5	31·5	33·2	45·9	47·9	46·3	34·3	38·5	32·6	47·2	48·4	33·0	46·5	35·8	51·8	38·4	45·2	40·1	31·9	41·5
6	30·9	38·6	38·2	37·9	45·2	35·7	46·6	36·6	41·1	39·2	36·4	45·6	43·1	43·1	46·1	38·6	43·4	45·9	43·1	40·7	46·4	43·0	51·5	33·8	39·5	34·5	40·2	46·1	38·4	43·9	36·4	40·1	33·8	47·2	46·6	46·0	41·7	43·2	48·9	40·8	39·5	36·0	32·2	41·4
7	29·9	31·9	34·9	38·6	48·6	33·4	50·6	43·4	37·1	33·7	37·9	44·9	51·1	40·1	47·1	30·1	44·9	49·9	41·0	48·9	50·9	38·3	49·8	32·8	44·5	35·5	36·1	44·3	36·9	48·4	28·2	37·0	38·0	41·6	51·8	43·8	39·9	47·5	46·8	41·4	31·8	33·7	36·0	41·3
8	31·6	28·6	34·2	40·9	48·9	26·9	48·9	49·2	37·6	41·2	42·2	43·0	36·6	42·4	44·0	32·2	43·1	51·9	42·2	41·0	40·5	37·0	43·8	36·1	37·8	34·9	39·9	48·4	35·4	48·6	27·0	39·1	39·1	37·0	54·9	43·9	35·5	48·6	46·4	38·4	43·4	32·1	55·3	40·7
9	31·6	26·2	39·2	35·9	43·6	26·7	48·9	50·6	37·4	36·9	39·9	43·9	42·0	42·4	39·0	31·6	43·5	50·9	45·4	52·4	38·7	38·1	39·5	32·1	32·0	32·5	37·8	41·7	39·3	39·5	28·3	41·0	40·8	31·7	53·4	37·2	34·9	49·1	45·5	40·0	40·0	29·2	55·1	40·1
10	40·9	29·6	40·9	31·6	38·9	25·9	50·2	51·6	38·4	36·4	31·1	42·7	51·1	51·4	45·1	31·0	39·2	48·1	35·3	41·2	41·2	45·3	35·8	34·7	32·1	32·5	39·8	47·6	37·0	40·9	30·1	38·3	39·0	53·3	54·3	37·0	32·8	51·5	52·1	36·9	34·7	32·4	51·9	40·2
11	36·6	32·6	37·6	28·6	37·2	20·9	50·6	38·7	31·7	45·9	44·6	41·7	48·9	46·3	46·9	34·2	36·7	50·5	42·4	38·2	37·7	36·0	35·2	35·1	38·1	40·5	34·1	40·1	44·3	41·2	28·2	44·1	28·6	49·8	50·8	36·7	40·1	45·4	52·9	30·8	35·9	30·3	47·3	39·0
12	33·3	34·2	40·6	28·9	36·9	32·2	49·6	44·6	34·1	39·9	46·4	38·9	49·4	42·9	48·1	39·6	33·4	49·9	44·7	36·7	38·9	32·7	41·8	33·1	40·1	41·8	35·5	45·0	51·8	32·8	27·8	33·2	30·0	44·8	51·9	34·0	45·9	33·0	51·9	32·3	38·7	29·3	48·7	39·6
13	33·9	38·2	37·9	39·1	37·6	27·7	39·6	46·2	35·6	36·9	45·4	42·0	46·8	37·1	47·4	40·1	30·4	47·9	42·9	36·0	37·2	35·5	49·8	38·5	40·8	41·8	35·9	47·3	52·9	36·0	25·7	31·3	25·5	46·0	53·3	31·9	45·3	40·5	51·0	40·1	44·9	27·2	44·6	39·6
14	39·6	34·6	37·2	45·2	37·9	28·7	33·6	46·6	34·0	33·9	45·0	48·0	45·1	46·1	45·4	41·1	45·2	44·6	41·4	42·7	37·9	38·1	40·8	41·1	40·5	41·5	25·8	39·3	49·1	43·7	29·2	40·2	24·5	44·8	47·7	49·4	46·2	39·4	50·8	38·4	51·7	36·4	43·4	40·6
15	32·6	45·6	38·2	41·2	33·4	33·9	31·9	48·6	34·4	37·0	47·1	38·5	43·7	49·4	44·6	34·6	36·2	40·1	41·2	50·7	38·7	34·0	36·5	34·1	40·1	39·2	25·5	42·7	47·9	47·3	32·6	46·2	24·2	47·2	50·8	53·8	48·9	35·7	49·0	30·4	50·3	44·2	37·1	40·3
16	30·6	39·9	35·6	44·6	26·2	32·2	31·1	50·6	32·7	44·9	39·2	49·8	45·7	44·6	47·7	34·9	31·2	42·1	37·5	50·9	42·2	38·1	38·5	40·1	35·3	37·8	30·2	40·5	50·3	47·6	37·1	46·3	29·8	49·8	42·3	50·9	43·2	41·5	47·1	26·6	43·3	38·2	30·5	40·0
17	34·9	31·6	43·6	40·6	23·6	42·2	37·9	49·6	33·6	45·6	40·0	48·6	42·9	40·7	50·1	38·9	32·7	40·1	39·4	43·7	41·7	35·8	39·5	46·0	31·3	36·8	24·5	39·3	47·0	46·8	38·6	44·8	31·1	51·5	41·4	48·2	39·4	42·2	49·0	30·4	38·4	31·8	34·3	39·8
18	32·1	39·4	38·9	41·9	30·9	32·2	43·6	44·6	42·1	39·4	45·1	49·9	39·9	51·1	50·6	34·4	32·6	41·8	40·2	47·9	39·2	40·8	47·4	52·1	33·5	34·8	30·1	29·3	41·4	42·4	40·4	45·1	27·5	48·1	45·8	49·9	36·0	36·0	41·0	30·2	37·1	34·3	44·4	40·4
19	26·6	28·9	33·2	41·7	31·6	32·6	45·9	43·6	33·4	32·1	48·9	45·0	38·9	51·4	47·0	31·6	34·4	38·4	36·4	49·2	40·2	32·8	47·1	46·1	32·5	47·8	30·8	28·5	39·8	44·1	39·9	40·2	41·1	40·8	45·9	43·0	35·8	46·8	47·2	29·9	34·5	27·1	38·6	39·3
20	25·2	44·9	37·3	37·9	44·2	32·6	44·6	42·4	30·1	41·9	44·2	44·7	38·9	43·9	51·1	30·4	38·5	40·9	31·7	43·4	40·2	29·9	42·5	51·5	37·1	50·5	33·9	30·8	46·2	42·6	32·9	38·5	42·5	38·1	37·3	37·7	34·5	49·0	51·4	33·0	39·9	24·4	43·6	39·7
21	31·2	33·6	23·6	31·9	42·9	47·6	45·9	45·1	29·1	38·9	48·9	50·4	37·4	41·6	53·1	28·9	37·4	41·1	40·9	38·7	40·9	29·8	42·5	40·5	34·1	46·1	33·1	30·9	51·1	45·8	33·2	34·7	45·8	32·7	29·9	38·9	33·0	46·5	44·9	33·9	39·3	30·2	44·1	38·5
22	29·6	30·2	21·2	30·3	27·9	51·6	39·9	44·6	32·9	38·9	46·6	45·9	32·9	47·9	51·5	30·4	41·9	41·3	44·9	32·9	36·2	28·8	48·5	44·8	34·6	49·7	28·5	33·2	49·6	45·3	31·1	36·2	37·4	31·6	32·9	33·3	34·5	43·5	45·7	34·2	51·5	21·5	44·1	38·5
23	29·6	33·6	36·4	29·1	27·2	41·9	39·6	41·9	36·9	41·9	33·1	40·6	42·9	43·4	48·1	26·9	29·4	34·9	48·9	44·0	31·2	24·5	35·5	46·8	41·4	47·8	22·5	40·2	44·1	32·6	30·8	39·8	36·3	34·7	29·6	32·6	33·7	40·3	39·8	36·9	42·9	40·2	39·0	37·5
24	30·9	33·9	46·9	29·9	27·6	31·6	32·7	44·9	34·7	45·9	43·1	37·0	42·9	50·4	47·9	26·5	18·4	33·6	41·9	48·4	32·7	26·8	31·6	48·9	38·8	50·5	30·1	42·8	34·6	46·8	31·5	35·9	31·2	37·8	33·0	38·0	31·7	38·4	49·3	33·8	42·8	43·2	37·9	37·5
25	25·7	30·3	36·9	30·6	31·6	31·2	29·7	38·2	31·6	47·4	53·1	45·9	41·9	44·4	40·6	27·4	18·6	27·5	49·7	40·9	40·9	21·3	28·4	51·5	31·9	44·9	25·4	38·0	40·2	47·0	32·1	40·0	27·6	36·2	44·0	34·2	39·6	36·2	49·0	30·2	47·4	43·2	28·2	36·8
26	27·6	36·7	41·2	27·9	32·6	28·1	29·6	37·4	28·6	44·1	41·6	36·5	41·4	46·9	36·4	25·0	25·1	32·4	39·4	36·0	39·2	22·3	28·1	46·8	30·8	35·5	25·8	33·4	45·7	44·2	32·8	45·7	31·0	34·9	48·4	38·6	41·7	33·6	49·1	27·7	40·6	45·4	30·4	35·9
27	29·9	36·2	37·6	37·2	33·2	29·3	30·2	41·8	27·0	41·6	50·1	39·5	41·1	47·0	37·2	23·5	29·2	34·7	38·9	41·4	37·3	31·4	28·6	45·5	37·1	43·8	32·9	32·4	41·7	43·4	31·1	41·0	30·9	34·8	45·8	37·7	44·1	32·1	50·2	29·3	36·3	46·6	29·2	36·7
28	34·9	38·9	40·2	33·7	31·9	32·1	29·4	42·9	25·1	41·6	47·0	32·6	34·9	47·4	39·9	23·6	32·6	38·0	31·9	38·7	33·9	27·3	30·8	47·8	34·1	34·1	29·1	29·5	34·5	45·3	41·0	41·4	29·5	34·6	41·3	25·2	40·9	37·7	43·2	28·9	33·1	48·1	25·7	36·3
29	38·9	46·9	40·3	28·6	35·6	26·1	26·2	44·2	24·4	41·5	36·1	32·1	40·2	32·1	39·9	25·7	32·9	37·9	36·9	49·9	40·2	37·8	30·5	45·5	40·1	31·9	24·5	40·6	46·8	42·8	44·3	39·1	32·1	31·8	39·9	31·1	44·0	36·6	45·4	24·1	36·1	46·6	33·2	36·6
30	35·6	38·9	39·9	37·4	28·7	27·2	26·6	41·6	24·1	41·4	47·1	31·4	46·7	36·0	41·1	28·1	37·1	38·4	35·9	51·7	49·4	41·8	28·5	48·1	46·2	31·8	27·5	37·7	51·4	40·2	38·9	49·8	28·5	37·2	36·3	33·5	47·1	36·2	49·2	31·7	42·6	42·9	42·1	38·4
31	38·6	33·9	46·2	28·7	31·4	25·1	25·4	36·6	27·9	41·2	49·2	30·1	45·3	41·4	43·0	29·4	40·9	30·6	33·7	46·0	51·9	29·3	28·5	44·9	36·5	45·1	40·0	35·3	50·2	43·2	38·4	42·8	25·2	34·7	36·7	34·3	49·6	33·2	46·2	29·9	41·9	40·5	46·3	37·9

