REPORT

OF THE

METEOROLOGICAL COMMITTEE OF THE ROYAL SOCIETY,

For the Year ending 31st December 1867.

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

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

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

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purport of that correspondence, and the steps by which the Meteorological Department of the Board of Trade became superseded by the Meteorological Committee of the Royal Society.

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

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

The Committee was appointed at the request of the Board of Trade, and consisted of the following gentlemen, viz. :—Francis Galton, Esq., F.R.S., General Secretary of the British Association for the Advancement of Science, nominated by the President and Council of the Royal Society; Staff-Commander Evans, R.N., F.R.S., Chief Naval Assistant to the Hydrographer of the Admiralty, by the Admiralty; T. H. Farrer, Esq., one of the Secretaries to the Board of Trade, by the Board of Trade.

† App. II.

and functions of the Meteorological Committee of the Royal Society.

EXTRACT FROM THE LETTER.

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

b. The President and Council also concur with the Committee in the opinion that "the digesting and tabulating results of observations is a function which requires a large knowledge of what the state of the science for the time being requires, as well as exact scientific method." They believe that this "would be much better, as well as more economically, performed under the direction of a scientific body, furnished with requisite funds, than it will be if left to a Government department." They would, however, limit the sea observations to those collected by British observers, and the land observations to those made within the British Isles, including those made at the lighthouses and coastguard stations. The President and Council assume, with the Committee, that "the aid afforded by Government would be in the shape of an annual vote, so made as to leave the Royal Society, or other scientific body charged with the duty, perfectly free in their method and in their choice of labour, but upon the condition that an account shall be rendered to Parliament of the money spent, and of the results effected in each year."

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

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

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

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

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

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

5thly. An estimate of the cost of both.

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

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

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

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

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

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

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

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

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

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

"The Hydrographer to the Admiralty.

"Colonel Smythe.

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

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

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

* App. II.

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

Mr. Robert H. Scott, Director of the Office.

Capt. Henry Toynbee, of the Mercantile Marine, as Marine Superintendent.

Mr. Balfour Stewart, as Secretary to the Committee and Director of the Normal (Kew) Observatory.

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

Functions of the Committee.

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

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

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

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

I.—Ocean Meteorology.

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

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

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

The complete set of instruments now issued is,

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

and in exceptional cases, an azimuth compass.

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

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

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

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

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

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

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

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* See page 25.

† See Report, pp. 13, 14.

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

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

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

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

It is evident that the periodical changes which take place in

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

† Ondersoekingen met den Zeethermometer; Utrecht, 1861.

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

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

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

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

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

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

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

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

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

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

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

INSTRUMENTS supplied &c. to the Royal Navy.

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

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

* L'Association Scientifique de France.

INSTRUMENTS supplied to the Mercantile Marine.

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

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

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

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

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

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

II.—TELEGRAPHIC WEATHER INFORMATION.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

SIR,

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

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

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

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

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

"SIR,

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

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

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

"I have, &c.

. . . . . .

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

"Edward Sabine, Chairman."

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

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

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

I have, &c.

The Secretary,
Board of Trade.

(Signed) ROBERT H. SCOTT,
Director.

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

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

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

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

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

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

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

TELEGRAPHIC WEATHER INFORMATION.

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

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

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

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

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

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

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

(Signed) T. H. FARRER.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The question to which replies were requested were these:

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

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

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

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

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

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

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

* April 1868. In addition to the stations in the British Islands to which telegraphic weather intelligence is sent, similar information is also sent to the Ministry of Marine in Paris, and to Hamburg. The Committee are glad to learn from a letter from Herr von Freeden, Director of the Norddeutsche Seewarte, dated April 22, 1868, that he had received 24 hours' warning of a severe north-west gale which set in suddenly at Hamburg on the 8th March, by means of a telegram sent from the Meteorological Office on the afternoon of the 7th.

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

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

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

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

III.—Land Meteorology of the British Isles.

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

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

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

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

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

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

Expenditure.

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

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

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

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

Weather Statistics in and near the British Isles :	
Six stations with self-recording instruments : collecting observations from intermediate stations, lighthouses, ships, &c. ; discussing observations, charting, and publishing results, annually - - - - -	4,250

Besides an outlay, to begin with, of 2,500*l.*, and whatever sums may be needed for additions to the buildings at Kew.

Telegraphy and storm warnings, annually - -	3,000
Grand total annually - -	£10,450

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

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

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

Royal Society, January 21, 1867.

Sir,

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

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

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

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

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

I have, &c.,

The Secretary,
Board of Trade.

(Signed) Edward Sabine,
Chairman of Meteorological Committee.

Draft of Estimates, Meteorological Department, Board of Trade.

Yearly Expenses.

Particulars.	Proposed Expenses for the Year 1867–8.
	£ s. d.
Salaries of Officers — Director	800 0 0
Salaries of Officers — Secretary to Committee	400 0 0
Salaries of Officers — Marine Superintendent	350 0 0
Salaries of Seven Clerks	1,000 0 0
Annual expense of eight observatories (including the central)	2,000 0 0
Purchase and repairs of instruments—Mercantile Marine	300 0 0
Ditto ditto Admiralty	400 0 0
Verification of instruments	50 0 0
Weather books	150 0 0
Travelling expenses	300 0 0
Carriage of instruments to and from the ports	150 0 0
Agencies at ports for supplying instruments to ships	200 0 0
Telegraphs	3,000 0 0
Office and contingencies	800 0 0
	£
Salaries	2,550
Expenses of observatories	2,000
Telegraphs	3,000
Books, instruments, &c.	900
Travelling expenses, carriage, agencies, and contingencies	1,450
	£9,900 0 0

Total - - Nine thousand nine hundred pounds.

Special Grant for Equipment, as proposed by the Government Committee in Parliamentary Return.

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

Total - - Two thousand nine hundred pounds.

Edward Sabine,
Chairman of the Meteorological Committee.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Preliminary.

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

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

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

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

Principles of Construction of these Instruments.

