

TENTH ANNUAL REPORT
OF THE
METEOROLOGICAL COMMITTEE

TO THE
LORDS COMMISSIONERS OF HIS MAJESTY'S
TREASURY.

For the Year ended 31st March, 1915
(the Sixtieth Year of the Meteorological Office).

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



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THE METEOROLOGICAL COMMITTEE, 1914-15.

Constituted by Minutes of the Lords Commissioners of H.M. Treasury, dated 20th May, 1905, and 31st March, 1910.

Appointed till

- March 31, 1915 ... Mr. W. N. SHAW, Sc.D., F.R.S., Director,
Chairman.
- Sept. 2, 1914 ... Rear-Admiral H. E. PUREY CUST, R.N.,
Hydrographer to the Navy (*to August 15, 1914.*)
- August 15, 1919 ... Captain JOHN F. PARRY, R.N., Hydro-
grapher to the Navy (*from August 16, 1914.*)
- March 31, 1915 ... Captain J. M. HARVEY, Principal Examiner
of Masters and Mates, Board of Trade.
Nominated by the Board of Trade.
- Dec. 2, 1916 ... T. H. MIDDLETON, C.B., M.A., M.Sc., Assis-
tant Secretary of the Board of Agriculture
and Fisheries. Nominated by the Board
of Agriculture and Fisheries.
- March 31, 1915 ... Professor ARTHUR SCHUSTER, F.R.S. Nomi-
nated by the Royal Society.
- Feb. 25, 1918 ... Captain H. G. LYONS, D.Sc., F.R.S. Nomi-
nated by the Royal Society.
- March 31, 1915 ... Mr. G. L. BARSTOW, C.B. Nominated by the
Treasury.
-

Subject to the discretion of the authorities by which they were respectively nominated, the members of the Committee hold office for a period not exceeding five years, but are eligible for reappointment.

THE GASSIOT COMMITTEE, 1914-15.

Appointed in accordance with Treasury Letter of 26th February, 1910, by the Royal Society on 17th March, 1910, to administer the Gassiot Trust, and to promote the scientific study of the branches of science to which the Trust relates, viz., Meteorology, Terrestrial Magnetism, Atmospheric Electricity, Seismology, and the cognate subjects.

Sir William Crookes, O.M. (*President of the Royal Society*).

Captain H. G. Lyons (*Chairman*).

Dr. C. Chree.

Mr. W. H. Dines.

Sir F. W. Dyson (*Astronomer Royal*)

Sir Archibald Geikie, K.C.B.

Dr. R. T. Glazebrook, C.B.

Sir A. B. Kempe (*Treasurer of the Royal Society*).

Sir Joseph Larmor, M.P.

Prof. H. F. Newall.

Sir Arthur Rücker.

Sir E. Rutherford.

Prof. Arthur Schuster (*Secretary of the Royal Society*).

Dr. W. N. Shaw.

Dr. G. T. Walker.

Mr. G. W. Walker.

Prof. W. Watson.

Mr. C. T. R. Wilson.

THE STAFF OF THE METEOROLOGICAL OFFICE AND OF THE OBSERVATORIES OF THE METEOROLOGICAL COMMITTEE, 1914-15.

Revised to include changes up to 30th June, 1915. Members of the staff whose names are in brackets are absent by permission on military service or other special duty.

DIRECTOR.

Sir Napier Shaw, LL.D., Sc.D., F.R.S.

METEOROLOGICAL OFFICE.

SECRETARIAL STAFF.

<i>Secretary</i> ...	... R. Corless,* M.A.
<i>Chief Clerk</i> ...	... T. D. Bell.
<i>Professional Assistants</i> ...	... C. E. P. Brooks, B.Sc., Miss E. R. Perkins, M.A.
<i>Graduate Assistants</i> ...	... [H. W. Braby, M.A.]
<i>Staff Assistants</i> ...	... [E. L. Ardley], H. L. B. Tarrant.
<i>Clerks</i> ...	... E. J. Hood, Miss R. E. Smith, Miss A. F. Poole. §
<i>Clerk Assistant</i> ...	... Miss E. C. While, B.A.
<i>Clerk Computers</i> ...	... Misses D. M. Buckeridge, D. G. Chambers, E. V. Turney.
<i>Probationers</i> ...	... E. L. Clinch, Miss W. A. Quennell.
<i>Office Keepers</i> ...	... W. H. Parsons, C. E. Goad.
<i>Store Keeper</i> ...	... A. G. Goad.
3 Messengers, 2 Office Boys.	

MARINE DIVISION.

<i>Marine Superintendent</i> ...	... M. W. Campbell Hepworth,* C.B., R.D., Commander R.N.R.
<i>Principal Assistant</i> ...	... W. Allingham.
<i>Staff Assistant</i> ...	... W. G. James.
<i>Clerks</i> ...	... J. T. Williams, H. Keeton.
<i>Clerk Computer</i> ...	... [A. A. Lovie.]
<i>Probationers</i> ...	... H. T. Smith, § [W. B. Greening], [2nd Lieutenant J. L. Gray], A. J. Tabor. §
<i>Boy Clerk</i> ...	... F. C. Warmington. §

* Inspector of Meteorological Stations.

§ Member of the corps of observers for the instruments installed at the Office.

FORECAST DIVISION.

<i>Superintendent</i> ...	... R. G. K. Lempfert,* M.A.
<i>Principal Assistant</i> ...	... F. J. Brodie.*
<i>Forecast Assistants</i> ...	... H. Harries,* R. Sargeant.*
<i>Clerk</i> ...	... A. T. Bench.
<i>Clerk Assistant</i> ...	... W. Hayes.
<i>Clerk Computers</i> ...	... A. G. W. Howard,§ [R. Pyser.]
<i>Probationers</i> ...	... C. F. J. Jestico,§ [N. C. Bradnock,†§] R. M. Poulter,§ C. C. Newman,§ E. T. Streets.

The staff at the Branch Office at Farnborough and at the Weather Station at Falmouth (*see* below), are associated with this division.

STATISTICAL DIVISION.

<i>Superintendent</i> ...	... [Captain E. Gold,* M.A.]
<i>Principal Assistant</i> ...	... J. Sheerman.
<i>Staff Assistants</i> ...	... A. H. Bell, A. R. Simpkins.
<i>Clerks</i> ...	... C. A. Bracey, L. H. Powers, C. W. Heinemann, Miss L. D. Sawyer.§
<i>Clerk Assistant</i> ...	... M. T. Spence.§
<i>Clerk Computer</i> ...	... A. E. Pycock.
<i>Supernumerary Clerk</i> ...	... [W. J. Tomkins.§]
<i>Probationer</i> ...	... Miss N. L. Despicht.§
<i>Boy Clerk</i> ...	... G. Barker.§
	1 Office Boy.

INSTRUMENTS DIVISION.

<i>Superintendent</i> ...	... F. J. W. Whipple,* M.A.
<i>Principal Assistant</i> ...	... R. F. Wallace.
<i>Clerk Assistant</i> ...	... [Lieutenant A. G. Gendle, R.N.V.R.]
<i>Clerk</i> ...	... F. W. Snell.
<i>Mechanical Assistant</i> ...	... J. H. James.
<i>Clerk Computer</i> ...	... [F. Levin.]
<i>Probationer</i> ...	... C. V. Ockenden.
	1 Messenger.

Lithographers—Messrs. Wyman & Sons, Ltd. (A. G. King, Artist).

Meteorological Field Service (Forecast Division) Additional Temporary Staff for Special Duty.

Major H. G. Lyons, R.E., D.Sc., F.R.S.

Captain C. J. P. Cave, M.A., J.P., Honorary Inspector (South Farnborough).

[Lieutenant A. E. M. Geddes, M.A.], Professional Assistant (Forecast Division).

E. H. Chapman, M.A., B.Sc., Professional Assistant (Forecast Division).

E. L. Hawke, B.A., Honorary Assistant (South Farnborough).

* Inspector of Meteorological Stations.

† Killed in action, May 9th, 1915.

§ Member of the corps of observers for the instruments installed at the Office.

METEOROLOGICAL OFFICE, EDINBURGH.

Superintendent Andrew Watt,* M.A.

METEOROLOGICAL OFFICE, SOUTH FARNBOROUGH.

Meteorologist-in-charge ... J. S. Dines,* M.A.

Professional Assistant ... F. Entwistle, B.Sc.

1 Office Boy.

OBSERVATORIES.

CENTRAL OBSERVATORY.

Kew Observatory, Old Deer Park, Richmond, Surrey.

Superintendent C. Chree, Sc.D., LL.D., F.R.S.,
Assistant Director of Observatories.

Professional Assistants ... E. G. Bilham, B.Sc., A.R.C.S.,
 E. H. Nichols, B.Sc. (temporary).

Staff Assistants E. Boxall, B. Francis.

Clerk Computer B. G. Brame.

Probationer L. G. Hemens.

Girl Clerk Miss K. R. Corrin.

Observer and Caretaker ... W. R. Corrin.

1 Handyman.

MAGNETIC OBSERVATORY.

Eskdale Observatory, Langholm, Dumfries-shire.

Superintendent L. F. Richardson,* B.A.

Professional Assistant ... [Lieutenant A. H. R. Goldie, M.A.]

Clerk Assistant P. N. Skelton.

Clerk Computer H. G. Harris.

Mechanic-Caretaker ... A. Stonier.

Boy Clerks J. Beck, David Black.

WESTERN OBSERVATORY.

Valencia Observatory, Cahirciveen, co. Kerry.

Superintendent L. H. G. Dines,* M.A., A.M.I.C.E.

Assistant M. Sugrue.

1 Handyman.

AEROLOGICAL OBSERVATORY.

Benson, near Wallingford.

Director of Aerological }
Investigations. } W. H. Dines, F.R.S.

Professional Assistant ... E. V. Newnham, B.Sc.

Mechanical Assistant ... [H. W. Baker.]

WESTERN STATION, FALMOUTH OBSERVATORY.

Professional Assistant ... C. D. Stewart, B.Sc.

Clerk Computer J. B. Phillips.

* Inspector of Meteorological Stations.

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For the Year ended 31st March, 1915 (the Sixtieth
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MAY IT PLEASE YOUR LORDSHIPS.

Meetings of the Committee have been held on 29th April, 24th June, 28th October, 25th November, 1914, 27th January, 24th March, 1915.

By Your Lordships' Minute dated 17th July, 1914, Captain John Franklin Parry, R.N., Hydrographer of the Navy in succession to Rear-Admiral H. E. Purey-Cust, C.B., was appointed a member of the Committee for a period not exceeding five years from 16th August, 1914.

Office and Observatory Staff.—A list of the members of the staff at the close of the year is given on pages 6-8.

The war has affected every side of the work of the Office, and in particular has entailed many alterations in the staff, although the number of men of military age is comparatively not large. By the accident of appointment in past years the staff consisted largely of men beyond the military age, or of boy clerks and probationers who were too young. One member, A. E. Gendle, was in training with the 1st. County of London Yeomanry when war was declared, and he was placed upon the same footing with regard to pay as members of the Civil Service by the terms laid down by the Prime Minister. He has now obtained a commission in the Naval Flying Corps.

Permission to enlist on the terms laid down for the Civil Service was granted also to—

A. A. Lovie,
N. C. Bradnock,
J. L. Gray,
W. B. Greening,
R. Pyser,
W. J. Tomkins,
F. Levin.

Two of the boy messengers and a workman at Kew Observatory also enlisted. H. W. Braby, M.A., Graduate Assistant, joined

the Royal Army Medical Corps. G. I. Taylor, M.A., Schuster Reader in Meteorology at Cambridge by appointment of the Committee, H. W. Baker, of the Benson Observatory, and H. Allnutt, of the Branch Office at South Farnborough, transferred their services to the Royal Aircraft Factory, and of the junior staff who had acquired useful experience of the work of the Office, two were attracted by more favourable offers elsewhere, just before the war, and three since its commencement.

Meanwhile a large amount of additional duty came upon the Marine Division, the Forecast Division, the Instruments Division and the Administrative Staff of the Office, and upon the Branch Office at South Farnborough and the observatories at Eskdalemuir and Valencia to meet the requirements of the Admiralty and the War Office, and after careful consideration the Committee felt themselves unable to grant facilities for which application was made by Lewis F. Richardson, Superintendent of the Observatory at Eskdalemuir, to join an ambulance corps, and by E. L. Ardley, cashier, H. L. B. Tarrant, Director's clerk, who had not fully recovered from serious illness, L. H. Powers, of the Statistical Division, and H. G. Harris, of the Eskdale Observatory, to offer their services to the War Office. P. N. Skelton, of Eskdale Observatory, failed to satisfy the conditions of the Army Medical Department in respect of eyesight. B. G. Brame, of Kew Observatory, was also precluded by considerations of health from enlisting.

The following members of the staff rendered assistance out of office hours for several months under Mr. Gold's supervision in connexion with the anti-aircraft service of the Admiralty:—Messrs. Ardley, Powers, Tarrant, Keeton, Brooks, Spence, Tabor, Stewart, Nichols, Brame, Ockenden.

In view of the loss of so many members of the staff and the possibility of the number of absentees being still further increased, there was a serious prospect of the Office work becoming so much disorganised that it might fail to meet the immediate requirements of the various Government Departments. Steps have therefore been taken to increase the staff of women clerks and to redistribute the work accordingly. This transition is not without difficulty, because so much of the clerical work is of a special character requiring long practice and experience; and meanwhile the statistical work has fallen into arrear. Endeavour will be made to restore it, as otherwise it loses a great part of its effectiveness in the service of the public.

The office of the Superintendent of the Valencia Observatory, Cahirciveen, becomes vacant at the close of the year by the retirement on superannuation allowance of Mr. J. E. Cullum, who has been in charge of the observatory since August, 1875. On the nomination of the Gassiot Committee, Mr. L. H. G. Dines, Senior Professional Assistant at Eskdale Observatory, has been appointed to take charge of the Valencia Observatory from 1st May, 1915.

The Committee desire to place on record their appreciation of the skill and devotion with which Mr. Cullum has discharged the

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duties of Superintendent during the long period of his tenure of the office.

Voluntary Assistance.—Numerous offers of assistance of various kinds have been made since the beginning of the war. The Director has accepted the services of Mr. C. J. P. Cave, J.P., late President of the Royal Meteorological Society, as honorary inspector for the Branch Office at South Farnborough, whose duties include short courses of lectures to the officers of the Royal Flying Corps, and since the close of the year Mr. E. L. Hawke, B.A., has been attached to the same establishment as honorary assistant.

International Co-operation.—At the commencement of the year the Office was preparing to bring into use the revised code for the exchange of daily meteorological reports between the Office and the Continent of Europe and for the transmission of information from the Islands of the North Atlantic and from Atlantic liners. This involved the measurement of rainfall in millimetres instead of hundredths of an inch in order to bring the daily values within the two figures allotted for it in the telegrams, and it had already been arranged to express barometric pressure in millibars instead of the conventional inches or millimetres of mercury at sea level in latitude 45° . These changes were duly carried out as from 1st May, 1914. The area of the map used for the Daily Weather Report had already been extended to include Spitzbergen.

The change of practice has given rise to some correspondence. The change from inches of mercury to centimetre-gramme-second units of pressure for the measurement of pressure has been made without any difficulty for the telegraphic reporting stations and in part for the climatological stations and the ships of the Mercantile Marine.

Some of the reasons which guided the Committee in adopting these changes have been set out in a preface to the second edition of the *Seaman's Handbook*. A note on the subject was communicated by request of the Editor, Professor Cleveland Abbé, to the "Monthly Weather Review" of Washington, and it is reproduced in Appendix I. to this report.

The re-examination of the basis of graduation has already yielded some useful results. A barometer has been designed which gives with sufficient accuracy readings of the pressure of the atmosphere, subject only to a single correction easily ascertained, and defined by an adjusted temperature of the attached thermometer. The reconsideration of the whole subject of testing the graduation in conjunction with the National Physical Laboratory has led to the recognition of an error in the practice of correcting barometers of the Kew pattern which has been overlooked during the whole period of fifty years or more in which those instruments have been used.

The Cambridge Scientific Instrument Company has presented to the Office a mercury barometer which reads in C.G.S. units by means of a pointer on a dial instead of a vernier. It is very convenient for reading and was designed for use on marine barometers. It was submitted, with other objects of interest, at the conversazione of the Royal Society in May, 1914, and

has since then been lent to Professor Duffield, of University College, Reading, for the determination of the variation of gravity at sea by comparison of its readings with those of an aneroid barometer. Professor Duffield has retained it up to the present time because he wishes to make further observations before reporting upon the behaviour of the instrument.

The adoption of the millimetre instead of the inch for the measurement of rainfall which was used for British as well as Continental Stations in the Daily Weather Report and other publications of the Office, because it had been adopted for the telegrams by which the information is transmitted, has met with less appreciation.

Dr. Mill, Director of the British Rainfall Organization, expressed his willingness to give the annual sums of rainfall at all the stations in *British Rainfall* for 1914 expressed in millimetres as well as inches if the Committee would meet the expense of printing caused by the necessary enlargement of the page. This has been arranged, and at the Meteorological Stations the change of practice from the use of inches to millimetres is being carried out.

The Committee have not regarded the war as a reason for any change of policy in this respect, because the use of the metric system for scientific purposes is not a characteristic according to which nations are likely to group themselves either now or in the future: the practice is already universal in certain subjects, and the only question is whether meteorology shall follow the example of the other sciences or not; the necessity of uniformity is exemplified by the publication of the representation of the meteorology of the Globe for 1911 by observations from stations at the rate of two for each ten-degree square, which is now passing through the press under the title of the *Réseau Mondial, 1911*, in which pressure is given in millibars, temperature in degrees absolute, and rainfall in millimetres for all stations.

A suggestion as to co-operation in Terrestrial Magnetism has come through from Potsdam by the intermediary of the Meteorological Office of the Netherlands, and as to common days for the study of the Upper Air from Lindenberg through the intermediary of the Danish Meteorological Service: but a proposal for a series of common days had already been received from Petrograd, and international co-operation in the form which had been developed by the exchange of views between meteorologists of all countries between 1874 and 1914, must be regarded as for the time being at an end.

Application for an exchange of observations with Petrograd, in view of the improved meteorological service for the empire of Russia, was received just before the war and repeated after its commencement, but no action has yet been possible.

One of the results of the Meeting of the International Committee at Rome was the appointment of a Commission for Agricultural Meteorology under the presidency of Monsieur Angot, the Director of the Bureau Central Météorologique at Paris. Early in 1914 a request was received through the Foreign

Office and the Board of Agriculture and Fisheries for a statement of the legislative enactments and the administrative processes by which provision is made in this country for meteorology with special reference to Agriculture. To this question a reply in brief is scarcely possible, because the work of the Office, as guided by tradition and precedent, has taken the line of offering information which is likely to be useful to agriculturists in the form of statistical reports and forecasts of weather, and to leave them to take advantage of it if they are so disposed. There is no professional staff at the Meteorological Office nor at the Board of Agriculture and Fisheries whose definite occupation is to study and develop the Application of Meteorology in Agriculture. Yet agriculture is regarded as one of the industries for which meteorological information must be useful. The reply prepared for the French Ambassador is of public interest, and it is therefore also reproduced in the appendix to this report.

