REPORT

OF THE

METEOROLOGICAL COMMITTEE OF THE ROYAL SOCIETY,

For the Year ending 31st December 1868.

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.

1869.

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PREFACE.

THE Meteorological Committee consists of gentlemen who were nominated in 1866 by the Royal Society, 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 is credited with a sum voted annually in the Estimates of £10,000, for the administration of which it is wholly responsible, and over which it is given the entire control.

The Committee holds a meeting of some hours' duration at least once a fortnight, when every subject on which action has to be taken by its executive officers receives its careful consideration. The duties of the Committee are onerous, and *entirely gratuitous;* they were accepted, and are very willingly performed by its members, on account of the earnest desire they severally feel for the improvement of Meteorological Science.

The Committee consists of the following members :—

GENERAL SABINE, R.A., President of the Royal Society, *Chairman.*

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 OF THE ADMIRALTY.

Colonel W. J. SMYTHE, R.A.

REPORT

For the Year ending December 31, 1868.

PART I.

Introductory.

In their first Annual Report the Committee entered at some length into the circumstances which attended the transference of the office from the Board of Trade to their superintendence, so that in this, their second, it is only necessary for them to give an account of the work carried on by their staff during the year.

The work of discussion of the materials furnished by the different observers is conducted in their office in London, under the supervision of Mr. Robert H. Scott, the Director of the office, assisted by Capt. Henry Toynbee as Marine Superintendent. In addition, Dr. Balfour Stewart, the Secretary to the Committee, by permission of the Kew Committee of the British Association, is charged with the general superintendence of the self-recording observatories (of which that at Kew under his own directorship is the chief), and with the preparation of the results furnished by them for ultimate discussion in the central office.

Subdivision of objects of inquiry.

The operations of the Committee, as stated in their last report, may be conveniently arranged under three heads.

I. *Ocean Meteorology,* comprising the investigation of the meteorological conditions of the entire ocean by means of observations furnished by officers in the Royal Navy and in the merchant service. Instruments are lent to observers for the purpose of carrying out these observations. The supply of instruments to the Admiralty is also undertaken by this branch.

II. *Telegraphic Weather Intelligence,* embracing the entire system of observation and of telegraphy required for the preparation of the daily weather reports, and for the issue to our own ports and to foreign countries of information of ordinary weather and of storms.

III. *Land Meteorology of the British Islands,* comprising the method of meteorological inquiry carried on at the seven self-recording observatories established by the Committee. The object of this branch is, firstly, to afford for these islands accurate meteorological information, similar to that published, under the auspices of their respective governments, in most European countries, and, secondly, to furnish better data for the study of our weather than had previously existed, so as to place the

system of telegraphic weather intelligence on a satisfactory scientific basis.

I.—Ocean Meteorology.

Collection of information.

The method adopted by the office in collecting materials on this subject has been to lend to captains in the mercantile marine, instruments which have been tested at Kew, and are returned for re-comparison with standards as soon as the voyage is over. The loan is granted on the condition of observations being regularly taken and entered in a meteorological register, which is issued with the instruments, and is sent to the office when they are returned.

The regular set of instruments supplied to a ship consists of: —

1 Marine barometer (Kew pattern).
6 Thermometers.
1 Thermometer screen.
4 Hydrometers.

In a few exceptional cases an azimuth compass is added.

Captains are allowed to purchase any of these instruments at cost price on condition of their keeping a register of their observations for the office.

In addition, the office undertakes the entire duty of supplying H.M.'s navy with all meteorological instruments used in the service. In the case of such supply the keeping of a register for the office is entirely voluntary, as the instruments are issued for the regular service of the Admiralty, and not for that of the Meteorological Office. Notwithstanding this, some of the best registers have been kept by officers in the royal navy.

Examination of registers.

The whole duty of supplying instruments, and of the subsequent examination of the registers is entrusted to the Marine Superintendent, whose long experience as a seaman and as a first-rate observer for the office specially fits him for the work. Capt. Toynbee takes care, if possible, to have a personal interview or at least to place himself in correspondence with intending observers. As soon as a register is sent in, it is examined by him, and a letter is written to the observer, requesting him, while the circumstances are still fresh in his memory, to furnish such particulars as to the position of the instruments on board ship, and the mode of taking the observations, as are necessary to explain his register thoroughly. These particulars are entered on the flyleaf of the register. It has been found advisable to take precautions such as the foregoing in order to avoid the accumulation of almost useless materials, some of which had unfortunately been already amassed in the office.

The registers which are in the office are in process of being systematically examined, previous to their being used for the purpose of discussion of their contents. If any register affords internal evidence of inaccuracy, such as a record of barometrical readings which does not exhibit the diurnal range between the tropics, or a series of readings of the dry and wet thermometers which do not differ, or other proofs that it is not trustworthy, it

is rejected. By the application of tests such as these, about half of the early registers bearing on the district now under investigation, which have been hitherto examined, had to be set aside.

The Committee are glad to be able to report that the extra care spent on the selection of observers has already begun to bear fruit, for the character of the registers now coming in shows a very marked improvement on many that were previously received.

Discussion of observations.

The systematic extraction of the materials contained in the log-books in the office, on the method devised by Captain Toynbee, and described at full length in the first Report, has made steady progress during the year. The district under examination is that lying between the parallels of 20° N. and 10° S. in the Atlantic Ocean. Most of the work which has been previously published for this region, traversed on every voyage to or from England by all vessels bound south of the equator, has been for areas comprising at the least five degrees of latitude and longitude (five-degree squares), and for periods of three months at a time. The accurate investigation of a district so interesting as this, is of such paramount importance to navigation that the Committee have directed that the materials should be extracted so as to allow of the calculation, if necessary, of mean results for the several elements for each month and for every square degree. These elements are pressure; temperature; tension of aqueous vapour; wind; condition of sky; motion of clouds; magnetic variation; ocean currents; and sea surface temperature.

The experience which has been obtained of the contents of the registers appears to show, as might be expected, that while there is an immense store of information for the regular tracks of vessels outward and homeward, observations are comparatively scanty for those parts of the ocean which lie off the great highways of trade. There is also a tendency of observations to accumulate in districts where light winds are prevalent, so that on the average of several years, the abundance of material for one district will indicate the prevalence of calms there. This is quite evident when we remember that in a calm a vessel may keep nearly the same position for days, and thus for that spot a great number of observations may be recorded by her captain, while in adjacent districts observers of equal accuracy may be carrying a fair wind, so that their vessels pass rapidly from square to square, and they are unable to record more than one or two sets of observations in each.

Completion of former work of the office.

In addition to this systematic work in the department of ocean meteorology, the Committee have set apart a certain portion of the funds at their disposal for the gradual completion of the several inquiries left by Admiral FitzRoy in an unfinished state. This has been entrusted to their staff to do at extra hours. The portions taken in hand, as mentioned in their first Report, have been sea-surface temperature for the South Atlantic Ocean, monthly wind data for the entire Atlantic Ocean, and meteorological information for the Pacific.

Sea-surface temperature S. Atlantic.

The monthly charts of surface temperature of the South Atlantic Ocean and the Agulhas current, comprising the mean temperatures for five-degree squares obtained from the discussion of Board of Trade registers, and those for each degree of latitude published by the Royal Meteorological Institute of the Netherlands*, have been completed and lithographed. In order to afford as complete information as to districts of special interest as it was in their power to do, the Committee have authorized the illustration of the charts by copious notes, consisting of extracts from the logs of captains who have noticed remarkable changes of temperature, with the actual positions in which the observations were made.† This information, as soon as it was in type, was communicated to the Admiralty, and has been already employed by the Hydrographic Office in the preparation of their pilot charts of the Atlantic, which appeared in last September, more particularly in the chart entitled "Stream and Drift Currents with Surface Temperature."

Wind data for Atlantic.

The wind data for the Atlantic, which are almost ready for publication, consist of the observations on wind (direction and force), taken from original documents in the office, and grouped for five-degree squares. The wind charts published in 1859 for a part of the North Atlantic, for the months of February, May, August, and November, were compiled from a portion of this information combined with data from Maury's Pilot Charts (relating only to direction of wind). The Committee have considered that they would be rendering a service to meteorology if they printed in a tabular form for the entire Atlantic Ocean the data for each month, relating both to direction and force of wind, collected by Admiral FitzRoy.

Meteorology of the Pacific.

As regards the meteorological information for the Pacific Ocean, an inquiry which Admiral FitzRoy had set on foot, but unfortunately did not live to accomplish, the discussion of the materials for Vancouver Island and for the coast of South America is completed, while that for the China Seas is in an advanced stage. On the appearance of the Atlantic pilot charts above referred to, the Committee were requested by the Hydrographic Office to supply it with any information which they might possess relating to the Indian and Pacific Oceans. They at once resolved that the discussion of these observations for the Pacific should be completed, and that the information therein contained should be forwarded to the Admiralty, so that, in so far as it was copious enough to be of service, it should be utilized for the benefit of the public.

It is hoped that in the course of another year they will be able to complete and issue all the arrears of unfinished work which they found in the office, and that without having in any way interfered with or delayed the progress of the new and

* Onderzoekingen met den Zeethermometer. Utrecht, 1861.

† Charts showing the Surface Temperature of the South Atlantic Ocean in each month of the year; compiled from Board of Trade Registers and the Charts published by the Royal Meteorological Institute of the Netherlands. London: Potter, Poultry, and Stanford, Charing Cross. Price 2*s.* 6*d.*

important discussions which they have laid out for their staff to work upon.

Deep-sea soundings.

The attention of the Committee has been attracted in a special way to the temperature of the sea below the surface, especially in the case of deep-sea soundings. The soundings made by Captain Shortland, of H.M.S. "Hydra," in the Indian Ocean, have revealed the existence of very cold water at great depths in that region; while the inquiries carried on in August and September last, off the north coast of Scotland, by Dr. Carpenter and Dr. Wyville Thompson, in H.M.S. "Lightning," under the command of Staff Commander May, have shown that close to our own coasts there are most interesting problems awaiting solution, regarding submarine temperatures.

Improvement of deep-sea thermometers.

All determinations of temperature at great depths must necessarily be effected by means of self-registering instruments, recording both maximum and minimum temperatures. Hitherto these instruments have been extremely unsatisfactory in their nature and construction. Not only have the indices been liable to displacement by a jar, owing to their possessing too great freedom of motion in the tube, but the graduation of the thermometer itself has been found to be at times as much as 5° or 10° wrong on its return from service. Accordingly very little dependence could be placed on observations made with such instruments. During last year the Hydrographer has himself taken up the question of the perfecting of deep-sea thermometers. These are almost exclusively supplied for the use of the navy, as merchant ships are of course unable, except on very rare occasions, to carry out such soundings, owing to the great length of time required to effect them. The instruments made under Captain Richards' superintendence show a great improvement as regards their form and construction, and such of them as have been already used in actual work have given great satisfaction to those employing them. The "Lightning" was supplied with instruments of the new pattern, as also the "Gannet," under Commander Chimmo, on the recent sounding cruise in the Gulf Stream.

Collection of new materials.

In the collection of new materials the Committee have proceeded very cautiously, looking much more to the quality than to the quantity of the observations likely to be obtained. Many commanders in the service of our leading ocean steam ship companies* have agreed to co-operate in the work, with the consent of their respective directors, and by their means a great amount of valuable material, especially for the Atlantic Ocean, is coming in. Instruments have also been lent to a few well-known and tried observers. In Appendix No. II. will be found a list of the documents received during the year in this department. At present the Committee are contemplating a more extensive issue of instruments, and with a view to this object they have resolved

* Among these may be mentioned Cunard's, Inman's, and Allan's Lines to North America; Cunard's Line, Halifax to the West Indies; Lamport and Holt's Line to the Brazils; the Royal Mail Steam Packet Company, Southampton to the West Indies. The Panama and New Zealand Company also contributed observations as long as the company was in existence.

to reconstitute the meteorological agencies at the ports, which, with the exception of that at Liverpool, have been almost inactive for the last few years, owing to a wish expressed by the Meteorological Department of the Board of Trade that the supply of instruments should be checked.

Estimate of probable progress of work.

The arrears of observations existing in the office are being subjected to a careful examination in order to ascertain their exact nature and probable value, and the Committee are now in a position to afford a more correct estimate as to the progress of their work than that given in their first Report.

The total number of documents which had been received up to the end of 1868 was 2,416, but of these a large portion consisted of observations made on land or in harbours, while about an equally large number were registers furnished by ships which did not pass through the part of the Atlantic now under investigation. It has been found that out of the first 800 documents examined, only 220 contained matter fitted for extraction in the course of the present inquiry. It seems, therefore, scarcely probable that for the area above named as many as 1,000 logs (being the number named in that report, p. 11) deserving discussion will be found in the office.

The estimated rate of extraction, viz., four days of six hours each for one person for each register, has been fully confirmed, so that as the amount of work to be done was over estimated, it may fairly be hoped that the extraction of data from all logs received up to the end of 1868, will be completed in a shorter space of time than that already named, viz., three years from the present date. When this is done, the question of the discussion and publication of the materials so extracted will have to be taken into consideration.

Supply of unpublished information to the public.

With a view to this object, arrangements have been made by which the clerks who are engaged on marine work are almost entirely relieved from taking part in the preparation of the Daily Weather Report, which formerly occupied a large portion of their time.

As regards the publication of materials in the office by other parties, and the supply of unpublished information to persons engaged in special investigations, the Committee have acted on the principles explained in a circular (App. III.) which is issued in answer to all applications on such subjects. During the year, copies of observations taken in the Indian Ocean during the months of January and February 1861 have been supplied, on the terms named in the circular, to Mr. C. Meldrum, Secretary of the Meteorological Society of the Mauritius, for his synoptic charts of the weather of that part of the world which are now in process of preparation. The Association Scientifique de France has again applied for information relating to the weather of the Atlantic Ocean, and accordingly M. Le Verrier, its president, has received extracts of logs for the year 1865, to aid in the preparation of his weather atlas.* Capt. V. Véron, on the part

* Atlas des Mouvements généraux de l'Atmosphère. *Vide* Report 1867, p. 12.

of the Marine Ministry in Paris, has asked for similar extracts for the month of December 1867, which have been furnished to him. In the case of the observations supplied to the French authorities, the Committee have made no charge for copying, receiving as they do efficient and material aid from France in the department of weather telegraphy.

Instruments: Admiralty account.

As regards the stock of instruments belonging to the office, two separate accounts are kept, one for those intended for Admiralty service, the other for those issued to officers in the mercantile marine. The distinction between these two accounts had not previously been very strictly preserved, so that when the Committee took charge of the office it was found that a considerable number of Admiralty instruments were on service at telegraph stations, in merchant ships, and at the several agencies. These instruments have, with few exceptions, been already recalled, others, where necessary, having been supplied in their stead.

It was also known that the books contained numerous entries of instruments charged against ships which had been for some time out of commission, &c. In each instance a letter has been written to the officer who was in command of the ship when the instruments were first supplied. By this means many of them have been traced to other vessels or restored to the office, while as to others, evidence has been obtained of their having been lost or seriously injured during service, so that they have been written off the books. The Admiralty account is accordingly in a much more satisfactory condition than it was formerly, and there is reason to hope for still further improvement.

In Appendix IV. will be found a list of all instruments supplied to the Royal Navy during the year, and also of the stock of instruments on hand on the 31st December 1868, with their present disposal, as collected from the last quarterly returns of the respective storekeepers.

Instruments: Board of Trade account.

In the case of the Board of Trade instruments, inquiries have been instituted with reference to the present disposal of all that had been issued by the office and were still outstanding. Whenever it was found that they were not employed for the public service they have been recalled. Exceptions, have, however, been made in special cases. The Navigation schools at Plymouth and Leith have each been allowed to keep a set of instruments for instruction of the pupils.

In the case of the Edinburgh Church of Scotland Training College, the special sanction of the Board of Trade having been obtained, permission was granted for a set of instruments to be retained, although the school is not a navigation school.

A considerable number of instruments, of the total value of about 100*l.*, had been at various times supplied on loan to the Scottish Meteorological Society (in addition to the 12 sets presented to it several years ago), principally for use at the stations established by that Society in foreign countries. The Committee

being anxious to avoid interference with the operations of the Society, and at the same time to render them as efficient aid as it was in their power to do, addressed the following letter to the Secretary to the Council in November :—

DEAR SIR,

I AM instructed by the Committee to inform you that this office is engaged in tracing the present disposal of the large number of instruments now outstanding on its books.

It appears that instruments to the total value of 100*l.* have been at various times issued to the Scottish Meteorological Society for use at its various stations, both home and foreign, in addition to the 12 sets originally presented to the Society. I enclose a list of these, and am further instructed to request that you will have the goodness to say whether all of these instruments are required by your Society or not, as in the latter case this office would be glad to have them restored, for use at sea. If, however, your Council wish to retain a part or even the whole of them, I am to inform you that this Committee would be prepared to present such of them as you may require to the Society, so that they can be removed from our books.

There are a series of observations from Janina in this office, which perhaps you might wish to have, in order to complete your records from that station.

(Signed) ROBERT H. SCOTT.

A. Keith Johnston, Esq., LL.D.,
Hon. Sec. Scottish Meteorological Society.

The reply to this letter was not received before the close of the year.*

In App. IV. will be found returns for the Board of Trade instruments, similar to the returns given for those on Admiralty account.

II.—TELEGRAPHIC WEATHER INTELLIGENCE.

Position of stations.