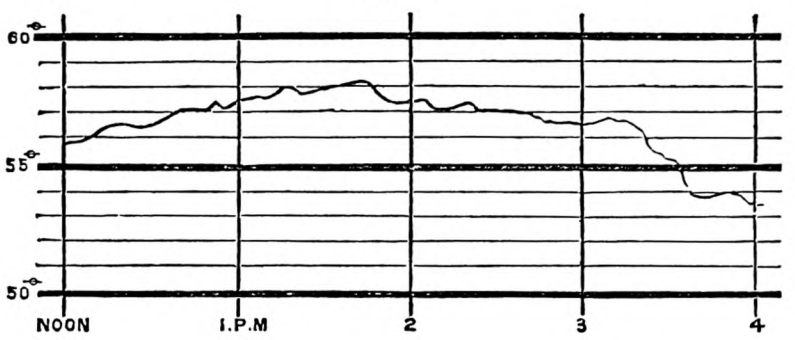
In order to obtain continuous records of any meteorological element, say, for instance, the temperature of the air, two things are obviously necessary:—

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

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

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

Fig. 1.



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

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

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

Principles of Construction of the Thermograph.

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

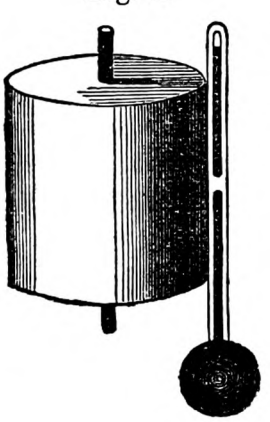
Now, in the first place, as it is always the simultaneous readings of these two instruments that have to be compared together, it is highly desirable that the tracings of the two given by photography should be so arranged as to place the simultaneous indications of the two thermometers, the one exactly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

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

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

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

Fig. 2.



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

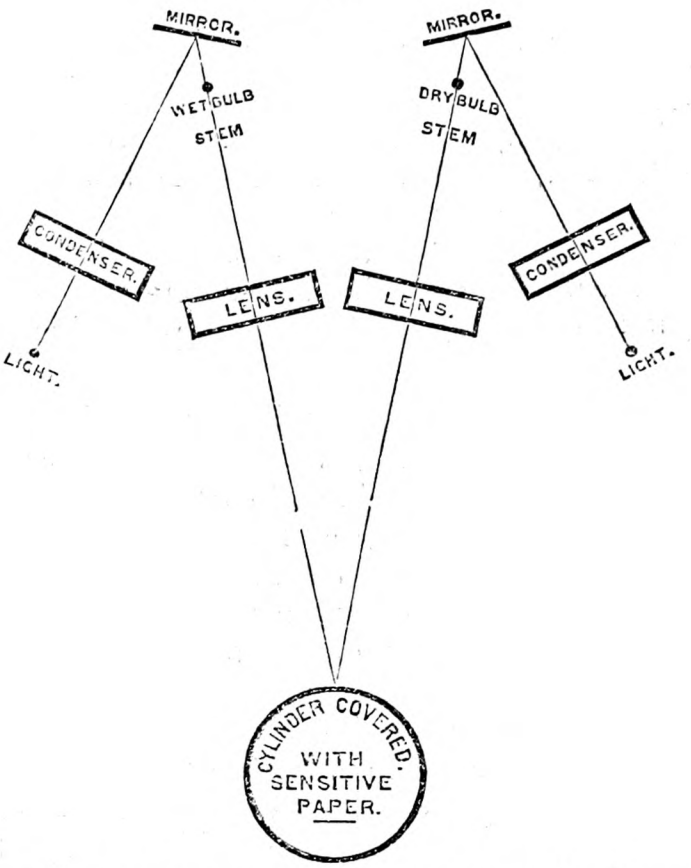
This precise arrangement has not, however, been pursued for several reasons; one of these is that we cannot well by this means have two dots of light, one denoting the temperature of the air and the other that of evaporation, the one vertically under the other on the same sensitive paper, so as to have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

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

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

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

Fig. 3.



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

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

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

Temperature-Scale.

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

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

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

In short the two requirements now stated are :—

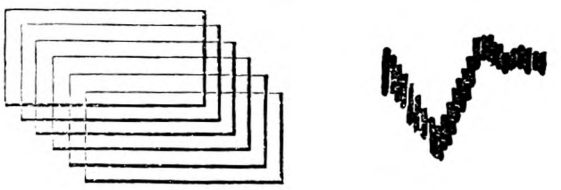
1. A constant scale value for the same curve.
2. The same scale value for both curves.

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

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

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

Fig. 4.



Time-Scale.

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

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

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

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

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

Standards of Reference.

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

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

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

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

Method of Tabulation.