In the foreground of the general question of the Application of Meteorology to Agriculture lie three questions of great importance for the work of the Office. They are: (i) What information about the weather should be collected at the Meteorological Office for the benefit of the public? (ii) Who should supply the information? and (iii) How should the information and the conclusions drawn from it be distributed? After sixty years of experience in meteorological work these questions might well be reviewed. An answer has been found to the first two, so far as the work in connexion with forecasts and gale warnings is concerned. The Office funds and organisation provide for the information from observatories and stations in this country and abroad necessary for the study of the daily weather.

For the purpose of climatology and the study of rainfall, which ought to find an application in agriculture, the practice is to rely upon the offers of observations by public authorities, central or local, and of private persons to supplement the observations obtained primarily for the service of forecasts and gale warnings. On the one hand many observations are now being offered by local authorities, and on the other hand the need for organisation of meteorological work in relation to agriculture is likely to become pressing in the times of stress which follow war, so that the subject deserves careful investigation. There is much misunderstanding on the part of the public with regard to questions of this kind. Occasionally public criticism is made on the assumption that the office is responsible for the lack of information from a particular locality, whereas the defect is really due to a lack of local organisation. The position of the Office in this matter has been set out by the Director in a memorandum prepared for the Board of Agriculture and Fisheries, and the Committee think it desirable to reproduce it in the appendix.

International Investigation of Ice in the Atlantic.—As the result of the International Conference following the loss of the S.S. "Titanic," the Committee have been informed that the organisation for the investigation of Ice in the Atlantic at the joint expense of the Powers interested therein has been entrusted to the Government of the United States. The publication of the

Report of the Scientific Work of the S.S. "Scotia," sent out by the Board of Trade in 1913, has given an example of the valuable work that may be expected from the use of a ship devoted to the regular scientific investigation of the air and water of the ocean. For the transmission of observations of weather and of the position of ice between the liners and the patrol vessels, the codes prepared by the Office for the "Scotia" have been adopted with certain modifications. For these messages the International Conference provided that pressures should be given in millimetres and temperatures in degrees centigrade.

Inquiry has been made by the Board of Trade as to the provision contemplated by the Conference for the exchange of weather information by wireless telegraphy between ship and shore, but no progress in that direction can be made while the war lasts.

No action has been taken with regard to the Meeting of the International Commission for Scientific Aeronautics which was to have been held in England in the spring of 1915, nor with regard to the ordinary International Conference of Directors of Institutes and Observatories which was projected for 1915 when the International Meteorological Committee met at Rome in April, 1913. A conference which was arranged to meet in Edinburgh in September, 1914, and which would have borne an international character was indefinitely postponed, and an International Congress at Venice, for which, with the approval of the Italian Government, invitations were issued for September through diplomatic channels, was first postponed till the spring, and then abandoned.

The equipment of the signal stations with the apparatus for gale signals on the new international code has not yet been begun.

OBSERVATORIES: PREMISES AND EQUIPMENT.

Kew Observatory.—The renovation of the interior of the main building of the Observatory has been followed up by further rearrangement of the paths and grounds and by some further changes in the equipment. The water-dropper for collecting electricity from the atmosphere is to be removed immediately from the main building to a place in the Instrument House on the west side where more suitable preparation has been made for the perpetual drip of water.

The Richmond Gas Company have laid a new gas-main. The Office of Works have arranged to lay a water-main for the continuous supply of river water for the better protection of the building against damage by fire. It will also be available for the general purposes of the buildings and grounds.

The thanks of the Committee are due to the Director of the Royal Gardens, Kew, and to Mr. Middleton for presents of trees and plants for the grounds.

The Committee have been informed, through the Treasurer of the Royal Society, that part of the money of the Gassiot Trust

Report of the Scientific Work of the S.S. "Scotia," sent out by the Board of Trade in 1913, has given an example of the valuable work that may be expected from the use of a ship devoted to the regular scientific investigation of the air and water of the ocean. For the transmission of observations of weather and of the position of ice between the liners and the patrol vessels, the codes prepared by the Office for the "Scotia" have been adopted with certain modifications. For these messages the International Conference provided that pressures should be given in millimetres and temperatures in degrees centigrade.

Inquiry has been made by the Board of Trade as to the provision contemplated by the Conference for the exchange of weather information by wireless telegraphy between ship and shore, but no progress in that direction can be made while the war lasts.

No action has been taken with regard to the Meeting of the International Commission for Scientific Aeronautics which was to have been held in England in the spring of 1915, nor with regard to the ordinary International Conference of Directors of Institutes and Observatories which was projected for 1915 when the International Meteorological Committee met at Rome in April, 1913. A conference which was arranged to meet in Edinburgh in September, 1914, and which would have borne an international character was indefinitely postponed, and an International Congress at Venice, for which, with the approval of the Italian Government, invitations were issued for September through diplomatic channels, was first postponed till the spring, and then abandoned.

The equipment of the signal stations with the apparatus for gale signals on the new international code has not yet been begun.

OBSERVATORIES: PREMISES AND EQUIPMENT.

Kew Observatory.—The renovation of the interior of the main building of the Observatory has been followed up by further rearrangement of the paths and grounds and by some further changes in the equipment. The water-dropper for collecting electricity from the atmosphere is to be removed immediately from the main building to a place in the Instrument House on the west side where more suitable preparation has been made for the perpetual drip of water.

The Richmond Gas Company have laid a new gas-main. The Office of Works have arranged to lay a water-main for the continuous supply of river water for the better protection of the building against damage by fire. It will also be available for the general purposes of the buildings and grounds.

The thanks of the Committee are due to the Director of the Royal Gardens, Kew, and to Mr. Middleton for presents of trees and plants for the grounds.

The Committee have been informed, through the Treasurer of the Royal Society, that part of the money of the Gassiot Trust

invested in Italian Irrigation bonds has been paid off. In consequence of the difficulty of renewing the investment in the same form the Royal Society after some time decided to change the form of the investment in accordance with the terms of the trust.

Eskdale Observatory.—At the close of last year, a proposal for the erection of two cottages within the Observatory grounds was under the consideration of Your Lordships. In September the Committee received a communication to the effect that in the circumstances the expenditure could not be sanctioned.

One of the objects of the proposal was that a post office for the village of Davington might be established at the Observatory. It was hoped that, in that case, the Postmaster-General would arrange for the delivery of letters before the collection of the outgoing mails and so enable a return of post from London to be brought within two days instead of requiring three days as it does now, or four days for letters posted in London on Thursday, Friday, or Saturday. The establishment of a post office would also put on a proper footing a practice which is growing up of using the telephone of the Observatory as a means of sending telegrams informally on the private business of those who live in the district.

The Committee have accordingly caused inquiry to be made as to whether accommodation could be made for public postal services in the existing buildings. The question has been considered by the Superintendent in consultation with a representative of the Post Office and the report is to the effect that the project is practicable. The Committee propose to authorise the staff of the Observatory to take up the postal duties on the terms usual with the Post Office in such cases, also the employment of an additional boy clerk as provision for the additional work entailed.

The amount of water collected in the underground chamber of the magnet-house continues to be a source of inconvenience and disquiet. On the occasion of a visit in July, 1914, the Director examined various aspects of the question and made a report upon it, with suggestions for regulating, warming and drying the supply of air which circulates through the building. Since the report was made the amount of water collected monthly in the trenches cut for the purpose by the Office of Works increased to such large quantities that the Office of Works now proposes to make further provision for draining away the water in the space surrounding the house.

Valencia Observatory.—The repairs to the Observatory buildings under the advice of Messrs. W. H. Hill and Son have been completed. The redecoration of the house was postponed until the superintendent to be appointed had come into residence.

Central Observatory for the study of the Upper Air.—Since 1905 the study of the general meteorology of the Upper Air for the Office has been entrusted to Mr. W. H. Dines, F.R.S., with an annual grant of £450 inclusive of all expenses. Mr. Dines has carried on his investigations at his own house and in 1906 he moved from Oxshott to suitable premises at Pyrton Hill, Watlington, for the purpose. In 1913 when he lost the right of occupation of Pyrton Hill he acquired a property at Benson, a modern

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name for the older Bensington in Oxfordshire, half way between Henley and Oxford, and he proposed there to set up an observatory for the study of the upper air and to come to an understanding with the Office for the use of the ground as a site for a permanent observatory. The Committee have had before them a report by the Director upon the proposal (*see Appendix*), and in view of its importance both from the scientific and the practical points of view, they have decided to give effect to Mr. Dines' proposal.

The nucleus of an observatory is already established at Benson, and will be developed as circumstances permit.

PUBLICATIONS. .

Exchanges of publications have been arranged with the following:—

Meteorological Bureau of the Amur District, Blagovechchensk, Russia-in-Asia; Blue Hill Meteorological Observatory, Readville, Mass., U.S.A.; Tôhoku Imperial Observatory, Sendai, Japan; St. Xavier's College Observatory, Calcutta; Comptroller of Water Rights, Parliament Buildings, Victoria, B.C.; Observatorio Meteorologico, Sucre, Bolivia; American Geographical Society, New York.

The following Libraries and Institutions have been added to the list of recipients of presentation copies of official publications:—Hong Kong University Library; Royal Observatory, Edinburgh; Patent Office Library, London; Department of Agriculture, Ottawa.

Special gifts of files of publications to libraries of institutions connected with the Office have been made by the Weather Bureau, Washington, to the Branch Office at South Farnborough, and by the Scottish Meteorological Society, Edinburgh, to the Kew Observatory.

The official publications issued or signed for press during the year are as follows:—

PERIODICAL.—**The Daily Weather Report** [to date].

Monthly Meteorological Charts of the Atlantic Ocean and the Mediterranean [to date].

Monthly Meteorological Charts of the Indian Ocean and Red Sea [to date].

The British Meteorological and Magnetic Year Book, comprising:—

Part I.—**The Weekly Weather Report** with Quarterly and Annual Summaries, and a wind-force Supplement up to date, with the exception of the maps, which have not been issued since August.

Part II.—**The Monthly Weather Report**, with a summary for the year [up to date, except for the Annual Summary, which is in the press].

Part III. (1).—**Daily Readings** at Meteorological Stations of the First and Second Orders [up to date].

Part III. (2).—**Geophysical Journal**. Daily readings in Meteorology, Solar Radiation, Seismology, Atmospheric Electricity and Terrestrial Magnetism, with the results of Soundings of the upper Air by means of kites and balloons. [To end of 1913.]

PERIODICAL.—**The British Meteorological and Magnetic Year Book**, comprising :—*continued.*

Part IV. (1).—**Hourly Values from Autographic Records: Meteorological Section.** Hourly values for pressure, temperature, humidity, rainfall, and sunshine for Kew, Eskdalemuir, and Valencia. [To end of 1913.]

Part IV. (2).—**Hourly Values from Autographic Records: Geophysical Section.** Hourly values for Terrestrial Magnetism, Atmospheric Electricity and Meteorology, for five observatories. [Volume for 1912 issued. 1913 in the press.]

Observer's Handbook, 1914 edition.

Calendar, with notes and diary of operations for the use of observers, for 1915.

OCCASIONAL.—**GEOPHYSICAL MEMOIRS.**—Vol. I., Part II., for 1912 :—

No. 8. Lag in Marine Barometers on Land and Sea, by Charles Chree, Sc.D., LL.D., F.R.S., Superintendent of Kew Observatory.

Vol. I., Part III., for 1913 :—

No. 9. On the relation between the velocity of the gradient wind and that of the observed wind. By J. Fairgrieve, M.A.

No. 10. The effect of the Labrador current upon the surface temperature of the North Atlantic, and of the latter upon air temperature and pressure over the British Isles. Part II. By M. W. Campbell Hepworth, C.B., R.D., Commander R.N.R., Marine Superintendent.

Title page, table of contents and index to Volume I.

Vol. II., Part I., for 1914 :—

No. 11. The South Wales Tornado of October 27, 1913.

Monthly Normals of Temperature, Rainfall and Sunshine for Stations in the British Isles, with illustrative maps. (Forms Appendix IV. to the Weekly Weather Report for 1913.)

The Seaman's Handbook of Meteorology. A companion to the Barometer Manual for the use of Seamen.

Instructions for Meteorological Telegraphy. 1914 edition.

Report of the Tenth Meeting of the International Meteorological Committee, Rome, 1913.

The Marine Observer's Handbook.

Other publications for which authority has been given and which are in preparation, but had not been issued on the 31st March, are as follows :—

Monthly Meteorological Charts of the South Atlantic Ocean.

Meteorological Charts of Davis Strait and Baffin Bay. (*In the Press.*)

Réseau Mondial. Climatological Report for the Globe for 1911.

Monthly and annual summaries of pressure, temperature and rainfall for stations selected at the rate of two stations for every ten-degree square of latitude and longitude. (*In the Press.*)

The Computer's Handbook. (*In the Press.*)

The Tabulator's Handbook.

Atlas of Tropical Hurricanes.

GEOPHYSICAL MEMOIRS.—

The Seasons in the British Isles, with normals for four observatories, and tables for their application in climatology.

Results of Pilot Balloon Ascents in Scilly Isles, November and December, 1911.

The report on the issue of the *Daily Weather Report* will be found on pp. 30, 31.

The report on the issue of the *British Meteorological and Magnetic Year Book* during the year will be found on pp. 44 to 46. The publication of certain Parts of the *Year Book* is still considerably in arrear.

Monthly Meteorological Charts.—By arrangement with H.M. Stationery Office, the representation of ocean currents on the Monthly Meteorological Charts of the North Atlantic and Mediterranean and of the Indian Ocean has been changed to conform with the Admiralty practice of indicating currents by means of flow-lines, with occasional arrow-heads to show the direction of flow. The method previously adopted was to indicate the ocean currents by means of short wavy-lines with arrow-heads attached. The result of the change has been to improve very considerably the representation, both actually and pictorially. The Controller of the Stationery Office has also been good enough to arrange for the preservation on zinc plates of the impressions of the dark-blue stones from which the currents are printed. The 12 monthly plates for each chart will thus be immediately available for use next year.

Seaman's Handbook.—An edition of the "Seaman's Handbook of Meteorology," consisting of 1,500 copies, was published in April, 1914. A reprint was ordered to meet a requisition of the Admiralty; and the handbook has been adopted by the Board of Trade, in conjunction with "The Barometer Manual for the use of Seamen," as a text-book in their examinations. Notification was received from the Stationery Office at the close of 1914 that a further supply was required. A revised edition has accordingly been prepared and is now in the press. The principal change made is the introduction in the diagrams and text of the new pressure units, based on the C. G. S. system.

Marine Observer's Handbook.—This octavo publication has now been completed and a supply of copies has been delivered. It takes the place of the folio "Instructions for Keeping the Meteorological Log." Bound copies will be issued to Captains of ships that observe for the Office.

The publication of the following papers, &c., may also be mentioned:—

By Dr. W. N. Shaw, F.R.S., Director—

Wind Gusts and the Structure of Aerial Disturbances. Aero. Journ., vol. 18, p. 172, 1914.

By Commander M. W. Campbell Hepworth, C.B., R.D., R.N.R., Marine Superintendent—

The Gulf Stream. Geographical Journal, vol. 44, pp. 429, 534, 1914.

By Mr. R. G. K. Lempfert, M.A., Superintendent of the Forecast Division—

The Application of Wireless Telegraphy to Meteorology in the Year Book of Wireless Telegraphy.

By Mr. E. Gold, M.A., Superintendent of Statistics—

Barometer Readings in Absolute Units and their correction and reduction. Q.J. R. Met. Soc., vol. 40, p. 185, 1914.

By Mr. Andrew Watt, M.A., Superintendent of the Meteorological Office, Edinburgh—

The Annual Rainfall of Scotland and the limits within which it fluctuates.
Journ. Scott. Met. Soc. vol. 16.

By Dr. Charles Chree, F.R.S., Superintendent of Kew Observatory—

The 27-day Period in Magnetic Phenomena. Proc. Roy. Soc., vol. 90 (A), p. 583, 1914.

Time Measurements of Magnetic Disturbances and their Interpretation.
Proc. Phys. Soc., vol. 26, p. 137, 1914.

Atmospheric Electricity Potential Gradient at Kew Observatory, 1898 to 1912
Phil. Trans., vol. 215, p. 133, 1915.

By W. H. Dines, F.R.S., Benson Observatory—

Cyclones and Anticyclones Journ. Scott. Met. Soc., 3rd series, vol. 16, p. 304, 1914.

Meteorological Office Press.—The Press has been in regular operation during the year. The regular issues of the *Daily Weather Report*, the maps for the *Monthly Weather Report*, and the *Monthly Meteorological Charts of the North Atlantic* and of the *Indian Ocean* have been made without fail. The maps for the *Weekly Weather Report* were issued up to the end of July, when they were discontinued because of the lack of information from Siberia, which is promised by the Russian Service. It is hoped to publish the missing numbers as soon as the information is available.

In addition to the above, orders for 33 lithograph forms for recording instruments, &c., have been executed, as well as a number of special orders for maps, charts, and diagrams to be used as working forms or for illustration of various publications.

The lithographic illustrations of the Report of the Board of Trade of the investigations carried out in 1913 by s.s. "Scotia" were also produced at the Office press.

LIBRARY.

The Author Card-Catalogue has been kept up to date. The index numbers corresponding with the classification adopted in the International Catalogue of Scientific Literature are entered on the cards so that the subject-catalogue can be prepared directly from them.

The subject card catalogue for the books added to the library since the last list of additions was printed *in extenso*, as an appendix to the Report of the Meteorological Council for the year 1904-5, and has been completed up to the end of 1914. The additions to the library received during the past year include about 700 books and pamphlets. The total number of books in the library is now about 24,700.

Some further progress has been made with the revision of the original catalogue and the Authors' and Subject Cards, necessitated by the re-arrangement of the library on the removal of the Office.

In the *Report of the Tenth Meeting of the International Meteorological Committee at Rome, 1913* (M. O. No. 216), will be found (1) a list of persons and institutions from whom publications containing meteorological data have been received during the last ten years with a brief indication of the nature of the information given; (2) a list of periodicals containing memoirs on meteorological subjects, which are received by the Office.

Among the most important presents to the library during the past year may be mentioned:—

The weather and climate of Chicago, by H. J. Cox and J. H. Armington.

The climatic factor, by E. Huntington.

Smithsonian physical tables, 6th edition (vol. 63, part 6 of Smithsonian Miscellaneous Collections).

Instrucções meteorológicas (Brazil), by J. de S. Ferraz, vols. 1 and 2.

Climatic variation in historic and prehistoric time, by O. Pettersson.

Seismometrische Tabellen, by Prince B. Galitzin.

Handbook of the Napier Tercentenary Celebration, edited by E. M. Horsburgh.

Instructions to observers, by the United States Weather Bureau.

MS. Register of observations at Downing, Flintshire, 1794 to 1834, presented by the Countess of Denbigh.

Among those acquired by purchase have been:—

Lehrbuch der Meteorologie, 3rd edition, by J. von Hann (Incomplete.)

The climate of Portugal, by D. G. Dalgado.

Maritieme meteorologie en oceanografie, by P. Bossen and P. van der Zee.

Waves of sand and snow, by Vaughan Cornish.

Animal flight, by E. H. Hankin.

Dew ponds, by E. A. Martin.

Les problèmes de l'atmosphère, by A. Bergeret.