The Mean Temperature of the coldest day in December in the years 1814 to 1856 was 18°·4, and it took place on the 24th day in the year 1830.
The Mean Temperature of the hottest day in December in the years 1814 to 1856 was 56°·0, and it took place on the 7th day in the year 1856.
The difference between these numbers is 37°·6, and it represents the extreme difference between the Mean Temperature of two days in the month of December in 43 years.
The day of the month whose Mean Temperature has been subjected to the greatest difference was the 25th; in the year 1830 its Mean Temperature was 18°·6; and in the year 1824 it was 53°·1: the difference between these numbers is 34°·5.
The day of the month whose Mean Temperature has been subjected to the least difference was the 4th; in the year 1814 its Mean Temperature was 31°·1; and in the year 1852 it was 51°·8: the difference between these numbers is 20°·7.

Mean Temperature of every day in the year, as deduced from the observations taken at the Royal Observatory, Greenwich, in the forty-three years ending 1856.

Day of the Month.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	°	°	°	°	°	°	°	°	°	°	°	°
1	36·9	37·0	39·7	43·8	50·3	56·8	60·0	62·3	58·9	53·8	47·3	42·4
2	35·9	37·1	40·7	44·3	51·5	57·5	60·6	62·5	58·9	53·5	47·2	41·8
3	35·8	37·2	41·0	44·2	50·9	57·3	61·3	62·3	59·2	53·4	46·0	40·8
4	36·8	37·5	39·9	44·4	51·5	56·3	62·3	62·5	57·8	54·0	45·0	41·5
5	35·9	38·5	39·0	44·9	51·8	57·0	63·2	61·8	58·4	52·9	46·0	42·5
6	36·8	38·6	39·5	45·5	51·9	56·5	62·7	61·6	57·9	52·3	46·2	41·4
7	36·2	29·9	39·7	45·7	52·3	56·6	61·6	61·8	57·7	52·7	45·6	41·3
8	34·9	39·5	39·8	45·6	52·1	57·4	60·9	62·1	57·8	51·7	44·0	40·7
9	34·9	38·9	40·3	44·4	51·0	58·0	61·0	61·9	57·6	51·0	43·1	40·1
10	35·6	38·5	39·9	44·7	50·9	57·5	61·8	62·2	57·7	51·8	44·5	40·2
11	35·5	38·2	40·8	44·4	51·6	58·5	62·0	62·5	57·5	52·4	44·9	39·0
12	35·9	37·9	41·4	45·2	51·3	58·7	62·2	61·8	57·0	50·9	44·5	39·6
13	36·8	37·6	41·8	45·0	51·0	59·0	62·1	61·9	56·8	50·3	43·4	39·6
14	36·1	38·1	41·8	46·4	50·6	59·7	62·3	61·1	57·3	50·2	42·5	40·6
15	34·8	38·6	41·5	46·5	51·9	59·1	62·4	60·9	57·1	49·2	42·0	40·3
16	36·1	38·2	42·3	46·1	53·1	58·7	61·7	61·1	57·3	48·9	42·5	40·0
17	36·7	38·0	41·5	45·6	54·0	58·7	62·6	61·0	57·4	48·8	42·0	39·8
18	36·7	38·2	41·0	45·7	53·5	58·6	62·0	61·0	56·4	49·2	42·3	40·4
19	36·7	38·4	41·7	46·0	53·0	59·1	61·2	61·0	55·4	49·9	41·8	39·3
20	36·2	37·7	42·5	47·4	53·9	59·2	61·4	60·5	55·5	49·4	42·4	39·7
21	36·6	38·7	42·0	47·6	53·7	59·9	61·2	60·9	54·5	48·7	42·6	38·5
22	37·5	39·4	42·3	48·0	53·2	59·4	61·5	60·0	55·4	49·5	42·1	38·0
23	37·3	39·7	41·9	48·1	54·4	60·8	61·4	60·5	55·1	49·1	40·5	37·5
24	37·7	39·1	41·3	47·4	54·8	60·9	62·0	60·1	55·7	48·1	41·3	37·3
25	37·7	40·1	40·6	46·9	54·9	61·5	61·9	60·3	55·3	47·0	40·3	36·8
26	38·8	39·4	41·7	47·9	54·8	61·9	61·5	60·2	54·7	45·7	40·9	35·9
27	38·4	39·5	43·0	47·4	55·0	61·8	62·1	60·3	53·8	46·7	40·0	36·7
28	37·9	39·4	43·5	48·2	55·4	62·4	62·8	60·2	54·1	46·9	42·0	36·3
29	37·7	....	43·3	48·9	54·6	61·5	62·6	60·0	53·5	45·4	42·4	36·6
30	37·9	....	44·2	49·7	55·1	61·8	62·4	59·8	53·5	46·6	42·6	38·4
31	37·6	....	43·8	....	56·2	....	62·3	58·4	....	46·8	....	37·9
Means	36·6	38·6	41·4	46·2	53·0	59·1	61·8	61·1	56·5	49·9	43·2	39·4

An inspection of the numbers in this Table will show that a period of daily observations of forty-three years is insufficient to determine the mean daily temperature, there being many instances in the above Table in which the difference between the temperatures of two consecutive days exceeds one degree; and in one instance, viz. between December 29 and 30, it is as large as 1·8.

For the purpose of determining the most probable mean temperature of every day, the numbers in this Table were laid down as ordinates, on a scale of five degrees to one inch, with the day of the year for abscissa. As every point thus laid down was entitled to equal weight, a curved line was determined, which passed through or near all of them, and in such a way that the area of the space above the adopted line of mean temperature was equal to that below the line at all times of the year.

By measuring the ordinates at every day the adopted mean temperature of each day was found, and in this way the next Table was formed.

Table showing the adopted mean temperature of every day in the year as determined from all the Thermometrical Observations taken at the Royal Observatory, Greenwich, in the years from 1814 to 1856.

Days of the Month.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	°	°	°	°	°	°	°	°	°	°	°	°
1	36·5	37·2	40·1	43·6	50·0	56·4	61·5	62·5	58·8	53·5	46·4	41·7
2	36·4	37·0	40·0	44·1	50·5	56·6	61·4	62·3	58·6	53·4	46·2	41·8
3	36·4	37·3	39·9	44·5	50·9	56·8	61·4	62·2	58·5	53·1	46·1	41·7
4	36·3	37·7	39·9	44·8	51·3	57·1	61·5	62·1	58·4	53·0	45·9	41·5
5	36·1	38·4	40·0	45·1	51·6	57·1	61·6	62·0	58·2	52·8	45·7	41·4
6	36·0	39·0	40·1	45·4	51·8	57·2	61·7	62·0	58·0	52·5	45·5	41·1
7	35·8	39·2	40·1	45·5	51·9	57·3	61·8	62·0	57·8	52·3	45·1	40·7
8	35·5	39·2	40·1	45·5	51·8	57·4	61·7	62·0	57·7	52·1	44·8	40·6
9	35·4	39·0	40·2	45·4	51·6	57·5	61·5	61·9	57·6	51·9	44·5	40·5
10	35·7	38·7	40·3	45·1	51·4	57·7	61·5	61·8	57·5	51·7	44·3	40·4
11	35·6	38·5	40·5	45·0	51·3	58·0	61·6	61·7	57·4	51·4	44·0	40·2
12	35·6	38·3	40·6	44·9	51·3	58·3	61·7	61·6	57·3	51·0	43·9	40·0
13	35·6	38·2	41·0	45·2	51·4	58·5	61·8	61·5	57·2	50·5	43·5	39·6
14	35·6	38·0	41·3	45·5	51·8	58·8	61·7	61·5	57·0	50·1	43·3	39·7
15	55·5	38·1	41·5	45·7	52·2	59·0	61·7	61·4	56·7	49·8	43·0	40·0
16	35·5	38·1	41·7	46·0	52·6	59·3	61·7	61·4	56·5	49·6	42·6	40·3
17	35·9	38·2	41·8	46·2	52·8	59·4	61·7	61·3	56·3	49·4	42·4	40·1
18	36·3	38·3	41·8	46·4	53·1	59·5	61·7	61·0	56·0	49·2	42·2	39·9
19	36·5	38·4	41·8	46·5	53·3	59·6	61·7	60·9	55·9	49·1	42·2	39·5
20	36·8	38·5	41·9	46·7	53·6	59·8	61·6	60·8	55·6	49·1	42·2	39·0
21	37·1	38·5	41·9	47·0	53·8	59·9	61·5	60·6	55·5	48·9	42·0	38·4
22	37·3	38·6	41·9	47·5	54·1	60·0	61·5	60·4	55·4	48·6	41·7	37·9
23	37·5	38·9	42·0	47·6	54·3	60·2	61·5	60·3	55·3	48·3	41·4	37·4
24	37·8	39·1	42·1	47·6	54·4	60·4	61·6	60·3	55·0	47·9	41·0	37·0
25	38·0	39·5	42·2	47·6	54·6	60·6	61·8	60·2	54·9	47·5	40·8	36·5
26	38·3	39·7	42·3	47·6	54·7	60·8	62·1	59·9	54·7	47·4	40·9	36·4
27	38·3	39·8	42·4	48·0	54·9	61·0	62·3	59·7	54·5	47·2	41·1	36·5
28	38·1	40·0	42·6	48·5	55·2	61·3	62·5	59·6	54·3	47·0	41·5	37·0
29	37·9	....	42·8	49·1	55·4	61·5	62·5	59·4	54·0	46·8	41·6	37·3
30	37·6	....	43·0	49·5	55·7	61·5	62·5	59·1	53·8	46·6	41·6	37·4
31	37·3	....	43·4	....	56·1	....	62·5	59·0	....	46·5	....	37·6
Means	36·6	38·6	41·4	46·2	53·0	59·0	61·8	61·1	56·5	49·9	43·2	39·3

