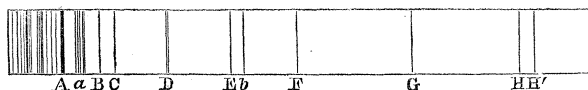


do me the favour of bringing this communication to the notice of the Society; and I need not say that I shall be exceedingly glad of any suggestions for improving the method and utilizing it in making systematic observations of any points which may be elucidated by its means.

Received December 6, 1875.

Surveyor-General's Office,
Calcutta, November 12, 1875.

DEAR SIR,—In continuation of my letter of last week I enclose a sketch of the lines in the extreme red rays, as nearly as I can make them out, from one of the photographs I have taken in the manner described, and the only one in which I have obtained the lines so clearly. It was taken at 1.48 P.M. on the 8th October (just at the close of our rainy season) with an exposure of 15 minutes, the same arrangement of spectroscope being used as for taking the two negatives I sent you last mail.



I have since writing made a successful experiment in obtaining reversed negatives on insolated, blue-stained, dry bromized collodion plates by means of the reversing action of the red rays passing through ruby glass, and also on similar plates prepared with bromized collodion coloured a bright yellow with tincture of annatto. I have also reason to believe that it will not be impossible to obtain the same reversing action through *blue* glass; but further trials are requisite.

I may also add that I have found that dry bromide plates prepared with the collodion containing annatto are more highly sensitive to the whole spectrum than any others; so that I have obtained the C, B, *a*, and A lines quite distinctly on such plates *unreversed*, and also one line below A at about the same distance from it as *a*.

III. "Report of the Meteorological Committee to the President and Council of the Royal Society on the Work done in the Meteorological Office since their appointment in 1866 to December 31, 1875."

The business of the Office will be reviewed under the three heads into which it is subdivided, and which are as follows:—

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

I. OCEAN METEOROLOGY.

The most important task of the Committee at its first institution was

to examine and to take stock of all the instruments and materials for work existing in the Office.

Inquiry was made into the actual condition and employment of all instruments outstanding on the books, whereby several were recovered, and several proved to be non-existent. Since 1867 no instruments have been supplied, except for the public service.

The books in the Office, which have been kept since 1854, enable us to trace the history and corrections of every instrument which has ever been purchased.

The entire store of documents in the Office was carefully examined by Capt. Toynbee; those that were worthless were set aside, and in the remainder the quality of each element which they contained was marked.

The Office then resumed the supply of instruments to observers at sea, and reorganized the agencies at certain ports. These agencies are paid according to results. The outcome of these operations is shown in the Annual Reports.

Among the most important benefits to the science attributable to the action of the Committee has been the great improvement in the quality of the logs sent in, owing to the care taken to select observers.

The following figures show the total number of logs, and the number of first-class logs, classed "*excellent*," which have been received each year from the *Mercantile Marine* since the management of the Office has been under the Meteorological Committee.

Year.	Total No. of Logs received.	No. of Excellent Logs.	% of Excellent Logs.	Year.	Total No. of Logs received.	No. of Excellent Logs.	% of Excellent Logs.
1867.	21	7	33	1871.	150	72	48
1868.	50	10	20	1872.	110	64	58
1869.	67	21	31	1873.	92	52	57
1870.	81	41	51	1874.	88	56	64

The marked improvement shown in the last few years is doubtless entirely due to a thoroughly systematic supervision by Captain Toynbee of all logs received. In every case where improvement is considered necessary, and reasonably practicable, the captain responsible for the log has been communicated with, and in many cases induced to call at the Office for a personal interview.

The high percentage of excellent logs in recent years is in no way to be attributed to a lower standard of excellence being used; on the contrary, the standard of excellence may be considered to have increased rather than to have diminished.

It seems that greater weight should be attached to the relative values above, from the fact that the classification has been carried out by the

same person throughout the whole period, so that the method of classification would doubtless be uniform.

The continuity of the observations and the hours at which observations have been recorded are of late years more in accordance with the generally accepted principles for the calculation of mean results.

At the same time it should be remarked that there is great difficulty in securing a supply of observers, and that it is in contemplation to relax in some measure the rigour of the tests applied to the observations.

As regards our Methods of Operation and our Instructions for keeping the Log, the latter were printed in full by the recent Maritime Conference held in London in 1874, and an extract of the Methods was also given.

The works published by the Office in this Department have been :—

- O. 4. Charts of Surface Temperature for the South Atlantic, Monthly, and for 5° Squares, representing the Observations from Board of Trade Registers, and also results for smaller spaces from the Dutch Records published in ‘Ondersoeking en met den Zeethermometer.’
- O. 11. Contributions to our Knowledge of the Meteorology of Cape Horn and the West Coast of South America. Monthly tables, charts, and summaries of observations from 5° Squares ; materials collected by Admiral FitzRoy, and supplemented by data from other sources and for other localities. This contribution is of some importance as preliminary to a more complete investigation into the meteorology of that region. Among the points brought out by it are the existence of an area of high barometrical pressure on the Tropic of Capricorn in the South Pacific, like those on the two tropics in the Atlantic, and also the fact that sea surface-temperature ranges *above* that of the air, even in the region of Humboldt’s Current.
- O. 12. The Currents and Surface-Temperature in the North Atlantic, 0°–40° N., giving, for 2½° Squares, Monthly Charts for Direction and Velocity, and for Temperature, and an Annual Chart.
These were the first monthly current-charts which were published, excepting those of Lieut. Fergusson for the Indian Ocean, &c.
- O. 13. On the Weather of the North Atlantic in February 1870. This paper will be noticed under Weather Telegraphy.
- O. 18. Contributions to our Knowledge of the Meteorology of the Antarctic Regions. This was a discussion, according to date and locality, of the materials contained in the logs of H.M.S. ‘Erebus’ and ‘Terror’ in 1840–43, and threw much additional light on the meteorological conditions of that region of the globe.