This branch is entirely under the superintendence of Mr. Scott, and an important change has taken place in it during the past year, owing to the development of the system of telegraphic intelligence of storms, which was only being organized at the close of the year 1867. At App. V. will be found a list of the home reporting stations, with the observers' names. They are 17 in number, and are situated 9 in England, 4 in Scotland, and 4 in Ireland, their positions being determined by the conditions of telegraphic communication with the outlying points of the coast. Some of them, like Greencastle and Liverpool, are in sheltered positions, and therefore unfavourably placed for observations of wind; but it is found, as a general rule, that the service is more efficiently performed if the station where the observations are made is one where the amount of ordinary telegraphic business done is considerable than where it is comparatively small. The Committee hope, however, to be

* The Council have, by letter dated Feb. 15, 1869, applied for the instruments in question, which have been accordingly presented to them.

able eventually to place some of their stations at more salient points of our shores than they have hitherto been.*

Improvements in service since last year.

All the stations have been visited by Mr. Scott in the course of the year except Nairn, from which the observer was absent at the time, and the state of things existing was found to exhibit a most marked improvement on that noticed in the first Annual Report. With the view of still further organizing the system, Admiral FitzRoy's pamphlet "Arrangements for Meteorological Telegraphy," was recast, and a new edition entitled "Instructions" was issued. It is hoped that by this means greater uniformity in the service will be ensured. A form of register was prepared for the private use of the observers, and also to afford some uniform plan of keeping a record of all observations taken, for reference in the case, unhappily of frequent occurrence, of errors in transmission of the reports. These changes, together with a strict system of inquiry carried out whenever a report shows a discrepancy with those from adjacent stations, have produced a very marked improvement in the reporting service.

Isolated stations of comparatively little value.

It may at this point be important to draw attention to the absolute necessity of having more than one station in an outlying district like the south coast of Ireland (where there are three), in order that the office in London may be able at once to decide whether any unexpected change reported from an out-station is only owing to an error in telegraphy, or is supported by the independent reports from other stations. The reports from Corunna and Skudesnaes are comparatively of minor value, owing to the stations being isolated. The messages from both of these places are especially liable to errors, caused by the number of different telegraphic lines they have to traverse, and the consequent chance of errors creeping in at the points of change; while even if they be transmitted correctly, independent corroboration of unexpected changes is very urgently needed. From the great distance of these stations it is obviously impossible to obtain satisfactory repetitions of doubtful telegrams, such as those constantly sent for from our own and from the French stations, in time to be of service in drawing up the daily weather reports.

Foreign stations.

The foreign reporting stations have all been organized through the offices of M. Le Verrier, Director of the Observatoire Impérial in Paris, and Captain Véron, the head of the telegraphic service of the French Marine Ministry. From the Observatoire reports are received from Paris (twice daily), and from Strasbourg and Lyons in France, as well as from Skudesnaes (at the entrance of the Stavanger Fjord in Norway), from the Helder, Brussels, and Corunna. In return for these it receives reports from Valencia, Greencastle, Nairn, Scarborough, Yarmouth, and Penzance, and in addition afternoon reports from the two first-named stations. The service with the Marine Ministry under-

* With this view Pembroke has been adopted as a station in place of Weymouth, since March 1st, as there had previously been only one station, Holyhead, on the Welsh coast, while there were four British and two French stations on the coasts of the English Channel.

went an entire reorganization at the commencement of the year, in which this office met with the most cordial co-operation from the French authorities as represented by Captain Véron. The stations which now report to London are Cap Grisnez, St. Mathieu (Brest), Ile de Grognon (L'Orient), Ile d'Aix (Rochefort), Biarritz and Cap Sicié (Toulon); Ile d'Aix sends in addition an afternoon report. The observations are entrusted to the chief watchmen at the newly established telegraphic stations which have been placed along the French coast. These six stations employ Admiral FitzRoy's reporting code, and are managed by the office in Paris on principles precisely similar to our own. In return for this information telegraphic intelligence of the weather prevailing in these islands is supplied to Paris daily, and intelligence of storms whenever it seems necesssary to send it. The service with them, as at present conducted, is most thoroughly satisfactory.

Geographical distribution of stations.

It will be seen from this list that the London office is in connexion with most of the prominent stations on the open seaboard between Cape Finisterre and Bergen; Cuxhaven alone is not fully established, as the direct cable from Hamburg is not yet in working order. It is, however, found by experience that owing to the geographical position of these islands, this office can in most instances transmit intelligence of more value than that which it receives from the continent. Accordingly the most earnest efforts of the Committee must be directed to improving their communications with the west coasts of Ireland and Scotland.

Heart's Content.

The service from Heart's Content has been in operation since the beginning of the year. It had at first been temporarily organized for a period of three months. At the expiration of that time the Committee notified to the Anglo-American Telegraph Company that the state of their funds would not allow of its continuance. On this the directors in the most liberal manner proposed to transmit the message free of cost, over their own line, if the Committee would defray the expense of its transit from Valencia to London. This offer was most thankfully accepted by the Committee, and the service has consequently been continued, its expense to the office being the same as that of an ordinary Irish station.

Preparation of daily weather report.

The daily observations are taken at 8 a.m., Greenwich time, except at Heart's Content, and most of the telegrams arrive in London at about 10 o'clock. An hour is required for their reduction, discussion, and the preparation of the Daily Weather Report, copies of which are at once supplied for the afternoon issue of several of the London papers. 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. Copies of the complete report are then sent by post to the newspapers for next day's morning issue, and to certain seaports which

have applied for it on the terms named in the circular issued by the Committee in March 1867. (See Report, 1867, p. 17.)* In addition, copies are supplied to a few meteorologists at a cost slightly exceeding the expense of postage.

Telegraphic weather intelligence.

The intelligence of storms which is sent out from the office is of different characters, according to the requirements of the place which receives it. In App. VI. will be found a list of the stations which are furnished with drums, in accordance with circular 278 of the Board of Trade issued in December 1867 (App. VII.). These stations are 101 in number, and are situated 68 in England, 26 in Scotland, and seven in Ireland. All the stations have been established and are carried on on the terms laid down in the circular, excepting the dockyards, which are of course under Admiralty management. The messages sent consist of an order to hoist the drum, accompanied by a brief explanation of the reasons why it is to be hoisted. The message is posted up at many stations as soon as it is received, for the public to read. It continues in force for 36 hours *and no longer*, from the time of its receipt, 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.

Weather semaphores.

The experimental semaphores, devised by Captain Toynbee, for the purpose of conveying to shipping intelligence of storms actually blowing, have been on trial since March 1868, but no decided conclusion has as yet been arrived at with reference to their use. Two of them are erected on the Trinity hulk at Blackwall, by the kind permission of the Trinity House ; one at Liverpool, by the assistance of the Mersey Dock Board and the Royal Mersey Yacht Club, and one at North Shields, by the assistance of the corporation of that town.

Telegraphy to Liverpool.

In addition to the foregoing, a special telegram is sent to the Underwriters' Association of Liverpool, whenever the difference between any two barometrical readings taken that morning in these islands, or on the adjacent French coast, exceeds half an inch. The message consists of reports of the atmospherical pressure and the wind at three or four stations. By this means intelligence of the general conditions of weather that morning reaches the underwriters' rooms daily before 1 o'clock, as long as the atmosphere continues in a disturbed condition. Half the expense of transmission of these telegrams is borne by the Association.

Telegraphy to the Continent.

The system of telegraphy of storms to foreign countries is not uniform in its character. To the Marine Ministry in Paris the same messages are sent as to our own south coast and to Jersey. Holland and Hamburg receive special telegrams similar to those which are sent to the Underwriters' Association of Liverpool, and just described. They convey the amount of atmospherical disturb-

* These stations are Banff, Buckie, and Cullen in Scotland; Cromer, Hayle, Hull, Grimsby, Silloth, and Teignmouth in England ; Carnarvon and Port Dinorwic, in Wales, and Belfast in Ireland.

ance, whenever the difference of readings over the same definite area exceeds 0·8 inch. The authorities at Hamburg hoist a drum at that port and at Cuxhaven whenever a telegram is received from London. These stations are thus precisely similar to those on our own coasts. In return for this intelligence immediate intimation is sent to London from France, Holland, and Hamburg, by the meteorological authorities in their respective countries, whenever a storm strikes any part of their coasts.* The arrangements for telegraphy of storms to Italy have been interrupted by the lamented death of Professor Matteucci in the course of the year.

Results of system.

The system of telegraphy of *facts* as contrasted with *prophecies* has thus been in operation for a year, and has proved, on the whole, eminently successful. It is evident that such a system can avail but little for the outlying coasts of Ireland and Scotland, but fortunately these shores are but little frequented by shipping.

It is hoped that by the careful study of weather which is now carried on the earliest signs of approaching disturbance may be more thoroughly known and recognized, so that even these distant stations may be benefited by the system as at present organized. The ports on the east coast of England can usually be warned of a storm in ample time, owing to the general tendency of storms to advance from the westward. As regards the cautionary telegrams sent to Hamburg the success has been most striking. Herr von Freeden, director of the Norddeutsche Seewarte at Hamburg, to whom the messages are sent, states† that—

> Up to the end of December 37 telegrams containing intelligence of actual storms or strong winds were received at Hamburg from the Meteorological Office in London. In 19 cases the storm came in the course of the succeeding night or next day ; in nine cases stiff breezes followed ; in six cases the wind remained high, and in three cases the wind was strong before the telegram arrived ; these latter were easterly winds.

Sunday reports.

The whole service of weather telegraphy is exposed to a serious weekly interruption from being necessarily suspended on Sundays. Even if arrangements for the receipt of telegrams in London were made, the labour would be almost entirely wasted, owing to the non-attendance of the telegraphic officials at their respective stations during the greater part of that day. The institution of a regular Sunday service would necessarily entail the attendance at the out-stations, during the day, of the telegraphist and the person who manages the signals, and would therefore involve large additional expenditure.

Coast-guard returns.

The arrangements which were kindly made by the Comptroller General of Coast-Guard in January 1868, for the supply of regular reports of storms from the stations under his superintendence, on

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* Prof. Mohn, director of the Royal Meteorological Institute of Norway, has entered into similar arrangements since January 1869.

† Jahres-Bericht der Norddeutschen Seewarte für das Jahr 1868, p. 14.

forms devised by the Board of Trade,* were in operation during the greater part of the year. The object of these reports was to afford additional information to the office with reference to the weather experienced on the coast, and thus to show in how far the Daily Weather Reports gave a fair representation of it, and consequently to what extent the Telegraphic Weather Intelligence rested on trustworthy information. These reports were carefully examined for a long period, when it was found that their object would be fulfilled without taxing the time of the coast-guard so heavily, by the records furnished by the self-recording observatories, by that time in full operation. Accordingly, at the request of the Committee, these reports were discontinued from most of the stations, the exceptions being a few selected posts on exposed parts of the Atlantic coast.

Study of weather.

The study of weather has been systematically carried on during the year. A chart is drawn every day, on which the data furnished by the telegraphic reports are entered. These are afterwards discussed according to definite rules, which have already begun to yield satisfactory results.† A large number of these weather charts has by this time been accumulated, and from the great ease with which such graphical representations of the phenomena of different storms can be compared with each other, facilities are afforded for the recognition of the recurrence of previously experienced types of weather. Thus, for instance, the severe southerly storm of January 24, 1868, which caused so much damage in Edinburgh, formed part of a remarkable series of atmospherical disturbances and successive storms. In December last, conditions of barometrical pressure and wind similar to those which had been the precursors of the storm in January were noticed, and they were followed by a southerly storm of nearly equal violence to that felt 11 months previously. In fact the similarity of weather extended over a period of 10 successive days in the two cases. Similar instances, though not so striking, have appeared, and in the direction of this inquiry it may fairly be hoped that solid progress may ultimately be made towards the interpretation of our weather and its most important changes.

Proposed publication of Daily Chart.

The issue to the public of a lithographed copy of the Daily Weather Chart, similar to the "Bulletin International," which is published daily by the Observatoire Impérial in Paris, has been frequently proposed, but the Committee have not considered it advisable to enter on an undertaking which must necessarily be a very costly one (to the extent of at least 350*l.* per annum), when it did not seem probable that the sale of the publication would nearly cover the expense of its production.

Among the lines of investigation which have been of late proposed with reference to the study of weather, has been the principle that the direction and force of the wind are related to

* Form Wr. 37, App. VIII.

† Vide also page 21.

Buys Ballot's law.

the distribution of atmospherical pressure at the earth's surface much more closely than to its actual amount at any one station. This view has long been held by Dr. Buys Ballot, the director of the Royal Meteorological Institute at Utrecht, and he has propounded a rule for foretelling the probable direction of the wind on any day, which may thus be stated :—"If any morning there be a difference of barometrical readings between two adjacent stations, "the direction of the wind which will blow at these stations "during the day will be nearly perpendicular to the line joining "the stations, and will have the place where the reading is lowest "on its left-hand side."

In order to test the truth of this rule, and its applicability to our own weather reports, Mr. Scott has investigated these latter for a period of nine months, and has submitted a report on the subject to the Committee, which they have allowed to be printed for private circulation.*

The general results to which this inquiry has led may be thus stated :—

The storms which were experienced during the entire period were all examined with reference to the total amount of difference between the barometrical readings taken on each day in these islands, or on that part of the coast of the continent which is comprised between Rochefort and the Helder, and from this examination it appeared that "if we notice on any morning a "difference of 0·60 in. between any two stations, the chance is "7 : 3 that there will be a storm within the succeeding 24 hours. "On the other hand, the chance is 9 : 1 that any storm which sets "in will be preceded by unmistakable signs of its approach, "although the barometrical difference of readings may not amount "to 0·60 in. at 8 a.m."

As regards the precise localities where the strong winds are felt a more minute investigation is required. For this purpose the difference between the barometrical readings at the principal stations has been taken daily and calculated as a gradient † for the distance between the stations. The winds experienced in the district adjoining the stations have then been compared with the gradients of the morning immediately preceding the time of their occurrence, both as regards direction and force.

It is found that as regards *direction* 90 per cent. of the strong winds experienced were correctly foretold in accordance with the law above quoted, while as regards *force*, on the assumption that a gradient of 0·12 in. per 100 miles indicated a gale, the percentage of fulfilment amounted to 60. The success was greatest with equatorial winds. These conclusions are very encouraging as general results, inasmuch as they afford a very strong corroboration of the value of the law as the foundation of a practical principle for the issue of cautionary telegrams.

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* Report of an Inquiry into the Connexion between Strong Winds and Barometrical Differences.

† A term first suggested by Mr. Thomas Stevenson, C.E.

Proposed issue of intelligence to collieries.

The Committee have had under consideration the question of supplying telegraphic intelligence of barometrical disturbances to collieries, inasmuch as sudden variations of atmospherical pressure necessarily affect the ventilation of the mines. With this view they have consulted several gentlemen of great experience in the working of collieries. The replies which they have hitherto received have been on the whole adverse to the organization of a system of colliery warnings, so that no scheme for the purpose has been adopted. At the same time intelligence has been sent regularly to certain collieries the proprietors of which have made special application for it.

Issue of fishery barometers on loan.

In order to diffuse among our coasting and fishing population a knowledge of the nature and use of the barometer, the Meteorological Department of the Board of Trade, at Admiral FitzRoy's suggestion, issued barometers of a large size and a peculiar construction, called fishery barometers, on loan to several small ports and fishing stations round the coast.* The number of these instruments which have been thus distributed is very considerable, amounting to 106, of which 57 are in England, 38 in Scotland, and 17 in Ireland (Appendix IX.). The Committee have continued to lend these instruments whenever the applicants seemed to have a fair claim for such assistance. As regards the issue to Scotch stations, the office is fortunate enough to possess, in the Board of Fisheries, advisers thoroughly acquainted with the wants of the fishermen of their own country, and it consequently is guided by their opinion as to its decision in each case. Mr. Primrose, the secretary to the board, spares no pains to arrive at a correct conclusion in each case which is referred to him.

The chief point looked to in granting the loan of an instrument is the existence at the place of a considerable population living by fishing, but yet not wealthy enough to be able to purchase a barometer. In several cases the Committee have succeeded in inducing the landlord of the place to procure such an instrument for the use of his tenants.

Barometer Manual.

A new edition of the Fishery Barometer Manual, written by Admiral FitzRoy, was called for in the course of the year, and the Committee ordered the work to be rewritten, so as to contain a notice of the latest trustworthy results which have been arrived at in the science. This has accordingly been done, and the book was ready for publication at the end of the year.†

Summary.

It will thus be seen that in this branch of the Committee's operations the chief features of the system of weather warnings instituted by Admiral FitzRoy, with the exception of those

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* The National Life Boat Institution has also issued a large number of similar instruments.

† Coast or Fishery Barometer Manual. Board of Trade, 1869. Compiled under the direction of the Meteorological Committee, by Robert H. Scott, M.A. London: Potter, 1869. Price 6*d*.

directly connected with the *prophecy* of weather, have been resumed and are now in full operation.

The preparation of the daily weather report occupies about the entire time of one clerk daily, and the discussions and investigations therewith connected give full employment to another. In order to accelerate the discussion of the telegrams when they come in, and at the same time to provide against a possible interruption of the service, owing to illness of those specially engaged on it, it has been arranged that each junior clerk in the office should in turn give assistance for one hour in the morning in the preparation of the weather report, and thus gain the necessary experience in dealing with the Telegraphic Reporting Code.

It is hoped that during next year the service of an additional clerk can be afforded for the study of weather, connected so intimately as it is with the operations of the third branch of the office.

III.—Land Meteorology of the British Islands.

Establishment of the observatories.

It will be remembered that in the last Report it was stated that three of the observatories established by the Committee, those at Kew, Stonyhurst, and Glasgow, were at work before the end of the year 1867. Within seven months after that time the four remaining stations had commenced their operations. The latest of these in point of date was Valencia, owing to the unavoidable necessity of carrying out considerable alterations in the house selected as the observatory, in order to fit it for the reception of the instruments. All these observatories were inspected by Mr. Stewart in the course of the year.