Traité de géographie physique, 2nd edition, by E. de Martonne.

Vorlesungen über Seismometrie, by Prince B. Galitzin.

Climate and health in hot countries, by Lieut.-Col. G. M. Giles.

Ice-bound on Kolguev, by A. Trevor-Battye.

Characteristics of existing glaciers, by W. H. Hobbs.

A selection of the volumes of the International Catalogue of Scientific Literature.

RÉSEAU MONDIAL.

A list of the foreign and colonial stations from which documents are received is given in Circular 001.

The additions to the list during the year under review include documents received from Abiusi and Minna in the Northern Provinces of Nigeria; Berbera, Somaliland; Mochudi, South Africa; Nambeya, Kitgum, Soroti, Kome, and Lira in Uganda; and Montserrat, West Indies.

Captain Tamplin's station at Chinkiang has been removed to Amoy.

The returns received from many stations have been examined and summarised month by month.

The copies of meteorological returns reprinted from Colonial Government publications and sent to the office for distribution have been issued for the year 1912.

Monthly meteorological statistics for a selection of stations representing the land areas of the globe have been prepared for 1911, with explanatory text, and sent to press. In connexion with this work lustrum-averages for a large number of stations in the British Colonies and for some foreign stations have been prepared.

INQUIRIES: PUBLIC MEMORY OF WEATHER.

The preparation of replies to inquiries from public authorities and private persons, based upon information contained in the files of the Office, forms an increasingly important part of its work. The gradual increase in the number of inquiries since 1903 is shown in the following table:—

Year.	For Scientific or Commercial Purposes.	For Evidence in Legal Proceedings.	From Newspaper Correspondents for Special Information.	Miscellaneous.	Answered by Letter.	Answered Personally.	Total.
1903-4 ...	258	94	217	65	166	468	634
1904-5 ...	259	116	221	70	136	530	666
1905-6 ...	293	99	206	84	160	522	682
1906-7 ...	427	73	166	24	243	447	690
1907-8 ...	503	94	97	24	294	492	786
1908-9 ...	540	99	99	87	297	528	825
1909-10 ...	469	98	112	39	298	420	718
1910-11 ...	516	107	115	62	351	449	800
1911-12 ...	582	129	113	33	456	401	857
1912-13 ...	533	159	106	24	459	363	822
1913-14 ...	790	144	91	26	646	405	1,051
1914-15 ...	639	92	56	29	463	353	816

The earlier months of 1914-15 showed a continuance of the increase.

Illustrations.—The Office is gradually compiling a useful collection of illustrations of meteorological phenomena, in the form of sketches, diagrams or lantern slides reproducing original records. The sketches and diagrams are being produced in form suitable for reproduction in the Office handbooks, from which they will probably find their way into text-books. Two specimens of illustrations in this form are given; one, a reproduction of a sketch of a halo, by Mr. G. A. Clarke, of Aberdeen, and the other, a reproduction of the meteorological records at South Kensington on the occasion of the snow-gale of December 28th, 1914 (p. 37).

FINANCE.

A statement of the receipts and payments during the year ended 31st March, 1915, is given on page 23. The amount of the Parliamentary Grant-in-aid for Meteorology, which was paid direct to the Committee by the Treasury, was £20,000 as in the previous year.

In addition to this, monies from grants voted by Parliament to the Royal Society on account of Eskdale Observatory and to the Advisory Committee for Aeronautics were paid to the Meteorological Committee for the maintenance of the Observatory and for experimental work in connexion with aviation respectively. The dividends of the Gassiot and the Rosse Trust Funds, administered by the Royal Society in respect of Kew and Valencia Observatories, respectively, have also been added to the Observatory revenues. By arrangement with the trustees of the Scott Antarctic Fund a sum of £164 has been received as the equivalent of the time devoted to the discussion of the results of the Magnetic Observations, by the Superintendent of Kew Observatory, in accordance with the arrangement referred to on page 10 of last year's report.

The sum total of these items was £1,764 17s. 3d., which, together with the grant of £20,000, provided £21,764 17s. 3d. as the revenue available for the work of the year. Repayments and other miscellaneous receipts totalled £5,942 12s. 11d., making a grand total of £27,707 10s. 2d.

Expenditure, including the recoverable items, amounted to £28,096 10s. 4d., so that the cash balance, which, at the commencement of the financial year was £1,250 16s. 8d., was reduced by £389 0s. 2d., and at the close of the year stood at £861 16s. 6d.

The balance at the commencement of the year included the sum of £630 mentioned in last year's report as paid in advance for instruments; the amount of £91 10s. was still in hand on 31st March, 1915, and a sum of approximately £90 was held to the credit of H.M. Stationery Office on account of forms and publications sold to the public.

ACCOUNT of RECEIPTS and PAYMENTS for the year ended 31st March, 1915.

Subject to correction upon audit by the Comptroller and Auditor-General:—

RECEIPTS.				PAYMENTS.			
	£	s.	d.		£	s.	d.
Balance from year 1913-14			1,250 16 8	Director			1,000 0 0
Parliamentary vote ..	—		20,000 0 0	OFFICE SALARIES (in- cluding Insurance):			
DEPARTMENTAL EX- PENSES REPAID:				Monthly	8,205 2 11		
Forecasts, &c.	95	17	1	Weekly	1,092 19 8		9,298 2 7
Marine, Statistical, and Administrative	81	0	10	EXPENSES OF OFFICE:			
Instruments	188	16	11	Rent, Heating, and Lighting	684 3 7		
			365 14 10	Furniture and Equip- ment	25 17 1		
INCIDENTAL EXPENSES REPAID:				Library	40 16 8		
D.W. Report	301	18	10	Insurances, Repairs, Incidental Expenses, and Consumable Stores	241 1 10		991 19 2
Divisional	72	13	1	POST OFFICE:			
Advertising Account ..	10	7	0	Postage	773 8 2		
			384 18 11	Telephones	83 1 10		
STATIONERY OFFICE ..	—		90 12 6	Telegrams	2,391 17 1		3,248 7 1
TELEGRAPH CHARGES REPAID	—		515 5 3	STATIONERY OFFICE:	—		47 8 10
TELEPHONE CHARGES REPAID	—		10 11 10	TRAVELLING EXPENSES	—		281 8 2
INSPECTIONS	—		176 13 0	SUPERANNUATION:			
INSTRUMENTS:				Funded Annuities ..	950 0 0		
Royal Navy	420	8	0	Non-funded pensions..	557 13 6		
Mercantile Marine, Sta- tions, &c.	2,404	2	7	Contribution to fund..	541 0 0		2,048 13 6
			2,824 10 7	COST OF INSTRUMENTS:			
SUPERANNUATION ACCOUNT:				Royal Navy	423 8 0		
Annuities	955	4	11	Mercantile Marine, Sta- tions, &c.	2,979 2 4		3,402 10 4
Interest on Investments	10	3	0	OBSERVATORIES, BRAN- CHES, AND STATIONS:			
			965 7 11	Kew	2,575 4 7		
OBSERVATORIES, BRAN- CHES, AND STATIONS:				Eskdale	1,470 16 6		
Kew	858	8	9	Valencia	554 2 5		
Eskdale	1,015	16	0	Farnborough	619 11 11		
Valencia	29	5	3	Falmouth	147 14 3		
Farnborough	315	13	0	Benson (net expendi- ture)	541 16 10		
Falmouth	9	9	7	Miscellaneous	1,732 9 2		7,641 15 8
Miscellaneous	105	5	3	LECTURES AND EXPERI- MENTS	—		158 5 0
			2,133 17 10	BALANCE:			
LECTURES AND EXPERI- MENTS	—		236 17 6	Cash at Bank	790 5 10		
			£28,958 6 10	" at Office	71 10 8		861 16 6
							£28,958 6 10

Note.—On 31st March the amount of 2½ per cent. Annuities held for the provision of Superannuation Annuities was £81 18s. 4d.

Accounts.—The following abstract shows approximately the net payments for this and the preceding years, together with the increase or decrease in 1914-15, as compared with 1913-14:—

NET EXPENDITURE.	1913-14.	1914-15.	Increase.	Decrease.
SALARIES :	£	£	£	£
Director	1,000	1,000	—	—
Office and Observatories ...	12,007	12,911	904	—
GENERAL ADMINISTRATION of Central Office :				
Rent, Heating, and Lighting	689	684	—	5
Furniture and Equipment	282	26	—	158
Library		41		
Insurances, Repairs, Incidental Expenses, and Consumable Stores.		57		
STATIONERY OFFICE ...	*	†	—	—
POSTAGE	399	572	173	—
TELEGRAMS	1,868	1,874	6	—
TELEPHONES	*	73	73	—
TRAVELLING EXPENSES ...	234	85	—	149
INSTRUMENTS	— 174	578	752	—
SUPERANNUATION	1,158	1,083	—	75
OBSERVATORIES (exclusive of Salaries) :—				
Kew	381	804	423	—
Eskdale	845	422	—	423
Valencia	129	93	—	36
Farnborough	136	71	—	65
Falmouth	2,082	75	—	260
Benson		201		
Miscellaneous		1,627		
LECTURES AND EXPERIMENTS.		‡		
		22,277		
NET CREDITS.				
Stationery Office Sales ...	—	43	—	—
Lectures and Experiments	—	81	—	—
Net Total ... £	21,036	22,153	—	—

* Not available for 1913-14.

† Receipts exceeded expenditure ; balance held to credit of Stationery Office.

‡ £43 15s. held to the credit of the Schuster Readership.

OFFICE PROPERTY.

The property of the Office includes leases of the premises at South Kensington and of the Observatory at Cahirciveen ; licences from the Crown to use the buildings of the Observatories at Kew and Eskdalemuir which are granted to the Royal Society and used by the Office in accordance with Your Lordships' letter, 3780/10, of 26th February, 1910 ; the use of the Observatory at Falmouth by an understanding with the Royal Cornwall Polytechnic Society, arrived at in 1913 ; furniture, fittings, equipment, and instruments at Kew and Eskdalemuir ; fittings,

equipment, instruments, and certain items of furniture at Cahirciveen; fittings and equipment at Aberdeen and Benson; instruments at Armagh, Stonyhurst, Oxford, and at 27 stations in the United Kingdom and on 201 ships. These are exclusive of a number of separate instruments on loan to various stations in the British Isles and the equipment of a number of stations abroad.

Inventories of this property in instruments are duly kept, and inventories of the equipment of the observatories are being prepared and verified; the property is insured against fire for the sum of £13,927 10s.

The stock of instruments in the Office on 31 March, 1915, kept for issue to stations was duly audited by the Superintendent of the Statistics Division.

At Kew Observatory there is a large collection of disused instruments which require to be sorted, reassembled and catalogued, and there is besides still in the dome of the Observatory the original photo-heliograph which represents the commencement of the photographic study of the sun in this country, and upon the use of which Mr. Warren de la Rue himself expended some £2,000. The instrument has not been used since 1897, and the Committee have taken steps towards adding it to those already on loan from the Observatory to the Science Museum. A memorandum on the history of the instrument drawn up by the Superintendent is printed as Appendix II. to this Report.

The following instruments are issued on loan to the Science Museum:—

No. in 1900 Catalogue, Physiography Section 2.	Date of Loan.	Instruments.
18	1876	Kreil's Barograph.
19	"	Ronalds' Photo-Barometrograph.
67	"	Eight-haired Saussure Hygrometer by Richer of Paris, formerly property of Sir. F. Ronalds.
95	"	Rainfall and Evaporation Gauge, Ronalds.
116	"	Balance Anemometer, Ronalds.
153	"	Dip Circle used by Sir James Ross.
158	"	Hansteen's portable Vibration Apparatus used on H.M.S. "Thunderer" in 1841.
162	"	St. Helena Magnetometers.
163	"	Declination Compass used by Richardson and Pullen.
172	}	Ronalds' Magnetographs { Horizontal Force.
173		
175	"	Drawings of Kew Magnetometers.
—	"	Browning's Spectroscope.
		Ronalds' Electrical Machine.
		Ronalds' Apparatus for Atmospheric Electricity.
		Thomson's Divided Ring Electrometer.
		Quadrant by Butterfield.
		Photographs of the Sun taken with the Kew Heliograph.
133	1893	Model to show Galton's Method of verifying Sextants.
		Balloon Thermometer, Casella 46561.
		Meteorological Office pattern Barometer, M.O. 171
		Fishery Barometer, M.O. 223.
		2 Ordinary Thermometers, E.T. 3267, 3360.

No. in 1900 Catalogue, Physiography Section 2.	Date of Loan.	Instruments.
133	1893	Maximum Thermometer, M.O. 1561. Minimum Thermometer, M.O. 1533. Screen. Raingauge, 8 inch, M.O. 372 ; Glass Measure, M.O. 1388. Hydrometer, B.T. 717, and glass to float ditto. Thermometer in Copper Case, Negretti and Zambra 4208.
4	1894	Marine Barometer, Bate 26.
17	"	Milne's Barograph.
57	"	2 Mahogany Sunshine Bowls, 88-9, year 1892
112	"	Hand Anemometer, M.O. 32.
114	"	Harris's Wind Gauge.
—	{ Mar. 1906 }	Galton Trace Computer. Galton Pantagraph. 5 Old Barometers by Pastorelli, Jones, Sargent, Dennis and Newman. 5 Hydrometers. Sympiesometer. 4 Old Spirit Thermometers. Old Mercurial Thermometer.
—	Nov. 1908	2 Deep-Sea Thermometers, each in Copper Case. Actinometer (Herschell). The first Spherical Lens for use in Sunshine Recorders. Dines' Kite and Meteorograph. Ballon-Sonde with Accessories. Model of the Region of the Winter Quarters of the S.S. "Discovery."
—	Mar. 1913	2 Ballon-Sonde Records: Limerick, 27.7.08, and Crinan, 29.7.08. Bridled Anemometer.
—	Aug. 1914	Collection of Pendulum Apparatus. The Collection includes those pendulums (numbered 6, 4, 4) which were used about 1870 at Kew and in India, and two others, Nos. 10 and 11.

A complete list of observing ships, observatories, and stations in connexion with the Office, with the names of the observers, is given in a separate circular (No. 001) entitled "Statement of Provisions for the Supply of Information to the Public." A statement of distribution of official copies of the publications of the Office, including the exchanges with the meteorological institutes and observatories of other countries is printed as an appendix to the *Report of the 10th Meeting of the International Meteorological Committee*. M.O. Publication No. 216.

The reports of the Superintendents upon the work of the four divisions of the Office, of the Meteorological Office, Edinburgh, of the observatories maintained by the Meteorological Committee, with a note on the stations inspected, are given in the following pages 27 to 56.

I.—MARINE DIVISION.

*Report by M. W. Campbell Hepworth, C.B., R.D.,
Commander, R.N.R., Superintendent.*

Collection of Information.—The number of vessels entered in the Office books as carrying the full set of meteorological instruments requisite for keeping a four-hourly meteorological log was 192 as compared with 209 during the previous financial year. In addition, there were 9 Atlantic liners among those from which reports were received by radio-telegraphy that are provided with mercury barometers lent by the Office. The allocation of full sets of instruments has been studied with a view to acquiring the largest possible number of reliable observations from oceanic regions for which information is most needed, bearing in mind the fact that the number of meteorological instruments available for marine purposes is limited.

Meteorological four-hourly logs, registers, and other documents, to the number of 1,714 were received during the year, as compared with 2,738 in 1913-14.

Meteorological Logs.—Of the meteorological log books which contain four-hourly observations, 148 have been classed “excellent,” or “very good,” after careful examination of the data they contain, as compared with 173 for the previous financial year.

Supplementary Information.—The arrangements for obtaining meteorological observations from the captains and officers of ocean-going ships who offer their co-operation, but who for various reasons are unable to keep the full log, or to whom the instruments requisite for that purpose cannot conveniently be lent, have been continued. Under these circumstances the observers have used their own instruments or those supplied by the owners of the ships; the corrections for which are ascertained from time to time by comparison with standards at home and abroad. By this means a large amount of information, which is noted on registers supplied by the Office, has been collected, and many of these data are immediately utilised in connexion with the preparation of the Monthly Meteorological Charts of the North Atlantic and Mediterranean, and of the Indian Ocean. Co-operation in this form is not confined to the personnel of British ships; the registers are also kept by a number of captains and officers under foreign flags.

As in previous years, a number of barograms have been received from ships of H.M. Navy and the Mercantile Marine which give a continuous record of pressure in various parts of the world.

The number of contributions received, classified according to the different lines of route, is shown in the following lists:—

Four-hourly Logs.

Cable Ships	...	{	United Kingdom	...	2
			North West Atlantic		1
			China	...	1
			Lapland	...	1

Four-hourly Logs—continued.

North Atlantic...	{	Canada ...	7
		United States ...	10
		Gulf of Mexico ...	11
		West Indies ...	5
Africa ...		S.E. and E. Coasts	3
China, coasting		...	3
East Indies ...	{	viâ Cape ...	9
		viâ Suez ...	36
China and Japan	{	viâ Cape ...	4
		viâ Suez ...	19
Australia ...	{	viâ Cape ...	29
		viâ Suez ...	28
Trans-Pacific ...		...	2
New Zealand ...		viâ Capes ...	22
South America, East Coast ...		...	23
United States, West Coast ...		...	1
Surveying	{	Australia ...	1
		West Indies ...	1
		S.E. Africa ...	1
River Thames	2
Whaling	{	Hudson Bay ...	1
		Cumberland Gulf ...	1

"Short" Logs.

East Indies, viâ Suez ...	2
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North Atlantic Registers (Form No. 121), Indian Ocean Registers (Form No. 122), and Radio-telegraphy Registers (Form No. 138).

Routes.		North Atlantic Registers. Form No. 121.	Indian Ocean Registers. Form No. 122.	Radio- telegraphy Registers. Form No. 138.
North Atlantic...	{ Canada ...	250	—	168
	{ United States ...	496	—	242
	{ Gulf of Mexico ...	83	—	—
	{ West Indies ...	29	—	—
	{ English Channel	1	—	—
Mediterranean...	...	81	—	—
Africa ...	West Coast ...	22	—	—
East Indies ...	{ viâ Cape ...	—	4	—
	{ viâ Suez ...	—	67	—
China and Japan	{ viâ Suez ...	—	10	—
	{ viâ Cape ...	—	2	—
Australia ...	{ viâ Cape ...	—	6	—
	{ viâ Suez ...	—	1	—
South America...	East Coast ...	12	—	—
Totals ...	...	974	90	410

"Excellent" observers.—A list of the 32 captains who, during the past year, have contributed logs classed as "excellent" is given in a special Circular, 001. Several of these observers have co-operated with the Office for many years; some have to their credit a number of logs that are "excellent," and among these should be mentioned Captain F. C. Mullan, F.R.G.S., who has kept 38; Captain G. H. Harris, Lieut. R.N.R., who has kept 28; and Captain W. G. Lingham, F.R.A.S., F.R.Met.Soc., who has kept 16 of that class. Those whose names appear in the "excellent" list for the first time are, Captain T. Baillie, S.S. *Baron Tweedmouth*; Captain C. C. Dixon, Barque *Elginshire*; Captain D. C. Horne, S.S. *Glenspean*; Captain G. B. Serra, Italian Barque *Mascotte*; Captain A. W. Simpson, S.S. *Clan Buchanan*; and Captain J. N. Williamson, S.S. *Atreus*.