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

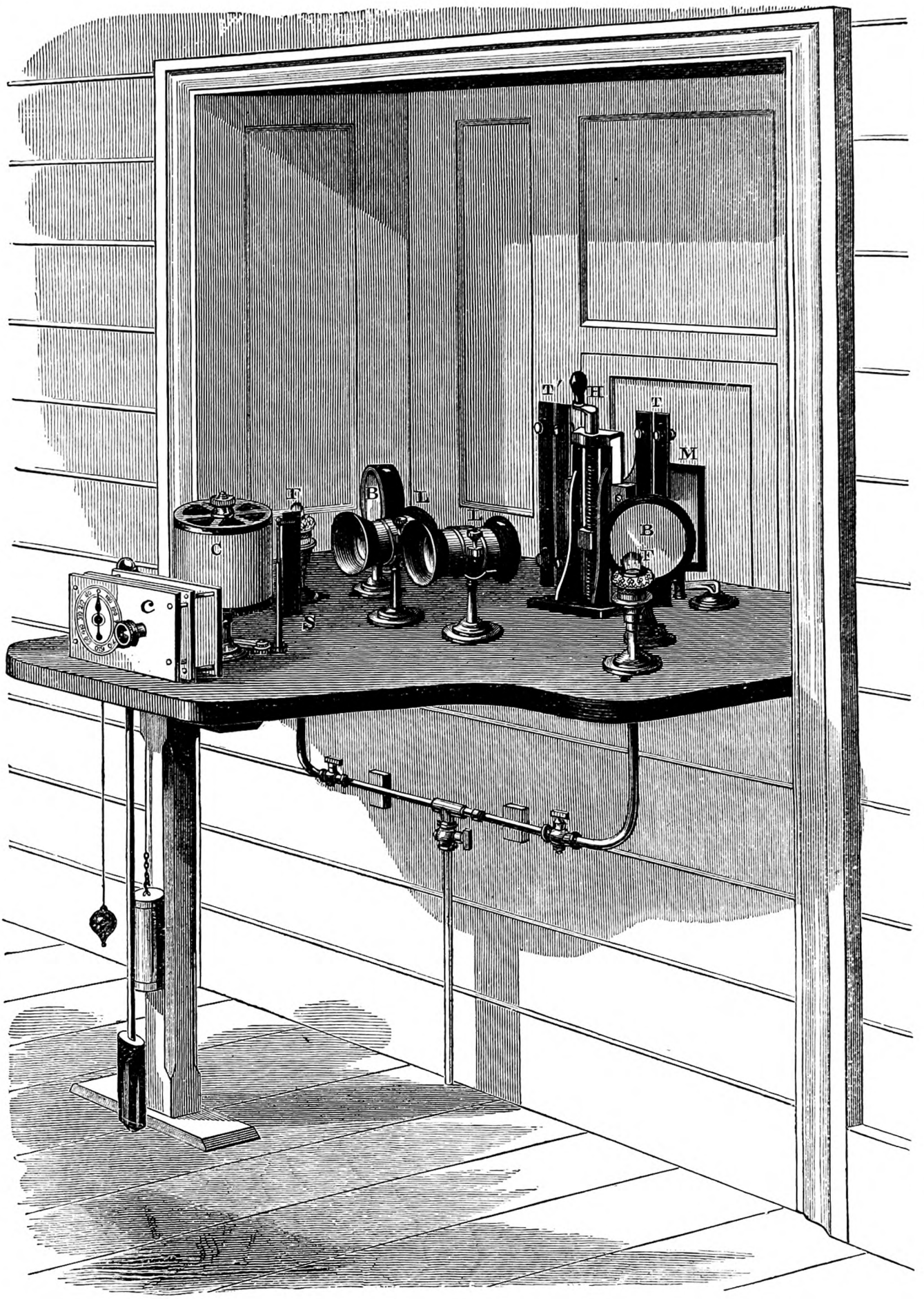
Mean difference between dry bulb standard and tabulated readings 0°·09, or less than a tenth of a degree.

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

The following table exhibits the readings for every hour of

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

PLATE I.



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

TABLE I.

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

In-door Arrangements of the Thermograph.

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

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

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

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

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

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

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

c is the clock.

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

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

Out-of-door Arrangements of the Thermograph.

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

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

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

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

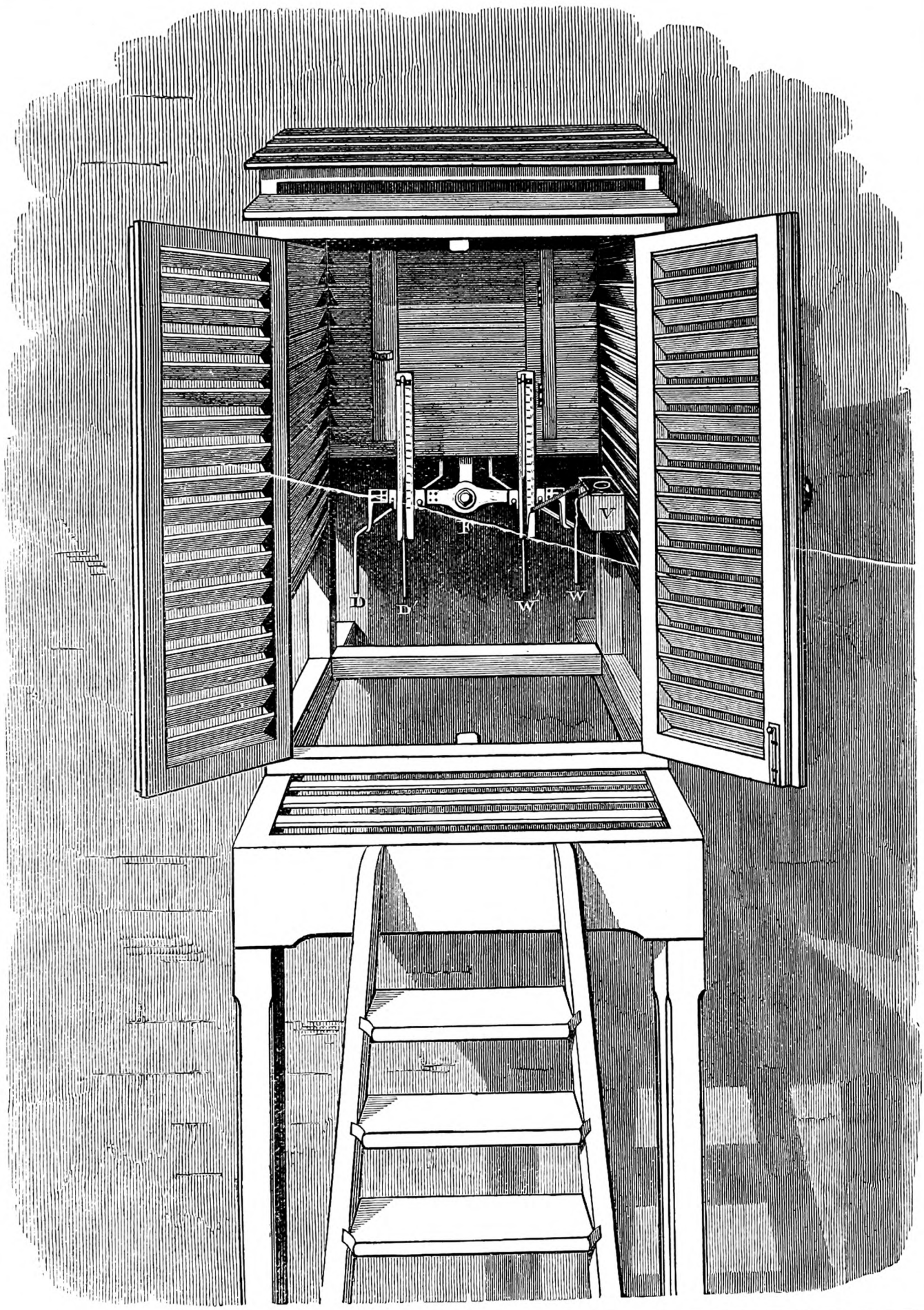
F is the frame carrying the thermometer, and capable of being raised and lowered (see sketch of in-door arrangement).