The following is a list of the stations :

Observatory.	Superintended by	Latitude N.	Longitude W.	Height of Barograph Cistern above Sea Level.	Records Commenced.
		° ′	° ′	Ft.	
Aberdeen -	D. Thomson, M.A., Professor of Natural Philosophy.	57 8	2 5	88·5	April.
Glasgow -	R. Grant, LL.D., F.R.S., Professor of Practical Astronomy.	55 51	4 16	184	January.
Armagh -	Rev. T. Romney Robinson, D.D., F.R.S., Astronomer.	54 22	6 39	207·3	May.
Valencia -	Rev. Thos. Kerr - - -	51 54	10 25	23·0	August.
Stonyhurst -	Council of Stonyhurst College.	53 50	2 25	360·7	January.
Kew - -	Kew Committee of British Association.	51 29	0 18	34	January.
Falmouth -	Royal Cornwall Polytechnic Society.	50 9	5 4	210·8	March.

It will be seen that they are distributed over the British Islands as uniformly as was compatible with the adoption, as far as was practicable, of establishments already in existence, so as

to ensure efficient scientific superintendence. It is very much to be regretted that the necessity of curtailing their operations, imposed on them by the wish of the Treasury contained in their letter of April 10th, 1867 (Report, p. 25), has compelled the Committee to abandon the idea of establishing an eighth observatory in the extreme north of Scotland, as much light would doubtless be thrown on meteorolgy generally and on the history of British weather in particular by records obtained from so distant a station.

Perfecting of system of tabulation, &c.

A considerable time has been required to get the whole system into working order. This could not well be otherwise with instruments of such delicacy and with so novel a scheme of observation. The causes of possible error which speedily showed themselves were very various, and accordingly the Kew Committee of the British Association were requested to turn their attention to the best means of ensuring accuracy in the numerical values obtained from the records furnished by the instruments. The suggestions made by that body have been adopted by the Meteorological Committee, and they compose Part II. of this Report. These suggestions refer, not solely to the tabulations, but also to the entire organization of the system, so as to ensure complete regularity in carrying it out. The operations referred to are conducted in the first instance at the several observatories, and subsequently at Kew, under Mr. Stewart's personal superintendence. It will be seen from the calendar (Appendix No. XII.) that the records and tabulations are sent to Kew weekly, and reach the office in London, where they are discussed, monthly. It is therefore scarcely necessary to say that information from the observatories cannot at present be used in the preparation of the daily weather report.

Proposed publication of records.

In the month of July the Committee began to consider the question of reproducing the instrumental records with a view to their publication. The expense of photolithography was found to be serious, so that it was resolved to have tracings of the curves made in the office, which were subsequently transferred to stone by the anastatic process. The observatories from whence materials for the purpose were available at this early period were Kew, Stonyhurst, and Glasgow; and for these stations the entire records for a space of 13 days in January were lithographed as a specimen, and a limited number of copies were distributed to meteorologists in order to collect opinions as to a future similar publication. The further consideration of the question was then postponed until the autumn, when the Committee resolved to reproduce another series of curves similar to the previous issue and to ask for suggestions as to their discussion. The period selected was the latter part of November, for which time the records were nearly complete.*

Weather study.

The Committee have also directed the attention of their staff

* The curves were issued in March 1869, and very valuable opinions as to the probable utility and the form and character of the proposed publication were received from the gentlemen to whom the impressions were sent.

to the utilization of the work of the observatories for the purposes of weather study. This subject is one of extreme difficulty owing to its absolute novelty. The preliminary trials which have been made have sufficed to show that while the continuity of the instrumental performances leaves little to be desired, the effect of local situation on the phenomena which present themselves for registration is very complicated, so that a much more extensive experience will be requisite before much progress can be made. This is most especially the case with the anemograms. It is found that coast stations, such as Valencia and Falmouth, register much higher velocities of wind than those situated inland, like Kew and Stonyhurst. The records are, however, used, in connexion with the issue of telegraphic weather intelligence, in order to trace the course of the various storms felt on our coasts.

Calculation of mean results.

The calculation of numerical results from the tabulations forms another most important department of the activity of the office. This subject has naturally been productive of a great deal of discussion, most of which has taken place since the beginning of the year 1869.*

It will thus be seen that the conversion of the continuous records furnished by their instruments into the form of mean numerical results, at once satisfactory to science and practically useful to the public, has been a subject which has throughout engaged the most earnest attention of the Committee.

Expenditure.

Deficit in year 1867.

On closing their accounts for the financial year 1867–8 the Committee found that their expenditure had exceeded the amount of the Parliamentary grant by about 500*l.*, as intimated in the note appended to page 26 of their Report. The reasons of this inadequacy of the funds to meet the expenses during the first year were fully set forth in that Report, and it is now unnecessary to recapitulate them.

Present financial position of office.

The amount of the vote for the year 1868–9 was 10,000*l.*, and as will be seen from the balance sheet (App. I.) this sum has received a slight increase from other sources, such as repayments for the supply of weather reports, for instruments sold to observers, and for a self-recording barograph and thermograph

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* In Appendix X. will be found specimens of tables which are now being calculated from the barograms and the dry and wet bulb thermograms. The mode of discussion of the anemograms has not yet been definitely settled. In fact, the entire question of the numerical discussion of the observations is still under consideration.

Table I. gives the monthly means of pressure and temperature, and the absolute maxima and minima of each element with their respective dates; and in addition the monthly means of vapour tension and of dry air pressure.

Table II. gives the five-day means of the readings of the barograms and the dry and wet bulb thermograms. A necessary addition to these tables will be a table of the periodic corrections for the different elements.

In addition to the foregoing, the entire results bearing on pressure, temperature, and humidity, at Kew observatory, for the year 1868, have been discussed; and considerable progress has been made in obtaining similar information regarding Stonyhurst.

disposed of to the India Office. These several additions have raised the debit side of the accounts to a total of 10,259*l.* 5*s.* 2*d.* As regards the credit side the Committee by most careful economy have succeeded in confining the expenditure for the year to somewhat less than 9,000*l.*, including in that sum the amount of 400*l.* for expenses connected with telegraphy, &c., during the month of March, of which the accounts had not been presented before the close of the financial year. Accordingly the Committee find themselves in a position to defray the sudden demand made on them for the expense of fitting up and furnishing a new office, as they, before the close of the year, have received an intimation from Her Majesty's Office of Works to the effect that it will no longer be possible for them to enjoy the possession of the rooms at No. 1, Parliament Street, so long occupied, rent-free, by the Meteorological Department. They are therefore compelled to seek for accommodation elsewhere, and as they possess no furniture, will be obliged to incur considerable expense in procuring fitments, &c., sufficient for their stores of documents and of instruments, and for their staff of clerks.*

Change of office.

The Committee are glad to be able to report that they find themselves in a position which justifies their developing the operations of the office more fully. The most urgent need in this direction, as already urged in last year's report, is the employment of additional clerks so as to accelerate the progress of the work in the Marine Branch, and to cope with the materials for discussion now coming in from the land observatories. This item will be the most important extension of the scheme of the office during the year 1869. For this purpose they contemplated last year (Report, p. 26) an ultimate application to the Treasury for a moderate increase of funds, a step which fortunately does not seem necessary for this year. The appointments alluded to will be all of a temporary nature, so as to be immediately terminable should the funds at the disposal of the Committee not allow of their continuance.

Employment of additional clerks.

The Committee may finally venture to express the hope that by means of great watchfulness in the financial management of the office they may be able, now that the preliminary expenditure has been defrayed, to carry on their operations, although on a more extended scale than heretofore, for the sum of 10,000*l.* during the ensuing financial year, notwithstanding the serious addition to their annual liabilities which has been caused by their being made chargeable with so large an amount for rent and office expenses.

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* On June 1st the office was removed to its new apartments, No. 116, Victoria Street. The rent of these rooms, with the expenses of fire, light, attendance, &c., will amount to about 500*l.* a year.

Summary.

It will have been seen from the foregoing pages that during the year the progress made in the several departments of the work carried on under the Committee's superintendence has been as follows:—

I. *Ocean Meteorology.*—The systematic extraction of information from the registers for the investigation of the meteorology of the Equatorial portion of the Atlantic Ocean has gone on at a steady rate, and the Committee have been able at the close of the year to employ additional assistance to accelerate this work. Various investigations found in an unfinished condition when the Committee took charge of the office have been re-commenced as extra work. Some of these have been completed and furnished to the Admiralty for embodiment in their series of pilot charts; others have been prepared for publication by the office, such as the charts of sea surface temperature for the South Atlantic Ocean.

The issue of instruments on loan to observers of known accuracy has been continued, and the character of the registers received has materially improved. Inquiry has been made into the present disposal of the large stock of instruments out on loan, and by this means many have been recovered for the use of the office.

II. *Telegraphic Weather Intelligence.*—No very material change has been made in the home reporting stations during the year, but the French naval authorities have added three to the number of foreign stations reporting to the office in London, thus rendering the intelligence sent every day much more complete and satisfactory. The system of issue of telegrams conveying the *fact* of an atmospherical disturbance to the coast has been set in activity during the year, and intelligence is sent to 101 stations on our own shores and to the adjacent coasts of the continent.

A systematic study of British weather, and especially of storms, has been commenced, which has begun to lead to satisfactory results. The materials for this have been the daily telegraphic weather reports, and returns from the coast-guard stations; for these latter will in future be substituted the continuous records from the self-registering instruments at the observatories.

The issue of fishery barometers on loan to small ports and harbours has been continued, and a new edition of the Fishery Barometer Manual has been published.

III. *Land Meteorology of the British Islands.*—The seven observatories were all in operation by the end of July. The utilization of the materials furnished by these establishments has formed the subject of most careful deliberation. Specimens of proposed forms of publication of the actual barograms, thermograms, and anemograms have been lithographed and distributed to meteorologists in order to elicit suggestions as to their discussion. The calculation of meteorological mean results from the tabulations has been commenced, and specimen tables for certain

of the elements are appended to this Report (Appendix X.). The attention of the Committee of the Kew Observatory has been drawn in a special manner to the regulation of the processes of observation, and the perfecting of the mode of tabulation of the numerical values of the records. It is hoped that by attention to the rules proposed by them, which form Part II. of this Report, the entire system will be carried on so as to be completely successful.

The relations of the office in London to the observatory of the British Association at Kew have been most satisfactory, the co-operation of that institution in the work has been most freely given, and the records from all the observatories are sent in from Kew to the central office in a state fit for immediate discussion.

Financial.—The expenditure of the past year has been within the income, so that the Committee have been enabled to meet the heavy expense of removal to and furnishing a new office, imposed on them by the necessity of vacating their rooms in Parliament Street. They are also in a position to engage additional assistance in the office so as to make more rapid progress in the important and extensive work they have undertaken. In Appendix XI. will be found a list of the present staff of officials, and of their several occupations.

PART II.

A Description of the Means adopted by the Meteorological Committee for ensuring Accuracy in the Numerical Values obtained from their Self-recording Instruments.

Method of examining observatory records.

In the first Report of this Committee the principles of construction of their self-recording instruments were fully described, and enough was said to render it probable that good results would be obtained; but the final method of tabulating from the traces of these instruments was not then decided on, nor had any scheme been devised for ensuring accuracy in the tabulated numerical values.

The labours of the Committee in this department have been materially aided by suggestions from the superintending Committee of the central (Kew) observatory, and also from the Directors of the various outlying observatories, and as a result the Committee are now satisfied that the process of examination to which the tabulated values are subjected before reaching the central office is such as to afford a satisfactory guarantee of accuracy.

It may be a fitting sequel to the description of these instruments (already given), to give here an account of the method adopted for ensuring accuracy in the results which they afford.

In the first place, the nature of the various instrumental errors and the best method of avoiding these may with propriety be described, and in the next place it may be desirable to give in detail the code of regulations adopted by the Committee for the guidance of their various observatories.

Barograph.

Causes of error in barograph tabulations.

The values of atmospheric pressure derived from this instrument are liable to have their accuracy affected by three causes :—

(1.) By an imperfect temperature compensation.
(2.) By a sluggish action of the mercury in the barograph tube.
(3.) By imperfection in the system of recording and tabulating.

Temperature compensation.

Temperature Compensation.—The method by which the barographs are compensated for temperature has been described in the Report of the Meteorological Committee for the year 1867. The precise position of the fulcrum of the glass rod was determined by means of some preliminary experiments made at Kew upon the first barograph. These experiments consisted in subjecting the instrument to a very considerable range of temperature

artificially produced, while frequent comparisons of its indications with those of a standard barometer gave the means of determining approximately what ought to be the position of the fulcrum. It may be presumed that the determination thus arrived at cannot be wrong more than one-tenth of the whole, and assuming this to be the case, the next point is to find what is the actual daily temperature range at the various observatories. Causes of error in barograph tabulations.

The following table exhibits both the mean and the maximum daily range for each month for each of the seven observatories up to the end of 1868. In all these, with the exception of Stonyhurst, a night observation is made of the temperature of the barograph at 10 o'clock, but the result will show that in Stonyhurst such an observation is unnecessary. It ought here to be borne in mind that from the system adopted in these instruments, namely, constant reference each day to a standard, it is only the daily range of temperature that we have to consider.

From the results of this table it would appear that assuming the temperature adjustment to be one-tenth wrong, the greatest error introduced from this cause into any of the observations during the year 1868 would be about 0·0024 in., while the mean monthly error would be unappreciable in all cases.

We may therefore with confidence presume that in these barographs the method of tabulation exemplified in the Report for 1867 and now practised is sufficiently accurate to obviate all effects of changes of temperature, and that it is unnecessary to resort to that more complicated but perfect system of reduction alluded to in the same Report, by which the influence of temperature may be completely eliminated. The near correspondence between the simultaneous standard and barograph readings, as exhibited in page 32 of this Report, is another proof that the temperature correction is practically perfect.

Sluggishness of Mercury.—As the barograph tube is always in perfect repose, and the adhesion of the mercury to the glass is not counteracted by tapping or moving the tube, it is desirable to test the results obtained in order to see if the influence of adhesion causes a perceptible sluggishness of the mercury. The standard barometers, to which in all cases the barographs are referred are on the other hand subject to motion, and are probably sufficiently moved in the operation of reading to counteract any sluggishness of the mercury. Sluggishness of mercury.

Now, four or five times each day, while the light is cut off from the recording cylinder of the barograph by the clock arrangement, the standard barometer is read. We can thus compare these standard readings with the simultaneous measurements of the barograms, these latter being of course properly tabulated, converted into true inches, and the residual correction applied as described in the Report of the Meteorological Committee for 1867.

Should there be any sluggishness in the mercury of the barograph we might expect to discover it by means of this comparison,

Daily Range of Temperature in Degrees Fahrenheit, as given by the Observation Hours.

1868.	Aberdeen.		Armagh.		Falmouth.		Glasgow.		Kew.		Stonyhurst.		Valencia.	
	Mean.	Max.	Mean.	Max.	Mean.	Max.	Mean.	Max.	Mean.	Max.	Mean.	Max.	Mean.	Max.
January - - -							1·9	4·9			0·2	0·8		
February - - -							1·4	3·0	0·9	1·7	0·2	0·6		
March - - - -							1·7	4·3	0·9	1·7	0·2	1·6		
April - - - -	2·1	3·7					1·6	3·4	1·1	3·1	0·1	0·6		
May - - - -	1·9	5·0			1·4	3·0	1·4	3·0	1·4	3·3	0·2	0·6		
June - - - -	2·1	3·7			1·7	6·7	1·9	4·1	1·5	3·7	0·4	1·8		
July - - - -	3·0	4·8			1·9	3·6	2·1	4·4	2·0	5·6	0·8	3·0		
August - - - -	1·9	3·2	1·7	3·9	1·7	2·8	1·9	4·8	2·7	7·0	0·5	1·3	1·4	2·5
September - - -	2·3	4·6	1·8	3·8	1·8	6·3	2·2	7·3	2·4	8·7	0·5	1·2	1·2	2·6
October - - -	1·5	2·5	1·9	3·6	1·4	3·0	2·0	6·0	0·8	1·8	0·6	2·7	1·2	2·7
November - - -	2·1	3·7	1·9	3·6	1·4	2·8	1·3	3·1	1·0	1·9	0·7	1·3	1·2	2·4
December - - -	2·0	6·3	1·4	2·2	1·1	2·3	1·3	4·9	0·9	2·5	0·7	2·4	1·0	4·3

for in such a case the barograph would lag behind, and thus read too low with a rising and too high with a falling barometer.

If therefore we presume that the standard barometer is free from sluggishness, and denote its readings by S, and those of the barograph by B, then S — B ought in the case of sluggishness of the barograph to be *positive* for a *rising* and *negative* for a *falling* barometer. Causes of error in barograph tabulations.

Several months' observations have been discussed in this manner for each of the observatories, and the result is exhibited in the following table:—

Name of Observatory.	Months used.	S − B (Barometer rising).	S − B (Barometer falling).
		In.	In.
Aberdeen	July to December	+0·00033	−0·00028
Armagh	September to December	+0·00045	−0·00032
Falmouth	August to December	+0·00006	−0·00020
Glasgow	July to December	+0·00027	−0·00025
Kew	January to June	+0·00027	−0·00019
Stonyhurst	January to June	−0·00042	+0·00058
Valencia	August to November	+0·00005	+0·00015

From this table we see how inappreciable in all the observatories is the retardation of the barograph barometer as compared with the standard, while in Stonyhurst the standard even appears to be a trifle more retarded than the barograph barometer.