As a mark of recognition of valuable co-operation, various publications of the Office have been presented to observers who have returned well-kept meteorological log books. The publications which have been chiefly used for this purpose are:—Monthly Wind Charts of the South Atlantic; Monthly Wind Charts for the Coastal Regions of South America; Meteorological Charts of the Southern Ocean, between the Cape of Good Hope and New Zealand; Meteorological Charts of the Red Sea; Charts showing the Surface Temperature of the Atlantic, Indian and Pacific Oceans; Monthly Current Charts for the Atlantic Ocean; Monthly Current Charts for the Indian Ocean; Quarterly Current Charts for the Pacific Ocean; Bound Copies of the Monthly Meteorological Charts of the North Atlantic and Mediterranean, also of the Meteorological Charts of the Indian Ocean; The Seaman's Handbook of Meteorology; and The Barometer Manual.

Obituary.—The Committee have noted with regret the deaths of nine of their old observers during the year ended 31st March last:—Captain W. Gillies, S.S. *Medway*, April; Captain J. W. Hatherley, S.S. *Mongolian*, March; Captain F. W. Hudson, S.S. *Port Hunter*, October; Captain J. McAuley, S.S. *Republic*, May; Captain G. Mitchell, S.S. *Castalia*, September; Admiral Sir G. S. Nares, H.M.S. *Alert*, January; Captain C. Payne, S.S. *Manchester Commerce*, April; Captain H. A. Schleman, S.S. *Sophocles*, March; Captain F. J. Symons, S.S. *Olenda*, May.

Use of Information received.—The information collected has been used, as already mentioned, as much as possible, on receipt, in the preparation of the Monthly Charts. The Monthly Charts of the Atlantic Ocean and the Mediterranean Sea and of the Indian Ocean and Red Sea have not been altered, except in detail, during the year. The weekly instalment of the North Atlantic charts with daily maps on the back, showing the distribution of pressure, winds, &c., over the Atlantic Ocean, prepared by the incorporation of the reports by radio-telegraphy from the ocean, with information received by telegraph from the other side was continued until the commencement of hostilities with Germany and Austria; since when the daily maps have been discontinued.

On these weekly issues five weekly maps are shown exhibiting the results of recent sea surface and air temperature observations, recent reports of ice, and of derelicts, and of fog, also a map of normal sea temperature for the period.

Since December, 1913, mean monthly maps of sea surface salinity and temperature of the North Atlantic; and since August, 1914, similar maps of the English Channel; have been included among the results shown on the back of each North Atlantic chart. Between July, 1914, and November, 1914, a map of similar data was given relating to the North Sea.

Observations from the logs of ships navigated in the Indian Ocean between the parallels of 10° N. and 20° S. and the meridians of 40° E. and 80° E. have been supplied to the Director General of Observatories, Simla, as in past years. Similar data relating to selected oceanic areas have been prepared for, and forwarded to, the Royal Dutch Meteorological Institute in compliance with a wish expressed in a resolution of the International Meteorological Committee. Information relating to drifting ice in the North Atlantic has been forwarded to *Lloyd's List* and to the *Shipping and Mercantile Gazette* regularly upon receipt of the reports.

The Admiralty have been furnished at the request of the Hydrographer to the Navy with the tabulated results of wind and sea surface temperature observations relating to the North Sea for all months of the year.

Information is given to seamen, upon application, either in person or by letter, regarding the meteorological conditions that are likely to prevail along a proposed route, either for sailing vessels or steamships.

II.—FORECAST AND GALE WARNING DIVISION.

Report by R. G. K. Lempfert, M.A., Superintendent.

The Daily Weather Service.—The most important change in connexion with the Daily Weather Service has been the adoption on May 1st, 1914, of pressure values in millibars and rainfall values in millimetres, in accordance with the decision of the Committee announced in the Report for last year. Steps had been taken during the previous year to equip the reporting stations with barometers bearing the millibar scale as well as that in inches, and with rain-gauge glasses graduated to read in millimetres. During the month of April the observers were asked to send to the office, by postcard, reports drawn up on the new system in addition to their telegraphic reports in the old system. The new system came into operation on May 1st.

At the same time the other changes in the telegraphic code arranged at the meeting of the International Meteorological Committee held in Rome in April, 1913, came into operation. Chief among these is the introduction of reports of the direction of motion of upper cloud.

Up to the outbreak of war the Daily Weather Service was carried on on the lines indicated in previous reports. The Daily Weather Report was issued each day at about 12.30 p.m.

Changes in Stations.—The only change in the list of official stations contributing information to the Daily Weather Report is the transfer of the work at North Shields to the coastguard at Tynemouth. The observations at North Shields had been for many years in charge of Mr. R. Moat, Telegraph Clerk, but the site of the station was not suited for the observation of sea disturbance, and, in a lesser degree also, of wind. When Mr. Moat asked to be relieved of his duties, the selection of a more suitable site was recognised as desirable, and by the courtesy of the Admiral Commanding Coastguard and Reserves, arrangements were made for the transfer of the station to the Coastguard at Tynemouth.

War Conditions.—The outbreak of hostilities affected the Forecast Division in many ways. The first effect was the almost complete paralysis of the work in consequence of the great congestion of the Post Office inland telegraph system and the operations of the censorship as regards the reports from foreign countries. Gradually as the pressure on the inland telegraph system was relieved normal conditions were restored as regards the reports from British stations. In order to add to the completeness of the home reports, arrangements were made for the supply of regular telegraphic reports from Falmouth Observatory and from the climatological stations at Oban and at Deerness, Orkney. During a temporary suspension of the usual observations at Blacksod Point, arrangements were also made for regular reports from the climatological station at Markree Castle.

After some delay, arrangements were made with the Chief Censor for the transmission by telegraph of the usual meteorological reports from allied and neutral countries, but it has not yet been possible to arrange for the resumption of the international service of reports from Iceland or of the service of wireless reports from Atlantic liners.

In spite of these disadvantages the Daily Weather Report has been prepared each day. For the greater part of August the Reports were, however, very fragmentary. The information from abroad has been supplemented by that received by post from neutral and allied countries. It has thus been possible to fill in the working charts at the Office to a very large extent, and corrections and additions for the Daily Weather Report have been published from time to time.

The usual supply of the information from British stations to foreign countries ceased and restrictions were placed on the circulation of meteorological information in this country. The issue of the current Daily Weather Report to the public was postponed until a period of fourteen days had elapsed, and the information supplied to the press was curtailed. The issue of weather forecasts and of reports of the duration of sunshine, amount of rainfall, and maximum and minimum temperatures at Health Resorts was continued. The issue of the "further outlook," extending the period covered by the forecasts to more than 24 hours when conditions appear to warrant such a course

has been suspended. At the same time, instructions were issued from the Press Bureau directing newspapers not to make public any meteorological information which was not issued by the Meteorological Office.

Many demands for information about current weather and forecasts have been made by the Admiralty and War Office since the outbreak of war, and the work of the division has been directed to satisfying the special requirements.

Results of Forecasts.—The difficulties arising out of the delays in transmission of reports rendered forecasting more uncertain than usual. During the early days of the war, the forecasts had to be based exclusively on British reports, and even after communication had been partially restored the delays remained considerable. The practice thus arose of holding over the preparation of the forecasts and reports for the press until the latest possible hour in the hope that more information would come to hand. The reports, as finally issued, were in more general terms than usual. On many occasions no attempt was made to differentiate the several districts. The cutting off of the reports from Iceland and Faroe and of the wireless reports from the Atlantic Ocean were felt as most serious losses to the service.

Fortunately, the weather conditions were of a simple type for a considerable portion of the time. Up to the middle of November there were prolonged periods of quiet, anticyclonic weather during which forecasting was exceptionally easy, while from the middle of November onward there was a very wet boisterous period. Depression followed depression in what may be called normal sequence for weeks on end, and the preparation of forecasts for periods not exceeding 24 hours presented no great difficulty. Seeing that both the material on which the forecasts were based and the form in which they were issued differed from the established practice, the usual statement of percentage successes is not given.

Harvest Forecasts.—The service of special telegraphic forecasts for agriculturists normally in operation during the summer months June to September takes the form either of a daily forecast of the weather for the following day, extended, whenever conditions appear sufficiently definite to justify it, to cover two or more days, or of "Special Notifications" sent only on occasions on which spells of several consecutive days of fine weather are anticipated. Notice of the impending break up of settled conditions is also issued in connexion with these spell forecasts.

The normal service was carried on during June and July, but on the outbreak of war the arrangements became much disorganised. The issue of forecasts for the following day was continued to the end of the season (September 30th), but in consequence of the curtailment of the information received from foreign stations, and the delay in the receipt of information from home stations, the issue of notifications in connexion with spells of settled weather had to be brought to a premature conclusion about the middle of August. The shrinkage in the number of

applications for these notifications is due, to some extent, to this cause. Notices were sent out to only 60 correspondents, as compared with 111 in 1913 and 87 in 1912, though many of these entered their names for two or more sets of telegrams.

The occasions on which the weather assumed a definitely settled type were not very frequent during June and July, but in all, seven notifications were issued before the suspension of the service of special notifications in the middle of August.

(1) The first notification was issued at 3 p.m. on 16th June to England and Southern Ireland. The pressure distribution was not of the definite anti-cyclonic type which is recognised as being most favourable to prolonged settled weather, but the conditions appeared to justify the issue of a notice: "Chances favourable for continuation of fair weather next few days." The notification was followed by three or four further days of dry weather over England except in a rather narrow belt extending from north to south across the country. Here thunderstorms, violent in places, were experienced on the afternoon of the 18th, within two days of the issue of the first telegram. Notification of local thunderstorms had been issued on the morning of the 18th. Further thunderstorms were experienced in the east and south-east of England on the 19th. On the morning of the 20th, notice of a spell of unsettled weather was issued, and showers duly followed during the late afternoon or night in most parts of the country. In the South of Ireland the weather remained broken throughout.

(2) A second notice was issued with rather greater confidence on the afternoon of 25th June. Practically no rain had fallen for two days previously. Apart from light showers in the district between Birmingham and the south coast on the evening of 30th June, no rain fell until 1st July, five days after the issue of the telegram. On the morning of 1st July a notice of approaching thunderstorms was circulated and storms became general during the afternoon and evening. On the morning of 2nd July notice of a spell of unsettled weather was circulated. Rain fell in greater or less quantities in most parts of the country during the following days up to and including 8th July.

(3) On 9th July the conditions appeared sufficiently settled to justify the issue of a telegram "Outlook moderately favourable to continuance of dry weather" to the English districts. The notice was extended on the following day to Ireland and Scotland. Notices of approaching thunderstorms had to be issued on the morning of 12th July, and of a definite change in the conditions on 13th July. Three or four days of dry weather followed the original notifications over a broad stretch of country in the east and also in South Wales, the Cornish Peninsula and Ireland, corresponding approximately with the forecast districts 1, 2, 3, 4a, 8 and 10. Thunderstorms occurred on the 11th, within two days of the issue of the notifications in the remaining parts of the country, districts 5, 6, 7, 4b and 5.

(4) A notice issued on 22nd July to the western districts proved a failure in consequence of the unexpected development of a low

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(4) A notice issued on 22nd July to the western districts proved a failure in consequence of the unexpected development of a low

pressure system over the mouth of the Elbe and Scandinavia, which proved of sufficient importance to cause rain in all parts of the United Kingdom.

(5) The weather remained unsettled, though there were long fine intervals for several days subsequently. On 29th July the afternoon observations again appeared moderately favourable and notices were circulated, but on 31st July, two days later, notice of an impending break had to be issued, as the morning observations showed a depression off the Irish coasts. This spread eastward during the day and caused rain in all districts.

(6) After the declaration of war on 4th August, the receipt of information from the Continent and from the Atlantic Ocean by wireless reports became very irregular and the issue of special notifications became more than ordinarily hazardous in consequence. On the morning of 11th August an anticyclone had become established over southern England, and the issue of a notice of continuation of fair weather seemed justified. Except for slight rain in the West of Scotland on the 11th, no rain fell on 11th, 12th, and 13th August. On the morning of the 14th notice of the approaching break was issued to the north and west and extended to all parts of the country in the evening. Thunderstorms occurred at night in Ireland and the south-west of England and also in parts of Scotland, and spread during the following day to the south-east of England. In the north-east of England and east of Scotland practically no rain fell until 21st August, ten days after the despatch of the first telegram of the spell.

(7) Though the foreign information had shrunk still further, another notice was issued on 17th August. No rain fell on that day or the two following days, but on the 20th it appeared prudent to issue notice of the probability of a change to less settled conditions in consequence of the appearance of a depression off our west coasts. Rain fell in Ireland on the 20th and in Scotland and England on the 21st.

As the receipt of Continental telegrams and of wireless reports from the Atlantic Ocean had ceased entirely, notice of the discontinuance of the issue of a "further outlook" or of notifications in connexion with spells of fair weather was issued to all subscribers. The limited information available did not justify the issue of forecasts covering a period of more than 24 hours.

Thus, of the seven sets of notifications issued, two proved completely successful, four only partially successful, inasmuch as rain fell in some of the districts to which the notices had been addressed within less than three days. One notice, that of 22nd July, must be classed as a failure.

Gale Warning Service.—The service of warnings for gales which have borne for many years the inappropriate title of "Storm-warnings" was continued after restrictions had been put upon the circulation of other meteorological information.

The Office has reason to think that such warnings are specially worthy of attention when navigation has to be conducted under the modern conditions of warfare.

The arrangements for the issue of gale warnings have, therefore, remained unchanged. The results for the year are summarised in the following table:—

GALE WARNING CHECKING, 1914.

Districts.	Summary of Occasions for Warning.		Summary of Warnings Issued.			
	Total Number of Occasions on which Warnings were necessary.	Percentage of Occasions of Gale effectively Warned.	Total Number of Issues.	Issues justified by subsequent Gales. Force 8 and upwards.	Issues justified by subsequent Strong Winds. Forces 6 and 7.	Percentage of Issues justified either by Gales or Strong Winds.
1. Scotland, N.E. { A	{ 13	92	{ 31	11	16	90
	{ 11		{ 27	11	14	
	{ 8	75	{ 24	5	15	76
	{ 8		{ 27	7	12	
2. " E. ...	{ 4	100	{ 19	4	13	79
	{ 4		{ 24	4	13	
3. " N.W. ...	{ 17	78	{ 30	11	11	75
	{ 15		{ 27	14	7	
4. " W. and North Channel ...	{ 10	85	{ 28	9	16	84
	{ 16		{ 28	13	9	
5. Ireland, N. ...	{ 19	77	{ 32	14	11	83
	{ 20		{ 27	16	8	
6. " S. ...	{ 21	75	{ 29	14	13	91
	{ 15		{ 25	13	9	
7. Irish Sea ...	{ 19	80	{ 27	13	12	95
	{ 21		{ 30	19	10	
8. St. George's Channel	{ 18	89	{ 28	15	9	93
	{ 20		{ 27	19	8	
9. Bristol Channel ...	{ 22	87	{ 30	17	8	90
	{ 23		{ 28	22	5	
10. England, S.W. ...	{ 25	82	{ 32	19	11	92
	{ 24		{ 30	21	6	
11. " S. ...	{ 17	86	{ 24	15	9	96
	{ 19		{ 25	16	7	
12. " S.E. ...	{ 11	70	{ 20	8	9	89
	{ 19		{ 26	13	11	
13. " N.E. ...	{ 6	100	{ 19	6	12	90
	{ 11		{ 21	11	7	
14. " E. ...	{ 8	87	{ 17	7	9	92
	{ 14		{ 21	12	7	
Average per District	{ 14.5 } { 16.0 }	84	{ 26.0 } { 26.2 }	11.2 14.0	11.6 8.9	88

NOTE.—In order to facilitate comparison with the statistical tables of the Board of Trade, which are made up for the year ending June 30, the figures for the two halves of the year 1914—January 1 to June 30, and July 1 to December 31—are given separately for each district. The upper line of figures in each case gives the particulars for the first half of the year.

The table is divided into two sections. The first deals with "occasions for warning," i.e., occasions on which the wind reached gale force at two stations at least in a district, and

failure to hoist a cone in good time would, therefore, count as a gale missed. On the average, adequate warning was given of 84 per cent. of all gales experienced. The second part of the table deals with the number of warnings issued to each district, and those "justified" by subsequent increase of wind. In order to show the extent of success attained, the hoists justified are divided in the table into two classes: (1) those in which the wind increased to gale force at at least two stations in the district, or in which the wind increased from force 8 to force 10 on the Beaufort scale after the receipt of the instruction to hoist; (2) those in which the wind increased to force 6 or 7 on the Beaufort scale at several stations in the district, without reaching force 8, the lower limit for a wind of gale force, at two stations.

The material used for checking the warnings consists of (1) the records of all coastal anemometer stations, (2) the wind observations made at the telegraphic reporting stations and published in the Daily Weather Report, and (3) the wind records—Beaufort estimates—contained in the logs and registers from selected light-ships and lighthouses, which are lent for the purpose by the various lighthouse authorities. In the aggregate, records from about 100 stations are examined in the process of checking the gale warnings.

The mean number of occasions of gales per district for the whole year was 30·5, as compared with 29·5 in 1913, and 30·8 in 1912.

During the first seven months of the year three occasions of gale (January 31st, February 10th, and March 16th), for which warnings were only partially effective, deserve mention. The closing days of January had been of a boisterous type, but on the evening of the 30th the barometer was rising on our western coasts, and there appeared to be no danger of an immediate renewal of wind of gale force. Nevertheless, a deep depression advanced during the night and caused a southerly gale in all western districts early on January 31st. Warnings were issued to all coasts at 8.30 a.m. on January 31st. They were effective in the eastern districts but late in the west, though in most western districts there was some increase of wind after the receipt of the warning, or a renewal of the gale after a temporary lull. Had a wireless report from longitude 21° west reached the Office on the evening of January 30th, instead of on the morning of February 1st, the cones would have been hoisted on that evening in the western districts.

On February 10th warnings were issued to the northern districts, but the unexpected development of a secondary disturbance in the south-west caused the gale to extend to the English Channel region.

The failure to give adequate warning of the gale on March 16th arose from telegraphic rather than meteorological difficulties. Warnings which had been fully justified expired at 8 p.m. on the evening of Sunday, March 15th, and, though the conditions shown by the evening reports on that day appeared threatening, instructions to keep up the cones were not issued, as only a small number of stations are open for the receipt

failure to hoist a cone in good time would, therefore, count as a gale missed. On the average, adequate warning was given of 84 per cent. of all gales experienced. The second part of the table deals with the number of warnings issued to each district, and those "justified" by subsequent increase of wind. In order to show the extent of success attained, the hoists justified are divided in the table into two classes: (1) those in which the wind increased to gale force at at least two stations in the district, or in which the wind increased from force 8 to force 10 on the Beaufort scale after the receipt of the instruction to hoist; (2) those in which the wind increased to force 6 or 7 on the Beaufort scale at several stations in the district, without reaching force 8, the lower limit for a wind of gale force, at two stations.