The numbers in this Table show the most probable mean temperature of every day in the year, and are used at the Royal Observatory, in comparison with daily temperatures to determine their departures from their average values. On examining the numbers in the preceding Table it will be seen that there are periods of some duration which are very remarkable on account of the difficulty of assigning a physical cause. Starting from the lowest number in January, they increase till the end of January, when there is a slight variation till the 15th of February. From the 15th of February it again increases (with the exception of four days at the beginning of March) till the 10th of May, when four days of cold follow. After this period the temperature may be said steadily to rise till the end of July (the temperature for the month of July varying only a few tenths throughout it), when it attains its maximum. After this the decline of temperature is very regular till the last week of November, when a sudden and considerable increase takes place. The law of daily increase of temperature at Greenwich must be the same for a considerable extent of country, its knowledge therefore helps us to that of the mean daily temperature of places where mean monthly temperatures have been determined. As there are many places whose monthly temperatures have been determined from observations extending over many years, the following Table of factors has been calculated, for the purpose of deducing the daily temperatures from them, and also to show in what manner the temperature of each month is spread over itself.

Factors to be multiplied into the mean temperature of each month, as found from observation, extending from 1814 to 1856, to determine the mean temperature of every day in the month.

Days of the Month.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	0·998	0·964	0·969	0·944	0·944	0·956	0·996	1·023	1·041	1·072	1·074	1·061
2	0·995	0·959	0·967	0·955	0·953	0·961	0·994	1·020	1·037	1·070	1·065	1·063
3	0·995	0·966	0·964	0·963	0·961	0·963	0·994	1·018	1·035	1·064	1·067	1·061
4	0·992	0·977	0·964	0·971	0·968	0·968	0·996	1·016	1·033	1·062	1·062	1·056
5	0·987	0·995	0·967	0·976	0·974	0·968	0·997	1·015	1·030	1·058	1·058	1·053
6	0·984	1·010	0·969	0·983	0·978	0·971	0·999	1·015	1·026	1·052	1·053	1·048
7	0·979	1·015	0·969	0·985	0·981	0·972	1·000	1·015	1·023	1·048	1·044	1·036
8	0·970	1·015	0·969	0·985	0·978	0·974	0·999	1·015	1·021	1·044	1·037	1·033
9	0·968	1·010	0·971	0·983	0·974	0·976	0·996	1·013	1·019	1·040	1·030	1·030
10	0·976	1·002	0·974	0·977	0·970	0·978	0·996	1·011	1·018	1·036	1·025	1·028
11	0·973	0·998	0·979	0·975	0·969	0·984	0·997	1·010	1·016	1·030	1·019	1·023
12	0·973	0·993	0·981	0·972	0·969	0·989	0·999	1·088	1·014	1·022	1·016	1·018
13	0·973	0·990	0·991	0·979	0·971	0·992	1·000	1·006	1·012	1·012	1·007	1·007
14	0·973	0·985	0·998	0·985	0·978	0·997	0·999	1·006	1·008	1·004	1·002	1·010
15	0·970	0·987	1·002	0·990	0·985	1·000	0·999	1·005	1·003	0·998	0·996	1·018
16	0·970	0·987	1·007	0·996	0·993	1·006	0·999	1·005	1·000	0·994	0·987	1·025
17	0·981	0·990	1·010	1·000	0·997	1·007	0·999	1·003	0·997	0·990	0·982	1·020
18	0·992	0·998	1·010	1·004	1·002	1·009	0·999	0·999	0·992	0·986	0·977	1·015
19	0·998	0·995	1·010	1·006	1·006	1·012	0·999	0·997	0·991	0·984	0·977	1·005
20	1·005	0·998	1·012	1·011	1·011	1·013	0·997	0·995	0·985	0·984	0·977	0·994
21	1·013	0·998	1·012	1·017	1·015	1·014	0·996	0·992	0·983	0·980	0·973	0·978
22	1·019	1·000	1·012	1·028	1·021	1·017	0·996	0·989	0·981	0·974	0·966	0·965
23	1·024	1·007	1·014	1·034	1·024	1·020	0·996	0·987	0·979	0·968	0·959	0·952
24	1·033	1·011	1·017	1·034	1·026	1·024	0·997	0·987	0·974	0·960	0·951	0·942
25	1·038	1·021	1·019	1·034	1·030	1·027	1·000	0·985	0·972	0·952	0·945	0·929
26	1·046	1·029	1·022	1·034	1·032	1·031	1·005	0·980	0·969	0·950	0·947	0·927
27	1·046	1·034	1·024	1·039	1·036	1·034	1·008	0·978	0·965	0·946	0·952	0·929
28	1·041	1·037	1·029	1·050	1·041	1·039	1·012	0·976	0·962	0·942	0·961	0·942
29	1·035	....	1·034	1·063	1·045	1·042	1·012	0·973	0·956	0·938	0·963	0·950
30	1·027	....	1·038	1·071	1·051	1·042	1·012	0·967	0·953	0·934	0·963	0·952
31	1·019	....	1·048	....	1·058	....	1·012	0·966	....	0·932	....	0 957

In this Table, that day in the month whose mean temperature is the same as that of the month is represented by unity; and those whose mean temperatures are less or greater than the mean of the month, are shown respectively by numbers greater or less than unity. An inspection of the numbers, therefore, very readily shows the increase or decrease of heat day by day in each month.

The use of this Table in the deduction of mean daily temperatures from monthly temperatures is very simple; let us suppose that the mean monthly temperature in January is 35°·5, then the mean temperature of the 1st of January would be $35{\cdot}5 \times 0{\cdot}998 = 35{\cdot}4$, and that of the last day would be $35{\cdot}5 \times 1{\cdot}019 = 36{\cdot}2$.

Table showing the distribution of heat over the year, the mean temperature of the year being represented by unity.

Days of the Month.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	0·747	0·761	0·820	0·892	1·022	1·154	1·258	1·279	1·204	1·095	0·949	0·853
2	0·745	0·757	0·818	0·902	1·033	1·158	1·256	1·275	1·199	1·093	0·945	0·855
3	0·745	0·763	0·816	0·910	1·041	1·162	1·256	1·272	1·197	1·086	0·943	0·853
4	0·743	0·771	0·816	0·917	1·049	1·168	1·258	1·270	1·195	1·084	0·939	0·849
5	0·739	0·786	0·818	0·923	1·055	1·168	1·260	1·268	1·191	1·080	0·935	0·847
6	0·737	0·798	0·820	0·929	1·059	1·170	1·262	1·268	1·187	1·074	0·931	0·841
7	0·733	0·802	0·820	0·931	1·061	1·172	1·264	1·268	1·183	1·070	0·923	0·833
8	0·726	0·802	0·820	0·931	1·059	1·174	1·262	1·268	1·180	1·066	0·917	0·831
9	0·724	0·798	0·823	0·929	1·055	1·176	1·258	1·266	1·178	1·062	0·911	0·829
10	0·730	0·792	0·825	0·923	1·051	1·180	1·258	1·264	1·176	1·058	0·906	0·827
11	0·728	0·788	0·829	0·921	1·049	1·187	1·260	1·262	1·174	1·052	0·900	0·823
12	0·728	0·784	0·831	0·919	1·049	1·193	1·262	1·260	1·172	1·043	0·898	0·818
13	0·728	0·782	0·839	0·925	1·051	1·197	1·264	1·258	1·170	1·033	0·890	0·810
14	0·728	0·778	0·845	0·931	1·059	1·203	1·262	1·258	1·166	1·025	0·886	0·812
15	0·726	0·780	0·849	0·935	1·067	1·207	1·262	1·256	1·160	1·019	0·880	0·818
16	0·726	0·780	0·853	0·941	1·075	1·213	1·262	1·256	1·156	1·015	0·872	0·825
17	0·735	0·782	0·855	0·945	1·079	1·215	1·262	1·254	1·152	1·011	0·868	0·821
18	0·743	0·784	0·855	0·949	1·085	1·217	1·262	1·248	1·146	1·007	0·863	0·816
19	0·747	0·786	0·855	0·951	1·090	1·219	1·262	1·246	1·144	1·004	0·863	0·808
20	0·753	0·788	0·857	0·956	1·096	1·223	1·260	1·244	1·138	1·004	0·863	0·798
21	0·759	0·788	0·857	0·962	1·101	1·225	1·258	1·240	1·135	1·000	0·859	0·786
22	0·763	0·790	0·857	0·972	1·107	1·227	1·258	1·236	1·133	0·996	0·853	0·776
23	0·767	0·796	0·859	0·974	1·110	1·232	1·258	1·234	1·131	0·988	0·847	0·765
24	0·774	0·800	0·861	0·974	1·113	1·236	1·260	1·234	1·125	0·980	0·839	0·757
25	0·778	0·808	0·863	0·974	1·117	1·240	1·264	1·232	1·123	0·972	0·835	0·747
26	0·784	0·812	0·865	0·974	1·119	1·244	1·270	1·225	1·119	0·970	0·837	0·745
27	0·784	0·814	0·868	0·982	1·123	1·248	1·275	1·221	1·115	0·966	0·841	0·747
28	0·780	0·818	0·872	0·992	1·129	1·254	1·279	1·219	1·111	0·962	0·849	0·757
29	0·776	....	0·876	1·004	1·133	1·258	1·279	1·215	1·105	0·958	0·851	0·763
30	0·769	....	0·880	1·012	1·140	1·258	1·279	1·209	1·100	0·953	0·851	0·765
31	0·763	....	0·888	....	1·148	....	1·279	1·207	....	0·951	....	0·769

The numbers in this Table very clearly show the distribution of heat over the year: the smallest number occurs on January 9, indicating that as the coldest day in the year; they then generally increase, till on April 29 the number is very nearly unity, indicating that day as the same as the mean of the year; they still increase on till July 28, when the largest number appears, after which the temperature declines to that of the mean of the year on October 21, and for the most part continuously to January 9. Therefore the number of days between that of the lowest temperature and that of the mean in April is 110 days; between the latter and the hottest day is 90 days; between the hottest day and the mean temperature in October is 85 days; and between the latter and the lowest in January is 80 days. The number of days between that of the lowest temperature and that of the highest is 200 days, and the time occupied in the declination of temperature is 165 days. The number of days the temperature is the same as the average of all is 2; above the average is 175; and below the average is 188.