Errors of recording and tabulating.—Under this head we may include, (A.) errors of adjustment and attachment of paper; (B.) errors of time and date; (C.) errors in tabulating from the traces. To begin with the first of these:—

(A.) *Errors of Adjustment and Attachment of Paper.*

Want of definition arising from an improper adjustment of the lens ought to be noticed, but it is believed that the definition is good in the case of all the observatories. As the instrumental constants for all the various barographs have now been determined, it would hardly seem expedient to alter the position of the lens, which would alter these constants, for the purpose of procuring greater perfection in definition. Errors of adjustment. Want of light.

The photographic sheet which is attached to the cylinder of the barograph ought to be evenly put on without any *bagging* or *bulging*, as if it bulged, besides giving a bad result, it might come into contact with the end of the temperature adjustment bar.

Care ought to be taken that there is no *want of light*, especially in the case of a low barometer; and finally, great precaution should be taken to avoid *finger-marks* and every species of *bad photography*.

(B.) *Errors of Time and Date.*

Suppose that the sheet has been placed in an unexceptionable manner upon the barograph cylinder, the next point is for the Errors of time and date.

Causes of error in barograph tabulations.

Errors of time and date.

operator to set the instrumental clock, before starting, to correct Greenwich mean time, as given by his chronometer. Now the instrumental clock has an arrangement for cutting off the light for four minutes every two hours, beginning to do so two minutes before an even hour and ending two minutes after it, and the practice is for the observer to read the standard barometer about five times every day at periods two minutes after even hours, as ascertained by his chronometer, or when the light should be about to be restored after having been cut off by the clock stop. If therefore the instrumental clock keeps good time and its stop acts, and if the observer reads the standard barometer correctly and at the proper moment as ascertained by his chronometer, and if he finally reduces his curves properly, the near coincidence between the corresponding curve and standard readings will be a good practical test, not only that all these operations have been properly performed, but also that throughout the curve the instrumental clock keeps good time with the chronometer. A further check with regard to time is afforded by the comparison made between the chronometer and the instrumental clock at the moment when the curve is taken off the cylinder, the results of which are recorded on the curve.

The clock may sometimes possibly stop, or the clock-stop may go wrong. Without discussing minutely these possibilities it may be sufficient to state that when any such misadventure occurs the curve ought to be inspected by the director of the central observatory.

There still remains the question of *date*. The security that a curve is rightly dated depends ultimately on the strong improbability that an observer at any of the observatories should make a mistake with regard to the first day of the week. When therefore he returns the barograph journal filled up, we may be quite certain that the observations entered on the line with Sunday were really made on that day, although he may possibly put the wrong day of the month on the form beside it.

Again, the photographic operator when he takes off a curve, should mark on the back in pencil the day of the week and month when the curve was taken off, and should also, after drying, write upon its face the hour and day of putting on and taking off as recorded by the journal. If, therefore, the accuracy of the observer in assigning the proper day of the month to Sunday be checked at Kew as each week's journals are transmitted to that establishment, and if it also be seen that the date written in pencil on the back of the curve corresponds to that written on its face, and if the times of starting and ending of the curve as described in front are found to agree with the curve itself as measured by a simple time scale, there can hardly be any doubt that the curve has been properly dated; if there still remain any doubt it will be dispelled when the tabulations from that curve are examined and it is found that the tabulated readings agree well with the simultaneous readings of the standard barometer.

(C.) *Errors in tabulating from the Traces.*

Causes of error in barograph tabulations. Errors in tabulating.

It will in the first place be necessary to discuss some arrangement for ensuring the entry under the *proper date* into the tabulation forms of the measurements from each curve, for even supposing that by the method now described we can ensure the proper dating of the curve, yet the tabulations from this curve may be entered under the wrong date in the tabulation form.

The appropriate check would seem to be the independent entry from the journal of the standard readings reduced. For if either of these two independent entries be wrongly made this will be seen by a non-coincidence of the reduced readings when compared with the simultaneous standard readings. Our security becomes, therefore, the security which we have that these two independent readings cannot both be erroneously entered, and this may be converted into a certainty if the assistant at the central observatory sees that the journal readings are entered under their proper dates into the barograph tabulation forms.

Having thus ascertained the entry into the tabulation forms under their proper dates of the tabulations and of the reduced standard readings, we come next to inquire what check there is for *accuracy of tabulations;* and here we may consider separately the cases of large and small errors.

But before proceeding to this part of the subject it may be desirable to say a few words regarding the system of barograph tabulation.

The progress made in tabulating the barograms up to the date of publication of the last Report of the Committee has been described in that report. The first operation is, by the aid of a simple tabulating instrument, carrying a scale with a vernier attached to it, and capable of being read to the thousandth of an inch, to measure the whole depth of the barogram for every hour.

This system is nevertheless laborious, implying two measurements and one subtraction for each hour, besides the application of tables of conversion, and the consequence is a liability to make an occasional mistake. But although at first it is absolutely necessary to have in the case of the barograph a tabulating instrument measuring inches, in order by its means to determine the constants of each instrument, yet when once these instrumental constants have been accurately determined it has been found serviceable to replace the tabulating instrument by another which gives the true pressure in one measurement, instead of requiring two measurements, one subtraction and one conversion. Instruments of this nature have been obtained by this Committee for their various observatories, by which the labour of tabulation has been greatly reduced and accuracy of result much increased.

Nevertheless there is still the liability to make an occasional blunder, and as this may take the shape of a large error, it is necessary to devise some means for detecting and obviating all such mistakes.

The best remedy appears to be the use of a simple kind of

Causes of error in barograph tabulations.

subsidiary tabulating instrument, consisting of an ivory scale having a breadth equal to one hour of the time scale, by means of which the hourly depth of the barogram may be read to the hundredth of an inch. If these readings be compared with the readings taken independently by the tabulating instrument, any error in the latter will be at once discovered. For the errors to which the tabulated measurements are liable are such as *five hundredths of an inch*, or *one-tenth of an inch*, errors of a large size which may easily be detected by the system of subsidiary measurement.

Large errors in tabulating.

The following is an example of a day's comparison after this method, exhibiting an error which has thus been brought to light:—

August 29th.	Tabulated reading from weekly Tabulation Sheet to the nearest hundredth. A.	Subsidiary Tabulation with Ivory Scale. B.	A – B in hundredths of an inch.	
1 a.m.	30·22	30·21	+ 1	
2	·22	·22	0	
3	·21	·21	0	
4	·22	·23	– 1	
5	·22	·22	0	
6	·23	·22	+ 1	
7	·24	·24	0	
8	·25	·25	0	
9	·25	·25	0	
10	·26	·26	0	
11	·26	·27	– 1	
Noon	·26	·27	– 1	
1 p.m.	·25	·25	0	
2	·25	·25	0	
3	·26	·27	– 1	
4	·25	·26	– 1	
5	·25	·25	0	
6	·24	·34	– 10	Error.
7	·24	·24	0	
8	·24	·25	– 1	
9	·25	·26	– 1	
10	·24	·24	0	
11	·24	·24	0	
Midnight	·24	·25	– 1	

It ought to be remarked as necessary to the completeness of the check, that the observer should first of all by means of his subsidiary ivory scale fill in column B, and then (meanwhile concealing B from his view) fill in column A from the ordinary tabulation sheets. The correctness of the column A – B should be tested at the central observatory.

Having by this means obtained correct tabulations, the next point is to check the accuracy with which the *residual correction* has been obtained and applied (see Report for 1867, page 46). And first, with regard to the method by which it is obtained, the latest practice has been to calculate it for each day separately, making the day begin at 11 a.m. The advantage of this arrangement is that each fresh paper, which is always put on between

10 and 11 a.m., will have its own residual correction.* The accuracy of calculation of this correction ought to be checked, and such a check may be devised out of the practice pursued at Kew, of taking the mean monthly difference between simultaneous readings of the standard and barograph readings corrected. If these differences are taken for each day apart, beginning the day at 11 a.m. and giving each difference its appropriate sign, then the residual correction may be presumed to be accurate, when for that day there are as many *minus* as *plus* differences. Also, when any such difference exceeds, say, ·005 of an inch, the accuracy with which the standard readings have been reduced to 32° ought in this case to be examined. When a standard reading is evidently wrong it ought to be noted as such on the curve, and should not be made use of either in calculating the residual correction or the monthly mean difference between standard and barograph readings. By applying both the above tests any error in the calculation of the residual correction will be detected and ought to be remedied at once. Having by this means obtained an accurately calculated residual correction, the accuracy with which this is applied to the various hours ought to be tested by the Kew assistant, who, obscuring from his view the column which embodies the values after the residual correction has been applied, should independently apply it on a separate piece of paper, thus producing a new column of corrected pressure, which ought to be compared with the old one ; any error discovered by this comparison should be corrected at once. Before leaving this subject it ought to be stated that the tabulating instrument as well as the subsidiary ivory scale are so arranged as always to ensure reading the proper point of the curve for every odd hour.

Causes of error in barograph tabulations.

Large errors in tabulating.

Should any portion of the curve be too *faint* for measurement with the ordinary tabulating instrument, but not too faint for measurement with the ivory scale, it ought to be measured with this scale, applying to the measurements so obtained their own appropriate residual correction. Such readings ought to be specially noted in the tabulation forms.

Should any part of the curve be *deficient from want of light or any other cause*, it ought not to be inked in. If the deficiency be in the border of the temperature curve it will be possible to correct it, but if it be on the barometric curve this cannot be done.

All curves in which the *clock has stopped or the clock-stop has been out of action* should be personally inspected by the director of the central observatory, in order that he may ascertain if the tabulations have been properly made.

Finally it is right to state that the accuracy of the method of checking the tabulated values now described has been practically confirmed by the bârograms for October at Kew being independently measured by two observers. The results of the two sets when compared together are found to differ very slightly

* A special arrangement regarding the residual correction has been made for Sundays and those days on which there are few observations of the standard barometer.

Causes of error in barograph tabulations.

from one another, the greatest difference being ·008 in., which may be supposed to denote a difference in each of ·004 on either side of the truth. This extreme difference only occurs three times in the course of the month, that is to say, in 744 observations.

The method of subsidiary tabulations now described is thus proved to be effective in discovering the larger errors that the observer is liable to make when he measures the curve. But to ensure an efficient standard of correctness, it is not only necessary

Small errors in tabulating.

that the larger errors should be altogether eliminated, but *smaller errors* should be reduced to a minimum. Thus an observer might be sufficiently cautious in reading his scale to make no large error, yet sufficiently incautious to read erroneously when he came to the third figure of decimals. For rough results such an observer might be reckoned a good one, but for the more delicate class of investigations his figures would be of less value.

The only way of perfectly eliminating this class of errors is for two independent observers to make separate measurements, each with a tabulating instrument, a course involving much additional labour and expense. But it is obvious that the standard barometer affords a ready approximate means of estimating the correctness of an observer's results. For should he be an incautious observer, the mean difference between the simultaneous readings of the standard and the barograph barometer will be comparatively great, but if he both observe his standard and measure his curves well the mean difference will be small.

The following table exhibits the results of monthly comparisons between simultaneous barograph and standard readings for the year 1868 for all the observatories.

MEAN DIFFERENCES between Barograph and Standard Readings.

—	Aberdeen.	Armagh.	Falmouth.	Glasgow.	Kew.	Stony-hurst.	Valencia.
1868.	In.	In.	In.	In.	In.	In.	In.
January -				0·0067	0·0027	0·0032	
February -				0·0045	0·0027	0·0032	
March - -				0·0039	0·0028	0·0025	
April - -	0·0035			0·0035	0·0027	0·0017	
May - -	0·0032		0·0042	0·0036	0·0025	0·0031	
June - -	0·0029	0·0049	0·0029	0·0036	0·0021	0·0021	
July - -	0·0032	0·0045		0·0026	0·0027	0·0032	
August - -	0·0031	0·0033	0·0032	0·0038	0·0025	0·0023	0·0033
September -	0·0023	0·0031	0·0041	0·0031	0·0025	0·0025	0·0027
October -	0·0028	0·0029	0·0024	0·0030	0·0017	0·0028	0·0031
November -	0·0019	0·0024	0·0017	0·0029	0·0015	0·0019	0·0038
December -	0·0022	0·0022	0·0022	0·0028	0·0018	0·0030	0·0033

It is imagined that the mean differences shown by this table have for all the observatories by the end of the year reached a minimum value not much larger than would be obtained by two observers reading the same standard, or by the same observer reading it twice.

But while the simultaneous readings of the standard and barograph barometer afford us one means of testing the correctness of the observation measurements, they do not yet do quite enough; for in the first place these simultaneous differences may be caused in part by an instrumental error or by some local peculiarity, such as rapid heaving of the barometer, and in the next place an observer may unconsciously bestow a greater amount of pains upon the measurements which are simultaneous with standard readings than he does upon his other measurements, and the above differences may not therefore be a true representative of his general correctness. A certain number of remeasurements of the curves of each observatory should therefore be made at the central observatory, and the monthly mean difference between these and the corresponding measurements by the local observer be recorded.*

Thermograph.

Causes of error in thermograph tabulations.

The accuracy of the thermograph results is liable to be deranged by three causes:—

(1.) By a cause depending on the situation and exposure of the instrument.

(2.) By instrumental deficiencies, and especially the arrangements connected with the wet bulb.

(3.) By a deficient system of tabulation.

Situation of Instruments.

Peculiarity of situation.

The situation of their various thermographs was a point carefully considered by the Meteorological Committee, and there is no reason to think that the effect of local peculiarity is considerable in the case of any of their instruments.

In the Report for 1867 this subject was alluded to, and the result of simultaneous comparisons made at Kew between the readings of two sets of dry and wet bulbs was given for the month of February, one of these sets being placed in a frame detached from the main building of the observatory, and the thermometers having very

* It was not until the various observatories had been supplied with their improved tabulating instrument that the final method of making these measurements was decided on. Since the beginning of 1869 the plan has been to make for each month for each observatory 40 remeasurements of the curve at Kew, obtaining also independently the residual correction. These final values are then compared with the corresponding values obtained at the outlying observatories, and the result of this comparison for the first three months of 1869 has been as follows:—

Mean Difference between 1st and 2d Measurements.

——	Aberdeen.	Armagh.	Falmouth.	Glasgow.	Kew.	Stony-hurst.	Valencia.
1869.	In.	In.	In.	In.	In.	In.	In.
January -	0·0020	0·0017	0·0026	0·0022	0·0012	0·0029	0·0017
February -	0·0030	0·0025	0·0023	0·0022	0·0023	0·0031	0·0026
March - -	0·0024	0·0021	0·0025	0·0026	0·0018	0·0030	0·0025

Causes of error in thermograph tabulations.

small bulbs; the other set being the wet and dry bulb standard thermometers of the thermograph frame.

The result seemed to indicate that the local peculiarity of either frame was comparatively small; indeed, taking the average of the month there was no residual difference between the dry-bulbs, while, on the whole, the thermograph wet-bulb stood 0°·12 higher than the other.

A similar comparison made for the month of July gave no residual difference either for the dry or wet bulbs.

Dr. Robinson of Armagh has likewise made a similar comparison between his thermograph dry-bulb and another thermometer placed at a higher elevation, and has obtained as the result of 150 observations made during the months of April and May a mean difference indicating that the thermograph thermometer read on the whole 0°·27 less than the other. While this difference is not large, Dr. Robinson is of opinion that the upper thermometer is more liable to be affected by the sun, and that the thermograph thermometer is in consequence the more correct. No other observations have been made on the subject.

Instrumental Deficiencies.

Wet-bulb arrangements.

The *wet-bulb arrangements* are peculiarly liable to go wrong, and the following course of action is suggested in order to reduce this source of error to a minimum.

The standard thermometers should be read at least five times a day at the moments when the light is cut off by the clock arrangement. The light remains cut off by this arrangement for four minutes, and it is necessary to read the standard thermometers *at the beginning* of this interval; the exact points in the curves corresponding to certain known readings of the standards may thus be determined. When the standards are read the observer ought to notice if both wet bulbs are acting properly. If both are right, the sign $\surd$ should be made after the recorded temperature of the wet standard. If the thermograph wet-bulb is wrong, the sign *t* should be made, and if the standard wet-bulb is wrong, the sign *s*. Either wet-bulb, if found wrong, ought to be put right at once. Should it happen that the wet-bulbs are frozen at the moment of observation, the present temperature being also below 32°, cold water should be poured over the wet-bulbs and the connecting strings. In a few minutes the wet-bulbs will by this means be covered with a fresh coating of ice; this should be repeated if necessary. If this operation is performed two or three times a day during very cold weather, there is reason to believe that the wet-bulb will always be covered with a sufficient coating of ice. But if the wet-bulb and the water of the water vessel be frozen from previous cold, the present temperature being above 32°, the ice of the water vessel may be thawed by warm water, using no more than is necessary for the purpose.

If these regulations be followed during the cold months of the year, it is believed that there are comparatively few instances where we may not know the temperature of evaporation during frost.

During dry weather the wet-bulb arrangement is again liable to go wrong, although from a different cause. The thread, which in the arrangement adopted lies along a copper groove, gets dry in its passage from the water vessel to the bulb, the capillary action ceasing. Sometimes it apparently rights itself without aid, but sometimes it continues wrong until it is put right at the next observation hour. The commencement and termination of such a wrong state of the wet bulb are generally so clearly indicated by the curve itself, that there appears to be little or no uncertainty in ascertaining what observations ought to be rejected. This action would best appear to be prevented by the use of an india-rubber tube lying along the metallic groove, and having one end dipping into the water of the water vessel; and through this tube the thread ought to be carried in its passage from the water vessel to the thermometer. Evaporation is thus avoided, and the arrangement will probably answer in winter. When the supply of water is too rapid, it may be easily and safely altered by turning up the tube.