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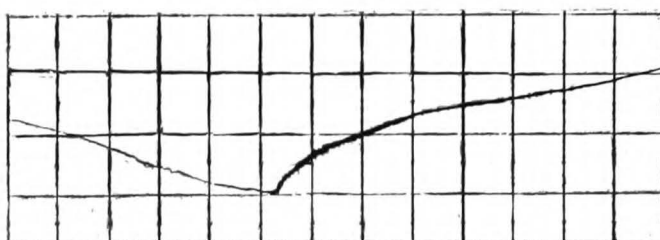
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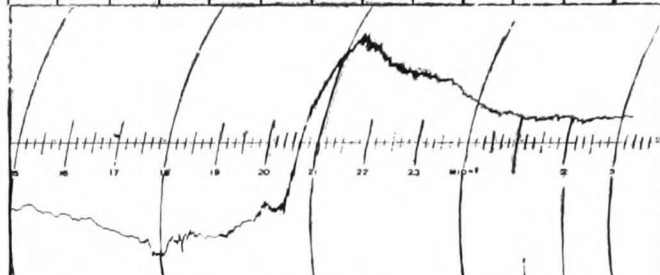
To face page 37.

PLATE I.

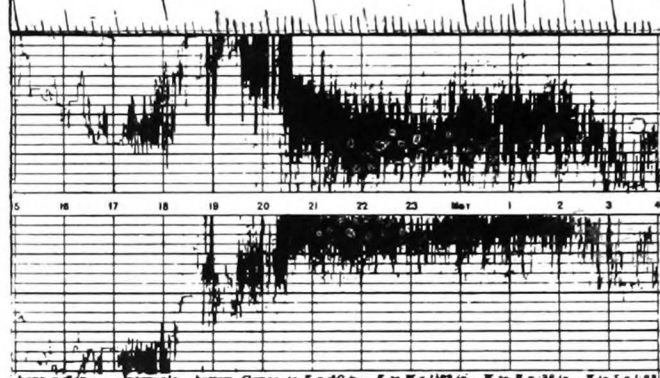
RECORDS AT SOUTH KENSINGTON.
15H. DECEMBER 28" - 4H. DEC. 29, 1914.



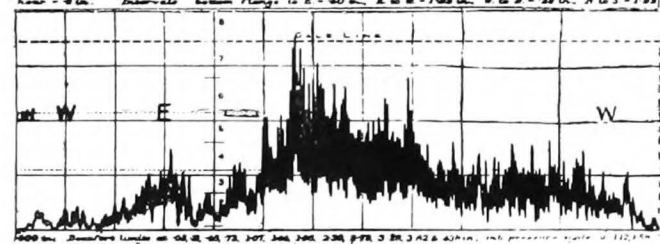
PRESSURE
MERCURY
BAROGRAPH.
IN MILLIBARS.



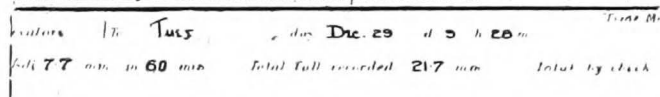
PRESSURE
MICROBAROGRAPH.
(MAGNIFICATION SIXFOLD)



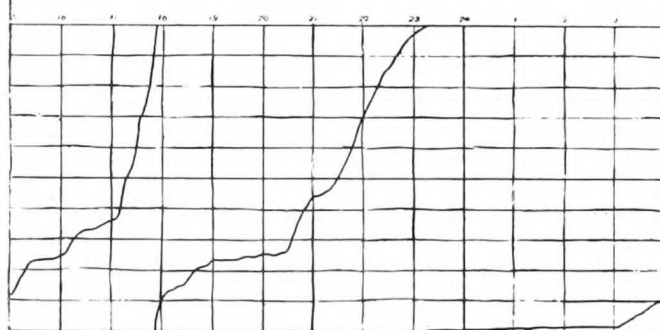
WIND
DIRECTION



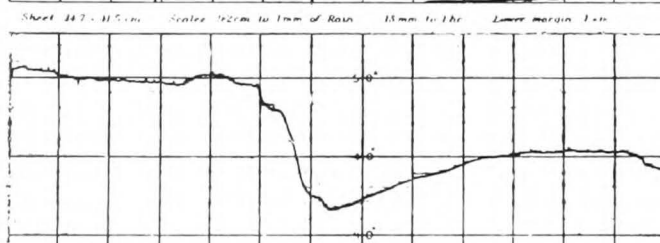
WIND
VELOCITY.
IN METRES PER SEC



RAINFALL.
IN MILLIMETRES



TEMPERATURE.



SOLAR RADIATION.
IN MW: PER CM.
6H. - 18H.
DEC. 28"

of telegrams on Sunday evenings. By 7 a.m. on Monday, March 16th, winds of gale force had again set in on the Irish coasts, in the Irish Sea, and along the English Channel. A less extensive failure, due to similar causes, occurred on Sunday, November 29th.

The early months of the war fortunately proved quiet, but two gales of some importance have to be chronicled during this period, one on September 17th, the other on October 30th. During the night from September 16th to 17th a depression developed off the north-west of Ireland and caused a considerable increase of wind in the English Channel. Instructions to hoist cones were issued at 8 a.m. on the 17th to the English Channel and south-east of England, but the warnings were too late to be effective in the west, though they were serviceable in the east. During the day the depression developed rather unexpectedly as it moved eastward, and gave rise to a north-westerly gale over the Irish Sea. The rough weather in the Channel led to the loss of H.M.S. "Fisgard II.," off Portland Bill, on September 17th.

The gale of October 30th led to the loss of the hospital ship "Rohilla," off the Yorkshire coast. The 1 p.m. reports on October 29th showed a rapid fall of the barometer in the east of Scotland, suggesting the development of a secondary disturbance over the North Sea, and the north cone was accordingly hoisted on all coasts except in the south and south-west of England. The secondary developed rather rapidly and gave rise to a strong north-easterly gale in the north-east of England early on October 30th.

About the middle of November a period of westerly weather, with frequent gales, set in, and cones were up on parts of our coast on the majority of days up to the end of the year. The most conspicuous gale occurred on December 28th. A small secondary disturbance was revealed by the afternoon observations off the south-west coasts, and the south cone was hoisted along the English Channel. The disturbance grew deeper and moved rapidly eastward. By 7 a.m. on the following morning it was centred over the eastern part of the North Sea. During its progress eastward it caused severe gales along the Channel and also over the east of England and southern parts of the North Sea and in the Low Countries. The high wind was accompanied by considerable snowfall. The development was so rapid that the warnings were barely in time to be effective on the coasts warned; no warnings were issued to the east coast, where severe gales were experienced.

Wireless Telegrams.—During the first seven months of the year the arrangements for the collection of information by wireless from Atlantic liners were carried on on lines indicated in previous reports. The number of messages received was well maintained. A further improvement in the direction of avoiding delay in transmission can be put on record. The percentage of morning reports which reached the Office in time for inclusion in the current issue of the Daily Weather Report increased to 9.4 per cent. as compared with 7 per cent. for 1913, and 5 per cent. for 1912.

Weekly Weather Report.—The preparation of the maps issued with the Weekly Weather Report has had to be discontinued on account of the insufficiency of the data. As far as possible the working charts at the Office have been completed from the weather reports of allied or neutral countries and from information received by post from ships at sea. The material for the preparation of the usual charts will ultimately be available and to a great extent it is already in the Office. No information has as yet been received for Siberia for the period August to October. Subsequently the Russian Daily Weather Reports again became normal and for later months the Siberian records are again complete, but after October there was delay in receiving through the post the usual reports from Iceland. These were not received until the middle of April. It is proposed to bring up to date the issue of the maps of the Weekly Weather Report as soon as circumstances permit.

Reports from Health Resorts.—The arrangements for the collection of evening reports from health resorts and for their issue to the newspaper press in a comprehensive report have remained unchanged. Data are only accepted for publication in these reports from stations which arrange for annual inspection by a representative of the Office. Fifty-six health resorts have availed themselves of the arrangement.

After the restrictions on the circulation of meteorological information to which reference has been made above came into operation, the issue of information regarding sunshine, rainfall, and temperature at health resorts was still authorised. Though the numbers of contributing stations has fallen off the service has been continued throughout.

WEATHER STATION: FALMOUTH OBSERVATORY.

The work of the observatory has been carried on on the lines indicated in previous reports. In addition to the regular observations, pilot balloon ascents has formed part of the routine work during the periods when Mr. Goldie was in charge.

The inspection of the stations in the south-west of England was also undertaken by Mr. Goldie.

The war has interfered with the normal working of the arrangements. The mobilisation of the territorial forces on the outbreak of hostilities deprived the observatory of the services of Mr. Brenton, the public librarian of Falmouth, who takes a share in the routine work of observing under the arrangement made with the Corporation. Subsequently Mr. Goldie was called upon to render additional assistance in the forecast division of the Office in London. During Mr. Goldie's absence temporary duty at Falmouth was taken by Mr. F. J. Brodie for a period of four weeks in autumn, but even with this assistance the observatory has had to be in sole charge of Mr. Phillips, the permanent assistant, for long periods. It is satisfactory to be able to report that under these disadvantageous circumstances it has been possible to keep the routine work up to date.

BRANCH OFFICE AT SOUTH FARNBOROUGH.

Report by J. S. Dines, M.A., Meteorologist-in-Charge.

The first part of the year 1914 was given up for the most part to the organisation of the routine work of the Office.

A complete set of instruments was installed, eye readings of the different elements being taken at the telegraphic hours of 7 a.m., 1 p.m., and 6 p.m., with continuous autographic records of pressure, temperature, relative humidity, sunshine, and rainfall.

Observations were telegraphed from the Central Office for the preparation of a weather map and forecast each evening, the forecast being drawn up with a special view to the requirements of aviators. A show case was erected facing the road which leads to the Royal Aircraft Factory in which are regularly exhibited current maps and forecasts, daily curves showing "Yesterday's Weather" and weekly curves of "Last Week's Weather."

Throughout the year pilot balloons have been sent up on almost every day that was suitable and in this manner a very large number of data about the upper air conditions have been accumulated.

Many inquiries as to upper air and other meteorological conditions from the scientific staff of the Royal Aircraft Factory have been dealt with and inquiries were also received from the Royal Naval Airship Squadron while this was stationed at Farnborough.

There have been frequent changes in the staff in the last few months of the year.

On January 23rd, Mr. H. S. Allnutt, mechanic-computer, left the office to take up work at the Royal Aircraft Factory. In his place an office boy, H. S. Pain, has been supplied by the Factory.

On February 24, Mr. H. S. Billett, B.Sc., professional assistant, left to take up an appointment in the Meteorological Service of the Government of South Africa. In his place Mr. A. H. R. Goldie, M.A., was transferred from Falmouth Observatory for duty alternatively at the Branch Office at South Farnborough or in the Forecast Division in London.

Since Mr. Billett's departure the Office has also had the advantage of assistance from Mr. C. J. P. Cave, M.A., who has acted as honorary inspector and has taken charge of the Office during the absence of the meteorologist-in-charge in connexion with forecast duty in London. During this time Mr. Cave has also delivered a course of lectures on meteorology to the members of the Royal Flying Corps stationed at Farnborough.

III.—CLIMATOLOGY AND STATISTICS DIVISION.

Report by E. Gold, M.A., Superintendent.

CLIMATOLOGY OF THE BRITISH ISLES.

Distribution of Stations.—A list of stations in connexion with the Office, in which particulars are given of the orders of the stations and of the Official publications for which the returns have been prepared is issued as a separate circular.

The distribution of the stations at the beginning of 1915 in the various districts may be summarised as follows:—

	Observatories.	Normal Climatological.	Auxiliary Climatological.	Telegraphic Reporting.	Sunshine (including Observatories).	Additional Rainfall.	Additional Anemograph.	Additional Barograph.
0. Scotland, N.	0	9	3	4	8	3	1	6
1. „ E.	1	20	15	3	14	2	4	4
2. England, N.E.	0	9	11	2	13	8	4	4
3. „ E.	0	9	11	2	16	14	3	2
4. „ Midlands	0	11	29	2	26	25	1	5
5. „ S.E.	0	8	33	2	35	16	4	7
London District	1	3	8	1	10	4	1	2
6. Scotland, W., and Isle Man.	1	14	14	2	13	4	1	3
7. England, N.W., and N. Wales.	0	12	20	2	24	20	4	5
8. England, S.W., and S. Wales.	1	6	30	3	28	37	2	2
9. Ireland, N.	0	5	1	3	4	3	1	4
10. „ S.	1	10	10	3	9	6	4	5
11. Western Channel	0	1	1	2	4	0	1	1
Total	5	117	186	31*	204	142	31	50

* Of these, 17 observe at 7 a.m., 1 p.m., and 9 p.m., and thus come under the international definition of a station of the second order. These stations have not been included in the 117 normal climatological stations. Aberdeen, Kew, Valencia and Eskdalemuir are given under Observatories and also under Telegraphic Reporting Stations.

Records have also been received from 7 additional thermograph stations, 12 additional autographic rain-gauge stations, 62 sea temperature stations. An autographic record of the intensity of radiation received on a horizontal surface is obtained at South Kensington, and the results from it are published in the Daily Weather Report and the Geophysical Journal. Daily reports are received by telegraph from 45 foreign stations.

Observatories are also maintained at Greenwich (The Royal Observatory), Oxford (Radcliffe Observatory), Bidston (Mersey Docks and Harbour Board), Southport (the Corporation), and Berkhamsted (E. Mawley, Esq.), and from these, records for occasions of special interest are courteously supplied from time to time.

NORMAL METEOROLOGICAL OBSERVATORIES, ANEMOGRAPH AND SUNSHINE STATIONS.

Observatories.—The work of the observatories is reported upon separately, pp. 49 to 54.

In connexion with the publication of the records in absolute units it had originally been necessary to convert the tabulated values from degrees Fahrenheit, inches of mercury and miles per hour into degrees absolute, millibars and metres per second; the records of pressure began to be tabulated in millibars in 1913-1914, and from the beginning of 1915 the records of temperature have been tabulated in degrees absolute.

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0. Scotland, N.	0	9	3	4	8	3	1*	6
1. " E.	1	20	15	3	14	2	4	4
2. England, N.E.	0	9	11	2	13	8	4	4
3. " E.	0	9	11	2	16	14	3	2
4. " Midlands	0	11	29	2	26	25	1	5
5. " S.E.	0	8	33	2	35	16	4	7
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7. England, N.W., and N. Wales.	0	12	20	2	24	20	4	5
8. England, S.W., and S. Wales.	1	6	30	3	28	37	2	2
9. Ireland, N.	0	5	1	3	4	3	1	4
10. " S.	1	10	10	3	9	6	4	5
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Anemograph Stations.—The number of anemograph stations which are maintained by the Office or from which records are regularly received at the Office is now 30, exclusive of the 4 observatories—Aberdeen, Kew, Eskdalemuir, and Valencia. The autographic records are tabulated or analysed week by week, and a summary of the results published in the Weekly Weather Report so that the information may become available for public use without delay. A similar summary for the month is included in the Monthly Weather Report, and an annual summary including the summary of gales, previously issued as an appendix to the Weekly Weather Report, has been published for 1914 with the usual climatological summary for the year which form No. XIII. of the Monthly Weather Report. Detailed information from four anemograph stations is published monthly in the Geophysical Journal (British Meteorological Year Book, Part III. (2)).

Records of Sunshine.—The number of stations from which returns of "bright sunshine" are received is 204. With three exceptions they are all situated in the British Isles, the exceptions being Georgetown, British Guiana; the Falkland Islands; and Chinkiang, or, subsequently, Amoy, China. The original records from 123 stations are retained in the Office whilst those from the remainder are sent to the Office monthly for examination and are then returned.

The differences between the observer's estimates and those made at the Office are usually small. On the average the observer's estimates during 1914 were about $\frac{1}{2}$ per cent. higher than the Office estimates; in the case of one or two stations the difference is nearly 2 per cent. but the cards remeasured include more than the ordinary proportion of broken burns, in the measurement of which, the greatest differences naturally occur.

Changes in Stations.—The observations at Poltalloch which had been used in the preparation of District Values in the Weekly Weather Report since 1900 were discontinued at the beginning of 1915, but the daily observations of rainfall were continued and arrangements were subsequently made for the weekly return of these to be sent to London.

Records from the anemobiograph of Mr. W. Farrer of Carnforth were received and analysed from June, 1914. The anemograph at Roche's Point was transferred to Weaver Point in June, 1914. A Dines' anemograph was erected for Dr. Crombie, of Dyce, Aberdeenshire, and the records have been received and analysed since July, 1914; the traces are of an exceptionally gusty character. A Dines' anemograph was erected for Mr. William Low at Balmakewan in July, 1914, and the records are now received and analysed. From the beginning of 1915 the records from the Dines' anemograph recently erected at the Royal Observatory, Blackford Hill, Edinburgh, have been received and analysed week by week through the courtesy of the Astronomer Royal for Scotland. The Robinson anemograph at Phoenix Park, Dublin, was dismounted in July, 1914; the record ceased at the end of January, 1914.

A new station was established at Tunbridge Wells in June, 1914, under the supervision of the Medical Officer of Health. The observations are being used in continuation of those supplied by the late Dr. Smart until April, 1913.

A climatological station was started by Mr. H. Foyle at Rathgar, Dublin, and subsequently transferred to Shankill; stations were also started at Banff (Duff House) and Ross (Chase-dale). The station at Rothesay was transferred at the beginning of December, 1914, to a new site at Ardencraig, and the instruments at Perth were transferred to Wellshill Cemetery in the same month.

The rainfall observations reported by Admiral Jeffries from Caragh Lake ceased in April, 1914. The reports began in September, 1906, in continuation of reports from Castle Gregory (Brandon Bay) March, 1904—May, 1906. Rainfall returns have been received from new stations at Lichfield, Kenninghall, and Corwen.

The following is a list of stations at which the observers have changed during the course of the year:—

Station.	New Observer.	Previous Observer.
York (Bootham)...	The Meteorological Curator	Hugh Richardson, M.A.
Fleetwood ...	T. R. Bailey ...	The late M. S. Gaulter.
Basingstoke ...	W. H. Pick, B.Sc. ...	T. V. Philpott.
Broomlands ...	J. C. Scott ...	William Muir.
Margate ...	C. J. Pemble ...	J. Stokes.
Cromer ...	W. P. Baker ...	W. H. Archer.
Tunbridge Wells...	F. C. Linton ...	The late F. G. Smart, M.B.
Rugby ...	J. H. Simpson ...	D. E. Shorto.
Chelmsford ...	R. M. Wilson, B.Sc....	Dr. Thresh.
Bettws-y-Coed ...	Dr. Fox ...	The Sanitary Inspector.
Lathallan ...	Alexander McRae (head gardener).	Dr. Ainsworth.
Forest of Dean ...	L. S. Osmaston ...	V. F. Leese.
Bromyard... ..	Mr. Hicks (temporary) ...	T. V. Philpott, M.A.
Welshpool ...	W. D. Lewis ...	W. H. Brooks.
Ushaw ...	Rev. T. L. Baines ...	Rev. C. Gelderd.
Abersychan ...	G. W. James ...	The late W. P. James.
High Wycombe ...	C. F. Thetford ...	R. O. Matthews.
Cockle Park ...	D. B. Johnstone Wallace ...	R. Thornton.
Birr Castle ...	Thomas Fegan ...	Dr. Boeddicker.
Shrewsbury ...	Col. H. L. Jessop, R.E. ...	Capt. Rathbone, R.E.
Ardtornish ...	Robert Brooks ...	E. Matthews.