Duties of Statt Cttee minutes 1869 p 11-12

F. 145 (1)

Change of views since date of Report /66 — mean working 3 years not carried out. Office temporary

Mistakes. — oceanic statistics in Office not so good as we thought

Naval contributions less useful.

Number of obsers' per square may be underrated — but we have no certain knowledge yet about that. — the Office has not endeavoured to decide, — On our supposition of 1.137,000 being wanted the estimated cost seems unreasonable see note p. 11 & p. 6 of Scotts report 64

System of moveable slips were tried but not found to correspond in practice as that employed, which has many merits

Weighting — difficulties have always been (?) raised. the subject has been always avoided by the executive. only at the very last moment has an attempt been made to (?) The Cttee have never adequately discussed the subject

Probable precision — a less technical term than has been used. The meaning (?) similar to that of probable error

"It is the greatest of the probable error that will henceforth serve us as a modulus of precision" Quetelet p. 82.

Short comings of Office.

As above mentioned no effort has been made to learn the minimum no of obsers' sufficient for that primary investigation defined in p. 11. 3rd para, supl.

The immense labour bestowed in Square 3, seems to have been in part superfluous & in part conducted without true statistical intelligence — An unnecessary number of materials may have been used and those used have been inadequately combined.

Not going into the question of weighting. (what is the cost of equalisation? p. if (?))

Nor into that of the number of obsers' per ship admissible, considering the long delay of ships facing contrary winds.

Not distinguishing different systems.

("Mean" as against "average". The former expressing the most probable occurrence the latter being merely an arithmetical fiction having nothing real object corresponding to it. Eg. Wheels to a wheeled vehicle when carriages are defined as common cabs hansoms, perambulators & wheel barrows.

$$\frac{10\times4+10\times2+5\times3+5\times1}{10+10+5+5} = \frac{80}{30} \qquad \frac{2\times4+2\times2+1\times3+1\times1}{2+2+1+1}$$

$$= \frac{16}{6} = \frac{8}{3} = 2\tfrac{2}{3} \text{ wheel each.} -)$$

Wanted at least a partial rediscussion of Square 3 by a competent Statist. 1st to discriminate systems — 2 as to the possibility & value of weighting. 3 Estimate of no of obsers' in reference to the probable precision of the results viz: that is is an equal chance that the errors in any case lies between ± limits which is a mere matter of observation (4) limits of attainable accuracy (a) as deduced from observations at islands. (b) from ocean statistics when very numerous. see last paragraph 42 Report.

continued from over (2)

<u>Weather telegraphy.</u>

p. 38. The weather has <u>not</u> been adequately analysed.

Wanted – types of weather – to be worked out first by a member of the office & revised by a really competent scientific man. (see below A)

? warn from Valentia & Falmouth.

Great increase of telegraphic aid. – Large Govt assistance.

<u>Land meteorology.</u>

The self recording have not been used as we hoped. They have been the most costly of our work see p. 29 Report for 1874 £3799

Minute accuracy is exacted to ensure good ... discipline, ... + 1/3 of salaries of office 700

Reasons for temporary discontinuance [illegible] say 4499

They have done a mass of sterling work [illegible] and printing 1000

enough to work with. [illegible] cost £5500 per annum

One year's intermission w.d pay for their future re-establishment certainly more than £5000.

They dont give [illegible] samples of the average weather – only barometer. Means are absurd. – wind [illegible] anemometers are discordant.

They give only an imperfect knowledge of weather elements, important items being omitted. upper currents – ~~[illegible]~~ ascending currents. cloud. temp: upper regions. ? electricity. sun spots.

Keep Kew Valentia Falmouth. Lend the other instruments

I proposed this Jan 30/71 ... p. 6 — They sh.d be worked up, summarised, indexed .. types of weather taken out.

strike & dip of barometric plane. – humidity has never been used.

Allot money to have this well done. & to have charts of past weather

(A) —— well worked up by a really competent man.

Requirements. cheap self recording (?) barom: ~~& wind~~. (for sea also)

(Power of expression
(New means of coordinating in time as well as space (2) wind, rain, therm: cloud.

Office sh.d be the international representative, & the Govt referee & sh.d correspond with societies – ~~[illegible]~~ & sh.d do international work. & sh.d undertake any job for which ~~payment is guaranteed~~.

Its head sh.d be a first rate statist & mathematician. having under him a ~~Registrar~~ of instruments & observers for navy ocean & land ? a staff [illegible] who should [illegible] private enterprise – & register observers: & have a library.

Meteor: work to be paid out of Govt grant or by special subsidy from time to time.

(OFFICIAL COPY.)

WEEKLY WEATHER REPORT.

ISSUED BY THE METEOROLOGICAL OFFICE, LONDON.
PUBLISHED BY J. D. POTTER, 31 POULTRY, AND 11 KING STREET, TOWER HILL;
AND E. STANFORD, CHARING CROSS.

VOL. I. No. 22.] WEEK ENDING MONDAY, JULY 8, 1878. [*Price 2d.*
[*Annual subscription, post paid, 12s. 6d.*

I.—SUMMARY OF TEMPERATURE AND RAINFALL IN THE UNITED KINGDOM FOR AGRICULTURAL AND SANITARY PURPOSES.

Explanation of the Map.—The United Kingdom has been divided into Meteorological districts, ten of which are included in the following Summary. They are separately numbered and shaded on the Map, and are similarly numbered in the letterpress, where they are also named.

The black dots show the positions of the Stations furnishing the reports on which the Summary is based. The names of the Stations are given in the following list under those of the districts to which they severally belong.

1. SCOTLAND, E.—Nairn, Aberdeen, Glenalmond, Leith.
2. ENGLAND, N.E.—Shields, Durham, Scarborough, York, Kelstern (Lincolnshire).
3. ENGLAND, E.—Yarmouth, Cambridge, Audley End (Saffron Walden), Rothamsted.
4. MIDLAND COUNTIES.—Nottingham, Leicester, Shrewsbury, Hereford, Cirencester, Oxford.
5. ENGLAND, S.—London, Marlborough, Strathfield Turgiss, Dover, Hastings, Hurst Castle.
6. SCOTLAND, W.—Laudale (Loch Sunart), Glasgow, Ardrossan, Silloth, Douglas (Isle of Man).
7. ENGLAND, N.W.—Stonyhurst, Manchester, Liverpool Observatory (Bidston), Holyhead.
8. ENGLAND, S.W.—Pembroke, Portishead, Falmouth, Plymouth.
9. IRELAND, N.—Dunfanaghy, Greencastle, Armagh, Donaghadee.
10. IRELAND, S.—Kingstown, Parsonstown, Roche's Point, Valencia.

Explanation of Summary.—The data for mean *Temperature* in the c... sponding ... ars are derived from the 13 years observations (1857-69), as determined by Mr. Buchan. Those for mean *Rainfall* have been obtained from the 10 years observations 1866-75. A rainy day is one on which at least a hundredth of an inch has fallen.

	Districts.	Temperature.				Rainfall.		
		Highest observed.	Lowest observed.	Average for the Week.	Above or below the Mean for the Week.	Number of Rainy Days.	Rainfall for the Week.	More or less than the Mean for the Week.
		Degrees Fahr.	Degrees Fahr.	Degrees Fahr.	Degrees Fahr.		In tenths of an inch.	In tenths of an inch.
Principal Wheat-producing Districts.	1. SCOTLAND, EAST	77	40	58	0 (average).	3	2	2 less.
	2. ENGLAND, NORTH-EAST	74	40	59	1 below.	2	1	4 less.
	3. ENGLAND, EAST	76	37	62	2 below.	2	1	5 less.
	4. MIDLAND COUNTIES	†82†	41	61	1 below.	2	1	5 less.
	5. ENGLAND, SOUTH	77	43	61	1 below.	3	3	1 less.
Principal Grazing, &c. Districts.	6. SCOTLAND, WEST	77	43	59	1 above.	4	6	2 less.
	7. ENGLAND, NORTH-WEST	71	45	59	1 below.	2	1	6 less.
	8. ENGLAND, SOUTH-WEST	72	51	62	0 (average).	3	2	4 less.
	9. IRELAND, NORTH	71	50	60	1 above.	4	3	4 less.
	10. IRELAND, SOUTH	71	47	61	1 above.	3	3	3 less.

† The maximum of 82° in the Midland Counties was registered at Nottingham only. The readings at the other stations did not exceed 75°.

General Remarks.

Weather during the week has been generally cloudy at our more eastern and northern stations, but finer in the west. Temperature has been a trifle above the mean in Ireland and the west of Scotland, but rather below in most other districts. The maxima were very low at the commencement of the week but were higher towards the close, a reading of 77° being reported from many English stations on the 6th and 7th. On the night of the 3rd the thermometer fell below 40° in "England, East," but no frosts are reported.

Rainfall has been less than the mean everywhere. The deficiency has been greatest (six tenths of an inch) in the north-west of England, and even at the midland and eastern stations it has amounted to five tenths of an inch.

Wind was moderate from the northward on the 2nd and 3rd but on the 4th it backed to S.W. and W., and breezes from those quarters continued until the 7th, when the wind returned to N.W. and N.