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

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

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

PLATE II.



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Influence of Local Peculiarities.

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

TABLE II.

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

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

TABLE II.—*continued.*

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

TABLE II.—*continued.*

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

Principles of Construction of the Barograph.

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

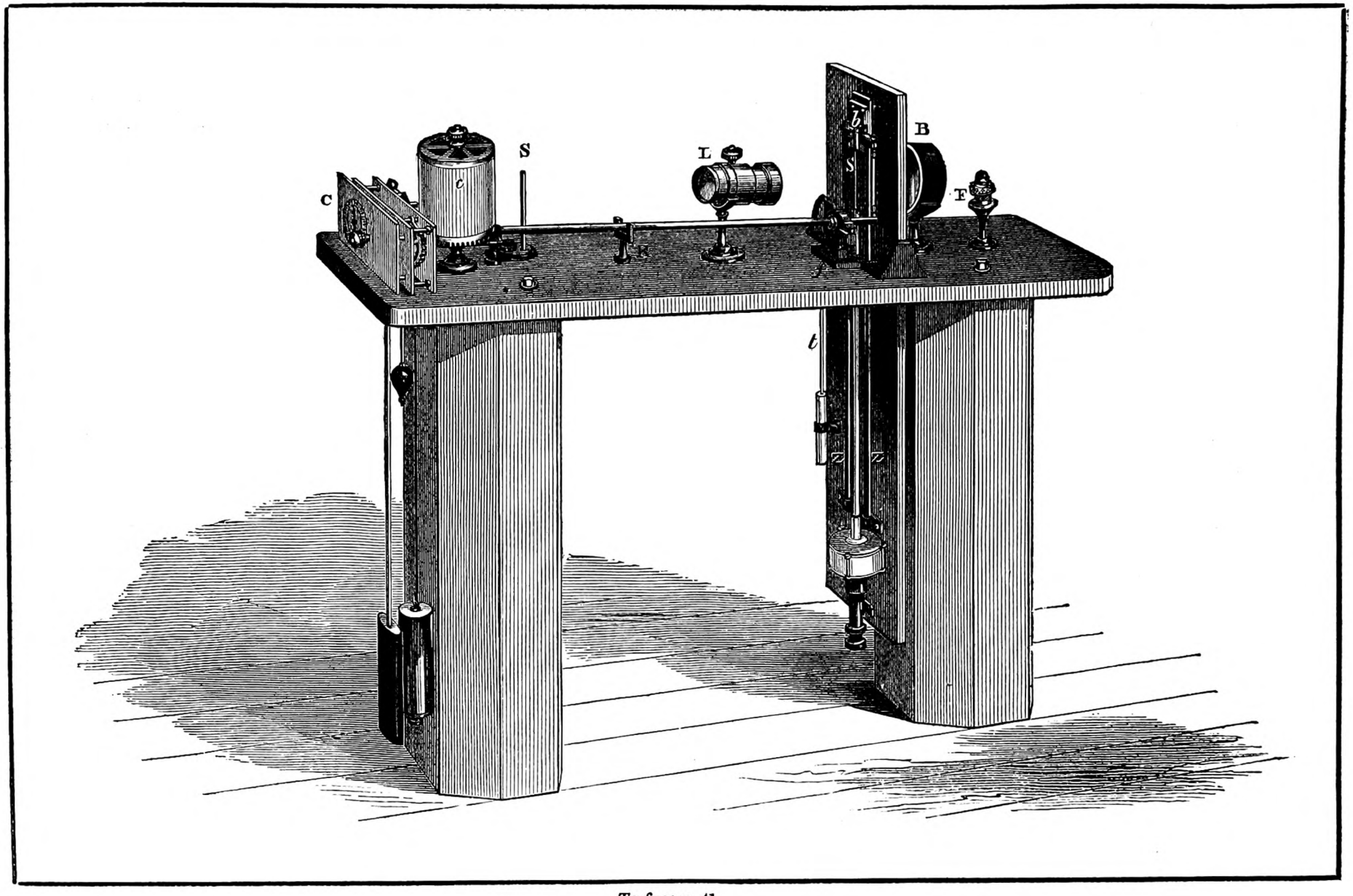
In the original barograph of Mr. Francis Ronalds, which may be regarded to some extent as the parent of these instruments, the compensation for temperature was made in the following manner:—Let us first suppose the absolute pressure of the air to remain constant, while the temperature of the mercurial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

The objection to this arrangement is twofold.

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

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

PLATE III.



To face p. 41.

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

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

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

F is the flame of gas or paraffin.

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

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

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

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

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

Temperature Compensation.

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

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

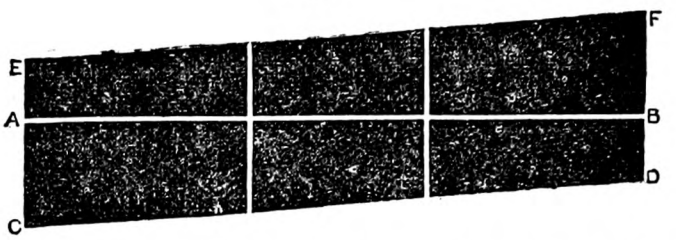
Now the upper boundary of the slit being fixed, while the surface of the mercury is variable, we should thus have traced by the action of light upon the paper, as the cylinder moves round, a blackened space, having below a level or straight and above a curved boundary, this curve being in fact the representation,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

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

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

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

Fig. 5.