Enlistment.—The following observers are reported to have enlisted in His Majesty's forces:—

W. E. Sotheby (Dwyran).
 John Dunlop (Kingston-on-Soar).
 L. G. H. Lee (Raunds).
 H. H. Wright (Morecambe).
 Professor Kershaw (Cirencester).
 H. W. Braby, M.A. (Hampstead
 (Rodington Road))

Professor Kershaw was reported to have been killed in action in November, 1914. The observations at all these stations are being continued.

Obituary.—The Committee record with regret the death of the following observers during the year:—

Fleetwood.—M. S. Gaulter, died April 27, 1914, commenced observations for the Office in 1886.

Perth.—A. M. Rodger, died October 14, 1914.

Geldeston.—E. T. Dowson, died October 4, 1914, commenced observations for the Office in July, 1879.

Woburn.—H. M. Freer, died September 9, 1914, commenced observations for the Office in October, 1898.

Abersychan.—W. P. James, died September, 1914, commenced observations for the Office in January, 1903.

Cirencester.—Professor M. Kershaw, B.A., killed in action, November 7, 1914.

Swarraton.—Rev. W. L. Eyre, died October 25, 1914, commenced observations for the Office in July, 1900.

Forgandenny.—Miss Frances Wood, died December 13, 1914, commenced observations for the Office in July, 1910.

Inspections.—A list of stations inspected during the year by representatives of the Office is given on pp. 55 and 56.

The reports of the Inspectors were dealt with generally immediately after they were received; certificates were issued in the majority of cases and the attention of observers was directed to details of method or equipment which were found to be at variance with the standard conditions. Usually steps were taken forthwith by the observers to remedy defects. In some cases where barometers were found to be affected by increased errors or to require renovation, observers were recommended to take the opportunity to have their instruments graduated in the new units or to exchange them for instruments so graduated. Other opportunities have also been taken for encouraging observers to adopt the new units; the simplification in the reduction of the observations has appealed to many. As a result the following volunteer stations are now equipped with "millibar barometers":—

<i>Station.</i>	<i>Observer.</i>
Newtownforbes	J. A. Boyle, for the Earl of Granard.
Cambridge	Curator of Botanical Gardens.
Egremont	J. Sherwen.
Llandudno	W. Little for the Town Council.
Sheffield	E. Howarth.
Southend	The Borough Surveyor.
Ipswich (Copdock)	F. L. Bland.
Bude	K. Durston.
Morecambe	The Borough Council.

<i>Station.</i>			<i>Observer.</i>
Weymouth	...	...	J. H. Bolam, Borough Electrical Engineer.
Malvern	...	...	E. W. Harris.
Rathgar, Dublin	...	...	H. Foyle.
Bognor	...	...	A. G. Thompson for the Climatological Society.
Banff	...	...	A. J. Leigh, B.Sc., for Dr. E. I. Spriggs.
Seskin (Carrick-on-Suir)	...	...	J. E. Grubb.
Thorntonhall	...	...	J. Wilson for A. Henderson Bishop.
Carnforth	...	...	W. Farrer.
Ballinacurra	...	...	J. H. Bennett.
Clongowes Wood	...	...	Rev. J. J. Gubbins, S.J.
Cromer	...	...	The District Council.
Mayfield	...	...	G. C. Lawson.
Penzance	...	...	C. H. Benn for the District Council.
Rhyl	...	...	The District Council.
Sevenoaks	...	...	The Borough Surveyor.

Publications.—The statistical publications of the Office which represent the "public memory of the weather" of each year for the purpose of future reference, have been grouped together under the general title "The British Meteorological and Magnetic Year Book." Part I., Weekly Weather Report. Part II., Monthly Weather Report. From the beginning of 1914 the tables were re-arranged and the space allotted to general remarks was reduced. In the Table of Summaries for stations a column was added for the heights of the stations above mean sea level and the column for the difference from average of the percentage duration of bright sunshine was omitted; the order of the columns was altered. A new table was introduced giving a summary of wind for the different stations from which pressure-tube anemograms are received. It shows the date and duration of gales and the duration of fresh or moderate winds and of calms and light airs, as well as the dates and times of extreme velocities.

In the Table for Districts, values of pressure for the week, the season and the year are included. They are expressed in millibars. These values of pressure are essential for statistical research on the sequence of weather as exhibited in weekly mean values.

Simultaneously with these changes in the tables, a change was made in the units used in the daily synoptic charts of the Weekly Report (*see* p. 30).

New averages of temperature, rainfall, and bright sunshine have been prepared for the period ending with the year 1910 and are published as an appendix to the Weekly Weather Report for 1913.

The observations at Bettws-y-Coed which had been used in the computation of district values were temporarily discontinued in 1914. No similar records were available in the district and the observations for Hawarden Bridge were accordingly not used in

the computation of District Values in order to compensate for the omission of the records for Bettws-y-Coed and preserve continuity in the series.

From the beginning of 1915 the values of accumulated temperature for individual stations have been omitted but the values for Districts are still computed and used as the basis of the classification for warmth. The space set free by the omission of accumulated temperature in the table of station values has been utilized partly to improve the appearance of the table which was previously getting overloaded and partly to provide for the insertion of a column of rainfall in inches in addition to the columns for values in millimetres, the unit adopted from January 1st, 1915.

Monthly Report.—In 1914 the report was modified and enlarged in consequence of the new arrangements with the Scottish Meteorological Society for the establishment of a Branch Office at Edinburgh and for the publication of additional data for Scotland.

A table based on the observations made at set hours for a selected number of stations was printed separately from the table containing the summary of observations referring to the daily period of 24 hours. In the latter table the data for all stations are collected together and the arrangement facilitates greatly reference to the information published in the Report.

A monthly table summarising the records of the anemographs in connection with the Office similar to the corresponding weekly table mentioned above was also included.

In No. XIII. of the Monthly Report for 1914 the tables of wind previously published in an appendix to the Weekly Report were collected together and supplemented by new tables and incorporated in the statistical summary for the year.

Year Book.—Part III. (1) **Daily Readings at Meteorological Stations of the First and Second Orders**, has been issued regularly about five weeks after the end of each month. It contains daily observations at eight Climatological Stations. From the beginning of 1912 the results have been expressed in absolute units. An Annual Supplement has been issued for 1914 giving for 11 stations complete climatological summaries for each month and for the whole year in a single table for each station. (2) The "Geophysical Journal" has been issued with less promptitude. The monthly parts up to and including April, 1913, are now completed. It contains daily meteorological, magnetic, electrical, solar and seismic data for Kew and Eskdalemuir, meteorological and magnetic data for Valencia and values of the wind components for four hours each day for Deerness, Holyhead, Scilly and Yarmouth. It includes also the results of the investigation of the upper air previously published in the Weekly Report, and particulars of the intensity of radiation recorded at South Kensington by the Callendar Instrument for recording the vertical component of the direct and diffuse solar radiation.

A special summary of the upper air data for the year 1912 has been prepared by Mr. W. H. Dines for publication as an annual supplement to the Journal for that year. A note on the seismicological records at Eskdalemuir has also been included.

Part IV. (1) Hourly Values from Autographic Records. Meteorological Section.—The publication of the hourly values of the meteorological elements at the normal observatories in connexion with the Office is a year behindhand largely owing to the increased work in connexion with the necessary conversion from the units in which the results have been tabulated. The monthly issues for 1913 for Kew, Valencia, and Eskdalemuir, have been completed, and the monthly summaries for Aberdeen are prepared. The photographic barograms are now tabulated directly in millibars, and the corresponding alteration for the thermograms has recently been made.

Part IV. (2) Hourly Values from Autographic Records. Geophysical Section.—The meteorological summaries for the five observatories for this Section have been completed for 1913. A note upon them will be published in the volume for that year which is now in the press. The work involved in the publication of this volume and in the preparation for publication of the results of registering and pilot balloon ascents in the *Geophysical Journal* has fallen upon the staff which deals with the preparation of Part IV., Section (1) of the Year Book.

Returns for Registrars-General.—Weekly summaries have been prepared regularly for the Registrars-General of Births, Deaths and Marriages for England and Wales and for Ireland. The Registrar-General for Ireland discontinued the weekly reports from the end of October, 1914.

A quarterly return of rainfall with general remarks upon the weather of the quarter is supplied to the Registrar-General for England and Wales.

A special quarterly summary of observations at Dublin, with remarks on the weather of Ireland during the quarter, has been supplied to the Registrar-General for Ireland.

Seasons in the British Isles.—Little progress has been made with the preparation of the Report on the Seasons in the British Isles, referred to on p. 47 of the Report for last year, and it has been impossible to complete the work.

Information based upon the weekly values of rainfall, temperature, and sunshine for the past 30 years has been sent regularly to the different agricultural shows at the request of the Board of Agriculture. The information has included a note of the weather of the week preceding the date of the show in the current year, and an indication of the statistical connexion between the weather of the corresponding week and of the following week during preceding years.

Miscellaneous.—A number of tables specially adapted for the rapid conversion from British to metric units has been prepared for use at the Observatories and in the Office.

The Superintendent was away on ordinary and special leave from July 1st to October 22nd in connexion with the visit of the British Association to Australia. A number of ascents of pilot balloons were made on the outward voyage and measurements of the intensity of solar radiation. With the assistance of the ships' officers, on the "Euripides" on the outward voyage via the Cape, and on the "Makura" across the Pacific, two-hourly observations

were made with an Assmann Pyschrometer and simultaneous readings taken from thermometers exposed in the usual screen. The balloons and instruments were provided by grants from the British Association and the Royal Society.

IV.—INSTRUMENTS DIVISION.

Report by F. J. W. Whipple, M.A., Superintendent.

Supply to the Navy.—The instruments necessary to maintain the establishment numbers at H.M. Naval Dockyards have been sent from time to time. The demand for instruments, especially aneroid barometers, increased considerably in the second half of the year. Instruments have been supplied to Kingsnorth and other Naval Air Stations.

The Mercantile Marine.—Instruments were issued from the Office to 45 ships of the mercantile marine during the year. The stock of instruments at the agents of the Office was maintained. New instruments were sent to 19 sea temperature stations. Eighteen gale cones were issued.

Telegraphic Stations.—Raingauge glasses showing the telegraphic code as well as the millimetre scale have been substituted for the ordinary glasses at the telegraphic stations. Small glasses graduated from 0.1 to 1.0 mm. have been issued to observatories.

Observatories.—A microbarograph, a Besson nephoscope and earth maximum and grass minimum thermometers graduated on the absolute scale, were issued to Kew. A water-level recorder was constructed at the Office for the same observatory. Regraduated barometers were sent to Kew, Falmouth, and Valencia. The outfit of a normal climatological station was supplied to Benson.

Supply on Repayment.—Instruments have been supplied to observers on repayment in about 140 cases. The only new stations requiring the complete climatological equipment were at Banff and Sevenoaks.

The meteorological instruments required by the Imperial Transantarctic Expedition for use on the s.s. "Endurance" and "Aurora" have been lent by the Office as well as two sunshine recorders; the remaining instruments for use on land were supplied on repayment. The thermometers provided for this expedition are graduated on the absolute scale.

Instruments have been supplied to the Dominions and Colonies under 37 requisitions. Dines pressure-tube anemometers were sent to India and South Africa, anemobiographs to Mauritius and Natal; Callendar recorders for temperature and radiation, together with an Ångström outfit went to South Africa; a hyetograph with an extended range was made for Zanzibar; large consignments of raingauge measures, thermometers, &c., were dispatched to the Commonwealth of Australia.

Exhibition.—An exhibit was sent to the Royal Agricultural Show at Shrewsbury; the Office was represented by Mr. A. E. Gendle. On Friday, July 3rd, the show was visited by H.M. the King, who spent some time in examining the instruments included in the Meteorological Office exhibit, and showed great interest in the records of a thunder-storm of the previous day.

Fishery Barometers.—Inspectors of the Fishery Board for Scotland and of the Board of Agriculture and Fisheries in England and Wales have continued to examine and report upon the barometers supplied for the use of fishermen in their respective districts. The stations supplied with these barometers now number 226, of which 61 are in England, 6 in Wales, 66 in Ireland, 88 in Scotland, 4 in the Isle of Man, and 1 in Jersey.

V.—METEOROLOGICAL OFFICE, EDINBURGH.

Report by A. Watt, M.A., F.R.S.E., Superintendent.

No change in the staff has occurred during the year. Since the beginning of January a large amount of new office equipment has been installed, and consequent re-arrangement of the library has made heavy demands on the time of the staff and will continue to do so for a considerable time to come.

Reports to the Registrar-General for Scotland.—The Monthly and Quarterly Reports required by the Registrar-General for Scotland have been regularly supplied on the lines indicated in the report for last year. The Quarterly Report now includes statistics for about 80 stations.

Supply of Returns to the Meteorological Office, London.—Statistical summaries of observations at Scottish stations have been regularly prepared and forwarded to the Meteorological Office, London, for inclusion in the Monthly Weather Report. During the year new stations have been established at Banff, and at the Garden of the Edinburgh and East of Scotland College of Agriculture at Liberton, Edinburgh. Observations have been accepted from Kelso (Broomlands). For March, 1915, returns from 62 stations were supplied to London.

At one or two stations work is being carried on with difficulty on account of dislocation due to the war, and at Poltalloch observations of rainfall alone are in the meantime available. At no station, however, has work been entirely discontinued.

Inspections.—The Superintendent inspected the following stations during the year:—Arbroath, Balmoral, Benwhat, Carnoustie, Colinsburgh, Crathes, Dalkeith, Dundee Harbour, Helensburgh, Kelso (Broomlands), Kettins, Lathallan, Leadhills, Logie Coldstone (Loanhead), Logie Coldstone (School), Montrose, Perth, St. Andrews, Stonehaven, and Thorntonhall.

Two or three of the stations visited do not as yet fully satisfy the conditions under which observations are accepted for inclusion in the Monthly Weather Report.

Inquiries.—A considerable number of general inquiries have been dealt with either by correspondence or at an interview. In five cases a fee has been charged for information supplied, and the total fees received have amounted to £1 17s. 6d. The importance of the Office as a bureau of information and advice is becoming more widely known, and, apart from inquiries for specific information for which a fee is charged, there have been fairly frequent consultations with persons engaged in educational and research work.

The Superintendent attended at the London Office for about a week in November, 1914, and again in March, 1915.

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OBSERVATORIES.

VI.—CENTRAL OBSERVATORY, KEW OBSERVATORY, RICHMOND, SURREY.

Report by C. Chree, ScD., LL.D., F.R.S., Superintendent, Assistant-Director of Observatories.

Staff.—Mr. C. D. Stewart, B.Sc., professional assistant, has been transferred to the Forecast Division of the Office and has been succeeded by Mr. E. G. Bilham, B.Sc., A.R.C.S., as resident observer. Mr. Nichols, B.Sc., was employed at the Observatory as an additional professional assistant principally in connection with atmospheric electricity.

Self-recording Instruments and Eye Observations.—A new pressure-tube anemometer was erected on the roof in April, 1914. On December 31, 1914, alterations were made to the *photographic barograph and thermograph* so that the light stop of the former instrument should come off, and that of the latter instrument come on exactly at the even hours. The object was to secure that the curve measurements made should in future refer to the exact hours.

The Benndorff electrograph was removed from its site in the hall in November, 1914, and re-erected in the electrical room outside, in the position to which it is intended ultimately to transfer the Kelvin water-dropping electrograph. Observations are being taken with the ionium collector at different distances from the wall of the building, with a view to selecting a convenient distance for the water jet.

A clock and drum have been fitted in the roof of the seismograph room for a continuous record of the *height of underground water* in the well in the basement.

All the meteorological records obtained, except those from the pressure tube anemograph and the float barograph, have been tabulated for each hour at the Observatory. The electrograms have been measured each day at 3 h., 9 h., 15 h., and 21 h., and the daily electrical "character" has been assigned up to the end of February. The hourly values of potential gradient for the year 1914 from ten selected quiet days a month have been measured up to the end of October. The maximum and minimum daily values of magnetic declination and horizontal force have been measured and the magnetic "character" assigned for all days up to the end of January. All the data of magnetic "character" for the year 1914 have been sent to the international centre for these data at the Royal Netherlands Meteorological Institute at de Bilt.

The declination and horizontal force curves for the first nine months of 1914 have been measured at each hour of the five quiet days selected internationally for each month. The calculation

of the resulting diurnal inequalities is not yet, however, complete. The seismograms have been studied up to the end of October. Returns have been made monthly during the latter part of the year to the Seismological Institute of the British Association at Shide.

Regular cloud observations have been made with the Fineman nephoscope in connection with the investigation of upper air. On days of bright sunshine observations of the intensity of solar radiation have been made with the Ångström pyrheliometer within half an hour of noon.

Observations of the air-earth vertical electric current have been made with the apparatus designed by Mr. C. T. R. Wilson, and observations of the positive and negative charges per cubic centimetre associated with the more mobile ions in the atmosphere have been taken with the Ebert apparatus. These electrical observations have been taken on most fine afternoons between 2 and 4 p.m. All the regular observations made with either the Wilson or the Ebert apparatus up to the end of January have been reduced and checked.

In addition to the work represented by the tables of results published in the *British Meteorological and Magnetic Year Book*, the following experimental work has been conducted at the Observatory:—

Fog and Mist.—The observations of a series of distant objects have been continued as in previous years.

Electrical Observations.—Some additional observations have been made with the Wilson and the Ebert apparatus, more especially near the hour of sunset and in connection with the solar eclipse on August 21st. The results of the eclipse observations were communicated to Mr. Carlheim Gyllensköld and the Director of the Magnetic Department of the Carnegie Institution of Washington.

Antarctic Magnetic Observations.—The work, of which the commencement was notified in last year's report, continues to be carried on by Messrs. J. Foster and C. Turl. A comparison has been instituted between the magnetic "character" of individual days as assigned on the international scheme at de Bilt and as deduced from the Antarctic curves. The results were embodied in a paper which the Superintendent read in February to the Physical Society, which will appear in the Society's "*Proceedings*."

Publication of the Results.—The *Geophysical Journal* (British Meteorological and Magnetic Year Book, Part III., Section 2) gives month by month particulars of barometric pressure, air temperature, humidity, wind direction and velocity, amount of cloud and weather at two fixed hours daily, also the daily totals of rainfall and duration of bright sunshine. It further includes for each day the minimum temperature on the grass, earth temperature at two depths, values of the electric potential gradient at four fixed hours, the electric and magnetic "character," the extreme values of magnetic declination and horizontal force and the ranges of these elements. The results are also given of the observations of solar radiation with the

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Ångström pyrheliometer and of electrical observations made near 3 p.m. with the Ebert and the Wilson apparatus.

Monthly summaries of the diurnal and seasonal variation of the magnetic declination and horizontal force and of the electric potential gradient in the atmosphere are given with corresponding data for other observatories of the Office, when they are available, in "*Hourly Values, Geophysical Section, Part IV., Section 2,*" of the same publication, which also contains mean monthly values of magnetic inclination, total force and vertical force and north and west components, along with a table giving recent mean values of the magnetic elements at the observatories whose publications are received at Kew Observatory.