The data from which the summary on the preceding page has been calculated are as follow :—

Districts.	Names of Stations.	Temperature.				Rainfall.		
		Highest observed	Lowest observed.	Average for the Week.	Difference from the Mean.	No. of Days with Rain.	Total fall in the Week.	Difference from the Mean.
		°	°	°	°		Inches.	Inches.
1. SCOTLAND, E.	Nairn	67	43	57·5	+0·7	3	0·37	−0·10
	Aberdeen	72	40	56·2	−1·1	2	0·21	−0·28
	Glenalmond	70	42	57·3	−0·3	3	0·04	?
	Leith	77	47	60·0	+2·1	3	0·15	−0·34
2. ENGLAND, N.E.	Shields	68	44	57·5	−1·5	4	0·29	−0·18
	Durham	74	40	59·3	0·0	2	0·04	−0·46
	Scarborough	72	46	59·3	−0·3	1	0·01	−0·52
	York	70	41	59·5	−0·4	3	0·07	−0·44
	Kelstern (Lincolnshire) ℞	71	41	58·7	−1·7	2	0·02	−0·45
3. ENGLAND, E.	Yarmouth	74	44	59·5	−1·4	2	0·19	−0·36
	Cambridge	75	39	59·8	−2·3	1	0·03	−0·47
	Audley End (Saffron Walden) ℞	76	37	59·4	−2·7	2	0·03	?
	Rothamsted	75	41	59·4	−3·3	2	0·05	−0·52
4. MIDLAND COUNTIES	Nottingham	? 82	41	63·4	+2·3	2	0·16	−0·44
	Leicester	72	43	59·3	−2·7	3	0·19	?
	Shrewsbury ℞	71	42	59·8	−1·1	2	0·19	?
	Hereford ℞	72	44	60·9	−0·4	0	—	−0·48
	Cirencester	74	43	60·7	−1·5	2	0·05	−0·54
	Oxford	75	46	60·3	−2·5	2	0·06	−0·45
5. ENGLAND, S.	London	77	45	61·2	−1·6	3	0·08	−0·44
	Marlborough ℞	74	44	60·2	−2·4	3	1·25	+0·75
	Strathfield Turgiss ℞	77	43	60·5	−1·7	1	0·08	−0·40
	Dover	71	47	61·1	−0·1	2	0·10	−0·34
	Hastings	70	47	59·0	−2·3	3	0·07	−0·29
	Hurst Castle	73	50	61·5	+0·1	2	0·33	?
6. SCOTLAND, W.	Laudale (Loch Sunart)	65	45	57·2	+0·6	5	1·66	?
	Glasgow	68	50	60·6	+3·0	5	0·58	−0·17
	Ardrossan	67	53	59·3	+1·7	3	0·36	−0·22
	Silloth	77	43	61·0	+2·1	3	0·35	−0·15
	Douglas (Isle of Man)	67	49	57·4	−1·4	3	0·16	?
7. ENGLAND, N.W.	Stonyhurst	70	45	58·4	−1·7	4	0·15	−0·67
	Manchester	70	48	58·9	−1·6	2	0·18	−0·50
	Liverpool Observatory (Bidston)	71	52	60·1	−0·2	0	—	−0·70
	Holyhead	67	52	59·6	−0·3	2	0·02	−0·36
8. ENGLAND, S.W.	Pembroke	65	53	60·4	−0·6	4	0·17	−0·26
	Portishead	72	51	62·1	0·0	2	0·10	−0·30
	Falmouth	68	54	61·8	+0·2	3	0·39	−0·21
	Plymouth	72	51	62·4	+0·9	1	0·05	−0·44
9. IRELAND, N.	Dunfanaghy	67	56	60·6	+2·2	4	0·32	?
	Greencastle	69	50	59·4	+0·9	5	0·27	−0·3
	Armagh	68	50	59·4	+0·3	4	0·06	−0·4
	Donaghadee	71	50	59·7	+1·1	2	0·64	?
10. IRELAND, S.	Kingstown	71	53	61·8	+2·1	1	0·06	−0·3
	Parsonstown	71	47	61·8	+2·1	5	0·24	−0·31
	Roche's Point	70	51	61·2	+1·1	4	0·50	−0·11
	Valencia	70	50	60·0	0·0	3	0·24	−0·34
SCOTLAND, N.	Sumburgh Head	57	42	50·9	−1·9	3	0·65	+0·37
	Stornoway	64	48	56·4	+1·9	4	1·78	?
	Thurso	63	46	55·5	+0·9	5	2·30	+1·89
	Wick	65	38	54·5	−0·6	4	1·87	+1·49
——	Scilly (St. Mary's)	69	55	62·0	+0·2	3	0·49	−0·05
	Jersey (Noirmont)	68	53	60·1	−1·6	2	0·24	−0·13

The observations made in "Scotland N." and the "Channel Islands" are not included in the Summary on page 1.
The stations marked with "℞" are in connection with the Meteorological Society.

II.—SUMMARY OF WEATHER IN WESTERN EUROPE
during the Week ending July 8, 1878.

Synoptic Weather Charts.—8 a.m.

Barometer and Wind.	Cloud, Rain, Sea, and Temperature.	**Weather** during the 24 hours succeeding the date of the Charts.
		**Tuesday, July 2.** *Weather* fine in Ireland, but very dull over the rest of the United Kingdom, with rain in the south and south-east, and at a few isolated stations elsewhere. *Temperature* very low for the time of year, the maximum readings reaching 70° in the south of Ireland only. In London the maximum was only 59°, or 32° colder than on June 26th. *Wind* northerly over the United Kingdom, north-westerly in France, Sweden, and Norway, and westerly in Germany; light to moderate in our Islands, but blowing strongly in Scandinavia, and a strong gale at Skudesnaes. *Sea* generally moderate in the west and north (but rough at Christiansund); slight elsewhere. *Barometer* highest over our Atlantic Coasts, lowest over the Gulf of Bothnia and Northern Russia. A shallow depression in the Channel moving eastwards, and the mercury consequently rising in our Islands during the day.
		**Wednesday, July 3.** *Weather* still fine in the west, and improving a little elsewhere, but rain again recorded in the south-east. *Temperature* low, but inclined to rise, the maximum values over Central England varying from 63° to 65°, while in the south-west 67° and 68° were reported. *Wind* northerly in the north, north-westerly in the south, and westerly in the south-east, but southerly airs setting in at Stornoway in the evening. *Sea* rough in the Skager Rack, moderate on our north-east coasts. *Barometer* still highest in the west, and rising generally, but slowly. A fall commencing in the extreme north-west of our Islands at evening.
		**Thursday, July 4.** *Weather* much finer over England than of late, but overcast in the extreme west and north, with heavy rain in Caithness, the Hebrides, and Shetlands, and a smaller quantity in other parts of Scotland and the west of Ireland. *Temperature* risen considerably, reaching 72° in London, and rising above 70° in many other parts of England during the day, and to 75° at Rochefort. *Wind* backing in most places; still north-westerly to westerly in the east and south-east, but southerly to south-westerly in the west and north, and blowing freshly at Valentia. *Sea* rather rough off the south-west of Ireland in the afternoon. *Barometer* now highest over the Bay of Biscay, Channel, and France, but falling generally, most in the north-west. Depressions outside our extreme west and north-west coasts, moving in a north-easterly direction towards Norway.
		**Friday, July 5.** *Weather* continues fine at the southern stations, but rather dull in the west and north, with rain in many places, especially in the north of Scotland and in Denmark. Sky very clear in France. *Temperature* showing little change; the maxima in England being above 70° in many places, while at Biarritz 86° was recorded. *Wind* southerly to south-westerly in the west and north, and blowing strongly in the extreme west; westerly in the east and south, and, though light in the east, blowing freshly in the Channel. Easterly winds prevailing in Spain and the southern parts of France. *Sea* rough in the west. *Barometer* highest over France, and still falling generally. Depressions still passing by our western and north-western coasts in a north-easterly direction, but only just skirting us, so that the gradients in our Islands continue moderate.

(*Continued over.*)

(*Continued.*)

Synoptic Weather Charts.—8 a.m.		**Weather** during the 24 hours succeeding the date of the Charts.
Barometer and Wind.	Cloud, Rain, Sea, and Temperature.	
		**Saturday, July 6.** *Weather* clear in France, fine but cloudy in the south of our Islands, and dull elsewhere, with rain in some places. *Temperature* rising a little in the south, and reaching 73° to 78° over central England, and 72° at Aberdeen during the day, the nights also being mild generally. *Wind* north-westerly at the northern stations, and westerly to south-westerly in the south, but northerly to easterly in the south of France; generally moderate in force, but blowing strongly from west to north-west on the eastern shores of the North Sea. *Sea* rather rough in the north, north-west, and south. *Barometer* highest in the south-west and south, lowest in the north and north-east, but gradients moderate. A depression lying over Scandinavia, and fresh disturbances advancing towards the same region from the Atlantic. Barometer changing very little and irregularly in our Islands.
		**Sunday, July 7.** *Weather* fine in a few localities, but on the whole cloudy and dull, with showers on our western coasts, and in the west of France. Thunder in the north-east of Ireland. *Temperature* unsteady in Scotland, but very little change in England, the maximum values varying from 72° to 77°, and the nights remaining warm. *Wind* veering to north-west very generally, and continuing light or moderate except on the eastern shores of the North Sea. *Sea* very little disturbed, except in the Skager Rack. *Barometer* rising briskly on our northern and north-western coasts, falling slightly in France. Two distinct but shallow depressions over Sweden, both travelling slowly to the eastward.
		**Monday, July 8.** *Weather* fine generally, but somewhat cloudy during the day. Slight showers of rain fell on our north-west coasts and in the south-west of France, and some rain at Stockholm. *Temperature* showing little change in the morning, but the maximum readings rather lower than on the 7th, though still above 70° over England; the succeeding night cool. *Wind* generally northerly and light to moderate in force, but drawing rather more towards north-west on the eastern shores of the North Sea; westerly over Germany. Later in the day wind backed towards west and south-west in the north-west, while south-easterly winds showed themselves on our north-east coasts. *Sea* moderate to smooth. *Barometer* risen generally in our Islands, fallen slightly in France; highest to the westward of Ireland, lowest over Russia and the Gulf of Bothnia, the gradients over Western Europe being slight. During the day the mercury began to fall briskly on our extreme north-west coasts.