Causes of error in thermograph tabulations.

Even when the action of the wet-bulb is unexceptionable, water must frequently be added to the water vessel. It is usual for this water to have the temperature of the air, but in cases of a great difference between the two bulbs this will be much above the temperature of evaporation; the consequence is found to be that in such cases there is a rise in the wet-bulb curve which in extreme cases may not completely right itself until a quarter of an hour has elapsed. This can only be remedied by each observatory doing all in its power to ensure that under such circumstances the water supplied to the water vessel shall represent as nearly as possible the temperature of the wet-bulb at that moment, and also that the supply of water from the water vessel to the wet-bulb shall be no greater than is necessary to keep the bulb thoroughly damp without dripping.

With regard to other deficiencies it will only be necessary to remark here such as are peculiar to the thermograph, since all those common to this instrument and the barograph have already been stated under the head of the latter.

In the first place, it should be noticed that there is sufficient *light* to illuminate the whole range of the curve in a proper manner. In order to ensure this, and at the same time procure the best possible definition, the heights of the thermometers may, as occasion requires, and without detriment to the instrument, be altered so as to bring the mean temperature of the time into a central position with respect to the lens and light. This change ought, however, to be made as seldom as possible, perhaps twice or thrice in a year, and when made great care ought to be taken that there is no strain upon the wet-bulb thermometer, through tightness of the thread, whether arising from frost or any other cause.

Insufficient light.

Errors in Trace and Tabulation.

The arrangement proposed for ensuring the entry under the *proper date* into the tabulation forms of the measurements of the thermograph curves, and of the standard readings corrected, is

Errors in trace and tabulation.

Causes of error in thermograph tabulations.

almost precisely the same as that stated in the case of the barograph.

Having ascertained the entry into the tabulation forms under their proper dates of the tabulations, and of the standard readings corrected, we come in the next place to consider the check upon *accuracy of tabulation*, and here as in the case of the barograph it will be necessary to consider separately large and small errors.

Large errors in tabulating.

In the first place, with respect to *large errors*, in order to prevent entirely their occurrence, it is necessary to resort to the system of subsidiary tabulations. An instrument for this purpose has been devised at Kew. It is unnecessary here to state its principle of construction; suffice it to say that the results furnished by it are used in the same manner as in the case of the barograph ivory scale already mentioned. By this means correct columns of tabulated readings may be obtained. Again, with regard to the *standard readings*, all that appears to be necessary is to examine both the accuracy of entry of the standard reading corrected, and the accuracy of tabulation for all those cases in which the recorded thermograph temperature is more than half a degree different from the corresponding standard reading, and to make any correction that may be found to be necessary. When a standard reading is evidently wrong it ought to be noted as such on the curve, and should not be made use of in calculating the monthly mean difference between standard and thermograph readings. Before leaving this subject, it ought to be stated that the tabulating instrument as well as the subsidiary scale are both so arranged as to ensure reading the proper point of the curve for every odd hour.

It ought to be noted that in tabulating from the thermograph curves the tabulating instrument should be set from the observation hours where there is little thermometric fluctuation.

All the dry bulb readings ought to be compared with the corresponding wet-bulb ones, and should the latter ever appear higher than the former, the case ought to be marked.

The *maximum* and *minimum* temperatures furnished by the outlying observatories ought to be checked.

All *large errors* may, it is hoped, be completely obviated by the means now described.

Small errors in tabulating.

With regard to *small errors* the plan adopted is the same as that for the barograph, viz.:—

1. To record the monthly mean difference between the simultaneous standard and thermograph readings.
2. To make 40 remeasurements from each month's curves at Kew.

The following table exhibits the results of the method employed for testing the accuracy of the thermograph tabulations as regards small errors:—

Column headings for each station: (1) Mean Difference between Thermograph and Standard readings. (2) Mean Difference between Thermograph and Standard readings. (3) No. of re-measurements made. (4) Mean Difference between first and second measurements. (5) Mean Difference between first and second measurements.

1868.	Aberdeen. (1) Dry.	Aberdeen. (2) Wet.	Aberdeen. (3)	Aberdeen. (4) Dry.	Aberdeen. (5) Wet.	Armagh. (1) Dry.	Armagh. (2) Wet.	Armagh. (3)	Armagh. (4) Dry.	Armagh. (5) Wet.
January										
February										
March										
April	·17	·16	12	·15	·15					
May	·18	·18	12	·16	·12	·10	·12	12	·12	·10
June	·18	·17	12	·11	·12	·13	·13	12	·09	·14
July	·15	·26	48	·16	·13	·15	·16	48	·10	·10
August	·14	·15	48	·16	·10	·11	·16	48	·10	·09
September	·11	·12	48	·08	·12	·13	·14	48	·06	·09
October	·10	·13	48	·10	·13	·17	·19	48	·07	·07
November	·18	·14	48	·09	·12	·12	·14	48	·11	·09
December	·10	·11	48	·17	·11	·10	·13	48	·06	·09

1868.	Falmouth. (1) Dry.	Falmouth. (2) Wet.	Falmouth. (3)	Falmouth. (4) Dry.	Falmouth. (5) Wet.	Glasgow. (1) Dry.	Glasgow. (2) Wet.	Glasgow. (3)	Glasgow. (4) Dry.	Glasgow. (5) Wet.
January						·14	·16			
February						·13	·13	12	·06	·05
March						·13	·14	12	·04	·05
April						·12	·15	12	·09	·15
May	·13	·12	12	·10	·12	·11	·11	12	·08	·12
June	·13	·09	12	·13	·07	·15	·12	12	·05	·10
July	·12	·15	48	·14	·10	·11	·12	48	·11	·07
August	·08	·14	48	·07	·10	·12	·10	48	·08	·08
September	·09	·09	48	·13	·14	·08	·09	48	·08	·07
October	·09	·09	48	·07	·06	·09	·09	48	·11	·11
November	·08	·07	48	·10	·07	·08	·10	48	·10	·13
December	·08	·07	48	·07	·10	·10	·09	48	·12	·09

1868.	Kew. (1) Dry.	Kew. (2) Wet.	Kew. (3)	Kew. (4) Dry.	Kew. (5) Wet.	Stonyhurst. (1) Dry.	Stonyhurst. (2) Wet.	Stonyhurst. (3)	Stonyhurst. (4) Dry.	Stonyhurst. (5) Wet.
January			12	·06	·05	·06	·11	12	·08	·12
February	·10	·10	12	·05	·06	·11	·20	12	·08	·07
March	·08	·07	12	·04	·03	·18	·35	12	·09	·30
April	·08	·08	12	·04	·05	·12	·15	12	·10	·12
May	·07	·08	12	·04	·07	·10	·16	12	·10	·05
June	·06	·07	12	·06	·08	·10	·15	12	·09	·08
July	·06	·09	48	·15	·08	·13	·13	48	·15	·16
August	·05	·07	48	·04	·06	·08	·10	48	·07	·07
September	·08	·07	48	·04	·06	·08	·09	48	·06	·10
October	·06	·06	48	·06	·05	·08	·08	48	·09	·09
November	·06	·06	48	·06	·04	·05	·08	48	·10	·10
December	·06	·06	48	·06	·05	·07	·09	48	·08	·07

1868.	Valencia. (1) Dry.	Valencia. (2) Wet.	Valencia. (3)	Valencia. (4) Dry.	Valencia. (5) Wet.
January					
February					
March					
April					
May					
June					
July					
August	·09	·08	48	·18	·20
September	·09	·12	48	·12	·10
October	·09	·12	48	·08	·08
November	·09	·10	48	·08	·08
December	·10	·11	48	·04	·05

It is believed that the results of this table afford satisfactory evidence not only of the accuracy with which the standard thermometers are read, but also of the accuracy of tabulation from the traces. A tendency in the monthly mean differences to decrease from their first values at starting will be noticed in the case of all the observatories.

Anemograph.

Causes of error in anemograph tabulations.

The accuracy of the anemograph is, like that of the thermograph, liable to be deranged by three causes:—

(1.) By a cause depending on the situation and exposure of the instrument.

(2.) By instrumental deficiency, such as friction.

(3.) By deficient traces and tabulations.

Situation of Instruments.

Peculiarity of situation.

These instruments are placed on the highest points of the various observatories, and as far as possible out of the reach of local influences. The exposure may therefore be considered good in the case of all the observatories.

Instrumental Deficiencies.

Instrumental deficiencies.

Friction is the most important of these, and may be supposed to affect to a small extent the records both of direction and velocity. The axle of the direction vane moves in a wooden bearing which is saturated with oil. It is believed that when the instrument is regularly attended to the friction consequent upon this arrangement can be kept very small.

As regards the influence of friction upon the velocity records, this has been determined in the case of the Kew instrument, and also by Dr. Robinson for his anemograph, which has been for many years in operation. The following friction coefficient has been adopted, with the concurrence of Dr. Robinson, as applicable to the records of all the anemographs belonging to the Meteorological Committee:—

Observed.	Miles.	Miles.
For velocities from	0·0 to 0·5	add 1·5
,,	1·0 to 3·0	add 1·0
,,	4·0 to 10·0	add 0·5

Errors of Trace and Tabulation.

Errors of trace and tabulation.

It ought to be noticed that *both the direction and the velocity pencils* are working well and freely on the paper.

It is also to be noticed that for all the observatories except Falmouth the *needle on the cylinder* goes through the centre of the crosses marked on the metallic paper.

In Falmouth the velocity pencil is slightly out in position, and in consequence that observatory has been directed to set to a point which is not quite in the centre of the crosses. The Falmouth instrument has also been oriented for this position of setting. A note of the proper position of setting for Falmouth is preserved

at Kew, and the assistant there ought to inspect each Falmouth anemogram to see that it has been properly set. Causes of error in anemograph tabulations.

With regard to *date*, each curve when taken off the cylinder should have both the day of the week and of the month written upon it, and when it reaches Kew it ought to be inspected by the assistant there in order to see that the observer has attached the proper day of the month alongside the day of the week.

He should also see that the week's curves sent are dated consecutively.

With regard to *time*, a prick made in the small time scale of the metallic sheet denotes in terms of the hour lines ruled on this sheet, the moment of starting, and a similar prick that of taking off. These pricks ought to denote the true chronometer times of starting and taking off very nearly, if the instrumental clock has been properly regulated. All *stoppages* of the instrumental *clock* ought to be marked.

It ought also to be noticed that the *cylinder is well clamped*, otherwise the friction of the pencil upon the cylinder may occasionally overcome that of the clamp, in which case the cylinder will slip.

With regard to *errors of tabulation*, the assistant at Kew ought in the first place to ascertain that the curve is tabulated under its *proper date*. Probably an intelligent inspection of the direction and velocity records in connexion with the tabulated results will be sufficient to determine this point. Large errors in tabulating.

A simple system of *subsidiary tabulations* has been adopted in order to check the direction results. The observer at the outlying observatory is requested to write down on a separate sheet in numbers the direction of the wind at each hour as read from the curve by his eye, and compare it as in the case of the barograph and thermograph with the tabulated results. The differences between the two columns, or A — B, ought to be inspected at Kew, and when they are greater than *two points* the case ought to be examined, and any error detected ought to be corrected at once. With respect to direction, fractional parts of a point ought not to be recorded.

With regard to *velocity traces*, the action of the instrument is such as to give by a glance at a curve the whole space travelled over by the wind for that day. Perhaps, therefore, it will be a sufficient check upon the velocity records if, in addition to an intelligent comparison of the traces and tabulations, each day's results are added up and the sum total compared with that derived by glancing at the curve. When the difference between these two daily sum totals is greater than *one-twentieth of the whole*, the tabulated velocities for that day ought to be gone over again, and if any error is detected it ought to be put right at once.

It is probably unnecessary to check the recorded oscillations, as these are of inferior scientific value, and additional labour bestowed upon them would appear to be superfluous.

Finally, in order to keep a check upon *small errors*, the system of making at Kew 40 remeasurements for each month, both for direction and velocity, has been adopted. Small errors in tabulating.

	Aberdeen.			Armagh.*			Falmouth.			Glasgow.			Kew.			Stonyhurst.			Valencia.		
	No. of re-measurements made.	Mean Difference.		No. of re-measurements made.	Mean Difference.		No. of re-measurements made.	Mean Difference.		No. of re-measurements made.	Mean Difference.		No. of re-measurements made.	Mean Difference.		No. of re-measurements made.	Mean Difference.		No. of re-measurements made.	Mean Difference.	
		Direc-tion.	Velo-city.		Direc-tion.	Velo-city.		Direc-tion.	Velo-city.		Direc-tion.	Velo-city.		Direc-tion.	Velo-city.		Direc-tion.	Velo-city.		Direc-tion.	Velo-city.
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
1868.																					
January - -																					
February - -										12	0·8	0·5	12	0·2	0·7	12	0·4	1·0			
March - - -							12	0·5	0·5	12	1·0	0·4	12	0·0	1·0	12	0·0	0·7			
April - -	10	0·5	1·0				12	0·2	0·9	12	0·2	1·0	12	0·3	0·8	12	0·1	0·6			
May - - -	12	0·4	0·8				10	0·3	1·1	12	0·2	0·7	12	0·1	1·0	12	0·7	1·5			
June - -	12	0·5	0·9				12	0·2	1·1	12	0·7	0·3	12	0·5	0·9	10	0·5	1·3			
July - -	48	0·1	0·5				48	0·3	0·6	48	0·3	0·9	48	0·1	0·9	48	0·2	0·5			
August - -	48	0·2	0·5				48	0·3	1·0	48	0·2	0·6	48	0·1	0·5	48	0·4	0·5	48	0·2	0·9
September - -	48	0·2	0·6				48	0·1	0·9	48	0·2	0·8	48	0·1	0·5	48	0·4	0·5	48	0·2	1·0
October - -	48	0·3	0·7				48	0·3	0·6	48	0·4	0·5	48	0·3	0·4	48	0·5	0·5	48	0·4	1·0
November - -	48	0·4	0·6				48	0·2	0·8	48	0·4	0·7	48	0·3	0·3	48	0·3	0·5	48	0·3	1·2
December - -	48	0·3	0·8				48	0·2	0·8	48	0·3	0·7	48	0·2	0·5	48	0·3	0·6	24	0·3	1·2

* The anemograph of Dr. Robinson is somewhat different from the others, and it is only since the beginning of 1869 that the method of checking his results has been finally decided on.

The table opposite exhibits the results of the method employed for testing the accuracy of the anemograph tabulations as regards small errors.

It will be seen from this table that the standard of accuracy, as represented by the smallness of the mean monthly differences, has gradually increased up to the end of the year.

APPENDIX.

APPENDIX I.

METEOROLOGICAL OFFICE REVENUE and EXPENDITURE ACCOUNT for the year ending 31st March 1869.

Dr. REVENUE.				CR. EXPENDITURE.					
To Parliamentary Vote	£10,000	0	0	By Salaries	£2,653	2	0		
„ Balance from year 1867–8	12	4	0	„ Instruments	111	15	2		
„ J. Balbirnie	4	5	0	„ Do (Admiralty)	289	9	7		
„ G. Dornbusch	10	0	0	„ Agencies at Ports	57	19	6		
„ Sale of signal staffs	4	8	3	„ Travelling Expenses	157	7	5		
„ W. W. Rundell	6	7	3	„ Telegraphy	2,284	2	2		
„ India Office	172	2	8	„ Observatories: Expenses	2,014	9	4		
„ S. W. Hodding	3	10	0	„ Do. Outfit	550	9	10		
„ Captain Otter, R.N.	0	15	0	„ Contingencies (Printing, &c.)	396	18	11		
„ Interest on deposit account	45	13	0					£8,515	13 11
				„ Cash in hand	23	2	5		
				„ Advance to Valencia Observatory	50	0	0		
				„ Bank of England account	124	15	10		
				„ London and Westminster Bank	1,545	13	0		
								1,743	11 3
	£10,259	5	2					£10,259	5 2

Examined and compared with the vouchers and found correct.

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

27 April 1869.

APPENDIX II.

The number of ships supplied during the year 1868 was 47, of which number 19 belonged to the various steam-ship companies now collecting observations for this office.

The above statement does not refer to ships in the Royal Navy, all of which are supplied with meteorological instruments from the office.

In addition to the registers returned from the ships referred to, documents amounting altogether to 35 in number have been registered during the year 1868, containing observations made at the following places:—

Place.	Observer.	Nature of Observations.
Aberdare	W. Thomas	Barometrical registry kept at Cwmaman Colliery.
Ascension	Naval Authorities	Daily thermometrical readings and Remarks on Wind and Weather.