- O. 20. Charts of Meteorological Data for Square 3, lat. 0° – 10° N., long. 20° – 30° W., and Remarks to accompany the Monthly Charts, 319 pp.

The charts show the means for all the elements for 2° squares, and consequently the best routes across the equator in each month; and the remarks contain extracts relating to currents, clouds, sea temperature, specific gravity, wind, weather, natural history, &c.

In an Appendix is given a Discussion of Four-hourly means of the Barometer, and Air and Sea Temperature for each Month and for the Year in the Northern and Southern Halves of the Square, from which have been calculated the diurnal-range corrections for the district.

This is the most elaborate paper ever published for any portion of the ocean; and the large relative proportion of labour bestowed on the district is justified by the considerations that the amount of material existing for it is quite exceptional, and that it lies on the highroad between the North and South Atlantic, and is the meeting-place of the two trade-winds.

The meteorologist thus finds the materials for a study of the conditions of wind, ocean-currents, weather, &c. in a region where two great currents of air are always meeting, with information as to the diurnal march of pressure and temperature in the region of the equator and at sea; while the sailor finds, in the monthly charts, diagrams of what he may expect to encounter on his passage through the Square at any season; and in the text containing the explanations he finds a discussion of the entire mass of information, and, as a final conclusion, advice as to the best route for crossing the Line in each month.

The public will, however, be in a much better position to judge of the work of the Office when the Charts, &c. now in the press, for the nine squares (lat. 10° S.– 20° N., long. 10° – 40° W.), of which Square 3 forms the centre, are published. In these charts, as dealing with a larger area and stretching from shore to shore of the Atlantic, are given not only charts of the same character as those above described (though for larger areas, owing to comparative deficiency of material), but also diagrams showing the direction of wind in connexion with atmospherical pressure and temperature, and of ocean-currents with sea-temperature.

There is also given a tabular statement contrasting the specific gravity of the sea in the easterly [going] or “Guinea” current and in the westerly currents due to each trade-wind.

In the Remarks copious quotations are made from the Logs in relation to the various phenomena which come under the

seaman's observation, such as the weather, the wind, the motion of the clouds in relation to the lower wind, the direction of the swell, the colour and luminosity of the sea, and the current rips; as well as information relating to the birds, fish, and insects that are met with, and the variation from month to month of the localities in which they are seen, and also appearances of submarine volcanic action in certain localities.

By these investigations it is believed that important light has been thrown on several subjects of general as well as of special interest.

1. As to the tendency of the wind blowing along a coast-line to draw round a cape.
2. As to the relation of the surface-temperature and the currents of the sea near the equator to the westerly gales of high northern and southern latitudes in their respective winters; as to the dipping of a cold current under a warm one, and the variation with the seasons in the amount of easterly current near the equator.
3. As to a probable relation between the well-known rollers of Ascension and St. Helena and the winter gales of the North Atlantic, and a corresponding relation of the rollers on the west coast of Africa to the winter gales of high southern latitudes.
4. As to the remarkable difference in direction of the wind in December on opposite sides of the Cape-Verde Islands, being *easterly* to the westward and *north-north-east* to the eastward of them.
5. As to the remarkable unsteadiness and gustiness of the north-east trade with a clear sky in Square 40 (lat. 10° – 20° N., long. 30° – 40° W.), in certain months.
6. As to the difference between the wind and weather of Square 303 (lat. 0° – 10° S., long. 30° – 40° W.), off Cape St. Roque and its neighbourhood, and those of the Squares lying to the eastward of that point, more especially in regard of the fact that in certain months the wind in Square 303, during the squalls which frequently occur, constantly changes between south-east and south-south-west in such a way that the seaman finds very great difficulty in working to the southward if he approaches too near the Brazilian coast.
7. As to the relation of the upper currents of the atmosphere (indicated by cloud motion) to the lower winds—*e.g.*, how the equatorial margin of one Trade appears to rise above the edge of the other Trade, how the upper clouds move from the north-east over the south-west monsoon on the coast of Africa, and how sometimes clouds move from the south-east, the sky looking very heavy towards that quarter, while the surface wind is steady from south-west.
8. As to the relation between heavy dew and sea-temperature in some

parts and at certain seasons, and the connexion between mist (haze) and African dust.

9. The diagrams give a picture of Maury's "wedge-shaped doldrums" which any sailor can understand, and the remarks show the weather experienced in them.

In these discussions the object of the Meteorological Office has been to determine the meteorological statistics of limited portions of the ocean in each separate month by means of results obtained by discussion of original observations extracted from the logs in the Office.

The scope of these publications is consequently different from that of the charts published by the Admiralty, which aim at giving a general view of what may be expected at each season (three-monthly period) over the Atlantic Ocean, as in the "Pilot" Charts, or the whole navigable globe, as in the "Wind and Current" Charts.

Of the two investigations in question Capt. Toynbee has given popular accounts in papers read before the United Service Institution (in 1873) and before the British Association (in 1875) respectively.

The Office having thus completed the examination of the district close to the equator in the Atlantic Ocean, about the most important and interesting to the navigator and meteorologist of any region in the world, has commenced the investigation of the meteorology of another great district lying on the highroad between Europe and the Indian and Australian seas, that of the Cape of Good Hope, which will be prosecuted in due course, the question of the best method of dealing with that district being under consideration.