Explanation of Charts.—The two Charts for each day show the general condition of the weather over Western Europe at 8 a.m. In the left-hand Chart the height of the barometer is expressed by "isobars," the value of each line being given in figures. The prevalent winds are shown by arrows, which are drawn flying *with the wind*, the force being indicated thus: ⟫⟶ = a heavy gale; ⟶ = a gale; ⟶ = a fresh to strong breeze; ⟶ = a light to moderate breeze; and ⊙ = a calm. In the right-hand Chart the weather is indicated as follows:—b = blue sky; c = detached clouds; o = overcast; m = misty (hazy); f = foggy; q = squally; r = rain; h = hail; s = snow; l = lightning; and t = thunder. The general distribution of temperature is shown by "isotherms," the readings at certain places being given in figures. Diagonal lines = rough sea, the shading being proportional to the disturbance.

(Signed) ROBERT H. SCOTT,
Secretary.

Meteorological Office,
116, Victoria Street, S.W.

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MEAN ANNUAL RAINFALL OF THE BRITISH ISLES,

FOR THE 24 YEARS FROM 1860 TO 1883,

(Published with the kind permission of the Scottish Meteorological Society.)

VI.—*The Rainfall of the British Islands.* By ALEXANDER BUCHAN, M.A., Secretary to the Scottish Meteorological Society.

[Read before the Society, 16th December, 1885.]

CLIMATE may be defined as that peculiar state of the atmosphere in regard to heat, moisture, and rainfall which prevails in any particular place, together with its meteorological conditions generally, in so far as these influence animal and vegetable life. The diversified characters which climate displays may be referred chiefly to the combined operation of these four different causes, viz.:—distance from the equator, height above the sea, distance from the sea, and prevailing winds.

The greatest differences, however, in the local climate of places situated at no great distance from each other, arise from differences in the rainfall. The arid plains of the North-Western Provinces of India, as compared with the fertile higher slopes of the Himalayas contiguous to them, and the widely contrasted climates of the western and eastern slopes of Scandinavia respectively, may be cited as illustrations. In the British Islands there are, perhaps, no stronger contrasts of climate than those presented by Skye and the Laigh of Moray. The mean temperatures of these two regions in no month of the year differ so much as two degrees, and for several of the months they are nearly identical. But the rainfall of Skye rises towards, and in many places exceeds, 100 inches annually; whereas, over the Laigh of Moray, it is only about 26 inches. Now it is this difference in the rainfall, with the clear skies and strong sunshine that accompany it, which on the one hand renders the south shores of the Moray Firth one of the earliest and finest grain-producing districts of Scotland, and on the other, renders the island of Skye quite unsuitable for the remunerative cultivation of cereal crops. It is this aspect of the rainfall which gives it so paramount a place in th climatology of a country.

Of all meteorological data, the rainfall is the most difficult to represent cartographically; and there is no other way to arrive at even a tolerable approximation to the average rainfall of a district than by numerous rain-observing stations well distributed over its surface. Hence, in this inquiry, all available statistics of the rainfall for the period of years selected, have been used—the number of stations being 1080 in England and Wales, 547 in Scotland, and 213 in Ireland, in all 1840 stations. Notwithstanding this comparatively large number of rain-gauges, very extensive districts remain wholly, or all but wholly, unrepresented.

The period selected for the investigation is the 24 years ending 1883, and the principal sources from which the information has been obtained are the returns published by the Meteorological Societies of England and Scotland, and by Mr. Symons. For the method of discussing the results we refer to the recently published Part of the *Transactions of the Scottish Meteorological Society*, pp. 131-33. It may be here enough to say that the whole of the averages have been calculated for, or reduced to, the same term of 24 years, beginning with 1860 and ending with 1883.

The 1840 averages were then transferred to large maps of England, Scotland, and Ireland, and, from the results thus shown, the British Islands were shaded into six divisions, these shadings showing the districts where the mean annual rainfall—

1st.—Does not amount to 25 inches.
2nd.—Is from 25 to 30 inches.
3rd.— „ 30 „ 40 „
4th.— „ 40 „ 60 „
5th.— „ 60 „ 80 „
6th.—Above 80 inches.

On the map exhibited on the wall, these divisions are shown by three tints of blue and three of red—the blue showing a rainfall exceeding 40 inches annually, and the deepest tinted blue the regions of largest rainfall; and the red, a rainfall less than 40 inches, the lightest tint marking off those parts of England where the rainfall is least, or where it is less than 25 inches annually.

The regions of heaviest rainfall, marked off by 80 inches annually or upwards, are these four:—

1. The greater part of Skye, and a large portion of the mainland to the south-east, as far as Luss.

2. The greater part of the Lake District.

3. A longish strip, including the more mountainous portion of North Wales; and

4. The mountainous district of the south-east of Wales.

The rainfall is also heavy on Dartmoor and certain portions of the West of Ireland, but in these parts it does not appear quite to reach 80 inches.

The West Highlands present the most extensive region of heaviest rainfall in the British Islands. The mountain masses, along whose slopes and plateaux the rainfall is precipitated, offer a practically unbroken face of highlands directly in the course of the rain-bringing winds from the Atlantic. Particular attention is drawn to the circumstance that these mountain masses present many lochs and valleys directly in the course of these winds; up which, therefore, the winds are borne, and these cooling as they ascend pour down the deluges of rain which deeply trench the sides of the mountains in the lines of their water-courses.

This region of heaviest rainfall lies so far to the North of Ireland that the rainfall is not lessened by a previous partial drying of the Atlantic winds in their passage thither. To southward, however, it is quite different. Over the whole of the extensive tract of Great Britain, from Luss to the Lake District, there is not a single rain-gauge whose annual average reaches 80 inches, even although a number of rain-gauges have been planted in the higher districts, and in positions likely to furnish approximately the maximum rainfall of these districts. The diminished rainfall is no doubt due to the partial drying of the Atlantic winds in their passage across Ireland before they reach Southern Scotland.

St. George's Channel and the Irish sea open a free passage to the south-westerly winds, here diverted into a more southerly course, to the North of England, and to Wales, and accordingly where the mountain masses of the Lake Districts, and of North and South Wales, oppose their course, the rainfall over large portions of these high districts exceeds 80 inches.

The maximum falls in these four districts respectively are 185·96 inches at The Stye in the Lake District; 128·50 inches at Glencroe, Argyllshire; 116·90 inches at Beddgelert, North Wales; 96·18 inches at Ty-Draw, Treherbert, South Wales.

The largest region of 60 to 80 inches rainfall is in the West

Highlands, surrounding the region of still larger rainfall of 80 inches and upwards, and it extends from the Crinan Canal to beyond Loch Assynt, in Sutherland; then follow the hills to the north of Galloway; the north and east of Dumfriesshire; large portions of the Lake Districts; of North and South Wales; Dartmoor, in Devonshire; of West Galway; and the mountainous districts of Kerry.

An annual rainfall of 40 to 60 inches covers extensive tracts of the British Islands—a rainfall of at least 40 inches characterising the climates of about a fourth part of the surface of England, of about the half of Ireland, and considerably more than the half of Scotland—the latter, taken as a whole, being by far the rainiest of the three divisions of the United Kingdom. It is to be noted that nowhere along the East Coast of Great Britain, or for some considerable distance inland, does the average rainfall anywhere reach 40 inches. In the east of Ireland, on the contrary, the rainfall exceeds 40 inches in Wicklow, the south of Down, and the middle districts of Antrim.

Over the whole of the west of Great Britain the rainfall exceeds 40 inches annually, except from St. Bee's Head to Dumfries, and from Holyhead to Lancaster, these districts being largely protected from the rain-bringing winds by the Cumberland and the Welsh mountains respectively. It may also be stated that the rainfall of the Orkney and the Shetland Islands falls short of 40 inches, whereas in the Hebrides it exceeds that amount.

The shadings of blue on the map show in a striking manner the extension eastwards of the area of the 40 inches and upwards annual rainfall by the mountains of Sutherland, the Grampians, the Cheviots, the Pennine Range, and the hilly ground of the south-western counties of England.

On the other hand, the breakdown, at various intervals, of the mountainous or hill plateau, which may be regarded as extending along the west of Great Britain from Cape Wrath to the Land's End, has an equally striking influence on the distribution of the rainfall; and as regards man's material interests is even more important. Thus, the opening of the Bristol Channel, between Wales and the Cornish Peninsula, is the avenue through which is spread a more generous rainfall over a large portion of Central England than would otherwise have been the case. Through the breakdown of the plateau between the Pennine Range and North Wales, another large portion of England, extending from

Cheshire round by Derbyshire, and thence northward through Yorkshire, has its rainfall also very materially increased.

But the most remarkable of these breakdowns is the great lowering of the water-parting between the Firths of Forth and Clyde. Through the opening thus formed the south-westerly winds pass freely, and overspread Dumbartonshire, Stirlingshire, and the whole of western Perthshire, precipitating over these regions, a rainfall truly western as regards its copiousness and the direction of the winds with which it falls; and through the same breakdown there is extended, even eastward through Kinross-shire, a rainfall of fully 40 inches—an amount which occurs nowhere else over comparatively level plains, so far to the east of the water-parting between eastern and western districts.

The following are the rainfalls, in inches, at several points of the Glasgow district:—Millport, 41·30; Largs, 48·52; Morland, 60·70; Kelly Dam, 68·36; Greenock, 64·25; Dunoon, 77·30; Helensburgh, 52·92; Cameron House, 62·95; Glengyle, 95·41; Balquhidder, 76·70; Lochearnhead, 65·50; Ochtertyre, 44·17; and Pitlochry, 36·33.

Of the greatest importance is it to note the rainfall of Clydesdale lying to the south of this breakdown. The amounts are, in inches—29·98 at Bothwell Castle, 30·54 at Dalziel House, 31·66 at Auchinraith, and 32·37 at Murdostoun. Now, it is simply the southerly element of the rain-bringing winds which makes the rainfall of the Hamilton district of Clydesdale so essentially different, both as respects its amount and the times of its occurrence, from that of the Clyde below Glasgow. It may be noticed here, that when the rainfall of the west is in excess of the average, the rainfall of West Perthshire is also in excess; and on the other hand, when there is an excessive rainfall over the Hamilton district, it generally occurs that the rainfall of eastern districts is also in excess. The peculiarity of the rainfall of Glasgow consists in this, that it lies midway between these districts, which are so differently circumstanced.