Place.	Observer.	Nature of Observations.
Australia (west coast) -	Lightkeeper - - -	Lighthouse Registers (2 stations).
„ Somerset (Queensland)	T. J. Haran, surgeon, R.N. -	Land Meteorological Registers furnished by office, &c.
Bangkok (Siam) -	Dr. Campbell - - -	Meteorological Registers.
Bermuda - - -	Dockyard Authorities - -	Anemometrical Records.
Falkland Islands (Port Louis) - - -	Sir J. C. Ross' Antarctic Expedition.	Meteorological Register and Diagrams.
Do. - - -	„ „ „	Tidal Register.
Harris (Hebrides) -	Capt. F. W. L. Thomas, R.N.	On the mean temperature of air and sea, &c.
Hermit island (St. Martin's cove).	Sir J. C. Ross' Antarctic Expedition.	Tidal Register.
Hong Kong & Shanghai	- - - -	Monthly means of thermometrical readings and Wind observations, &c.
Indian Ocean - -	- - - -	Chart showing 10 different hurricane tracks, prepared by the Government of Mauritius.
Kerguelen's Island (Christmas Harbour).	Sir J. C. Ross' Antarctic Expedition.	Tidal Register.
Lancaster Sound (Port Leopold).	Sir J. C. Ross' Arctic Expedition.	Tidal observations and corresponding barometrical readings, with remarks by Sir J. C. Ross.
Milford Haven - -	E. Edwards - - - -	Anemometrical Readings.
New Zealand (Bay of Islands).	Sir J. C. Ross's Antarctic Expedition.	Meteorological Register and tidal observations.
Nice (Maritime) - -	Dr. A. E. Blest - - -	Meteorological Register kept during October 1863.
Norway - - -	- - - -	Observations at Christiania Observatory and the lighthouses on the Norwegian coast.
Orkney - - -	Rev. C. Clouston - - -	Anemometrical Readings.
Scotland, N.W. coast -	Commander W. Chimmo, R.N.	Observations on ozone.
Sombrero Island - -	R. H. Twigg, C.E. - -	Meteorological Register during Sept. and Oct. 1867, and remarks on the hurricane of 8th and 9th Sept.
America, U.S. (Fort Steilacoom, Camp McPherson).	Dr. D. Walker - - -	Land Meteorological Registers furnished by U.S. Army Medical Department.
Waringstown (Ireland)	T. Waring - - - -	Monthly means of observations taken during the year 1862.

The office has also received during the year numerous printed documents and books from various observers and societies in communication with it, and a regular exchange of publications is kept up with the principal meteorological organizations in foreign countries and in our own colonies.

APPENDIX II.—A List of Documents received from Ships during the year 1868.

Captain's Name.	Ship.	Tons.	Owners.	Voyage.	Months of Register.
Banner, F. W.	Lady of the Lake	307	Turner, Edwards, & Co., Bristol	To and from Callao	6
Blake, E. J.	Panic	449	E. Bates, Liverpool	To and from Singapore	8
Brooker, E. W.	Sylvia	695	H.M.S.	Surveying in China Seas	14
Brooks, Samuel	S.S. City of London	1,880	W. Inman, Liverpool	Five voyages to and from New York	7
Carruthers, F. P.	Minero	478	C. L. Claude, California	To and from Coquimbo	6
Cock, A. H.	Blanche	168	C. T. Wood, Bristol	To and from West Coast of Africa	3
Connop, Albert	Mercara	396	J. M. Gladstone, Liverpool	To Vancouver's Island	4
Cook, T.*	S.S. Russia	1,710	J. F. J. Burns, Glasgow	Six voyages to and from New York	6
Corbett, George	S.S. Lagos	783	African S.S. Co., London	To and from West Coast of Africa	2
Croft, A. J. M.	SS. Calabar	763	African S.S. Co., London	To and from West Coast of Africa	3
Daly, M. J. (Chief Officer)	Ellen Austen	—	Not known	San Francisco to Liverpool	4
Evans, G.	Attila	1,164	J. A. Woods, Newcastle	To and from Calcutta	9
Fry, Alfred	Foam	311	R. & W. King, Bristol	To and from West Coast of Africa	4
Gales, Isaac C.	Flechero	730	J. Hainsworth, Liverpool	To Melbourne, Adelaide, and home	10
Green, W. F.	Silvia	1,401	Moore & Carlyle, London	To Calcutta	3
Hamilton, R. V.†	Sphinx	1,061	H.M.S.	To Newfoundland, West Indies, &c.	5
Harrison, J.	S.S. Aleppo	1,399	Burns & MacIver, Liverpool	Four voyages to and from Boston	4
Harvey, Thomas	Leander	2,760	H.M.S.	Rio Janeiro to Valparaiso	3
Hayes, James	S.S. Cassini	687	Liverpool, Brazil, & R. Plate S.N. Co.	To and from Rio Janeiro	2
Henderson, Henry	Hope	285	Theo. Black, Blyth	To Shanghai	4
Hicks, G. W.‡	Indus	1,319	P. & O. Steam Navigation Co.	To and from Hong Kong	9
Jessen, T. N.	Tuisco	426	T. N. Jessen, Flensburg	Glasgow to San Francisco and Melbourne	8
Kelly, W.	Alexandra	1,352	T. Brocklebank, Liverpool	To and from Calcutta	5
Lecky, S. T. S.	S.S. Uruguay	1,301	Liverpool, Brazil, & R. Plate S.N. Co.	To and from Monte Video	2
Lecky, S. T. S.	S.S. Uruguay	1,301	Liverpool, Brazil, & R. Plate S.N. Co.	To Malta, Trieste, and return	1

* Meteorological Register was kept chiefly by W. Greenwood, 2nd Officer.
† " " " by C. W. Ross, Navigating Lieutenant.
‡ " " " by S. W. Hodding, 2nd Officer.

LIST OF DOCUMENTS, &c.—*continued.*

Captain's Name.	Ship.	Tons.	Owners.	Voyage.	Months of Register.
Luce, J. P.* - -	Esk - -	1,169	H.M.S. - - - -	At Auckland to Sydney, Norfolk Island, Auckland, Fiji, Sydney, Melbourne, Adelaide, Sydney, Auckland, Bahia, and Portsmouth	9
McMicken, W. - -	S.S. Australasian	1,513	Burns & MacIver, Liverpool -	Five voyages to and from New York -	4
Martyn, J. A. - -	S.S. Sidon, China, Tarifa	—	Burns & MacIver, Liverpool -	Four voyages to and from New York -	3
Martyn, J. A. - -	S.S. Siberia -	1,698	John Burns, Glasgow - -	Three voyages to and from Boston -	3
Mayne, R. C., C.B.† -	Nassau - -	695	H.M.S. - - - -	To Rio Janeiro, and several passages between that Port and the Strait of Magellan, surveying - - -	18
Moodie, E. R. - -	S.S. Cuba -	1,534	Burns & MacIver, Liverpool -	Five voyages to, and four from, New York	4
Mossop, Clement -	Candahar -	1,418	T. & R. Brocklebank, Liverpool -	Two voyages to and from Calcutta -	13
Nares, George S.‡ -	Salamander -	818	H.M.S. - - - -	Queensland to England - - -	4
Phelps, Henry§ - -	Orontes - -	2,812	H.M.S - - - -	To and from Malta - - -	1
Potts, T. C. - -	Aracan - -	789	T. & R. Brocklebank, Liverpool -	To and from Calcutta - - -	7
Price, T. F. - -	Pembroke Castle -	410	J. Simpson, Swansea - -	To and from West Coast, South America	5
Reid, C. W. - -	Lord Strathnairn -	1,267	J. Farnworth, Liverpool - -	To and from Calcutta - - -	8
Rivett, Richard - -	S.S. Atrato -	1,970	R.M.S.P. Co., London - -	Four voyages to and from West Indies -	6
Robinson, J. J. - -	Brother's Pride -	1,236	Not known - - -	Cape Frio to Port Payta - -	2
Roskell, T. F. - -	S.S. City of Boston	1,650	W. Inman, Liverpool - -	Four voyages to and from New York -	3
Shortland, P. J.‖ -	Hydra	818	H.M.S. - - - -	In Mediterranean and thence to Bombay, Aden, Natal, and Plymouth	20
Slaughter, Peter -	Spray of the Ocean	805	E. C. Friend, Liverpool - -	To Kurrachee, Annesley Bay, Bombay, and Liverpool	8

* Meteorological Register was kept chiefly by E. W. Creek, Navigating Lieutenant.
† " " " by D. G. Tandy, Lieutenant.
‡ " " " by T. J. Haran, Surgeon.
§ " " " by W. W. Vine, Navigating Lieutenant.
‖ " " " by J. J. Hayward, Paymaster.

LIST OF DOCUMENTS, &c.—*continued.*

Captain's Name.	Ship.	Tons.	Owners.	Voyage.	Months of Register.
Stirling, J.	Evangeline	965	F. A. Clint, Liverpool	From Calcutta	3
Studdert, Robert	Hotspur	1,142	T. E. Smith, Gosforth	To and from Calcutta	7
Thompson, J. M.	British American	1,207	C. Hill, Bristol	To and from Callao	7
Tronson, J. M. (Assistant Surgeon).	Hogue	1,846	H.M.S.	In river Clyde	1
Tully, Thomas	Baroda	1,364	T. Brocklebank, Liverpool	Two voyages to and from Calcutta	15
Watson, T. O.	Peter Joynson	956	P. Joynson, jun., Liverpool	To Calcutta	4
Watson, W.	S.S.Scotia&Palmyra	—	Burns & MacIver	Eight voyages to and from New York	7
Wherland, F.	Tudor	1,986	S. R. Graves, Liverpool	To Callao and Chincha Islands	4
Whiteway, Lewis	Dennis Brundrit	462	P. Whiteway, Runcorn	To and from Valparaiso	7
Wight, H. P.	Gosforth	810	T. E. Smith, Gosforth	To and from Calingapatam	7
Wilkinson, G. R.	Victoria	—	H.M. Colonial S. Sloop	Coast survey, Victoria, Australia	7
Wood, Henry	Evangeline	965	F. A. Clint, Liverpool	To Calcutta	3
Woolward, Robert	S.S. Douro	1,785	R.M.S.P. Co., London	Four voyages to and from West Indies	7
Beaufort, Sir F.	Woolwich	—	H.M.S.	To, at, and from East Indies	24
Crozier*	Terror	—	H.M.S.	To, at, and from Antarctic Regions	50
Dayman, J.*	Leander	—	H.M.S.	Van Dieman's Land to England	5
Parry*	Alexander	—	H.M.S.	In Arctic Regions	2
Parry, W. C.*	Fury	—	H.M.S.	In Arctic Regions	3
Ross, James C.*	Cove	—	H.M.S.	In Arctic Regions	9
Ross, James C.*	Erebus	—	H.M.S.	To, in, and from Antarctic Regions	48
Ross, John*	Actæon	—	H.M.S.	To and from Arctic Regions	13
Ross, John*	Briseis	—	H.M.S.	In the Baltic and on the Channel station	16
Ross, John*	Isabella	—	H.M.S.	To and from Arctic Regions	6
Ross, John*	Victory	—	H.M.S.	In Arctic Regions	38
Unknown*	Whaler	—	-	In Arctic Regions	6

* These documents were received in January 1868, from Lieutenant-General Edward Sabine, President of the Royal Society, &c.

APPENDIX III.

SIR, Meteorological Office, 2 Parliament Street, London.

I AM instructed to inform you that the Committee have decided that

Any public body that wishes to have a copy of any unpublished meteorological information which is in the office can obtain it by stating the nature of the information required, the object for which it is wanted, and by paying the expense of copying.

I am further to state, that in case of the publication of such information or of results derived wholly or in part from it, an acknowledgment of the source from which it has been obtained must be annexed.

I have the honour to be,
Sir,
Your obedient servant

_____

Director.

To

_____

APPENDIX IV.

INSTRUMENTS supplied, &c. to the Royal Navy.

	Barometers.	Aneroids.	Thermometers.			Hydrometers.
			Ordinary.	Max.	Min.	
January 1st, 1868, afloat - -	212	420	881	14	13	233
Issued in 1868 - - -	65	110	267	25	23	40
	277	530	1,148	39	36	273
Returned in 1868 (including damaged Instruments) - - -	89	114	342	29	24	112
January 1st, 1869, afloat - -	188	416	806	10	12	161

ADMIRALTY INSTRUMENTS in use at Stations, including Dockyards, Naval Stations, and Admiralty Surveys by Shore Parties.

January 1st, 1867, in use - -	84	98	177	?	?	40
Issued in 1867 - - -	8	11	25	10	7	—
	92	109	202	10	7	40
Returned in 1867 - - -	22	18	12	3	3	—
January 1st, 1868, in use - -	70	91	190	7	4	40
Issued in 1868 - - -	5	10	5	1	1	—
	75	101	195	8	5	40
Returned in 1868 - -	12	20	62	9	10	1
January 1st, 1869, in use - -	63	81	133	?	?	39

Admiralty Instruments lost, destroyed, &c., *i.e.*, written off Books.

	Barometers.	Aneroids.	Thermometers.			Hydrometers.
			Ordinary.	Max.	Min.	
In 1867	15	23	165	16	11	96
In 1868	5	20	268	14	9	51
Total in two years	20	43	433	30	20	147

Disposition of Admiralty Instruments on January 1st 1869.

Afloat in Royal Navy	188	416	705	*10	*12	158
In merchant ships	2	—	—	—	—	—
At stations for use	63	81	133	—	—	39
In store, at M.O.	164	68	265	43	43	138
„ Woolwich	15	10	39	8	7	12
„ Chatham	3	7	18	2	2	17
„ Sheerness	10	11	42	7	7	13
„ Portsmouth	4	15	24	6	6	26
„ Devonport	5	12	36	9	9	32
„ Queenstown	4	5	11	3	3	12
„ Gibraltar	4	4	6	1	1	4
„ Malta	2	9	46	1	1	28
„ Halifax	5	5	24	3	3	4
„ Bermuda	9	9	18	2	1	16
„ Jamaica	6	3	11	1	1	8
„ Ascension	4	2	10	—	—	—
„ Cape of Good Hope	3	9	11	1	—	16
„ Hong Kong	10	24	45	—	—	24
„ Valparaiso	4	1	23	2	2	16
Totals	505	691	1,467	99	98	563

Instruments supplied &c., to the Mercantile Marine.

	Barometers.	Compasses.	Thermometers.	Hydrometers.
January 1st, 1868, afloat	58	18	332	220
Issued in 1868	49	8	271	192
	107	26	603	412
Returned in 1868	45	14	210	158
January 1st, 1869, afloat	62	12	393	254

Instruments in use at Stations, viz., Telegraph Offices, Lighthouses, Observatories, Navigation Schools, &c.

January 1st, 1867, in use	109	8	279	57
Issued in 1867	19	1	25	6
	128	9	304	63
Returned in 1867	19	—	50	—
January 1st, 1868, in use	109	9	254	63
Issued in 1868	10	—	29	4
	119	9	283	67
Returned in 1868	18	2	29	12
January 1st, 1869, in use	101	7	254	55

* The exact numbers of maximum and minimum thermometers in service are not known, owing to no record of them having been kept previously to 1867.

INSTRUMENTS lost or destroyed in Merchant Ships or at private Stations.

——	Barometers.	Compasses.	Thermometers.	Hydrometers.
In 1867 - - -	11	2	106	30
In 1868 - - -	11	2	157	82
In two years - -	22	4	263	112

DISPOSITION of Board of Trade Instruments on the 1st January 1869.

Where.	Barometers.	Compasses.	Thermometers.			Hydrometers.
			Ordinary.	Max.	Min.	
In merchant ships -	60	12	393	—	—	254
In naval ships - -	—	—	101	—	—	3
In use at stations -	101	7	254	40	39	55
In store at M.O. - -	82	18	218	12	13	118
„ Queenstown -	—	—	12	—	—	—
„ Gibraltar -	—	—	12	—	—	—
„ Bermuda -	1	—	—	—	—	—
At Southampton agency -	2	2	48	—	—	20
„ Bristol - -	4	5	6	—	—	14
„ Liverpool - -	13	7	64	—	—	60
„ Belfast - -	2	3	18	—	—	21
„ Hull - - -	8	5	8	—	—	—
„ Leith - - -	4	1	23	—	—	12
„ Greenock - -	1	2	6	—	—	2
„ Glasgow - -	1	3	1	—	—	12
Totals - -	279	65	1,164	52	52	571

Deep sea Thermometers.—On the 1st January 1869 there were 49 of these instruments on service in the Navy, and one in a merchant ship.

APPENDIX V.

LIST of STATIONS reporting Meteorological Observations by Telegraph to the Office, with the Observers.

Nairn - - -	W. D. Penny - - - -	Schoolmaster.
Aberdeen - -	J. Gibson - - - -	Telegraph Superintendent.
Leith - - -	T. Bolton - - - -	Telegraph Clerk.
Shields - - -	T. Allaway - - - -	Do.
Scarborough - -	F. Shaw - - - -	Do.
Yarmouth - -	T. Robinson - - - -	Do.
Ardrossan - -	W. McNeil - - - -	Do.
Greencastle - -	J. Kelly - - - - -	Do.
Holyhead - -	J. Andrews - - - -	Do.
Liverpool - -	S. Jones - - - -	Do.
Valencia - -	E. O'Sullivan - - -	Do.
Cape Clear - -	G. Griffin - - - -	Do.
Roches Point - -	W. Kennedy - - - -	Do.
Pembroke - -	J. C. Walker - - - -	Do.
Penzance - -	J. Senior - - - -	Do.
Plymouth - -	W. Pinchin - - - -	Do.
Portsmouth - -	T. Hardy - - - -	Do.
London* - -	Clerks in Meteorological Office.	
Heart's Content -	J. Weedon - - - -	Telegraph Superintendent.

* Reports not sent by telegraph.

APPENDIX VI.

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" signals 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 65 in England, 26 in Scotland, and 7 in Ireland.

December 31st 1868.