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

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

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

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

Standard of Reference.

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

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

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

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

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

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

Method of Tabulation.

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

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

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

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

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

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

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

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

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

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

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

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

Table III.

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

* See Figure 5.

Principles of Construction of the Anemograph.

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

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

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

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

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

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

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

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

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

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

Arrangement for Velocity.

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

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

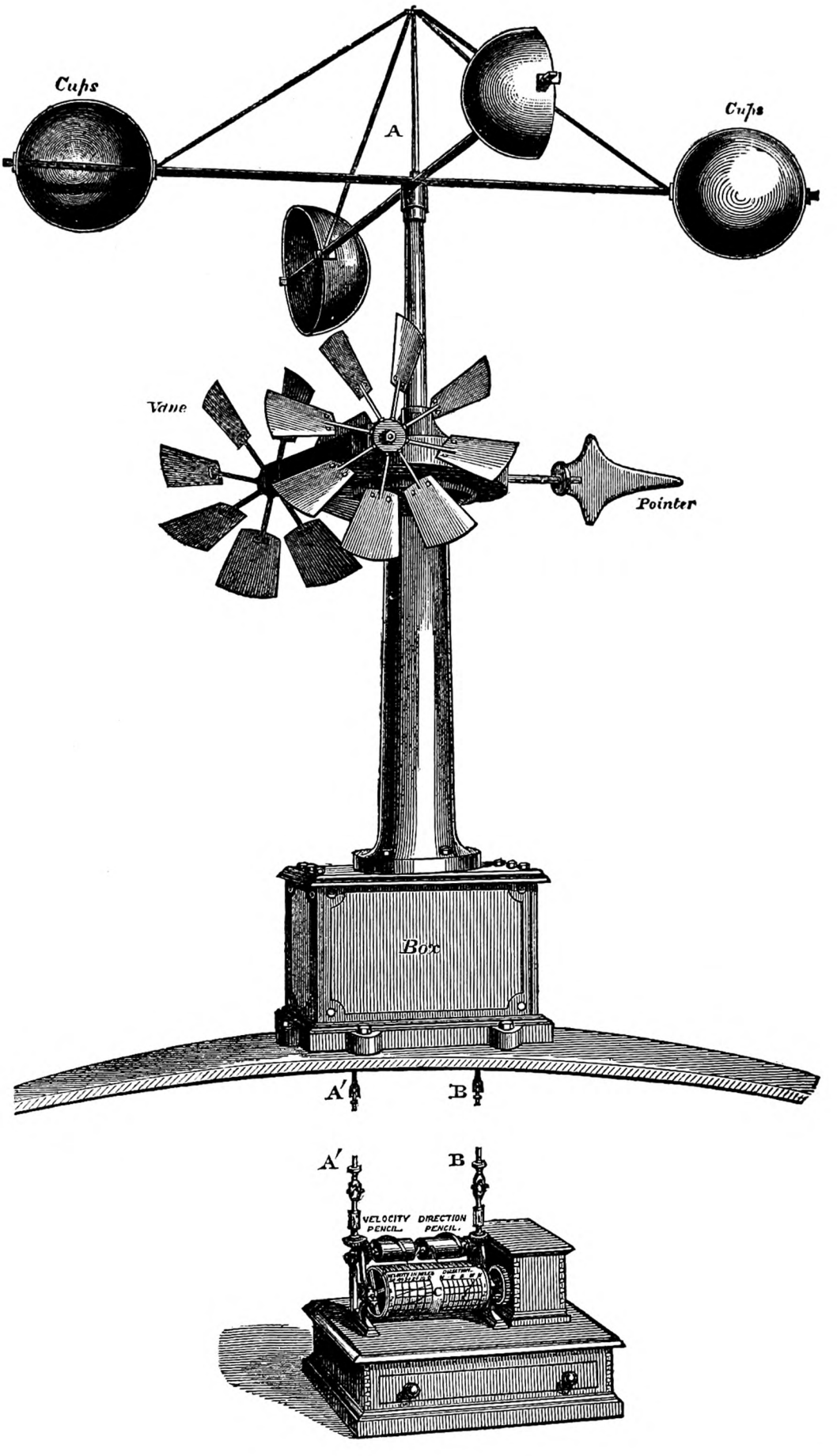
* The anemographs for the various observatories were made partly by Mr. Casella, and partly by Messrs. R. & J. Beck.

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

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

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

PLATE IV.



To face p. 48.