Another inquiry of considerable interest, of the same nature as that noted as O. 13, is being instituted into the wind and weather of the North Atlantic during the month of August 1873. For this the Office has obtained the loan of 280 logs, as will be mentioned later on.

While thus working at its own materials the Office has not been neglectful of foreign publications of value bearing on Ocean Meteorology.

Three of these have been specially published, in addition to the reproduction of the Dutch Sea-Temperature Observations for the Atlantic, which have been already mentioned.

These three are:—

- N. O. 4. Routes for Steamers from Aden to the Straits of Sunda and back. Translated from a paper by Lieut. J. E. Cornelissen, of the Royal Meteorological Institute, Utrecht.
- N. O. 5. On the Winds, &c. of the North Atlantic along the Tracks of Steamers between Europe and America. Translated from a paper by Herr von Freeden, of the Deutsche Seewarte, Hamburg.
- N. O. 7. Notes on the Form of Cyclones in the Southern Indian Ocean. Reprint of a paper by C. Meldrum, M.A., F.R.A.S., Secretary of the Meteorological Society of the Mauritius.

With reference to the Recommendations contained in the Report of the Committee of Inquiry (1866) in relation to the subject of Ocean Meteorology (p. 15 of their Report) it may be said :—

- a.* As regards the works and discussions of observations now in progress. Recommendations have been carried out in principle, but with such variations in detail as appeared necessary.
- b.* As regards the collection of further observations. Recommendations have been carried out as closely as it was found feasible to do so.
- c.* As regards the method of extracting the observations. The plan of loose cards suggested was tried for a certain time, but was subsequently given up for another (described in the Report of the Meteorological Committee for 1867, pp. 8 and 60) which experience showed to be preferable.
- d.* As regards the method of discussing and tabulating the results of observations when extracted. These recommendations have not been fully carried out; on the one hand the work has been conducted to a much greater degree of minuteness and over more limited areas than was contemplated in the report, such a plan being considered to afford results of a more valuable character in the interests of navigation.

On the other hand, with every desire to carry out the recommendations of the Report, it has not been found practicable to *weight* the observations, and consequently to assign *the degree of probable precision* to the results.
- e.* As regards the publication of meteorological results. The recommendations have been carried out in principle but not to the letter. The publications of the Office have been more methodical than those criticised in the report.
- f.* As regards the publication of other results useful to navigation. The recommendations as regards communication of hydrographical notices to the Admiralty have been fully carried out. The report, however, did not apparently contemplate the publication of any data in the form of charts by the Meteorological Office; it was, however, considered by the Meteorological Committee that for certain purposes, as indicated by the foregoing statement, the form of a chart was preferable to ordinary letterpress.

II. WEATHER TELEGRAPHY.

The first action prior to the resumption of the issue of storm-warnings was the inspection of the stations.

This has been annually carried out ever since. Much that was objectionable has been gradually improved, and at present 16 out of the 29 stations are provided with the Stevenson's thermometer-screen.

Observers have been changed from time to time, so that at present only 12 are telegraph clerks, and all are distinctly and immediately responsible to the Office.

The Office may fairly claim for its service a higher degree of scientific accuracy and completeness than exists in any *at present* in operation in Europe. It must always be remembered that, as a rule, telegraphic stations are not likely to be good stations for general climatology, the conditions which determine the choice of locality being widely different in the two cases. It seems therefore less incumbent on the Office to publish means for temperature, &c. for these stations than would appear to have been held by some authorities, to judge from the evidence on the subject laid before the recent Science Commission.

A difficulty in dealing with Weather Telegraphy is to be found in the frequency of telegraphic errors, which renders any absolute dependence on figures received by telegraph impossible. Some idea of the extent to which this evil affects the scientific prosecution of weather study and interferes with the formation of correct views of the essential facts with the promptitude that is required for the practical application of the deduced results—the issue of warnings to the coasts—may be gathered from the fact that in the case of one single station, Oxford, 49 errors were detected (on receipt of the original MS. messages) in the space of 18 months, which were all proved to be due to inaccurate transmission, and were in addition to a considerable number which had been discovered at first inspection of the telegrams (owing to the glaring discrepancy of the reports from those of adjacent stations), and had been corrected by repetition of the message.

This number gives about 32 errors per annum; so that on this hypothesis there would be 32×29 or 928 errors from British stations coming in every year, which it is apparently impossible to detect by simple inspection of the telegrams.

Of errors in barometrical and thermometrical readings as received by telegraph and suspected from their discrepancy *inter se*, the Office discovers more than 1000 every year, frequently eliciting a correction by repetition of the telegram and correspondence with the observers.

The following memorandum shows the present condition of the Weather Service :—

A. Comparison of the "Daily Weather Report," as it appeared at the time of the Report of the Committee of Inquiry in 1866, with the same Report as now published.

Contents.