Verification Work.—The testing of compasses and compass bowls has now ceased, the equipment necessary for the work having been set up at the National Physical Laboratory. The instruments whose verification was concluded in the year ending March 31, 1915, were as follows:—

Unifilar Magnetometers (one with two collimator magnets)	2
Inclinometers (with 28 dip needles in all)	5
Vertical force magnet	1
Solar maximum thermometers	12

The solar maximum thermometers were compared for the National Physical Laboratory.

One of the magnetometers tested, at the request of its future owners, the United States Coast and Geodetic Survey, underwent an elaborate comparison with the Kew magnetometer, with the object of comparing the Kew instrument with the standard at the Coast and Geodetic Survey's observatory at Cheltenham, near Washington.

Instruction in Magnetic Measurements.—A course of instruction in the use of the ordinary absolute magnetic instruments was given to Lieut. Daughlish, R.I.M.S., at the request of the India Office. Facilities for learning and practising the use of absolute magnetic instruments were afforded to Mr. James and Mr. Hussey attached to Sir Ernest Shackleton's Antarctic Expedition. Assistance was also given to Mr. James in erecting and studying the Eschenhagen magnetograph destined for use in the Antarctic.

Requisitions.—Prepared photographic paper, as used at Kew, has been supplied on requisition to the other observatories of the Meteorological Office and to the Radcliffe Observatory, Oxford.

Library.—The rearrangement of the books has been continued. Duplicates have been sifted out, including numerous authors' copies of papers by General Sabine, Mr. Broun, Dr. Balfour Stewart, and Mr. G. M. Whipple, as well as old Reports of the Kew Committee.

Loan of Instruments.—In the course of the year a number of pieces of apparatus, including pendulums swung by Captain Basevi in India, were lent to the Board of Education for the Science Museum, South Kensington. The following is a list of

the instruments, apparatus, &c., the property of the Meteorological Office, which is at present date out of the custody of the Superintendent on loan from the Observatory:—

To whom Lent.	Articles.	Date of Loan.
New Zealand Government.	Dip Circle, by Barrow, with one pair of needles and bar magnets, and a tripod stand.	1899
" "	Unifilar Magnetometer, by Jones, marked N.A.B.C.	1909
Cambridge Scientific Instrument Company.	Assmann's Aspiration Hygrometer ...	1915
Board of Education, Science Museum, South Kensington.	Articles specified in the list given in the Annual Report of the Kew Committee for 1893.	1876
	Shelton Sidereal Clock with gridiron pendulum and diaphragm.	1914 and 1915
	Invariable Pendulums Nos. 4, 4 and 6, by Thos. Jones, also Nos. 10 and 11.	
	Three Agate Planes, Nos. 4, 6, and 10	
	Vacuum Chamber with iron collar ...	
	Wooden Frame for supporting Pendulums.	
	Two Pressure Gauges	
	Two Brass Graduated Arcs	
	Two Thermometer Boxes	
	Observing Telescope	
	Two portions of the base of the Kew Vacuum Chamber, 1828-9.	

VII.—MAGNETIC OBSERVATORY—ESKDALE OBSERVATORY, LANGHOLM, DUMFRIESSHIRE.

Report by L. F. Richardson, B.A., Superintendent.

Magnetics.—Continuous records have been obtained of the north, west, and vertical components of the earth's magnetic field. Absolute observations of the earth's magnetic field have been made weekly, and are used to standardize the magnetographs. Numerical values of the north, west, and vertical components are being computed for every hour throughout the year, for publication in *Hourly Values, Geophysical Section*. Preliminary values of daily maxima and minima are being printed in the *Geophysical Journal*.

The classification of the days of the year according to the amount of magnetic disturbance has been continued and the results are forwarded periodically to the International Magnetic Commission.

The magnetic disturbances of 1913 have been examined and found to be of two distinct types. (A note on these disturbances was communicated to *Nature*, 1914, Dec. 24).

Meteorology.—Telegraphic reports to the Daily Weather Service have been continued at 7 a.m. and 6 p.m. Values of the tempera-

ture, barometric pressure, humidity, wind direction and force, sunshine and rainfall have been obtained for every hour throughout the year, from the traces of autographic instruments, standardized by eye-observations. They are prepared for press at the Meteorological Office, and will be printed in the *Meteorological and Magnetic Year Book*, Part IV.

The weather and cloud are observed and noted seven times daily, and a diary is kept. Observations of the intensity of solar radiation have been continued by means of the Ångström instrument.

On many clear days during the period, the wind velocity and direction at heights of one kilometre or more above sea level have been observed by a pilot balloon and theodolite; the results are published in the Daily Weather Report for the following Sunday.

A comparison is in progress between two types of thermometer screen.

Atmospheric Electricity.—A continuous record has been obtained of the voltage per metre of height near the earth's surface. The days are classified according to the amount and character of the disturbance of the record. The average daily oscillation of voltage is being determined for the quieter days, and the times of the more notable disturbances obtained for publication in the Year Book. Observations of positive and negative charges in the air have been made on a number of fine afternoons with the Ebert apparatus. The results are published in the *Geophysical Journal*.

Seismology.—The three Galitzin seismographs continue to give records of the components of the natural tremors of the ground in the north, west, and vertical directions. The earthquakes and microseisms are tabulated and printed in the *Geophysical Journal*.

The Omori instrument is maintained in operation.

A few inquiries from private individuals have been answered.

VIII.—WESTERN OBSERVATORY.—VALENCIA OBSERVATORY, CAHIRCIVEEN, CO. KERRY.

All the self-recording apparatus of a first-order meteorological station have been kept in continuous operation throughout the year, and the hourly tabulations are being published as usual. Reports have been sent regularly by telegraph three times a day, but an evening report made specially to the *Daily Telegraph* has been discontinued. Cloud observations in connexion with the international investigation of the upper air have been made on the prescribed days of each month.

Absolute observations of magnetic declination, inclination and intensity, have been made each fortnight throughout the year by the Superintendent. The results have been prepared for publication in the *Geophysical Journal*.

IX.—**ABERDEEN OBSERVATORY.**

Besides the ordinary work of a meteorological station of the first order, observations of cloud motion in connexion with the international investigation of the upper air have been made, and daily observations of cloud motion for transmission to de Bilt. Observations of the upper air by means of pilot balloons have also been made regularly under Professor Niven's direction.

Two papers discussing these observations have been prepared by Mr. A. E. M. Geddes, M.A., one on pilot balloon ascents watched by two theodolites has been published in the *Journal of the Royal Meteorological Society*, the other on ascents with one theodolite has been privately printed.

A number of interesting photographs of clouds and sketches of aurora and striking atmospheric occurrences have been contributed by Mr. G. A. Clarke to the Office collection.

Two sketches of halo by Mr. Clarke have been reproduced by half-tone process as illustrations of the Office Handbooks, and are included in this report in Plate II. opposite.

X.—**AEROLOGICAL OBSERVATORY AT BENSON.**

Report by W. H. Dines, F.R.S., Director of Aerological Investigations.

Investigation of the Upper Air in 1914.—Some particulars of the number of registering balloons sent up and of the number recovered during 1914 are given in the following list:—

	No. sent up.	No. recovered.
Benson	14	7
Pyrton Hill	9	6
Eskdalemuir	12	3
Mungret College		4
Ditcham Park		5

From various causes the total is much less than in previous years. The compulsory removal of the Meteorological Office Station from Pyrton Hill to Benson in the spring greatly hindered the work during the first half of the year, and in the latter part owing to the war the supply of rubber balloons, which were obtained from Continental firms, failed; also the ascents from Manchester have been discontinued and the ascents from Ditcham Park were fewer than usual.

The percentage of recovered balloons, viz., 50 per cent. from Benson is a low one, but the locality in this respect is a little more favourable than that of Pyrton Hill, since Benson is about six miles further to the west. But it is plain from the figures in the list that Eskdalemuir is not a suitable station, and indeed its proximity to the Firth of Forth and the North Sea suffices to explain the low percentage of successful ascents.

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PLATE II.

SOLAR HALOS OBSERVED AT ABERDEEN.

Reproduced from sketches by G. A. Clarke, Aberdeen Observatory.



Solar Halo of 22° radius, May 27, 1912. Complete circular halo, with arc of contact, Semi-major axis of the ellipse of which the arc of contact forms a part was about 29° .



Solar Halo of 22° radius, March 5, 1908, with arc of contact, mock sun ring, and mock suns (parhelia).

PLATE II.

SOLAR HALOS OBSERVED AT ABERDEEN.

Reproduced from sketches by G. A. Clarke, Aberdeen Observatory.



Solar Halo of 22° radius, May 27, 1912. Complete circular halo, with arc of contact. Semi-major axis of the eclipse of which the arc of contact forms a part was about 29° .



Solar Halo of 22° radius, March 5, 1908, with arc of contact, mock sun ring, and mock suns (parhelia).

After many inquiries, an English firm has been found to supply balloons at a reasonable price, the present difficulty lies in the supply of meteorographs, since no mechanic is available to make them. It should be possible to keep up the regular ascents on the international days till the end of the summer, and it may be hoped that by that time the conditions may be more favourable.

XI.—STATIONS IN CONNEXION WITH THE OFFICE: INSPECTIONS IN 1914.

The inspectors were as follows:—

Districts 0, 1 and 6	...	...	...	Mr. A. Watt, Mr. L. F. Richardson, Mr. L. H. G. Dines.
District 2	...	...	...	Mr. H. Harries.
" 3	...	...	...	Mr. R. Sargeant.
" 4	...	...	...	Mr. R. Corless, Mr. H. Harries.
" 5	...	...	...	Mr. H. Harries, Mr. F. J. Brodie.
" 7	...	...	...	Mr. F. J. W. Whipple.
" 8	...	...	...	Mr. R. Corless, Mr. A. H. R. Goldie.
" 9	...	...	...	} Mr. J. S. Dines.
" 10	...	...	...

The following is a list of the stations visited:—

OBSERVATORIES.

Aberdeen.	Valencia.
Armagh.	

ANEMOGRAPH STATIONS.

†Brighton.	Hexham.	Scilly.
Deerness.	Holyhead.	Spurn Head.
†Dover.	†Kingstown.	Weaver Point.
Fleetwood.	†Plymouth.	Yarmouth.
Gorleston.	†Quilty.	

TELEGRAPHIC REPORTING STATIONS.

Aberdeen.	Holyhead.	St. Ann's Head.
†*Bath.	Jersey.	Scilly.
Birr Castle.	Lerwick.	Spurn Head.
Blacksod Point.	Malin Head.	Stornoway.
Castlebay.	*Nairn.	Tynemouth.
†*Clacton-on-Sea.	†*Newquay.	Valencia.
Donaghadee.	Nottingham.	Wick.
†*Dover.	Portland Bill.	*Yarmouth.
Dungeness.	Roche's Point.	

* Information from this station is included in the evening reports from Health Resorts supplied to the Newspaper Press.

† These stations are maintained by the Local Authority or by the Harbour Authority, or, in the case of Quilty, by the Railway Authority.

HEALTH RESORTS CONTRIBUTING TO THE EVENING REPORTS FOR THE PRESS.

Aberystwyth.	Harrogate.	Ross-on-Wye.
Bexhill-on-Sea.	Hastings and St.	Ryde (I. of W.).
Bettws-y-coed.	Leonards.	St. Andrews.
Blackpool.	Hythe.	Scarborough.
Bognor.	Ilfracombe.	Skegness.
Bournemouth.	Leamington Spa.	Southend-on-Sea.
Brighton.	Littlehampton.	Southport.
Bude.	Littlestone-on-Sea.	Southsea.
Buxton.	Llandudno.	Stonehaven.
Carnoustie.	Lowestoft.	Swansea.
Cheltenham.	Malvern.	Teignmouth.
Colwyn Bay.	Margate.	Tenby.
Cromer.	Morecambe.	Torquay.
Douglas.	Oban.	Ventnor (I. of W.).
Eastbourne.	Paignton.	Walton on Naze.
Exmouth.	Penzance.	Weston-super-Mare.
Felixstowe.	Ramsgate.	Weymouth.
Folkestone.	Rhyl.	Worthing.

CLIMATOLOGICAL STATIONS.

Arbroath.	Dublin (Phoenix	Rugby.
Balmoral.	Park).	Rugeley.
Blockley.	Fulbeck.	Seskin.
Carnforth.	Lathallan.	Shrewsbury.
Chelmsford.	Loanhead.	Thorntonhall.
Colinsburgh.	Logie Coldstone.	Ventnor (Hospital).
Copdock.	Mallaranny.	Waterford.
Crathes.	Rauceby.	Whithy.

Besides the stations which are wholly or partially maintained by the Office in connexion with the daily weather service, the list includes a large number of stations maintained by local authorities and private persons to whom the Committee are indebted for their co-operation in maintaining an adequate public record of the weather in the British Isles.

At the observatories and anemograph stations the instruments were dismantled and cleaned and all necessary repairs were carried out. At telegraphic reporting stations and climatological stations the instruments, their exposure and the arrangements for the work, were examined. In a number of cases the inspectors were able to make suggestions for improving the observations by bringing them into line with recognised conventions. Points requiring attention which could not be settled on the spot have been dealt with by correspondence. Certificates of efficiency have been given to those stations which complied with the requirements of the Office in regard to the incorporation of the observations in the official publications.

THE FIVE YEARS, 1910-15.

With the close of the year 1914-15 the second quinquennial period of the appointment of the Meteorological Committee was completed. The five years have been marked by noteworthy progress in the consolidation and development of the work of the Office.

In drawing attention to the termination of this period of their appointment the Committee beg leave to repeat here the following extracts from their letter to Your Lordships of 2nd December, 1914:—

Consolidation of the Work of the Office in the Five Years, 1910-15.

The five years now concluding have been marked chiefly by the consolidation and extension of the meteorological and geophysical work within the administration of the Office.

New Premises and Museum.—In 1910 the work of the Office was transferred to new premises at South Kensington, which are held on lease from the Office of Works at an annual rent of £640. With the assistance of private donations to the extent of £300, a museum for the display of meteorological results of general interest has been formed in connexion with the library, out of Office funds, and nearly completed. The Office is, in consequence, now visited by parties from schools and other educational institutions, chiefly on Saturday afternoons. It is generally the subject of favourable comment from visitors, both British and foreign, and the facilities which the Office affords, educationally and otherwise, are much more widely known.

Lithographic Press.—The printing press in the basement, which started in 1911, has been found to be most useful. It has taken up more space than was originally assigned to it, and still needs more, so that there is an encroachment on the available space for office storage, which, combined with the larger requirements of the clerical staff and the increasing volume of documents, is making insistent pressure for more room.

Lecture Room.—The original plan of using the library as a lecture room is becoming more and more inconvenient, and at the same time the usefulness of a lecture room as an auxiliary to the work of the Office has been most clearly shown.

Kew and Eskdale Observatories.—At the commencement of the period the physical observatories at Kew (Old Deer Park, Richmond) and Eskdalemuir came under the administration of the Office, as part of the scheme put forward five years ago by the Royal Society and the Committee and sanctioned by Their Lordships. In 1913 the testing staff of the National Physical Laboratory was withdrawn from Kew, and the buildings have been altered in order to remedy certain defects and to make them more suitable for their purpose.

Falmouth Observatory.—The observatory at Falmouth, initiated by the Meteorological Committee of the Royal Society in 1868, and maintained by the Royal Cornwall Polytechnic Society since that date with a subvention from this Office of £250 a year, has come under the direct administration of the Committee as a weather station, because the Society was no longer able to maintain it, but was prepared to allow the use of the building, rent free.

Branch Office at South Farnborough.—At the request of the Army Council, an observatory and Branch Office for the assistance of aircraft pilots has been brought into operation in the Royal Aircraft Factory at South Farnborough.

Withdrawal of Subventions.—Subventions of long standing to Glasgow University and to Stonyhurst College, in aid of the maintenance of meteorological observatories of the Kew type, which also date from 1868, have been withdrawn. The subventions to the Royal Meteorological Society, paid in consideration of the Society supplying copies of the observations at certain stations for official publication,

have also been withdrawn, and all the Society's stations now report directly to the Office, and the observations are available for public use.

Meteorological Office, Edinburgh.

Scottish Meteorological Society.—The subvention previously paid to the Scottish Meteorological Society on similar grounds has been increased to £350 a year, but the terms have been so modified that the observations at all the stations in connexion with the Society are now available for the public in an office which is recognised as the Meteorological Office, Edinburgh.

In consequence of this consolidation, the Monthly Weather Report of the Office now presents a full summary of the climatological observations made by public authorities or private persons in the United Kingdom.

Subventions still remaining.

The only examples now remaining of subventions to other controlling authorities or their servants in consideration of specific returns, are:—

British Rainfall Organisation.—£25 to the British Rainfall Organisation for a monthly map of rainfall in the British Isles. It is proposed to increase this in consideration of an important alteration in the Annual Volume of "British Rainfall."

Aberdeen Observatory.—£295 to the Physical Department of the University of Aberdeen for the observatory which is managed by the Professor of Natural Philosophy, but is closely identified with the work of this Office, and is, in fact, the principal establishment of the office for the study of the Meteorology of the North Sea.

Armagh Observatory.—£50 to the Archbishop's observatory at Armagh.

Anemograph and Daily Weather Report Stations.—£670 for 23 telegraphic reporting stations and four separate anemograph stations, which are in the hands of coastguards, lightkeepers, municipal officials or private persons. Part-time service is appropriate in these cases, so that this item will remain, but as both kinds of station belong to the study of the daily weather, the tendency is to include an anemometer with a telegraphic station, and not to make its care a separate undertaking.

Importance of the Consolidation for the Efficiency of the Office.

The consolidation of the various institutions has brought a considerable increase of the work of the Office and of the expenses incidental thereto. It has, however, enabled the Committee to organise the meteorological work with more definite relation to the objects for which this Office stands. Those objects, speaking broadly, are as follows:—

- i. The collection of observations from ships on all oceans, together with the discussion and publication of meteorological results, for the benefit of sailors, and as a contribution to the meteorology of the globe.
- ii. The collection and publication of reports received by telegraph, and the issue of forecasts and storm warnings based upon them.
- iii. The maintenance of observatories and anemograph stations to furnish material for the scientific study of the phenomena of weather, as exhibited on the daily charts, and the application of the study to the improvement of forecasting, and other purposes.
- iv. The organisation and maintenance of a trustworthy public memory of the weather, which is available for reference at any time by all classes of the community, and which forms a basis for the study of the Climatology of the United

Kingdom in comparison with that of other countries, and in relation to Agriculture, Public Health and other public purposes; the discussion of the observations with a view to the definition of climatic factors for this country in comparison with others, and ultimately, to the relationships of seasons and the establishment of more general laws of climate and weather, that should lead up to a reasoned forecast of coming seasons.

- v. Co-operation with the British Dominions and foreign countries for improving the organisation and the instruments by which the purposes enumerated above are to be pursued, and for the effective representation of the meteorology of the globe.

Reference to the Annual Reports of the Committee will show that these purposes have been vigorously pursued. The activity of all divisions of the Office has been well marked, especially in relation to the public services in this country and the dominions.

Board of Trade.—The various inquiries and conferences following the loss of the "Titanic" in 1912 led to many sudden and unforeseen demands upon the Marine Division by the Board of Trade, for charts, information about ice, &c., at short notice, or for more elaborate compilations and for advice and assistance in organisation. All of them have been creditably met or are now being dealt with.