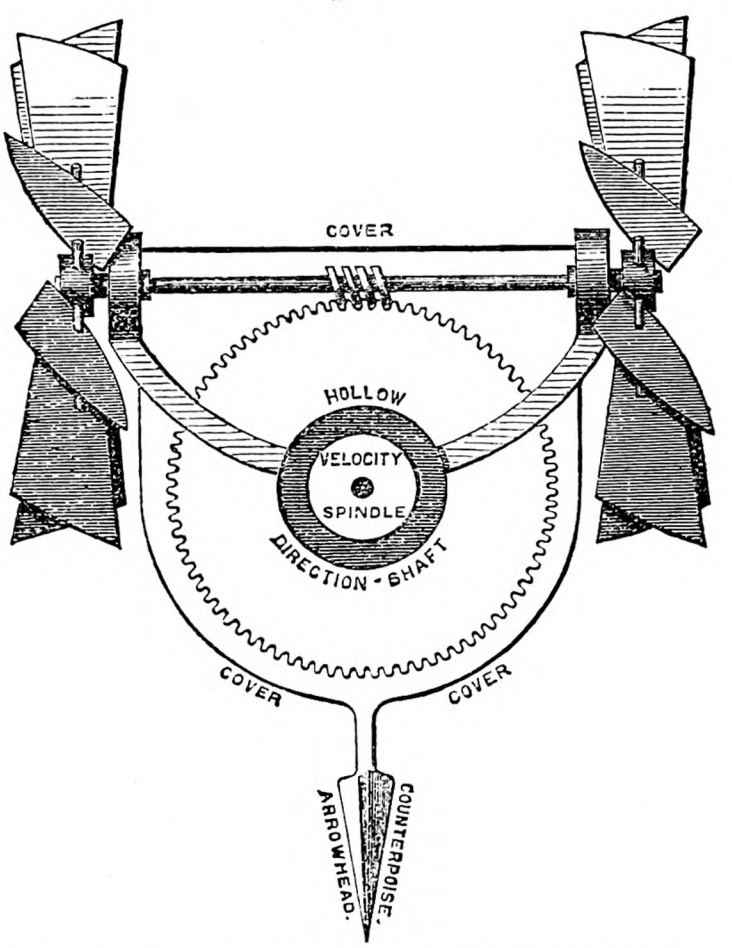
that when the spiral velocity pencil has marked 50 miles it leaves off at the left and commences again from 0 miles at the right. The appearance of the record traced in this manner in 24 hours will be seen by referring to a facsimile of one of the Kew *anemograms* (Plate VI.)

Arrangement for Direction.

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

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

Fig. 6.



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

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

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

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

Oscillation of Wind.

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

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

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

Friction Co-efficient.

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

TABLE IV.

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

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

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

Pressure of Wind.

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

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

Table V.

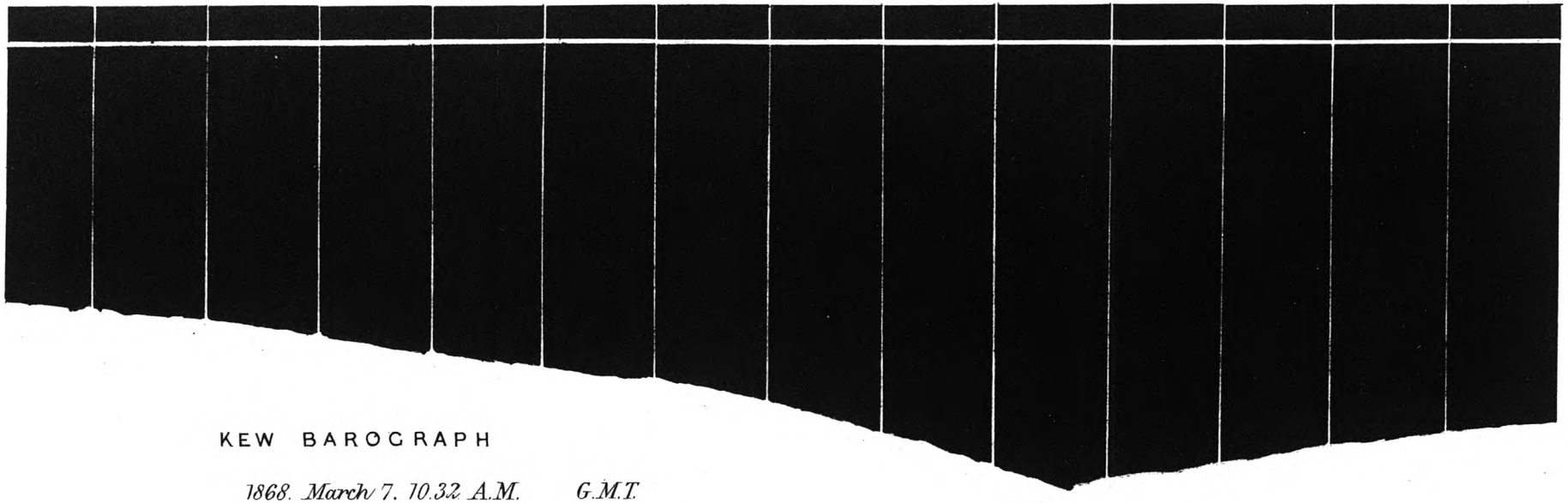
Date	Saturday, March 7th.						Sunday, March 8th.					
	Velocity of Wind in miles per hour.*			Direction of Wind.	Oscillation of Wind.		Velocity of Wind in miles per hour.*			Direction of Wind.	Oscillation of Wind.	
Hour, G.M.T.	Velocity uncorrected.	Approximate correction for friction.	Velocity corrected.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