1866.	1875.
1.—REPORTS GIVEN, FOR 8 A.M., FROM 20 STATIONS.	1.—REPORTS GIVEN, FOR 8 A.M., FROM 51 STATIONS.
16 in the United Kingdom. 4 on the Continent. Countries represented being— British Isles, exclusive of the Shet- lands, Hebrides, and Scilly. France and Holland.	29 in the United Kingdom. 22 on the Continent. Countries represented being— British Isles, including the Shet- lands, Hebrides, and Scilly. France, Holland, North Germany, Denmark, Norway, Sweden.
2.—NATURE OF INFORMATION GIVEN.	2.—NATURE OF INFORMATION GIVEN.
A.— <i>Tabular matter.</i>	A.— <i>Tabular Matter.</i>
For 8 A.M. :— Barometer. Dry-bulb thermometer. Wind. Weather. Sea-disturbance.	For 8 A.M. :— Barometer, and change in past 24 hours. Dry-bulb thermometer, and change in past 24 hours. Wet-bulb. Wind. Weather. Sea-disturbance.
For past 24 hours :— Extreme wind. General weather. Rainfall.	For past 24 hours :— Maximum temperature in shade. Minimum temperature in shade. Rainfall.
	For 6 P.M. on previous day (44 stations) :— Barometer. Dry-bulb thermometer. Wind. Weather.
	For 2 P.M. on previous day (9 stations) :— Barometer. Dry-bulb thermometer. Wet-bulb thermometer. Wind. Weather. Sea-disturbance.
B.— <i>Written Matter.</i>	B.— <i>Written Matter.</i>
Explanation of table. Remarks. Forecasts, for two days.	Explanation of table. Remarks.
C.— <i>Graphic Representations.</i>	C.— <i>Graphic Representations.</i>
Nil.	Four small charts of Western Europe, showing for 8 A.M. :—
	1. The distribution of pressure, with notes as to the changes which have occurred in the different localities since the previous morning.
	2. Similar information as to the air- temperature in the shade.
	3. The prevalent winds, the sea-dis- turbance (when rough or high), and the portion of our coasts (if any) which has been warned,

1866.	1875.
	4. The weather at each station, and the regions in which a measurable quantity of rain has fallen in the past 24 hours. When the fall at any station has been heavy (<i>i.e.</i> more than 0.5 in.) the amount is entered in figures (to the nearest tenth of an inch) close to the position of the station at which it has been measured.
D.— <i>Corrections and Additions.</i> Nil.	D.— <i>Corrections and Additions.</i> At the end of each month a sheet is published containing the corrections (when obtainable) for all the errors which have been detected throughout the month, together with copies of all returns which have been received too late for insertion in their proper places.
E.— <i>Weekly Summary.</i> Nil.	E.— <i>Weekly Summary.</i> A summary of the weather over North-western Europe is published each week, giving a brief résumé of the conditions observed on each day, and a <i>general</i> summary for the whole week, calling attention to the more general changes reported.
3.—ISSUE. A <i>very</i> few copies used to be issued, viz. to certain newspapers and one or two subscribers.	3.—ISSUE. In addition to about 10 written copies (for 2nd edition of 'Times' and some other evening papers and one or two subscribers), 595 lithographed reports are printed daily. Of these about— 525 copies are issued daily. 6 do. do. weekly. 8 do. do. monthly. 16 do. do. half yearly. Of those issued <i>daily and weekly</i> , about 300 are issued to subscribers, and the remainder are sent free to Public Offices or for exhibition at seaports, or in return for observations from volunteer observers.

It should also be remarked that since the 1st of April, 1875, Daily Weather Charts have appeared in the 'Times' and other newspapers. The form of these charts and the method of producing them in time for publication were first initiated by a member of the Committee.

Since January 1, 1876, arrangements have been made by which a chart for 6 p.m. is supplied to the 'Times' at the expense of that journal.

As regards actual work effected in this Department, the Office may point to the following papers:—

N. O. 1. A Paper by Mr. Scott confirming the universal relation between the direction and force of the wind and the differences in barometrical readings, which had been already propounded

by Professor Buys Ballot. This paper tended to establish the value of gradients for the purposes of weather study.

- N. O. 2. A Paper by Capt. Toynbee on the curves of the Meteorological Observations taken on board the steamers running between Europe and America, showing that as on their voyages outward they meet, and on their homeward route they run with, cyclonic systems of wind which are crossing the Atlantic, the succession of the phenomena is much more rapid in the former than in the latter case. In fact, in some of the homeward runs, the barometer is found *to rise when the wind is southerly*, thus showing that the ship is outstripping the disturbance.

- N. O. 3. Also by Capt. Toynbee, shows by a number of instances the value of isobaric curves for the purposes of weather study, and also draws the attention of sailors to the fact that the tack on which they are from time to time (that is, the direction in which they are sailing with regard to the wind) affects very materially the rate of the changes that are taking place in the indications of the meteorological instruments, the barometer falling less rapidly, or even rising, when they are on the starboard tack (that is, with the wind on the right), and the converse when they are on the port tack, in the Northern Hemisphere.

- O. 13. Also by Capt. Toynbee, was undertaken in order to throw light on the storm in which the 'City of Boston' is supposed to have foundered. It is the most elaborate discussion of Atlantic weather which has appeared, and it shows, *inter alia*, how incomplete the materials are, and must be, for any synoptic weather-charts extending over a wide stretch of ocean. It illustrates the generation of the Atlantic winter gales over the warm-water area on the prolongation of the Gulf-stream, and proves that the centres of disturbances in some cases move to the east or north-east, at a rate exceeding 30 miles an hour—a fact which is confirmed by the records of the self-recording observatories in these islands, and by the general results of the observations made over the whole of Northern Europe.

In order to carry out the same method of investigation over a more extensive field, the Office has undertaken the examination of the weather of the Atlantic for the entire month of August 1873, when a very severe cyclonic storm swept along the American coast and did enormous damage in Nova Scotia. It is hoped that light will be thrown on the actual formation of, and the subsequent modifications in, this serious storm, so that some attempt may be made to solve the vexed problem of the precise direction of the motion of the air in cyclones in reference to the position

of the centre of the disturbance. The Office has appealed to the owners of all British vessels at sea in the Atlantic during the month in question, and has met with a very satisfactory response, having received no less than 280 logs, a larger number than has ever before been available for such an inquiry.