The valleys of the counties of Kirkcudbright and Dumfries, with the intervening ridges lying athwart the course of the rain-bringing winds, show the inevitable result of a rainfall successively diminishing on advancing eastward. But on arriving in Eskdale, the most easterly of these valleys, we meet with a rainfall considerably in excess of that of any of the valleys to westward at the same elevations. The larger rainfall of Eskdale is due to its lying more in

the line of the Solway, and having immediately to eastward a high mountainous region, which the south-westerly winds must cross in their passage to eastward. The distribution of the rainfall over this hilly region, and over the valleys on each side of it, is instructive. Thus, at Kirkconnel Hall, near Ecclefechan, it is, in inches, 39·64; Canonbie, 49·72; Carlesgill, 58·00; Eskdalemuir, 63·30; Tudhope (on the ridge 1961 feet high), 76·43; and on the east of the watershed, at Teviothead, 54·86; Borthwickbrae, 44·36; Hawick, 33·55; and thence continues diminishing in descending the valley to 26·50 at Springwood Park, near Kelso. The reason why the rainfall of this region is thus distributed is, that the air on the windward side of the ridge being suddenly raised to a greater height in crossing the range, its temperature is continually reduced by mere expansion, and copious precipitation follows; whereas on the leeward side, as the air descends to lower levels, its pressure (or density) being increased and its temperature also thereby increased, it gradually becomes drier, and accordingly the rainfall diminishes rapidly with the descent of the aerial current to the low plains. A similar distribution of the rainfall is seen in crossing the Downs from Brighton to London, and over all other regions similarly situated.

It is the rapid increase of the temperature and drying of the air as the wind passes from high and wide plateaux into lower levels, which determines the areas of least rainfall of the British Islands. Accordingly, the smallest average annual rainfall, varying from about 22½ to 25 inches, occurs in England, and overspreads a large portion of the south-eastern Counties, extending from the Humber to the estuary of the Thames, exclusive of the higher grounds of Lincoln and Norfolk, where the rainfall rises above 25 inches. In every other part of the British Islands the rainfall is above 25 inches. The influence of the higher grounds of Norfolk and Lincoln in swelling the rainfall, most probably by increased falls with easterly winds, is very striking. Similarly the rainfall of the Yorkshire Wolds is in excess of surrounding districts. Between the valley of the Thames and the Humber the rainfall nowhere exceeds 30 inches, except near the Chiltern Hills. It will be observed that the northern limit of the region marking off a rainfall under 25 inches annually is at the Humber, or near where Great Britain suddenly shrinks in breadth. It is, however, probable that the larger rainfall of the eastern part of Yorkshire, as compared with what

obtains further south, may also in part be occasioned by causes analogous to those which give Western Perthshire its large rainfall.

In Scotland no rain gauge gives an annual average under 25 inches. In three districts, however, the averages are only slightly in excess of 25 inches, and less than 27 inches, these districts being (1) Lower Tweeddale, from about Coldstream to Jedburgh; (2) the low-lying parts of East Lothian; and (3) the shores of the Moray Firth, from the mouth of the Spey round to Tain. It will be seen that these districts are not only well protected by extensive high lands from the rains of the south-westerly winds, but also from the, in many cases, torrential downpours of south-easterly winds. It is this double protection which gives the driest of its climates to these parts of Scotland.

In Ireland, on the contrary, only a small district round Dublin shows a rainfall less than 30 inches—this district being well protected by the Wicklow mountains from the rain-bringing winds; and as in that island there is no continuous mountain mass stretching north and south, there is no such great difference of rainfall and temperature shown between the eastern and western climates of Ireland as in the case of Scotland and England.

The narrowness of the strip round the east of Scotland, where the rainfall does not exceed 30 inches a year, is an interesting feature of which the rain maps constructed for individual months suggest the explanation. Of the rainfall of eastern districts, the larger proportion is due to easterly winds; and by much the larger portion of these falls usually takes place neither on the low-lying coasts nor at any great distance inland, but in the intermediate region, at heights from about 250 feet and upwards. The falls are also very heavy in low-lying valleys that open out so as to face these rain-bringing easterly winds. Of these rains the weather of October, 1880, afforded an excellent illustration. The rains of that month fell with strong north-easterly winds, and the foreshores, looking to the north-east, of the Firth of Forth, the Moray Firth, and the Pentland Firth, had a monthly rainfall above the average, being in some places more than double the average; whereas over the rest of Scotland the rainfall was under the average, being over very extensive breadths from 70 to 98 per cent. less than the mean rainfall for October.

One of the most marked features of the climates of the South of England, to which many of our invalids are sent, is due to the influence of the Downs on the rainfall. Over the whole of the

somewhat broad region occupied by the Downs the rainfall exceeds 30 inches, rising near Petersfield to 40 inches. Along the south coast, and for a varying distance inland, as determined by the physical configuration, the average is less than 30 inches from Dover westward as far as the east shores of the Isle of Wight. On proceeding still further to westward, the annual rainfall slowly but steadily rises, till on rounding Prawle Point, in Devonshire, it begins to exceed 40 inches, and with this increase of the rainfall there is a still more striking increase of the temperature in the winter months.

The whole of the results arrived at in this inquiry, show conclusively that the key to the distribution of the rainfall of the British Islands is the direction of the rain-bringing winds in their relation to the physical configuration of the surface.

Looked at broadly, there are four very distinct causes of rain, viz.:—(1) The moist south-westerly winds; (2) rains, often very heavy rains, from the east, extending but a little way inland; (3) the annual fall of temperature from August to January; and (4), those peculiar influences that have their fullest development in the thunderstorms of summer over low-lying extensive plains. The rainfall of the British Islands has been examined with reference to its seasonal distribution in relation to the physical configuration of the surface. The mean rainfall of each place for the past 20 years has been calculated for the 12 months, these being reduced to 30 days each. The mean of those 12 months being taken, the mean monthly rainfall of the year was then ascertained; and with this latter mean, each monthly mean was compared, and its excess or defect entered in percentages, on 12 maps.

The moist south-westerly winds acquire their maximum annual predominance in December and January, and as these winds come loaded with the vapour of the Atlantic, the rainfall rises above its monthly mean over nearly the whole of Scotland. Two patches, however, are to a great extent exempt, these being the districts lying on the leeside of the greatest stretch of mountainous land, viz., to the north-east of the Grampians, and to the east of the Moffat and Lead Hills. Similarly in England during these months the rainfall is considerably below the average over the whole of the dry districts, extending from the Tweed southwards, and bounded on the west by the water-partings of the Mersey and the Severn, and on the south by the bed of the Thames, including the northern slopes of Kent.

During the time of the great annual fall of temperature from August to January, the greatest excess over the mean monthly rainfall occurs in September and October, when the fall of temperature is most rapid, westerly winds very prevalent, and heavy rains with easterly winds, chiefly the easterly winds of cyclones, of most frequent occurrence. In these months the rainfall reaches the annual maximum over large districts in the east of Scotland, and over all but the whole of England.

In the northern and the extreme western districts, nearly all thunderstorms occur during the winter months; whereas, few thunderstorms occur in eastern and central districts at this season, but nearly all occur in the summer months, a remark which applies with greatest force to the more extensive level, or comparatively level, portions of the country. Now, from the frequent occurrence of thunderstorms and thunder showers, the annual rainfall of these districts approaches to, and in not a few cases reaches, the annual maximum in the summer months. The local excess begins to show itself in June, is extended in July over the agricultural districts of Scotland and England which are best suited for the ripening of wheat and barley. In August there is shown a still further development and extension of the summer rains over these and adjoining districts. In this respect the climates of the important agricultural centres resemble the climates of Central Europe, where the rainfall rises to its maximum during the summer months.

To return again to the rainfall of Glasgow, the following are the annual amounts in inches in certain districts and along certain lines radiating in different directions from the city:—Glasgow, 40·20; Bushy Hill, 37·33; Bothwell Castle, 29·98; Dalziel House, 30·50; Lanark, 35·66; Wiston, 45·33—Queen's Park, 36·24; Newton Mearns, 52·63; Black Loch, 57·60—Paisley, 45·37; Castle Semple, 52·10; Blair, 53·63; Ardrossan, 41·03—Kilbarchan, 63·42; Kilmalcolm, 57·28; Greenock, 64·25; Overton, 71·45—and New Kilpatrick, 48·05; Dumbarton, 48·25; Cameron House, 62·95; Luss, 80·45; Firkin, 96·05; and Ardlui, 115·46. These figures show in a striking manner the extraordinary variations of climates there are in the immediate neighbourhood, or within easy reach, of Glasgow. Quite recently an inquiry was set on foot in Berlin, where numerons rain gauges were planted, with the view of arriving at some clear understanding as to the amount of observational information required in order to state

definitely what the actual rainfall of a district is. Might I suggest to the Mathematical and Physical Section of the Philosophical Society that a similar investigation be taken in hand, and forty or more rain-gauges be added to those already in use. In a few years not only would the Society be able to answer the question proposed by the Berlin meteorologists, but in answering it state with satisfactory precision the character and limits of the various local climates which differ so widely from each other in the neighbourhood of Glasgow.

[*See Map printed with permission of the Scottish Meteorological Society.*]

Royal Geographical Society.