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

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

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

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



KEW BAROGRAPH

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

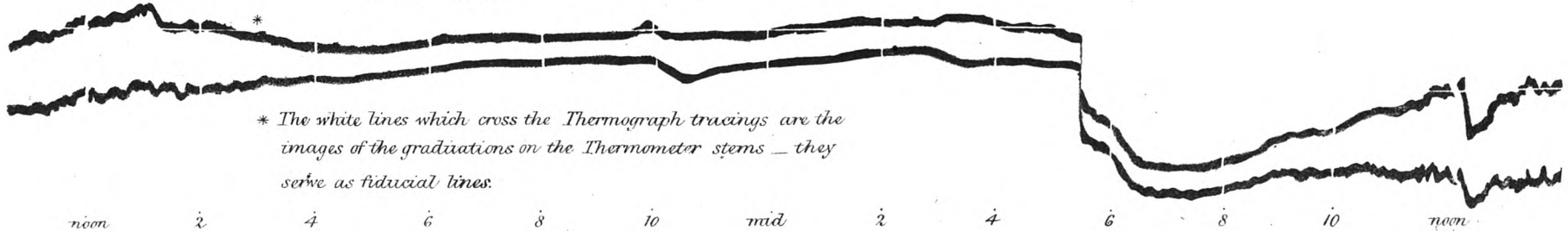
8. 1.58. P.M

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

KEW THERMOGRAPH

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

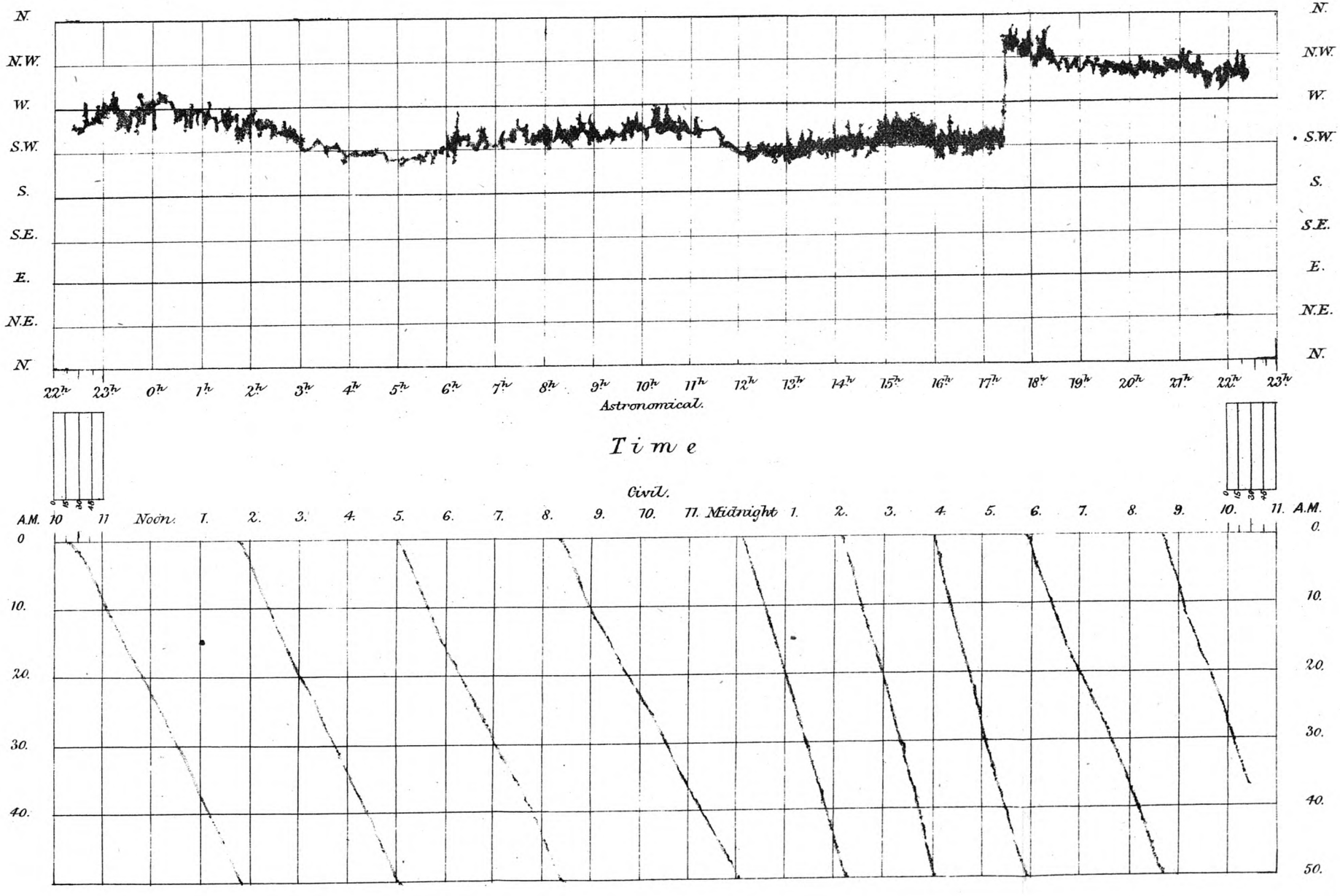
8. 1.58. P.M. "



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

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

Plate VI.



ANEMOGRAPH CURVE.

Kew Observatory.

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

APPENDIX.

APPENDIX I.

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

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

Examined and compared with the vouchers and found correct.

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

8 May 1868.

APPENDIX II.

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

Board of Trade to Royal Society.

SIR, Board of Trade, August 30, 1866.

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

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

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

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

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

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

I have, &c.

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

Royal Society to Board of Trade.

Royal Society, Burlington House,
October 27, 1866.

Sir,

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

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

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

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

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

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

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

b. The President and Council also concur with the Committee in the opinion that "the digesting and tabulating results of observations is a function which requires a large knowledge of what the state of the science for the time being requires, as well as exact scientific method." They believe that this "would be much better, as well as more economically, performed under the direction of a scientific body, furnished with requisite funds, than it will be if left to a government department." They would, however, limit the sea observations to those collected by British observers, and the land observations to those made within the British Isles, including those made at the lighthouses and coastguard stations. The President and Council assume, with the Committee, that "the aid afforded by Government would be in the shape of an annual vote, so made as to leave the Royal Society, or other scientific body charged with the duty, perfectly free in their method and in their choice of labour, but upon the condition that an account shall be rendered to Parliament of the money spent, and of the results effected in each year."

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

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

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

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

> 3rdly, You ask for a detailed statement of the establishment which will be necessary at Kew, for the purpose of receiving and discussing Meteorological Observations.
>
> 4thly, A similar statement with respect to local observations in the United Kingdom.
>
> 5thly, An estimate of the cost of both.

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

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

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

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

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

I remain, &c.,

(Signed) W. SHARPEY, M.D.,

The Secretary, Board of Trade. Secretary, R.S.

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

CIRCULAR.

Board of Trade, November 29, 1866.

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

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

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

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

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

T. H. FARRER.

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

Board of Trade to Royal Society.

Board of Trade, December 5, 1866.

SIR,

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

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

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

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

I have, &c.

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

Royal Society to Board of Trade.

Royal Society, Burlington House,
December 15, 1866.

SIR,

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

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

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

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

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

"The Hydrographer to the Admiralty.

"Colonel Smythe.

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

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

I remain, &c.

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

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

Board of Trade to Royal Society.

Sir, Board of Trade, December 22, 1866.

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

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

I have, &c.