The charge of the issue of storm-warnings &c. has necessarily been wholly confided by the Committee to the Director of the Office, who, in reply to our inquiry how far the principles by which he is guided admit of being formulated, has furnished us with the following remarks:—

“The chief of these principles, which are only announced with very great diffidence, as being liable to material modification with the growth of experience, are as follows:—

“I. *The Law known as Buys Ballot's*, which is simply a general application of the Law of Storms announced by Redfield and Reid.

“The intelligent application of this principle to wind motion, even on the most extensive scale, has been the chief point in which modern meteorology offers a contrast to prior investigations into the science.

“This law gives not only the direction of the wind, but also its force, which is measured with more or less accuracy by means of gradients. That it is not absolutely true in all cases and conditions is more than probable, although precise statements on this subject are not accessible as yet.

“As regards Direction, the indraught of wind across the isobars in front of an advancing storm is indisputable, as is the effect of land in modifying the motion of the air.

“As regards Force, it is clear that the same gradient does not accompany the same force of wind from all points. A further proof of this statement is to be found in a fact which has been elicited by the investigations into the meteorology of the sea, that for the same force of wind the gradient is less in the S.E. than in the N.E. Trade.

“II. *The mutual Relation of areas of low and of high Barometrical Pressure*, the former being to a great extent regulated as to their motion by the latter, and skirting them on their western, northern, and eastern side, at least; so that when we have an area of high pressure situated over a portion of these islands, we can form a good idea of the probable direction of motion of cyclones in our neighbourhood—*e. g.*, the existence of an anticyclone over Ireland is accompanied by the advance of cyclonic disturbances southwards over the Baltic or North Sea, causing northerly gales on the east coast of England.

“The above principle is manifestly incomplete, inasmuch as it takes no account of the rarity of any westward motion in the cyclones.

This latter circumstance, however, appears to be a local peculiarity, and it is probable that if the weather were studied over a wider area, as in the synoptic charts of Capt. Hoffmeyer, or those projected, but not yet carried out, by the United States Signal Office, light would be thrown upon it. It is certain that a motion westward does sometimes occur even over these islands, as well as in lower latitudes, as, *e. g.*, over Turkey in Asia, from Bagdad to Salonika, Nov. 3-6, 1869.

"The appearance of secondary cyclones in connexion with larger disturbances of the same nature is gradually attracting more and more attention. These systems are imperfectly developed, inasmuch as, generally speaking, they exhibit no easterly winds of much force, manifesting themselves on the southern side of their primaries, and intensifying the violence of the westerly winds which blow under such circumstances.

"It must be admitted that, not unfrequently, the arrival of one of these satellite depressions, in advance of a more serious storm, has enabled the Office to give timely warning of the latter.

"The comparative rarity of the easterly winds in our cyclonic storms is probably traceable to the constant existence of an area of deficient pressure near Iceland, which renders the formation of steep gradients for easterly winds an unusual phenomenon.

"There appear to be some indications of principles by which we can recognize whether or not a cyclonic disturbance is speedily to be succeeded by another.

"If, after the centre of a depression has passed over us, the shift of wind and fall of temperature causes a great clearness of the air, intense radiation occurs at night, the thermometer on the grass falling 10° to 14° below that in the shade 4 feet above the ground. Under such circumstances it has been noticed that the advent of a new depression is imminent. When, however, the series of successive depressions has ceased for a while, the weather clears much less rapidly, and radiation is not nearly so marked.

"On the whole thus much may be affirmed, that it is to the general conditions of atmospherical pressure *over as large an area as possible* that we are to look for an insight into the probable changes which are likely to ensue. To this subject I shall shortly recur.

"III. *Temperature.*—As regards the relation of this element to atmospherical disturbance, there are no definite principles which can be said to be generally admitted as true. This may be gathered from the almost total silence on this subject on the part of those who replied to the circular of the Leipzig Storm-Warning Committee in 1872.

“Thus much may, however, be said:—

“A great contrast of temperature over a limited area, or, so to speak, a great thermometric gradient, being an indication of serious atmospheric disturbance, is a precursor or concomitant of a storm. This fact has been clearly pointed out by Dove; but more recent evidence on the same head is to be found in the circumstance that for five days, January 26–30, 1870, the mean of the temperatures at 8 A.M. at London and Valencia differed 16° , being 28° and 44° respectively, a heavy southerly gale blowing all the time over Ireland. A more recent instance, in which a remarkable contrast of temperature immediately preceded a very serious storm, was on the 13th of November, 1875, when the reading at Scilly was 57° , and at Wick 21° . These figures give the very large difference of 36° . The gale of Sunday, November 14th, with its accompanying high tide, will be fresh in the memory of all.

“Another mode of utilizing temperature in the forecasting of storms is to be found in the long-established fact that an abnormally high temperature, close stuffy weather, frequently precedes a storm. This principle has not been reduced to numerical measure as yet.

“IV. *Vapour-Tension and Rainfall.*—Very much weight is attached by several meteorologists to the indications obtainable from these elements, as Mohn and Loomis consider that their disturbance and intensity determine the direction and velocity of motion of cyclones, and that even the very existence of a cyclonic disturbance depends on the presence of aqueous vapour in abundance.

“For the area of our storm-warning system this indication is necessarily of minor value, inasmuch as our district is so intersected by water that no portion of it will show such contrasts in regard of vapour-tension as subsist in continental stations.

“V. *Sea-Disturbance.*—This is at times a most valuable help towards gaining a knowledge of coming storms; but it is very untrustworthy. The sea-disturbance, being caused by the wind, is propagated in the direction in which that wind is *blowing*, not in that in which it is *advancing*. Thus a very heavy sea may roll in on our coasts without any gale reaching them; and conversely heavy gales, even westerly gales, like that of November 22, 1872, may come on without any premonition in the way of a ground-swell.