NORTH.	WEST.	SOUTH.	EAST.
Inverness.	Maryport.	Teignmouth.	Tynemouth.
Nairn.	Workington.	Exeter.	Sunderland.
Burghead.	Whitehaven.	Exmouth.	Middlesborough.
Lossiemouth.	Barrow.	St. Helier } Jersey.	Redcar.
Buckie.	Morecambe.	Gorey }	Whitby.
Portsoy.	Fleetwood.	Cowes.	Filey.
Banff.	Blackpool.	Portsmouth.	Withernsea.
Fraserburgh.	Lytham.	Littlehampton.	Hull.
Peterhead.	Runcorn.	Hastings.	Goole.
Aberdeen.	Southport.	Rye.	Grimsby.
Stonehaven.	Liverpool.	Worthing.	Boston.
Montrose.	Queensferry.	Devonport.	Lynn.
Broughty Ferry.	Mostyn.		Yarmouth.
Dundee.	Holyhead.		Harwich.
Anstruther.	Port Penrhyn.		Chatham.
Alloa.	Carnarvon.		Sheerness.
Grangemouth.	Aberystwith.		Faversham.
Granton.	Milford.		Woolwich.
Leith.	Llanelly.		Ipswich.
Fisherrow.	Porthcawl.		Dover.
Dunbar.	Penarth.		
Eyemouth.	Cardiff.		
Berwick.	Newport.		
	Weston-super-Mare.		
	Burnham.		
	Ilfracombe.		
	Barnstaple.		
	Fremington.		
	Instow.		
	Hayle.		
Glasgow.	Penzance.		
Greenock.	Falmouth.		
Campbelton.			
Girvan.			
	Kingstown.		
	Howth.		
	Belfast.		
	Dungarvan.		
	Youghal.		
	Tralee.		
	Galway.		

Information is also exchanged with France, Holland, Hamburg, and Norway.

Stations added since December 31st, Brighton, Cromer, and Pembrey.

APPENDIX VII.

Circular No. 278. M. 8542.

Telegraphic Weather Information.

Sir, Board of Trade, 30 Nov. 1867.

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 or fishing stations which are accessible by telegraph, notice of serious atmospheric disturbance 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 telegraphic 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 the 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.

I am, &c.

T. H. Farrer.

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

APPENDIX VIII.

*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 of 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 IX.

List of Places supplied with Fishery Barometers.

Those supplied during the years 1867–8 are distinguished by an asterisk.

Shetland Isles.—Sandsair, Lerwick.

Orkney Isles.—Burray.

Scotland, east coast.—Stroma, Staxigoe and Elzie, Sarclet, Lybster, Portmahomack, Cromarty, Avoch, Nairn, Burghead, Portessie, Port Knockie, Portsoy*, Whitehills, Gardenstown, Rosehearty, Pitullie, Findon, Portlethen, 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.—Portsea, St. Helens (Isle of Wight), Gorey (Jersey), Poole, Weymouth, Portland, Budleigh-Salterton, Cawsand, Mevagissey, Gorranhaven, Truro, Devoran, Penrhyn, Falmouth, Newlyn, Mousehole.

England, south-west coast.—St. Ives, Hayle, Port Isaac, Fremington, Burnham, Highbridge.

Wales.—Swansea, Milford.

England, north-west coast.—Fleetwood, Morecambe, Maryport.

Isle of Man.—Port St. Mary*, Peel.

Scotland, south-west coast.—Port Patrick, Stranraer.

Ireland, east coast.—Belfast, Bangor, Strangford, Ardglass, Dundalk, Howth, Kingstown.

Ireland, south coast.—Dungarvan.

Ireland, west coast.—Valencia, Dingle, Tralee, Ballina*, Killybegs*.

Ireland, north coast.—Bunbeg, Burton Port, Dunfanaghy, Rathmullen.

Scotland, west coast.—Portree (Isle of Skye), Plockton ; and in the *Hebrides*, Stornoway, Cromore, Babyle, Obb, Ness.

APPENDIX X.

SPECIMENS of TABLES in process of Calculation.

TABLE I.—MEAN MONTHLY METEOROLOGICAL RESULTS from the continuous Automatic Records at the Seven British Observatories, commencing July 1868.

Months.	Thermometer.					Barometer.					Pressure.	
		Extremes.					Extremes.					
		Max.		Min.			Max.		Min.			
	Means.	Day.	Ther.	Day.	Ther.	Means.	Day.	Bar.	Day.	Bar.	Vapour.	Dry Air.
KEW.												
July - -	67°·3	22nd	89°·6	4th	51°·2	in. 30·035	23rd	in. 30·400	28th	in. 29·614	in. ·399	in. 29·636
August -	63·1	5th	85·2	27th	49·3	29·838	1st	30·273	22nd	29·105	·430	29·408
September -	59·1	7th	85·3	10th	43·3	29·831	7th	30·346	29th	29·192	·380	29·451
October -												
November -												
December -												
Means -												

TABLE 1.—Mean Monthly Meteorological Results from the continuous Automatic Records at the Seven British Observatories, commencing July 1868—*continued.*

Months.	THERMOMETER.					BAROMETER.					PRESSURE.	
	Means.	Extremes. Max. Day.	Max. Ther.	Min. Day.	Min. Ther.	Means.	Extremes. Max. Day.	Max. Bar.	Min. Day.	Min. Bar.	Vapour.	Dry Air.
FALMOUTH.												
July - -	63°4	22nd	78°2	31st	53°8	in. 29·873	31st	in. 30·127	29th	in. 29·440	in. ·450	in. 29·423
August -	61·0	4th	73·8	23rd	53·1	29·728	27th	30·196	21st	29·197	·434	29·294
September -	59·8	8th	72·0	30th	49·1	29·560	1st	30·120	29th	28·805	·434	29·126
October -												
November -												
December -												
Means -												
STONYHURST.												
July - -	62°1	15th	83°3	24th	45°4	in. 29·701	23rd	in. 30·162	28th	in. 29·131	in. ·388	in. 29·313
August -	60·4	4th	84·4	30th	47·0	29·503	1st	29·916	21st	28·805	·385	29·118
September -	55·9	6th	80·0	12th	41·0	29·484	8th	30·098	29th	28·686	·346	29·138
October -												
November -												
December -												
Means -												
GLASGOW.												
July - -	60°6	15th	80°7	23rd	45°3	in. 29·862	23rd	in. 30·325	28th	in. 29·214	in. ·464	in. 29·598
August -	58·6	4th	83·9	26th	47·0	29·616	1st	30·048	22nd	29·082	·341	29·275
September -	53·2	6th	75·0	13th	37·3	29·696	8th	30·311	29th	28·806	·322	29·374
October -												
November -												
December -												
Means -												

TABLE I.—Mean Monthly Meteorological Results from the continuous Automatic Records at the Seven British Observatories, commencing July 1868—*continued.*

Months.	THERMOMETER.						BAROMETER.					PRESSURE.	
	Means.	Extremes.				Means.	Extremes.					Vapour.	Dry Air.
		Max.		Min.			Max.		Min.				
		Day.	Ther.	Day.	Ther.		Day.	Bar.	Day.	Bar.			
ABERDEEN.													
July - -	58°·6	8th	75°·3	23rd	44°·7	in. 29·946	23rd	in. 30·455	28th	in. 29·407		in. ·362	in. 29·584
August -	57·4	1st	75·0	19th	45·3	29·696	2nd	30·112	22nd	29·090		·377	29·319
September -	53·0	5th	71·7	30th	40·9	29·822	8th	30·405	28th	29·021		·322	29·500
October -													
November -													
December -													
Means -													
ARMAGH.													
July - -	61°·1	14th	79·7	23rd	44·6	in. 29·886	23rd	in. 30·330	28th	in. 29·008		in. ·418	in. 29·468
August -	58·3	4th	80·0	19th	43·0	29·636	1st	30·036	21st	29·032		·379	29·256
September -	54·7	6th	77·9	30th	41·2	29·611	9th	30·214	29th	28·665		·361	29·250
October -													
November -													
December -													
Means -													
VALENCIA.													
July - -	—	—	—	—	—	in. —	—	in. —	—	in. —		in. —	in. —
August -	59·3	2nd	77·2	19th	49·6	29·880	30th	30·244	21st	29·084		·392	29·488
September -	57·1	5th	68·6	30th	48·1	29·738	7th	30·342	28th	28·687		·382	29·356
October -													
November -													
December -													
Means -													—

TABLE II.—FIVE-DAY MEANS of the THERMOMETER and BAROMETER, from the continuous Automatic Records at the Seven British Observatories, commencing 30th June 1868.

THERMOMETER.

5 Day Periods.	Kew.	Falmouth.	Stonyhurst.	Glasgow.	Aberdeen.	Armagh.	Valencia.
	°	°	°	°	°	°	°
June 30 to July 4	62·1	61·6*	62·2	63·2	57·6	61·1*	
„ 5– 9	65·7	—	60·7	58·3	58·6	60·1	
„ 10–14	67·6	65·7*	63·3	61·6	57·5	65·4	
„ 15–19	71·1	64·8*	61·8	60·1	60·7	57·9*	
„ 20–24	70·0	65·7*	62·0	59·6	59·9	61·2*	
„ 25–29	66·5	62·8	63·6	62·6	58·5	60·5	
Aug. 30– 3	68·5	63·5	65·6	64·2	61·5	64·8	65·7
„ 4– 8	68·5	64·8	64·5	62·5	61·3	61·3	61·0
„ 9–13	64·2	61·6	60·3*	57·9	56·9	57·3	58·1
„ 14–18	64·5	60·9	62·6	60·6	58·3	59·1	59·4
„ 19–23	59·2	58·6	55·8	55·1	55·2	54·1	56·5
„ 24–28	58·0	58·5*	54·5	52·9	54·6	54·1	57·6
Sept. 29– 2	61·0	60·5	58·9	56·4	56·4	59·1	59·9
„ 3– 7	66·9	64·1	65·2	59·5	60·1	62·0	61·0
„ 8–12	59·2	62·9	54·1	51·5	51·4	51·8	57·5
„ 13–17	56·9	59·1	50·4	48·5	49·3	50·6	58·1
„ 18–22	57·8	58·8	56·4	54·3	53·8	55·5	55·8
„ 23–27	56·9	56·4*	53·3	52·3	50·7	52·8	54·2
Oct. 28– 2							
„ 3– 7							
„ 8–12							
„ 13–17							
„ 18–22							
„ 23–27							
Nov. 28– 1							
„ 2– 6							
„ 7–11							
„ 12–16							
„ 17–21							
„ 22–26							
Dec. 27– 1							
„ 2– 6							
„ 7–11							
„ 12–16							
„ 17–21							
„ 22–26							
„ 27–31							
Means							

* In every case in which, owing to any cause, five hourly records are deficient during the five days to which the mean refers, the figures have been marked with an asterisk. The committee would observe that the records for 1869 show a marked improvement as regards continuity on those obtained in the previous year.

TABLE II.—Five-Day Means of the Thermometer and Barometer, from the continuous Automatic Records at the Seven British Observatories, commencing 30th June 1868.—*continued.*

WET THERMOMETER.

5 Day Periods.	Kew.	Falmouth.	Stony-hurst.	Glasgow.	Aberdeen.	Armagh.	Valencia.
	°	°	°	°	°	°	°
June 30 to July 4 -	54·9	57·7*	55·7*	57·4	51·3*	55·9*	
„ 5– 9 -	57·0	—	57·1*	54·3	53·8*	55·9	
„ 10–14 -	60·3	61·7*	57·3	55·3*	53·6*	59·5*	
„ 15–19 -	62·5	61·7*	57·5	55·5	55·7*	55·2*	
„ 20–24 -	60·9	60·8*	57·5	55·8	54·5*	58·3*	
„ 25–29 -	59·9	58·9*	56·1	56·0	54·9*	55·4*	
Aug. 30– 3 -	58·4*	59·5*	58·6	57·9	57·3	59·1	60·9
„ 4– 8 -	62·2	60·9	58·2	57·2	56·8*	57·1	56·9*
„ 9–13 -	60·0	57·6	57·1	55·2	53·7*	54·9	54·4
„ 14–18 -	61·6	58·1	56·7	56·7	55·2	54·9	54·9
„ 19–23 -	55·9	54·5	52·1	51·6	51·4*	51·2	52·6
„ 24–28 -	53·1	54·4*	51·1	50·1	49·4*	51·0	55·1
Sept. 29– 2 -	57·4	67·9	55·8	54·1	52·7*	56·1	57·7
„ 3– 7 -	60·9	61·3	60·7	56·4	56·7	57·3*	56·2
„ 8–12 -	53·6	58·0*	50·4	47·5	47·5	50·1	54·1
„ 13–17 -	51·1	56·0*	46·6	44·6	45·4	47·2	54·3
„ 18–22 -	55·1	56·5	53·3	52·4	52·5	53·3	53·1
„ 23–27 -	54·1	—	51·0	49·7	48·6	51·5	51·7
Oct. 28– 2 -							
„ 3– 7 -							
„ 8–12 -							
„ 13–17 -							
„ 18–22 -							
„ 23–27 -							
Nov. 28– 1 -							
„ 2– 6 -							
„ 7–11 -							
„ 12–16 -							
„ 17–21 -							
„ 22–26 -							
Dec. 27– 1 -							
„ 2– 6 -							
„ 7–11 -							
„ 12–16 -							
„ 17–21 -							
„ 22–26 -							
„ 27–31 -							
Means -							

* See note, p. 59.

TABLE II.—Five-Day Means of the Thermometer and Barometer, from the continuous Automatic Records at the Seven British Observatories, commencing 30th June 1868—*continued.*

BAROMETER.

5 Day Periods.	Kew.	Falmouth.	Stony-hurst.	Glasgow.	Aberdeen.	Armagh.	Valencia.
	in.	in.	in.	in.	in.	in.	in.
June 30 to	29*	29*	29*	29*	29*	29*	29*
July 4 -	1·105	·955	·806	1·111*	1·100*	1·047	
„ 5– 9 -	1·083	·945	·735	·893	·980*	·921	
„ 10–14 -	1·061	·860	·787	·996	1·129	·994*	
„ 15–19 -	·976	·885*	·595	·712	·769	·754*	
„ 20–24 -	1·171	·861*	·812	·973	1·053	·990	
„ 25–29 -	·821	·732*	·499	·656	·785	·453*	
Aug. 30– 3 -	1·069	·906	·738	·886	·978	·869	·988
„ 4– 8 -	·864	·695	·419	·503	·504	·505	·771
„ 9–13 -	·695*	·501	·331	·486	·642	·462*	·646
„ 14–18 -	·732	·540*	·461*	·707	·843	·679	·826
„ 19–23 -	·729	·670*	·461	·483	·532	·535	·853
„ 24–28 -	1·071	·961	·575	·615	·583	·732	1·087
Sept. 29– 2 -	1·184	1·039	·772	·869	·911	·897	1·156
„ 3– 7 -	1·111	·908	·752	·894	·973	·832	1·063
„ 8–12 -	1·118*	·851	·837	1·062	1·182	·959	1·126
„ 13–17 -	·849	·549	·578	·830	·944	·743	·742
„ 18–22 -	·642	·262	·309	·588	·785	·513*	·602
„ 23–27 -	·561	·255*	·139	·341	·471	·139*	·372
Oct. 28– 2 -							
„ 3– 7 -							
„ 8–12 -							
„ 13–17 -							
„ 18–22 -							
„ 23–27 -							
Nov. 28– 1 -							
„ 2– 6 -							
„ 7–11 -							
„ 12–16 -							
„ 17–21 -							
„ 22–26 -							
Dec. 27– 1 -							
„ 2– 6 -							
„ 7–11 -							
„ 12–16 -							
„ 17–21 -							
„ 22–26 -							
„ 27–31 -							
Means -							

* See note, p. 59.

APPENDIX XI.

LIST of PERSONS in the EMPLOYMENT of the METEOROLOGICAL COMMITTEE on December 31st, 1868, with their Occupations and Amount of Yearly Salary.

Name.	Duties.	Salary.
		£ s. d.
Robert H. Scott -	Director of the Office - - - - -	800 0 0
Capt. H. Toynbee -	Marine Superintendent - - - - -	400 0 0
Senior Clerks.		
W. Salmon, R.N. -	Ocean meteorology; reduction of logs - -	210 0 0
J. S. Harding, jun. -	Correspondence and accounts - - -	160 0 0
R. Strachan - -	Care of instruments, and correspondence therewith connected* - - - - - -	190 0 0
F. Gaster† - -	Preparation of weather report, and investigations of daily weather by returns from Observatories - - - - - - - -	110 0 0
Junior Clerks.		
C. Harding - -	Ocean meteorology; reduction of logs - -	100 0 0
R. H. Curtis - -	Do. Do. - - -	83 10 0
F. Steventon - -	Preparation of weather reports, and assistance to Mr. Gaster - - - - - -	80 0 0
J. S. Harding, sen.	Registry of documents, and assistance in accounts - - - - - - -	‡78 0 0
Commissionaire -	Messenger; assistance in instrument room when required - - - - - - -	21*s.* per week.
Balfour Stewart -	Secretary to the Committee; Director of the Normal (Kew) Observatory - - -	£ s. d. 400 0 0
Rev. Thos. Kerr -	Director of Valencia Observatory - - -	250 0 0

All junior clerks give assistance in turn in the preparation of the weather report, when required.

APPENDIX XII.

CODE of REGULATIONS adopted by the METEOROLOGICAL COMMITTEE for ensuring ACCURACY in the RESULTS derived from their SELF-RECORDING INSTRUMENTS.

In the first place a set of rules have been framed for the guidance of the various observatories, including the central observatory at Kew. Secondly, a set of forms have been constructed on which to register the deficiencies and mistakes in the returns from the various observatories, copies of which when filled up are forwarded to the directors of these observatories on the one hand and to the Meteorological Office on the other. Thirdly, a diary of operations has been constructed, from which each observatory may know the times at which the various documents ought to be sent to Kew. Fourthly, each month's results are laid before the Meteorological Committee, accompanied with the remarks of the

* Including an allowance of 50*l.* for care of instruments.
† Mr. S. Jeffery was engaged in January 1869, for the discussion of returns from observatories; salary 3*l.* per week.
‡ Calculated weekly.

director of the central observatory, which are then printed in the minutes of that body.*

Regulations for Barograph.