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

(Signed) T. H. Farrer.

APPENDIX III.

Arrangement of Data Book.

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

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

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

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

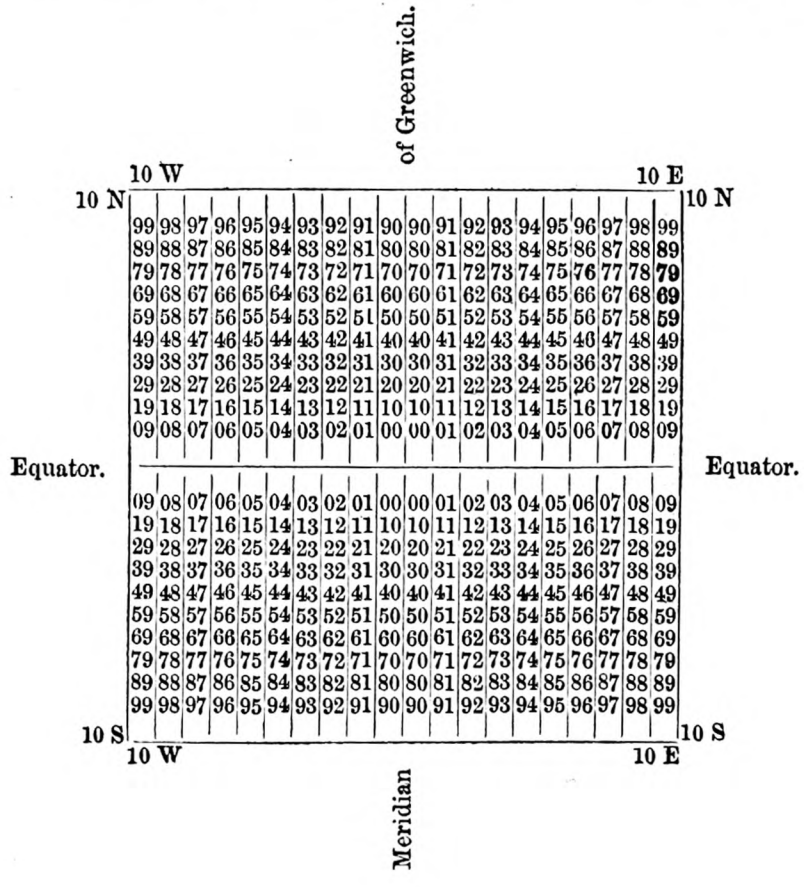
It will be seen from these that in each case the openings 00 and 99 correspond respectively to the lowest and highest latitude and longitude.

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

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

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

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



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

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

* Meteorological Register kept chiefly by the owner, H. F. Watt.
† " " " by Samuel White Hodding, 2nd officer.
‡ " " " by Frederick W. Banner, chief officer.

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

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

* These documents are printed.

APPENDIX V.

CORRESPONDENCE RELATIVE TO TELEGRAPHIC WEATHER INTELLIGENCE.

Board of Trade to Meteorological Committee.

Board of Trade, 31st May 1867.

SIR,

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

I am, &c.,

(Signed) T. H. FARRER.

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

Meteorological Committee of the Royal Society to Board of Trade.

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

SIR,

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

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

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

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

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

"SIR,

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

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

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

"I have, &c.,

. . . .

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

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

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

"Storm from west at Penzance and south coast, hoist signal."

Masters of coasters and others, on seeing the signal, might apply to know the nature of the information which had been received from the central office.

I have, &c.,

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

Board of Trade to Meteorological Committee.

Board of Trade, Whitehall,
11th July 1867.

SIR,

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

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

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

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

Meteorological Committee to Board of Trade.

Meteorological Office,
15th July 1867.

SIR,

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

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

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

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

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

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

Board of Trade to Meteorological Committee.

Board of Trade, Whitehall,
5th August 1867.

SIR,

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

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

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

I am, &c.,

(Signed) C. CECIL TREVOR.

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

Board of Trade to Meteorological Committee.

Board of Trade, Whitehall,
30th October 1867.

SIR,

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

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

I am, &c.,

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

Meteorological Committee to Board of Trade.

Meteorological Office,
7th November 1867.

SIR,

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

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

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

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

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

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

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* Not printed. † p. 64.

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

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

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

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

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

I have, &c.,

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

Board of Trade to Meteorological Committee.

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

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

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

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

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

I am, &c.,

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

Meteorological Committee to Board of Trade.

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

Sir,

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

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

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

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

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

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

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

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

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

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

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

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

Board of Trade to Meteorological Office.

Board of Trade, Whitehall,
22d November 1867.

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

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

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

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

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

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

* This enclosure is not printed herewith.

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

TELEGRAPHIC WEATHER INFORMATION.

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

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

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

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

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

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

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

(Signed) T. H. FARRER.

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

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

Inspecting Officer's Division or Receiver's District _____

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

PARTICULARS OF PLACE AND DATE OF REPORT.

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

STATE OF WEATHER.

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

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

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

(Signature and Title of Officer forwarding this Report.

DIRECTIONS.

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

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

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

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

Figures to denote the Force of the Wind.

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

APPENDIX VI.

Practice of other Countries in 1867, with reference to Telegraphic Weather Intelligence.

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

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

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

An abstract of these letters is here subjoined:

Ministère de la Marine
Paris, le 25 Juillet 1867.

ABSTRACT.

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

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

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

(Copy.)

Royal Meteorological Institute,
Utrecht, 12th August 1867.

SIR,

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

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

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

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

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

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

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

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

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

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

Robert H. Scott, Esq., Meteorological Office.

"Ministero della Marina,

"CHER MONSIEUR, Florence, 28 Juillet 1867.

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

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

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

"C. MATTEUCCI.

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

"K. K. Central Anstalt für Meteorologie,

"Vienna, 31 July 1867.

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

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

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

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

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

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

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

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

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

"(Signed) C. JELINEK."

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

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

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

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

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

"(Signed) H. MOHN."

APPENDIX VII.

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

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

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

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