“The distance to which waves may be propagated is indicated by what has already been mentioned as probable, that the ‘rollers’ of Ascension and St. Helena may be due to N.W. gales in the North Atlantic.

“VI. *Local Signs.*—These are really among the most important indications of coming change; but practically they can scarcely be

utilized by us. They cannot be reduced to rule, and they depend almost entirely on personal experience. It is impossible in a telegram to convey the entire line of reasoning which leads one, in the absence of instruments, to know that a storm is impending. The character, elevation, and motion of clouds, the colour of the sky, the clearness or the contrary of the air, the appearance of the aurora, and numerous other signs are well known to every one who studies weather; and from these helps the cabinet meteorologist is entirely debarred. He is like a physician dealing with a case by correspondence, without the chance of a personal interview with his patient; for what can a resident in an inland town like London, on any given day, know of the look of the weather on the sea-coast on the same day.

“If, in conclusion, I were asked how our weather service could be most directly improved, on the supposition that larger means were available for its prosecution, I should say,—

“A. The supply of cheap self-recording instruments to our principal stations, so that the reporters should be able to furnish intelligence as to the changes which have taken place immediately previous to the epoch for which the report is framed.

“The erection at a number of well-exposed outlying stations of the automatic signalling-anemometers described in the Report of the British Association for 1874, p. 37, in order to warn the nearest telegraphic stations of the fact that the wind has reached a given velocity, say 30 miles an hour. Want of funds has hitherto prevented the carrying out of this plan.

“B. Additional stations at well-selected points on our west coast, as at Mullaghmore, on Donegal Bay, and at high levels, as at Settle, in Yorkshire.

“The former especially to give more accurate indications of wind, which from our present stations is often necessarily incorrect, owing to the precipitous character of our western coasts, which affects the direction and force of the wind. The latter to furnish means for a study of the differences of atmospherical conditions in a vertical direction, which has yielded very valuable results whenever it has been prosecuted.

“C. Additional reports daily. This is a most pressing want; it has been partially met by the enterprise of the public press, the ‘Times’ having begun (Jan. 1876) to bear the expense of an evening message from some stations.

“D. Improved accuracy in transmission of the reports. This is, I fear, hopeless!

“E. Extension of the area covered by our reports. This raises the question of international exchanges; and in this particular it must be remembered that stations are not of equal value, for a report

from an outlying post, as Valencia or Sumburgh Head, is worth to the continental meteorologists many times more than a report from a continental station is to us.

“The extension of our system westwards, were it possible, would be of incalculable value ; but America and even Newfoundland are too distant for us to reason with any degree of certainty on what the changes taking place there may portend to us.

“Reports from the Azores, if supported by others from Spain and Portugal, would be of value ; but they would require confirmation. At least two simultaneous reports from independent stations in that group of islands would be required, in order to afford means for checking doubtful statements or errors in telegraphy.

“F. An increase of the staff of the Office.

“To summarize. More information from existing stations, a large extension of our area of observation, and a reinforcement of the staff for weather study, are the chief requirements of our telegraphic system at present.”

In the matter of the “Recommendations on the subject of Weather Telegraphy, Daily Forecasts, and Storm-Warning, and upon observations of Weather within or affecting the British Isles,” made by the Committee of Inquiry (1866), it may be said that the progress of this department of meteorology since 1866 has been so considerable that the importance of several of the Recommendations has been materially modified by recent experience. The Office has carried out the recommendations in principle as regards the development of the observing system, the issue of storm-warnings, and the discontinuance of weather forecasts, and as to the checking of the warnings. It has not, however, for reasons which will be stated hereafter, published a series of maxims, nor has it been found possible, with the present staff, to analyze strictly the principles on which the issue of warnings, &c. has been carried out from day to day.

The staff has been quite insufficient to cope with the serious discussion of the weather charts which are daily accumulating.

The Office has cooperated readily with the United States Signal Office in its project for synchronous observations over the whole globe.

III. LAND METEOROLOGY OF THE BRITISH ISLANDS.

This branch of the Office has been carried out in accordance with the plan sketched out in the letter from the President and Council of the Royal Society to the Board of Trade of June 15, 1865, approved by the Committee of Inquiry (1866), and sanctioned generally by the Treasury in a letter to the Board of Trade, dated November 30, 1866. The number of stations originally proposed was six, with possibly two additional points of observation, situated in the south-west and in the north-west of Ireland respectively. The six stations specified were accepted and have been in continual operation until now. The Treasury did not

sanction the insertion on the estimates of the full sum proposed by the Meteorological Committee for the year 1867-68; and accordingly the Committee at first determined to defer the establishment of the station at Aberdeen, in consideration of the greater importance of records from Valencia. At the request of the authorities at Aberdeen, conveyed through the Duke of Richmond, Chancellor of that University, the Committee resolved to reconsider their proposal; and ultimately Aberdeen was included in the list of places fitted out with self-recording instruments.

The choice of these stations was guided by the fact of the existence in each locality, except Valencia, of some scientific body to whom the instruments could be entrusted. This involved the necessity of placing the instruments in the best available positions on the premises of the respective institutions, the funds available being totally inadequate for the erection of special structures for the reception of the instruments or the maintenance of special observing establishments. Hence have arisen the defects in arrangements as concerns temperature in regard of elevation above the ground at Falmouth and Aberdeen, and to a less degree at Valencia, and as to proximity to buildings in all the observatories. In respect of the four other observatories, not above named, there is no doubt the thermometrical indications do afford as thoroughly satisfactory a record of temperature as is required—this point having been proved by direct experiments by Dr. Stewart for Kew, and by the Rev. Dr. Robinson for Armagh.