RESEARCH DEPARTMENT, January 16, 1905

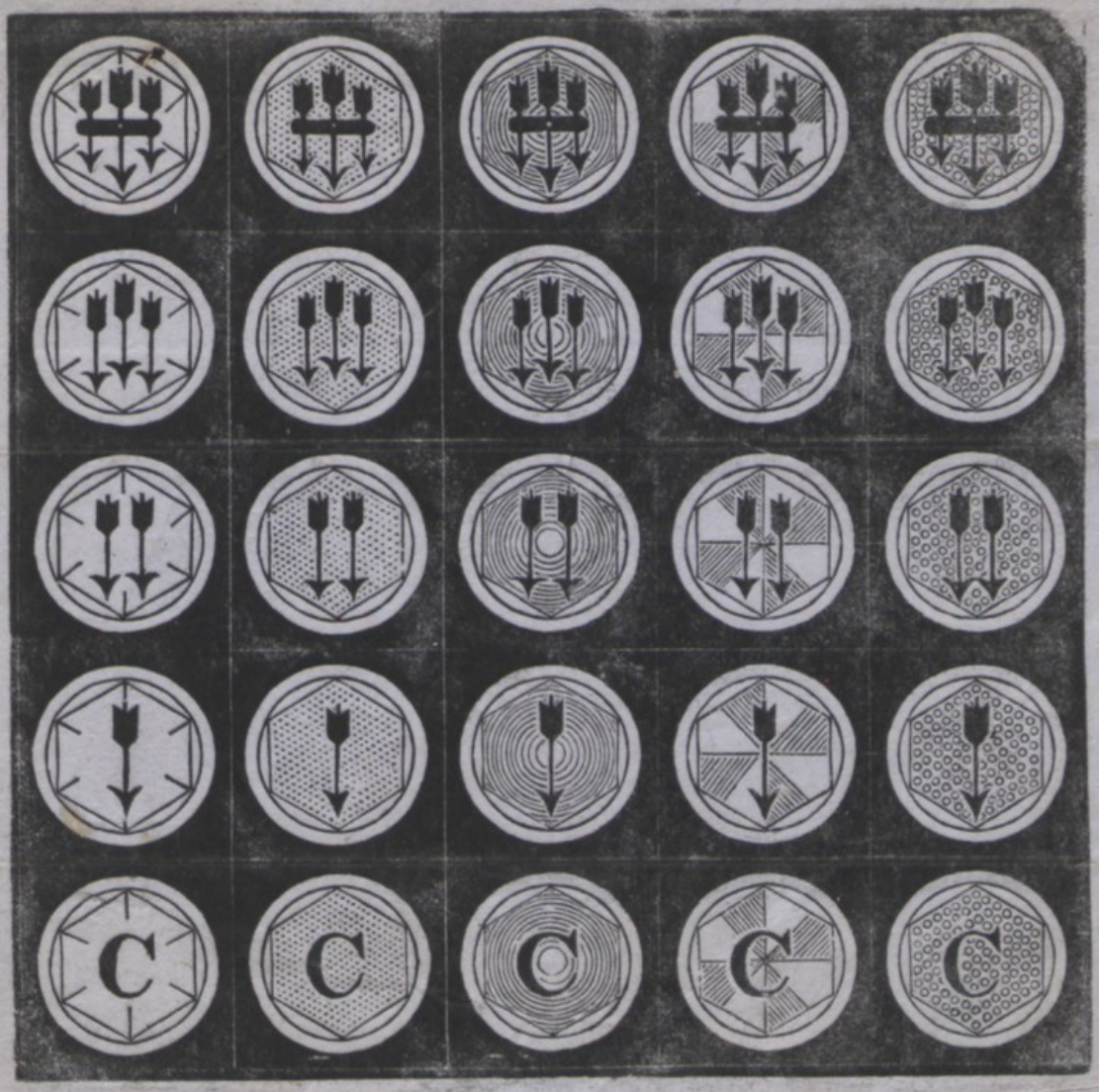
ANTARCTIC CLIMATOLOGY. By Lieut Royds.

Some Temperature Data.

Navigable Season in 1902.

Month.	*Discovery*, 1902.			*Discovery*, 1903.			Cape Adare, 1899.		
	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.
January .	25·9	41·5	8	24·9	39	9	33	48·9	22·5
February .	15·8	29·2	−0·8	10·9	32	−10	26·4	..	..
March . .	7·3	27·5	−13	−1·8	25·5	−21	17·7	31·1	−2·5
April . .	7·5	19·8	−31	−17	5·2	−43	10·3	30	−10
May . .	−12·9	19	−39·6	−17	9·2	−52	−4·6	23·2	−31
June . .	−16	13	−47	−16·3	17	−48	−11·8	14	−36
July . .	−8·6	15	−38	−21·5	12	−55	−8·6	23·8	−39·9
August. .	−17	6	−50·5	−18	11·8	−54	−13·4	18·9	−43
September.	−13	15	−44·5	−20	13·2	−59·5	−11·9	11·5	−36
October .	−9	11	−41·8	−7·5	12	−43·8	−1·8	19·6	−35·5
November .	12·2	27·8	0	..	..	..	17·8	45·7	−4
December .	23·4	39	4	..	..	..	31·8	42·2	+20
Year . .	−0·1	41·5	−50·5	−4·6*	39	−59·5	+7	48·9	−43

* November and December of 1902 used.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(1)

Memorandum.

The subjoined points are respectfully submitted as a possible line of examination for Mr Scott, supplementary to the printed papers.

Memorandum on Organization

Report on work done.

The numbers appended refer to Mr Scott's printed evidence on the several points.

These above 13,000 to his evidence before the Science Commission; the lower numbers to his evidence before the present Committee.

Brussels Conference & subsequent co-operation in Maritime Meteorology of Nations represented there &c.

Present condition & Maritime Meteorology. (A summary of the facts on this head will be inserted in the Memorandum.)

Cost of discussion & observations per 1000 sets. This will also be inserted in the Memorandum

Repeat questions 26, 27, 28, 42, 44 & part of 45, 61 63, 74, 76 & 84, 102 to 109, 116.

Difficulty of obtaining Observers.

2

Proposals for co-operative action in Maritime Meteorology.

Co-operation established between Holland & Hamburg.

Uniform mode of publication.

Prof. Buys Ballot's views on co-operation.

_____ Criticism on our Data Books

_____ _____ on our Charts.

Single subjects v. Collective charts like those of M. O.

Annual publication for single degree squares.

Ideas about an International Office.

Districts which are already published. Observations

thence still required for synoptic work.

Proposal of Leverrier for partition of the globe between

different nations. (Ca. 14, 454).

Atlas des mouvements généraux de l'Atmosphère.

Meldrum's Charts. Indian Ocean.

Capt. Hoffmeyer's request for information.

Admiralty Charts, Materials not believed to be

deficient in quantity to make more detailed

charts.

3

Weather Telegraphy.

Defects of system, owing to our geographical position.
Contrasts with United States in that respect.
Difficulty of getting information from the West.

Newfoundland
Azores
Bermudas

Signal Ships. H.M.S. "Prior"
Want of extra stations on West Coast.
Difficulty owing to thinness of population.
Want of stations at high levels.
Deficiency of Reports as to frequency.
Difficulty of warning ships at anchor.
Position taken by Meteorological Committee in 1867 as regards warnings.
Work of office now chiefly routine work for Newspapers.
Staff quite insufficient for systematic study of weather.
Results of warnings.
Want of Screw use of Telegraphs.
Liability to interruption of communications.
Proposal for use of Signalling Anemometer.

Difficulties in connection with Observers for Orographic Stations.
Exchange of information with foreign countries.
Warnings to Collieries.

Land Meteorology of the British Isles.

British Rainfall organisation.
Necessity for more funds for Experiments & discussions.
Difficulty of ensuring uniformity in :-
Instruments
Methods
Hours of Observation.

Proposals for international action.
Vienna Congress.

Entire salaries of Staff shown in Statement of Accounts

Amended answer to Qu. 13,969.

Memorandum

Saturday 2.30 pm

The amended Memorandum on Organization has not yet come back from the printers, but I submit the following notes as subjects on which my Sirs by the Treasury Committee might bring out some facts of interest. This is sent to Messrs de La Rue Galton & Strachey privately for approval & suggestions

M.F.L.

Ocean Meteorology

Brussels Conference

Coöperation in the subjects of matters referred thereto.

Dutch Method of obtaining observers

Preparation of Special Sailing Directions for each voyage.

in Hamburg &c

Methods of treating Maritime Meteorology

A Charts of Mean Results

B Synoptic Charts

Relative merits of these different Methods

Proposal of LeVerrier for partition of the Seas

Globe between different Nations

Atlas des Mouvements Généraux

Meldrum's charts. Indian Ocean

1

Memorandum

Saturday 2.30 pm

The amended Memorandum on Oceanography has not yet come back from the printers. But I submit the following list of subjects on which any [illegible] by the Meeting [illegible] might bring out some facts of interest. This is I think [illegible] better [illegible] Saturday [illegible] for approval & suggestions

M.F.

Ocean Meteorology

Brussels Conference

Conference on the subject of nautical observations at sea.

Best method of obtaining observations

Preparation of special Sailing Directions for each voyage. i.e. Maury's

Methods of treating Maritime Meteorology

A Charts of Mean Results

B Synoptic Charts

Relative merits of these different methods

Proposal of Le Verrier for [illegible] of the sea State between different nations

Atlas des Mouvements Généraux

Meldrum's charts. Indian Ocean

I 33

Weather Telegraphy 2

Defects of our system owing to our geographical situation
Contrast with U.S. in this respect
Deficiency of reports as to frequency.
Sunday interruption unlikely to be soon removed
Difficulty as to signals to ships at anchor ~~in offing~~.
Position taken by Met Com^tee in /67 as regards warnings
Incorrectness of idea that they were opposed to the issue of intelligence as distinguished from warnings.
Warnings suspended by Board of Trade at suggestion of Treasury Ltr W 5215 Parl Pap 240/67 p 8.
Impression conveyed by Mr Milne Home's reply to Q 12,527 (Sc. Com^n) relating to this subject not quite accur[ate]
June 8/67 Com^tee suggested readiness to issue telegra[phic] intelligence & hoist a signal as soon as stations should [have] been inspected
Action of Brit Ass^n, & Scot. Met. Soc had no influence on the resumption of storm warnings.
Information was supplied at his own request to the Duke of Buccleugh to enable him to announce officially at Dundee in his capacity of President BA that the warnings were to be issued. This announcement was never made.

Difficulty as to getting information from the W
New Foundland
Azores
Faroes
Signal Ships
Cost of H.M.S. "Brisk" in stocks £50,000.
Want of intermediate stations on our own coasts,
difficulty owing to thinness of population.
stations at high levels.
Want of free use of the telegraphs.
Liability to interruption of communications.
Proposal for use of signalling arrangements
difficulties in connection with obscurance for telegraphic
stations
Exchange of information with foreign countries.

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Land Nationalisation

Existing Organizations in the United Kingdom
Importance of assisting Colonial organizations
Difficulty of securing uniformity in
Instruments
Methods
Forms of Alienation
Proposals for International Action
Vienna Congress
Permanent Comtee