Outlying Observatory.

(1.) The curves, journals, and tabulation forms to be written upon according to the pattern furnished.

(2.) Always begin a new month with new forms. The curves and forms are to be numbered consecutively from the beginning of the year, as will be seen from the diary.

(3.) Clock to be set to Greenwich mean time at starting, and its error not to exceed two minutes in two days.

(4.) The barograph thermometer and the standard barometer, and its attached thermometer, ought to be read five times a day, if possible, while the light is cut off by the clock-arrangement. The light remains cut off by this arrangement for four minutes, and it is necessary to read the standard barometer *at the end* of this interval—the exact points in the curve corresponding to certain known readings of the standard may thus be determined. It ought to be noticed when the standard is heaving or oscillating.

(5.) The instrument should always be started between 10 and 11 a.m. Greenwich mean time on those days mentioned in the diary.

(6.) Every change made in the instrument, every stoppage of clock, &c., and all peculiarities in the curve, noticed by the observer, should be inserted in the journal under the head of "Remarks," with the exact time attached thereto. Should the height of the barometer cistern be altered, or any change made which will affect the curve, this ought, as already mentioned, to be noticed; it is, however, considered that all such changes ought to be avoided.

(7.) The previous week's curves, journals, and tabulations should be sent to Kew every Thursday, as mentioned in the diary.

Central Observatory (Assistant).

(8.) The assistant at Kew shall examine each curve in order to see if there is any want of light or appearance of bagging, or of finger marks, or of bad photography, and he shall occasionally see that the temperature bar is in proper action.

(9.) He shall see that the clock and clock-stop have been in good action for the time of the curve.

(10.) That the instrumental clock does not differ more than two minutes from the chronometer as recorded on the curve.

(11.) That the date written on the back of the curve agrees with that on the face.

(12.) That the curve is properly written upon after the pattern.

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* In these remarks there is recorded, amongst other things, each blank in the traces during the month. The following were the blanks for February 1869:—

Anemograph (direction)	-	10	hourly records	lost out of	4,704.
Ditto (velocity)	- -	20	„	„ „	4,704.
Barograph	- - -	13	„	„ „	4,704.
Thermograph (dry bulb)	-	2	„	„ „	4,704.
Ditto (wet bulb)	- -	12	„	„ „	4,704.

(13.) That in the barograph journal the proper day of the month is placed alongside of Sunday, and that the others follow consecutively.

(14.) That the times of starting and stopping the curve as recorded in the journal have been properly recorded on the face of the curve.

(15.) Finally, he shall ascertain, by means of a simple inspection of the curve, that the beginning and ending, as shown by the curve itself, are the same as those described on the face of the curve.

(16.) He shall see that the journal readings of the standard barometer are entered under their proper dates into the barograph tabulation sheets.

(17.) Then examine in a general manner the accordance of the barograph and standard readings for each day. If these two tests be satisfactory he may conclude that the tabulations and standard readings have both been entered under their proper dates.

(18.) Check the accuracy of the subtractions made in the tables of subsidiary measurements furnished by the outlying observatory.

(19.) Investigate all cases where A − B is greater than ·02 in.; if an error be revealed in the tabulations, this error ought to be corrected at once. These corrections ought to be made before the next step in the process is commenced.

(20.) Then ascertain the accuracy with which the residual correction has been found according to the method described, and whenever it has been found necessary to alter the residual correction, a correction should also be made in the last column of the tabulation papers.

(21.) Then check, after the manner described, the accuracy with which the residual correction has been applied, producing a new column of corrected pressure, which he shall compare with the old one, and any error discovered by this comparison shall be corrected at once.

(22.) Portions of the curve too faint for the ordinary instrument, but capable of being measured by the ivory scale, shall be measured, corrected, and marked as specified.

Central Observatory (Director).

(23.) The assistant at Kew shall bring all curves and tabulations which exhibit deficiencies personally before the director of the central observatory, and the latter shall make the necessary remarks on the curves and tabulations, or cause them to be made, and shall communicate all cases of failure to the Meteorological Committee on the one hand and to the director of the observatory where the failure occurred on the other, making any remark that may tend in his estimation to obviate in future the cause of failure.

(24.) He shall also communicate as above the monthly mean differences between the barograph readings reduced, and the simultaneous standard readings.

(25.) He shall also communicate as above the result of 40 remeasurements for each observatory for each month, to be made at Kew, noting (1) the greatest difference, (2) the mean difference irrespective of sign, (3) the residual difference (if any), taking signs into account.

Regulations for Thermograph.

Outlying Observatory.

(1.) The curves, journals, and tabulation forms to be written upon according to the pattern furnished.

(2.) Always begin a new month with new forms. The curves and forms are to be numbered consecutively from the beginning of the year, as will be seen from the diary.

(3.) Clock to be set to Greenwich mean time at starting, and its error not to exceed two minutes in two days.

(4.) The standard thermometers should be read at least five times a day at those moments when the light is cut off by the clock-arrangement. The mode of dealing with the wet-bulb has been already described, p. 34.

(5.) The instrument should always be started between 10 and 11 a.m. Greenwich mean time, on those days mentioned in the diary.

(6.) Every change made in the instrument, every stoppage of clock, &c., and all peculiarities in the curve noticed by the observer, should be inserted in the journal under the head of "Remarks," with the exact time attached thereto.

(7.) The muslin and connecting threads ought to be taken off the bulbs, washed, and replaced as often as they become soiled.

(8.) The previous week's curves, journals, and tabulations should be sent to Kew every Thursday, as mentioned in the diary.

Central Observatory (Assistant).

(9.) The assistant shall examine each curve in order to see if there is any want of light, bagging, finger marks, bad photography, or defective action of wet bulb, during however short a space of time.

(10.) He shall see that the clock and clock-stop have been in good action for the time of the curve.

(11.) That the instrumental clock does not differ more than two minutes from the chronometer as recorded on the curve.

(12.) That the date written on the back of the curve agrees with that in front.

(13.) That the curve is properly written upon after the pattern adopted.

(14.) That in the thermograph journal the proper day of the month is placed alongside of Sunday, and that the others follow consecutively.

(15.) That the times of starting and stopping the curve as recorded in the journal have been properly recorded on the face of the curve.

(16.) He shall ascertain, by means of a simple inspection, that the beginning and ending, as shown by the curve itself, are the same as those described in front of the curve.

(17.) That the journal readings of the standard thermometer are entered under their proper dates into the thermograph tabulation sheets.

(18.) He shall examine in a general manner the accordance of the thermograph and standard readings for each day. If these two tests be satisfactory, he may conclude that the tabulations and standard readings have both been entered under their proper dates.

(19.) Check the accuracy of the subtractions made in the tables of the subsidiary measurements.

(20.) Investigate all cases in which A — B is greater than 0°·5 Fah.; and if an error is revealed, it ought to be corrected at once.

(21.) Examine both the corrected standard reading and the corresponding tabulated one for all those cases in which there is a difference greater than 0°·5 between the two.

(22.) Compare the dry-bulb readings with the corresponding wet ones, marking and examining all those cases in which the latter appear higher than the former.

(23.) Check the accuracy of the maximum and minimum temperatures furnished by the outlying observatories.

(24.) Record the monthly mean differences between the simultaneous standard and thermograph readings.

(25.) Make 40 remeasurements as specified.

Central Observatory (Director).

(26.) The assistant at Kew shall bring before the director of the central observatory all curves, with their corresponding tabulations, that are deficient from any cause, and the director shall make the necessary remarks on the curves and tabulations, or cause them to be made, and shall communicate all cases of failure to the Meteorological Committee on the one hand, and to the director of the observatory where the failure occurred on the other, making any remarks that may tend in his estimation to obviate in future the causes of failure.

(27.) The director of the central observatory shall also communicate as above the monthly mean differences between the simultaneous thermograph and standard readings, as well as the result of the 40 remeasurements made at Kew.

REGULATIONS FOR ANEMOGRAPH.

Outlying Observatory.

(1.) The curves and tabulation forms to be written upon according to the patterns furnished.

(2.) Always begin a new month with new tabulation forms. The curves and forms are to be numbered consecutively from the beginning of the year, as will be seen from the diary.

(3.) The pricks on the curve, when compared with the Greenwich mean times of commencement and taking off, ought to agree with the latter within five minutes at each end.

(4.) The curve should be taken off at 10h. 30m. a.m., and a new one replaced if possible at 10h. 32m., Greenwich mean time.

(5.) Every change made in the instrument, every stoppage of clock, &c., and all peculiarities in the curve noticed by the observer, should be recorded on the blank part of themetallic sheet of paper, with the exact time attached thereto. The orientation should be tested once a month.

(6.) The previous week's curves and tabulations should be sent to Kew every Thursday, as recorded in the diary.

Central Observatory (Assistant).

(7.) The assistant at Kew shall examine each curve in order to see if both pencils work well and freely, and if the paper has been accurately attached to the cylinder, and if the cylinder has not slipped.

(8.) He shall see that the clock has been in good order during the time of the curve.

(9.) That the curve is properly written upon after the pattern adopted.

(10.) That in the writing upon the curve the proper day of the month is placed alongside the day of the week.

(11.) That the times of putting on and taking off as recorded by the pricker do not differ more than five minutes from the chronometer time.

(12.) He shall inspect the direction and velocity curves in connexion with the tabulated results, in order to ascertain that each curve is tabulated under its proper date.

(13.) Check the accuracy of the subtractions made in the tables of the subsidiary direction measurements.

(14.) Examine all cases in which A — B is greater than *two points*, and if an error is revealed it ought to be corrected at once.

(15.) Check the accuracy of the velocity tabulations, according to the method herein indicated ;

(16.) Make 40 remeasurements for each month, both for direction and velocity, as in the case of the other instruments.

Central Observatory (Director).

(17.) The assistant at Kew shall bring before the director of the central observatory all curves, with their corresponding tabulations, that are deficient from any cause, and the director shall make the necessary marks on the curves and tabulations, or cause them to be made, and shall communicate all cases of failure to the Meteorological Committee on the one hand, and to the director of the observatory where the failure occurred on the other, making any remarks that may tend in his estimation to obviate in future the causes of failure.

(18.) The director of the central observatory shall also communicate as above the result of the 40 remeasurements made at Kew.

I.—WEEKLY FORM FOR REGISTERING DEFICIENCIES.

_____ BAROGRAMS, &c.

(*Received at Kew,* _____.)

Tabulation No. and corresponding Documents.

Points noticed at Kew.	Results and Remarks.
1. Deficiency in number of documents sent -	
2. Errors in numbering and writing upon them -	
(A.) Want of light in curves - - -	
(B.) Bagging in do. - - -	
(C.) Finger marks, &c. in do. - - -	
3. Action of clock - - - -	
4. Regulation of do. - - - -	
(D.) Action of clock-stop - - -	
5. Errors in dating curves - - -	
(E.) Do. in entry or date of entry of journal readings of standard into tabulation sheets - -	
6. Do. in date of entry of tabulated readings into tabulation sheets - - - -	
7. Do. of subtraction in subsidiary tables -	
8. Do. of tabulation discovered by subsidiary tables	
(*c.*) Do. in calculating residual correction - -	
(*d.*) Do. in applying residual correction - -	
9. Ten remeasurements - - - -	
(1.) *Greatest difference* - - -	
(2.) *Mean difference irrespective of sign* -	
(3.) *Residual difference* - - -	

II.—WEEKLY FORM FOR REGISTERING DEFICIENCIES.

_____ THERMOGRAMS, &c.

(*Received at Kew*, _____.) Tabulation No. and corresponding Documents.

Points noticed at Kew.	Results and Remarks.
1. Deficiency in number of documents sent -	
2. Errors in numbering and writing upon them -	
(A.) Want of light in curves - - -	
(B.) Bagging in do. - - -	
(C.) Finger marks, &c., in do. - - -	
(*a.*) Defective action of wet bulb - - -	
3. Action of clock - - - -	
4. Regulation of do. - - - -	
(D.) Action of clock-stop - - - -	
5. Errors in dating curves - - -	
(E.) Do. in entry or date of entry of journal readings of standard into tabulation sheets - -	
6. Do. in date of entry of tabulated readings into tabulation sheets - - - -	
7. Do. of subtraction in subsidiary tables -	
8. Do. of tabulation discovered by subsidiary tables	
(*b.*) Do. in maxima and minima - - -	
9. Ten remeasurements.	
(1.) *Greatest difference* - - -	
(2.) *Mean difference irrespective of sign* -	
(3.) *Residual difference* - - -	

III.—WEEKLY FORM FOR REGISTERING DEFICIENCIES.

_____ ANEMOGRAMS, &c.

(*Received at Kew*, _____.)

Tabulation No. and corresponding Documents.

Points noticed at Kew.	Results and Remarks.
1. Deficiency in number of documents sent -	
2. Errors in numbering and writing upon them -	
(*e.*) Action of pencils - - - -	
(*f.*) Errors of attachment of paper - - -	
(*g.*) Slipping of cylinder - - - -	
3. Action of clock - - - -	
4. Regulation of do. - - - -	
5. Errors in dating curves - - -	
6. Do. in date of entry of tabulated readings into tabulation sheets - - - -	
7. Do. of subtraction in subsidiary tables -	
8. Do. in direction discovered by subsidiary tables	
(*h.*) Do. in velocity discovered by subsidiary arrangement - - - - -	
9 (*a.*) Ten remeasurements (*direction*).	
(1.) *Greatest difference* - - -	
(2.) *Mean difference irrespective of sign* -	
(3.) *Residual difference* - - -	
9 (*b.*) Ten remeasurements (*velocity*). - -	
(1.) *Greatest difference* - - -	
(2.) *Mean difference irrespective of sign* -	
(3.) *Residual difference* - - -	

Specimen of Diary of Operations for 1869.

JANUARY.

Day of Month.	Day of Week.	No. of Bar. and Ther. Sheets taken off this day.	No. of Anem. Sheet taken off this day.	No. of Journals and Tabulations ending this Day.	Send to Kew.				Remarks.
					Bar. and Ther. Curves, Nos. inclusive.	Anem. Curves, Nos. inclusive.	Journals and Tabulations, Nos.	Weather Report for	
1	Frid. -	1	1						
2	Sat. -		2	1					
3	**Sun.** -	2–3	3						
4	Mon. -		4						
5	Tues. -	4–5	5						
6	Wed. -		6						
7	Thur. -	6–7	7		1 to 3	1 to 3	1		
8	Frid. -		8						
9	Sat. -	8–9	9	2					
10	**Sun.** -		10						
11	Mon. -	10–11	11						
12	Tues. -		12						
13	Wed. -	12–13	13						
14	Thur. -		14		4 to 11	4 to 10	2		
15	Frid. -	14–15	15						
16	Sat. -		16	3					Kew to send in documents for December 1868 to the central office.
17	**Sun.** -	16–17	17						
18	Mon. -		18						
19	Tues. -	18–19	19						
20	Wed. -		20						
21	Thur. -	20–21	21		12 to 17	11 to 17	3		
22	Frid. -		22						
23	Sat. -	22–23	23	4					
24	**Sun.** -		24						
25	Mon. -	24–25	25						
26	Tues. -		26						
27	Wed. -	26–27	27						
28	Thur. -		28		18 to 25	18 to 24	4		
29	Frid. -	28–29	29						
30	Sat. -		30	5					
31	**Sun.** -	30–31	31	6					

FEBRUARY.

Day of Month.	Day of Week.	No. of Bar. and Ther. Sheets taken off this Day.	No. of Anem. Sheet taken off this Day.	No. of Journals and Tabulations ending this Day.	Send to Kew.				Remarks.
					Bar. and Ther. Curves, Nos. inclusive.	Anem. Curves, Nos. inclusive.	Journals and Tabulations, Nos.	Weather Report for	
1	Mon.		32						
2	Tues.	32–33	33						
3	Wed.		34						
4	Thur.	34–35	35		26 to 31	25 to 31	5		
5	Frid.		36						
6	Sat.	36–37	37	7					
7	**Sun.**		38						
8	Mon.	38–39	39						
9	Tues.		40						
10	Wed.	40–41	41						
11	Thur.		42		32 to 39	32 to 38	6 and 7	January	
12	Frid.	42–43	43						
13	Sat.		44	8					
14	**Sun.**	44–45	45						
15	Mon.		46						
16	Tues.	46–47	47						
17	Wed.		48						
18	Thur.	48–49	49		40 to 45	39 to 45	8		
19	Frid.		50						
20	Sat.	50–51	51	9					
21	**Sun.**		52						Kew to send in January documents to the central office.
22	Mon.	52–53	53						
23	Tues.		54						
24	Wed.	54–55	55						
25	Thur.		56		46 to 53	46 to 52	9		
26	Frid.	56–57	57						
27	Sat.		58	10					
28	**Sun.**	58–59	59	11					

LIST OF PUBLICATIONS, &c.

ISSUED UNDER

THE AUTHORITY OF THE METEOROLOGICAL COMMITTEE.

To be obtained of all Booksellers.

OFFICIAL.

No. 1. Report for 1867. Presented to Parliament.

2. Instructions for Meteorological Telegraphy. Potter, 31, Poultry.

3. Fishery Barometer Manual, Potter, 31, Poultry.

4. Charts of Surface Temperature, South Atlantic Ocean. Potter, 31 Poultry ; and Stanford, Charing Cross.

5. Report for 1868. Presented to Parliament.

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.

No. 2. Report to the Committee on the Meteorology of the North Atlantic, by Captain H. Toynbee, Marine Superintendent.

LONDON:
Printed by GEORGE E. EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty.
For Her Majesty's Stationery Office.