Absolute uniformity in conditions of exposure is totally unattainable, as was fully recognized at the Vienna Meteorological Congress in 1873.

The observatories were set in action in 1868, and with the year 1869 the publication of the 'Quarterly Weather Report' was commenced. This was projected in order to overcome the difficulty, universally recognized, of the absence of uniformity in epochs of observation in the different countries. A reproduction of the automatic curves was considered to be of paramount importance in order that the records at observatories should be independent of any choice of hours for observation or of any scales, and the value of such a reproduction was strongly urged by the Committee of Inquiry (1866).

The execution of the plates was rendered possible by the invention of certain special instruments and processes, for which the Office is indebted to Mr. F. Galton and Mr. De La Rue, and which are in constant use, as explained in the several Annual Reports of the Office.

The curves were at first reproduced by the lithographic process, but of late years that of copper-plate printing has been introduced.

The degree of accuracy aimed at is 0·02 in. for the barometer, and 0°·5 for the thermometer; and the plates furnish a continuous record of—
Pressure.

Temperature (Dry and Wet Bulb).

Vapour-Tension.

Wind (Direction and Hourly Velocity).

Rain (Hourly Amount).

It may be asserted, without fear of contradiction, that no record of a completeness and accuracy at all approaching that attained by the plates in question has yet been attempted in any other country, and that moreover the Meteorological Office is the only Meteorological establishment which itself publishes the materials for testing the accuracy of its published numerical values.

In the matter of accuracy many important advances have been made since 1867, owing to the growth of experience, and the methods of treatment of the records have much improved.

The text of the 'Quarterly Weather Report' has been a consecutive journal of the weather, and the tables have given the five-day means of the barometer and the dry and wet thermometer, from hourly measurements of the curves, together with monthly means of the same elements, and of vapour-tension and deduced dry-air pressure, as well as extreme readings of the barometer and dry thermometer.

A request having been made for the publication of the actual hourly readings of the measurements of the curves, this has been complied with. These volumes have been issued since January 1874, and distributed to the principal libraries at home and abroad.

The preparation of the plates and tables above mentioned occupies nearly the entire time of the available staff of the Office; so that no present prospect exists of a systematic discussion of the returns, so as to calculate the periodical variations of the different elements. This for the seven observatories will be a heavy task; and it is for consideration whether some special steps should not be taken for effecting it, as the first five-yearly period over which the observations extended closed with the past year, and it was held by the Vienna Congress that such calculations should be effected for "lustra" (periods of five years) ending with years which, according to our present calendar, are multiples of five.

The 'Quarterly Weather Report' has contained in addition various appendices, which are as follows:—

1869. Notes on easterly gales.

1870. Mean barometrical pressure at telegraphic reporting stations.

Rainfall at telegraphic reporting stations.

A translation of Bessel's Paper on the Determination of the Law of a Periodical Phenomenon.

1871. A discussion of the anemometrical results for Sandwich Manse, Orkney, 1863–68.

Mean monthly rainfall at certain stations in the United Kingdom,

Constants for Bessel's Formula for the Observatories for 1869–70.

1872. Discussion of the anemometrical results at Bermuda, 1859-63.

1873. Rainfall of the London district for 60 years, 1816-1872, by G. Dines, F.M.S.

Results of observations taken at certain stations of the Second Order for the year 1873.¹

The Appendix last mentioned leads to an important subject calling for remark—the study of the climatal conditions of these islands by means of returns from stations auxiliary to the self-recording observatories.

Such stations have been gradually organized; and in January 1873 the Committee were able to inform the Registrar-General, in reply to an inquiry made by him, that if the Office were called upon to furnish materials to him for his statistical returns, it was in a position to do so.

Of late the list of stations in connexion with the Office has received an important reinforcement by the conclusion of an arrangement by which the Meteorological Society (of London) supplies returns from some of its stations, in return for a small annual grant to defray the expense of copying.

That Society has recently organized a system of stations with much care, which exhibit a satisfactory agreement as to the character of the instruments and the conditions under which all the observations are taken.

This cooperation of the Society, and of a considerable number of private observers throughout the country who have volunteered to supply their schedules of observation gratis, renders it possible for the Office to take its part in the general international scheme of publication of returns from eye-observations proposed by the Permanent Committee of the Vienna Congress, in order to facilitate climatological inquiries.

The publication of these returns, demanded for 15 stations in the United Kingdom, has been commenced for England and Ireland. As for Scotland, it is hoped that the Scottish Meteorological Society will supply their quota of materials for this international object.

The Committee have felt it their duty to afford every facility to their Director to attend, as their representative, the meetings of the various Meteorological Congresses which have been held of late years, and, moreover, have entertained the members of the Conference on Maritime Meteorology, which was held at their Office in August 1874.

The Office is therefore at present fulfilling all that is called for from this country for international purposes, as defined by the Permanent Committee of the Vienna Congress; and there can be no doubt that the information now coming in is, as regards accuracy, fully equal, if not superior, to any published from a similar system of stations in any country.

Further may be mentioned the fact of the recent publication by the Office, at the request of the Government, of a volume entitled “Instructions in the Use of Meteorological Instruments,” which has been compiled with the assistance of several meteorologists unconnected with the Office.

The Scottish Society have sought to obtain a grant in aid of their general objects from the Parliamentary vote ; but the Committee have considered that, as they are only agents for directing the application of the fund at their disposal, they have no authority to make grants to be dealt with at the discretion of other bodies, and that their action is restricted by the conditions that the objects to which it is directed shall be among those for which the grant is made, and that the expenditure shall take place in a manner that admits of their exercising a control over its objects and results.

Before leaving this branch of the subject, the Committee would remark that their operations would have been seriously crippled in the year 1871, when the British Association withdrew its annual subsidy to Kew Observatory, the central observatory of their system, had not Mr. Gassiot, one of their own body, come forward and most munificently placed in the hands of the Royal Society a sum of £10,000 for the endowment of the establishment, thereby affording ample funds for the continuance of the observatory in full activity.

In conclusion the Committee would make a few general remarks on the principles that have guided them in organizing the Meteorological Office and controlling its operations.

They have considered it to be their duty to give general effect to the recommendations of the Committee of 1866, and to establish and carry on for a considerable length of time, with the least possible amount of change, a well-arranged and uniform system of observation and of publication, being satisfied that continuity of method is one of the most essential elements of success in dealing with complicated physical phenomena.

The Committee on their first appointment laid down with much deliberation the course to be pursued by the Office, and gave considerable attention to the removal of the numerous difficulties which necessarily occurred in the establishment of so much that was novel, especially in connexion with the self-recording instruments.

Seeing that the Committee of 1866 had recommended a renewed inquiry into the proceedings of the Office after three years' trial, and feeling that under any circumstances its constitution was only provisional, the Committee have aimed at leaving the principal officers employed in the duties of the department as little fettered as possible as to the precise manner in which details were conducted, looking rather to securing satisfactory results of the work, and to exercising that strict financial control over the application of the funds placed at their command which their duty to the Royal Society and the Government required of them.

They have also felt that, in the existing condition of meteorological knowledge, it would have been not only presumptuous on their part, but positively mischievous to have attempted to assume a position of authority in enunciating new doctrines of their own or in criticising the

opinions of others, and that their power of producing useful results would have been seriously impaired if they had in any way departed from the purely neutral attitude of accumulating a faithful record of facts destined to furnish materials for scientific discussion.

Although there exists a large quantity both of published and unpublished data in the possession of the Office, which places their staff in an exceptional position for conducting elaborate investigations into the conditions of the weather, nevertheless the Committee have found it impossible to provide for the adequate carrying on of such investigations by means of their own staff, the time of their chief executive officers being so much occupied by the heavy current business of the Office as to leave them no leisure for the purpose; nor have the Committee been able to assign out of the funds at their disposal enough to secure additional assistance of a proper scientific character. If they had diverted any of these funds to purely scientific discussions it would have crippled other parts of their work, which appeared to them, under the existing conditions and for the time being, to be still more important and to be, in a measure, obligatory on them.

It will readily be understood that the Committee holding such views makes no claim to having given an independent impetus to the progress of any special branch of meteorological science, though they feel satisfied that their operations have in an important manner facilitated the natural development of accurate meteorological conceptions. All conversant with the facts will agree that a very great advance has been made in this respect since the Committee was formed. The Committee will not attempt to distinguish all the various causes that have conduced to this advance; but among them are certainly to be recognized the organization of the system of continuously self-recording observatories and the publication in the 'Quarterly Weather Reports,' with a remarkable degree of accuracy, of a graphical reproduction of the records thus obtained; the constantly increasing attention paid by the officers of the Meteorological Office to the accurate and prompt preparation and distribution of the lithographed Daily Weather Charts, their intelligent study of the facts recorded under their direction, and their cordial cooperation with other bodies interested in similar objects, whether in this country or abroad. The experience gained in the preparation of the Daily Morning Weather Charts has enabled the Office to prepare smaller charts, which are supplied for publication in several daily papers in London and the provinces. This indication that such information is appreciated by the public is further corroborated by the fact that similar Charts containing information for the evening have been asked for, and are now furnished by the Office to the 'Times.'

The Committee being aware that the Government has entrusted to another body the duty of inquiring how the functions they have performed may best be discharged in the future, they will only permit

their remarks to extend beyond a review of the past in three particulars.

First. They look forward with great hope to the effect of increased international cooperation on a large scale, towards which important steps have already been taken at recent Meteorological Congresses. The detached labours of numerous meteorological institutions will thereby be presented in a strictly comparable form, and may readily be combined in synoptic charts or in any other manner into a single whole. They think it is impossible to overstate the importance of measures tending to such a result.

Secondly. They consider it to be a point of much importance that the meteorological societies and independent observers of this country should be more generally induced to work in unison with an Office maintained by grants from Parliament, so far as their several efforts are directed to the same field of inquiry. Administrative difficulties have hitherto prevented the accomplishment of as much in this direction as could be desired; but the Committee fully recognize that it would be advisable to utilize more completely than has yet been done the energy of independent meteorological societies or individuals, and they believe that this admits of being effected on conditions that would be suitable and acceptable to them.

Lastly. They feel it necessary to say that for the further advancement of Meteorology greater attention to its more strictly scientific aspect will in the future be essential. Merely empirical rules, however sound be their foundation, can never become really trustworthy guides of action until the principles that underlie them are established, and the circumstances are appreciated under which deviations from the ordinary course of events arise. It can hardly be disputed that in the course of the past nine years, since the appointment of the Committee, the general progress of the science of Meteorology in this country and abroad has been such that the application to it of exact principles seems to have become not only possible but requisite; without them the full practical advantage of existing means of observation will not be secured, and it is only by aid of scientific discussion of the facts that these principles are to be ascertained.

They would suggest, as a probable mode of attaining the object they have in view, the application of a portion of any future grant to the preparation of reports, or the carrying out of researches on special subjects connected with meteorological science by qualified persons to be selected from without and employed independently of the ordinary staff of officers engaged on other duties.

The Committee are only too well aware of the difficulties that are likely to attend the progress of Meteorology as an exact science; but difficulties apparently as great have been overcome in other directions, and perseverance and time will doubtless remove those now in question.