Dominions beyond the Seas.—The Instruments Division has kept the Navy and our own stations supplied with meteorological instruments, and in addition has supervised the whole of the supply of instruments for the new Meteorological Services of the Commonwealth of Australia and of the Union of South Africa. It has also met the requirements of all the Crown Colonies and Rhodesia, and supplied some to Canada, India and various antarctic expeditions. These services are vitally important for the progress of Meteorology, because they keep the meteorological establishments of the different parts of the Empire in touch with one another.

Municipal Authorities.—Through the Statistical Division or the Forecast Division, the Office is in communication, on questions of meteorological organisation, with the representatives of some 175 municipal, educational, or other corporations having local jurisdiction, and 250 private observers.

The Admiralty.—But in the present time of emergency it is the organisation of the Forecast Division which chiefly calls for remark. A number of provisions arranged simply with a view to the efficiency of the Office as a public institution have proved to be indispensable since the outbreak of war, in order to meet the requirements of the Admiralty. All the observatories had been newly organised to take part in the daily weather service and thereby to become cognisant of the problems which they are intended to elucidate, and they have thereby become available for supplying information to the Office at any time, day or night. The other reporting stations had also been so organised in conjunction with the observatories, that the Forecast Division has not failed to meet promptly and efficiently whatever wishes the Admiralty has expressed for information as to the weather over any part of the British Isles and neighbouring seas, for the use of the Navy, the Air Department, or the officials at headquarters.

From a different point of view also the Committee's provisions for efficiency in peace time have been found indispensable in emergency. The Admiralty expressed the wish that the telegraphic reports should be kept confidential, and yet should be compiled and printed as usual and distributed with a restricted circulation. The lithographic press on the premises, and new telephone arrangements just completed, enabled an effective order to be given to meet this requirement forthwith.

So far as the Office staff is concerned, the net result up to now has been that what was originally provided for the service of the general public has been found necessary, and has therefore been "commandeered" by the Admiralty for the public service. The work has been carried on without any undue stress upon the staff, but at the sacrifice of certain "appropriations in aid," in consequence of the suspension of the supply of information to the public.

Terrestrial Magnetism, Seismology, &c.

The consolidation referred to in paragraph 3 has made the Meteorological Committee responsible for the work of the observatories in other physical subjects besides meteorology. The principal additional subjects are Terrestrial Magnetism, Seismology, and Atmospheric Electricity. Of these subjects, Atmospheric Electricity is likely to become of immediate practical importance through the recording of distant lightning by means of wireless receiving instruments. Terrestrial Magnetism, apart from questions concerning the Mariner's Compass, is at this stage mainly of academic interest in this country; and in the same way, as regards Seismology, so far as this country is concerned, the actual earth movements have more relation to the problems of Geology and Mining than to administrative measures concerning destructive earthquakes; but both are co-operative studies now carried on on an international basis, in which other units of the Empire are very closely interested, and this country ought to be in a position to afford guidance in the methods of observing and in the interpretation of the results. It is also to be remarked that the problems which present themselves for solution in magnetic and seismological observatories certainly require the co-operation of a meteorological observatory, and the co-ordination of all three studies in one locality, even if they are not concentrated under the same roof, is of great advantage.

When they are combined in one observatory the organisation ought to be sufficiently ample to allow each study to proceed with some degree of independence, so that each observatory requires a three-fold staff. The staffs of the two principal observatories of the Meteorological Office are not large enough for this division of labour to be properly carried out, and to bring them up to the required scale three additional professional assistants and two additional clerical and technical assistants are required.

The Committee have noted that Your Lordships in communicating your pleasure with respect to the estimate of expenditure for the future, do not regard the work of the observatories in terrestrial magnetism and seismology as being in the same relation to the Exchequer as the other subjects which are included in the work of the Office.

Meteorological Office,
June, 1915.

NAPIER SHAW,
Chairman.

APPENDIX I.

REPORTS AND MEMORANDA.

1. "Pressure in Absolute Units" (Monthly Weather Review of the United States Weather Bureau, January 1914).
2. The Organisation of the Meteorological Office, London, with special reference to Agricultural Meteorology.
3. Climatological Stations and Local Authorities.
4. Central Observatory for the Investigation of the Upper Air.

I. PRESSURE IN ABSOLUTE UNITS.

By W. N. SHAW, Sc.D., F.R.S., Director of the Meteorological Office.

(Reprinted from the "Monthly Weather Review" of the U.S. Weather Bureau for January 1914.)

From time to time, and especially within the last few years, the adoption of absolute units for representing atmospheric pressure has been urged on scientific grounds, and there is a general consensus of opinion that absolute units are the most suitable for dealing with meteorological theory, especially in relation to the upper air.

Through circumstances which are not altogether within my own control I have had to face the adoption of absolute units as a practical question and also as an educational question. In fact, I have had to ponder over replies to the following questions:—

What units for pressure and temperature should be adopted in the publication of monthly values of pressure for a *réseau mondial*?

What units should be employed by lecturers and teachers who wish to interest students of mathematics and physics in the development of meteorological science?

What graduation should be employed for a barometer in order to commend most effectively to the wider public the results of meteorological study?

I find the answer to all these questions in absolute units on the C.G.S. system, with only an outstanding uncertainty as to whether the millibar or the centibar is to be preferred.

Perhaps I had better explain that the *bar* represents the C.G.S. "atmosphere," that is, a pressure of 1,000,000 dynes per square centimetre, the dyne being the C.G.S. unit of force. The dyne is the force which produces an acceleration of 1 centimetre per second per second, in a mass of 1 gram. The weight of m grams when the gravitational acceleration is g centimetres per second per second, is mg dynes. The bar is approximately equivalent to 750 millimetres, or 29.5 inches, of mercury at 0°C. and standard gravity. The centibar is one-hundredth, the millibar one thousandth, of the bar.

It is quite possible that I may be to some extent affected by unconscious bias in favour of the ultimate application of theory to practice. If absolute units are the best for theory, they are the

units of the future; for the practical applications of meteorology must ultimately be guided by theory, just as those of astronomy are at the present day. For me this supplies the answer to my first question. The time is coming, if it has not already come, when students of meteorology will deal with the earth as a whole on the basis of observations and will recognise that anything short of that is inadequate for the solution of the more general problems of climate and weather.

To my second question, as to what are the best units for educational purposes, there is only one answer. So far as the United Kingdom is concerned, in all schools and colleges, wherever the elements of mathematics, physics, and chemistry are instilled into the rising generation, they are in association with the metric system as a part of scientific education. Two consequences result therefrom: In the first place, a complete divorce of all scientific experience from the meteorological practice of everyday life, a divorce which may perhaps be sufficiently illustrated if I say that in the laboratory a water-bath of 98° is a very different thing from bath-water of 98° in everyday life. The whole of the disastrous effect of this divorce is hardly to be appreciated by those who have nearly accomplished their life's journey with comparative success in spite of that disadvantage, but that is no reason for disregarding its importance to the young, and therefore let me call special attention to another aspect of it.

Between professors and students of the mathematical and physical schools of our universities there is a "freemasonry," of which the use of metric units is a sign and from which the students of meteorology are apt to find themselves excluded. To express my meaning in the fewest words, let me say that if in a country assembly for the advancement of science, an unknown stranger should get up and speak in metric units, the initiated physicist would at once say "he must be one of *us*," and the uninitiated meteorologist would say "he is one of *them*"; but if he should begin his discourse by speaking in inches and grains, the physicists would at once say "we need not listen—there can be no dynamics or physics in this," and in the most out-of-the-way meteorological assembly, if any one should be heard speaking in metric units, he would not be set down as an eccentric or a crank, but as a person with exceptional scientific associations.

This being so, what should be the line of action of a meteorologist who lays claim to some portion of the scientific spirit? Surely this—not to remain in the isolation that excludes us from the sympathy of fellow-workers, but to turn the tables upon our friends and say to the grand masters of our cult, "We will accept a metric system, but we cannot accept your millimetre, because when we make a change we must take care not to perpetuate the unscientific practice of representing the pressure of the atmosphere by a length. We know that the millimetre which you use is not really a length at all, and is really only a millimetre under conventional conditions of temperature and latitude which never occur together, but our students, who have yet to learn that important fact, will have clearer ideas from the start if they do not begin with that confusion. We are prepared to do what

physicists have often aspired to do, but have not had the courage or coherence to carry out, namely, to use pressure units for pressure measurements and leave length units to measure lengths with. Nor can we accept your centigrade scale with the freezing-point of water as its zero. We cannot let our students adopt the conception of negative temperatures, which is a survival of the time anterior to the conservation of energy and which has sooner or later to be explained away with much labour and practical inconvenience."

Let us now deal with the third question: What kind of barometer should be put before the general public with due regard for the teachings of modern meteorology? We know that it is still the practice to sell barometers with the customary legends—

28.0	28.5	29.0	29.5	30.0	30.5	31.0 inches.
Stormy.	Much rain.	Rain.	Change.	Fair.	Set fair.	Very dry.

and that many newspapers reproduce day by day a barometer dial of this kind. On metric barometers we find the same legends, but "Change" is opposite to 760 millimetres instead of 29.5 inches, and the steps are 10 millimetres instead of half inches. That is in itself sufficient condemnation of what on other grounds is quite intolerable, and in these days we want to suggest some alternative that will not spoil the instrument-makers' trade, nor yet convey to the countryman misleading ideas.

The first idea that an official meteorologist would suggest is that no countryman would have done his duty by the atmosphere unless he had compared his local reading with that of the corresponding issue of the daily bulletin. To do that he must reduce his readings to sea-level, so, absolutely, the first requirement is a simple means for giving, with sufficient approximation, the sea-level pressure. The next idea to be inculcated is that the actual pressure of the atmosphere at the moment does not matter as a general rule, but only the changes which are taking place, and which can be watched locally with great advantage. What could be better for this purpose than to mark some point within the range of the barometer 100 and note the differences from that point as percentages? Coming to details, it can only be regarded as providential that the point on the barometer against which the word "Change" is inscribed, being 29.5 inches, corresponds almost exactly with 100 centibars; consequently the temptation to use centibars and write 100 there is irresistible. Then obviously we must make the range of the dial or the tube big enough to show the changes which are to be expected in the district in which it is to be used, and the countryman will at once realise within what percentages of the middle value the pressure has varied in the past, and therefore may be expected to vary in the future. It is curious that 100 centibars, although not the mean value of the sea-level pressure, is in the middle of the usual range, and is, in fact, the middle line of the ordinary record-sheet of a Richard-barograph, which is marked 75 centimetres or 29.5 inches.

By way of suggesting that it is variations of the barometric pressure which count, and not the particular level, we can give the frequencies of occurrence of different barometric pressures, so that the observer can see for himself whether conditions are normal or

exceptional, and so keep an eye on the working of his instrument as well as on the weather.

I have set out these suggestions in a *Land Barometer*,* with a rotating circle for reduction to sea-level. It is not necessary to enter into any further explanation; what is set out on the dial ought to be self-explanatory. But I ought to say a word about the frequencies. I cannot now recall where I got the figures which are engraved on this first dial. I have made new figures for subsequent specimens, which give the average frequency of barometric minima below 100 centibars and maxima above 102 centibars, for Valencia, Aberdeen, and Kew combined. The figures are not applicable to any particular place without further inquiry, and their entry on the dial is a challenge to the observer to verify or improve them for his own locality.

With the *Sea Barometer* things are different. The observer has no daily weather chart at hand to show the distribution of pressure at sea-level with which he can check the readings of his own barometer, and for any check he must rely upon the normals for his locality. Nor can frequencies of barometer values be easily given for a sailor whose course runs north or south. A barometer, on the pattern of the Land Barometer, for the transatlantic voyage might be made, but for the sailor who is not restricted to the transatlantic passage the normals for different latitudes along the thirtieth west meridian seem the most effective, and they are shown on the Sea Barometer dial.

These two barometer dials seem to suggest the centibar as the C.G.S. unit most likely to be useful in practice. So far no one has had any effective experience with instruments graduated to give pressure in absolute measure, and the millibar has given its name to the battlefield between the old and new, because it was adopted by Prof. Bjerknes as a substitute for the millimetre. Fortunately the difference between centibars and millibars is only the difference of a decimal point, and the practice as to observing and publishing may be allowed to shape itself as convenience in practice dictates.

While I am writing on the subject of absolute units, I should like to add a word about the proposal of Prof. Bjerknes to record heights in "dynamic metres," which has given rise to fierce controversy. The quantity which it is really sought to express by the use of the term "dynamic metres" is the product gh , which is in fact the potential energy of unit mass at the height h . This quantity may quite appropriately be called the *geo-potential*, that is, the potential due to the earth's gravitational attraction at the height h . In the units which Prof. Bjerknes employs, the acceleration g becomes numerically 0.981 for latitude 45° , and if h is expressed in metres, gh differs from h by less than 2 per cent.

Thus the expression for the height in metres is numerically little different from the expression of the *geo-potential* in what Prof. Bjerknes calls *dynamic metres*. The objection to the

* Illustrations of the two new forms of aneroid barometers graduated according to C.G.S. units were included in the Report for 1913-14.

suggestion may be briefly expressed by saying that what is sought to be represented is not really height as generally understood, for example, in a pilot balloon sounding, which is essentially a geometrical measurement, and the unit in which the geo-potential is expressed is not a *metre*, nor any fixed length; it has not the unitary "dimension" of a length.

The objection to changing the "dimension" of a unit by prefixing an adjective is perfectly sound, but it is really a curiosity of scientific literature to find the objection to the use of "dynamic metre" for the expression of geo-potential denounced as immoral in an article which stoutly upholds the use of the "time-honoured millimetre" as a unit of pressure, without even an adjective as a warning to the unwary.

Mr. F. J. W. Whipple, of my Office, has proposed a solution of the difficulty which seems to me to meet the case in a satisfactory way. He points out that we have no special name for the unit of acceleration, and that in quoting the acceleration of gravity for a particular latitude we have to express it as, say, 981 centimetres per second, per second. He suggests the name *leo*, an abbreviation of the name of Galileo, of immortal memory in connection with gravitation, as a suitable name for the acceleration of a dekametre per second, and in this unit the acceleration of gravity in latitude 45° would be 0.981 *leo*. Then on the analogy of the *kilogram-metre* or the *foot-pound*, both time-honoured as units of work or potential energy, a *leo-metre* would be the potential energy of unit mass raised through 1 metre against an acceleration of 1 "leo" or of unit mass raised through $1/g$ metres against the acceleration of gravity. Thus Prof. Bjerknes' "height" in *dynamic metres* would become the *geo-potential* in "*leo-metres*," and would differ numerically from the real height in metres only by about 2 per cent.

In this way all the objections on the score of morality or unsound terminology would be avoided, and yet the numerical value of the geo-potential in "*leometres*" would enable us to keep in mind a close approximation to the actual height in the consideration of the dynamic problems of the atmosphere.

It seems clear that the time has come when meteorologists may properly turn their attention to the reconsideration of their units and their nomenclature, and that the call comes with almost equal force from the theoretical, the educational, and the practical sides of their work.

2. MEMORANDUM ON THE ORGANISATION OF THE METEOROLOGICAL OFFICE, IN LONDON, WITH SPECIAL REFERENCE TO AGRICULTURAL METEOROLOGY.

(Drawn up by the Director of the Meteorological Office at the request of the Foreign Office, dated 2nd February, 1914, for the use of the French Ambassador.)

His Excellency asked to be informed of the "*textes législatifs et administratifs* qui réglementent les services de météorologie générale et plus particulièrement de météorologie agricole en Grande Bretagne."

Textes législatifs.—The only legislative authority for the Meteorological Services of this country in any year is the appropriation by Parliament of a sum as a "Grant-in-Aid" for the "Meteorological Office" in the Appropriation Act of that year.

A "Grant-in-Aid" is a fixed sum handed over by H.M. Treasury to be administered, under conditions laid down by the Treasury, by some body of persons, whether constituted expressly for that purpose or not, who become responsible for the expenditure, and for any administrative action taken in conformity with the prescribed conditions.

The Ministers responsible to Parliament for the grant, the Lords of the Treasury, accept no responsibility for the actions of the administrative body, provided they are within the prescribed conditions.

The grant for the expenses of the Meteorological Office was fixed at £20,000 in the year 1913. It is included in the Votes for Scientific Investigation, and is made to the Meteorological Committee, a body constituted by a Minute of the Treasury.

By custom, the Committee which administers a "Grant-in-Aid" is allowed to undertake the administration of other grants, and also to receive payment for special duties undertaken for or services rendered to private persons, public bodies, or, in certain cases, to Departments of Government. It is not entitled to the official services of the Post Office or other Departments of State, but by special arrangement the Meteorological Office enjoys certain official facilities with regard to the priority of meteorological telegrams and with regard to stationery and printing.

The total expenditure on the various services in the administration of the Meteorological Committee is about £30,000 a year. It must, however, be pointed out that the meteorological observations available at the Office include those which are carried on primarily for their own purposes and at their own expense, by municipal corporations and private persons. With regard to these, the Office acts only as adviser, organiser, compiler and publisher of results. This voluntary work—taking observations of rainfall also into account—probably represents an expenditure of £20,000, making the whole expenditure on meteorological services in this country, including municipal and private enterprise, about £50,000, of which £21,000 is provided by Government.

Textes administratifs.—The only *textes administratifs* for the Meteorological Services are the Minute of the Lords Commissioners of H.M. Treasury, dated 20th May, 1905, constituting a Director of the Meteorological Office and a Meteorological Committee with the Director as Chairman, and subsequent Treasury Minutes re-constituting the Committee or appointing members thereof.

A copy of Treasury Minute of 20th May, 1905, is appended.

In accordance with regulation, accounts of the receipts and expenditure of the Office for each year are audited by the Comptroller and Auditor-General and reported to Parliament; and a Report upon the work of the Office is presented each year to the

Treasury and laid before Parliament by Command of His Majesty.

Any Member of Parliament is, therefore, at liberty to raise any question upon the accounts or the report, but otherwise, with the limitations herein indicated, the Director and Committee have full discretion as to the objects to which the funds shall be devoted and the means which shall be adopted for securing them.

The practice of the Office is guided by tradition, which has been formed in the past 60 years. The Grant-in-Aid has been increased from time to time for reasons urged either by the controlling authority or by parliamentary critics of the Office. Each increase has carried with it the intention to accomplish some specific object, and therefore, a tacit obligation on the part of the controlling authority; but the Treasury has never made conditions about details of expenditure, and has always accepted the statement of the proposed allocation of the grant without comment; so that the Committee is not bound by any conditions, but merely guided by its own judgment in accordance with tradition and practice.

It is important to note this in the consideration of the special application of Meteorology to Agriculture. That is one of the objects of the Office, but any other of the applications of Meteorology in the interest of the public is equally so. There is no special allocation of funds for the application of Meteorology to Agriculture as such.

The operations of the Meteorological Office being guided so largely by tradition and practice, without any *textes administratifs*, which prescribe its duties and operations in detail, the only means of obtaining a conspectus of the guiding principles of its organisation is by reference to the Annual Reports which have been issued since 1868, to occasional reports before that date and to the reports of certain Committees of Inquiry, from which the present organisation has grown. It now comprises a Central Office with four technical divisions, two branch offices, six meteorological observatories, about thirty subsidised stations and upwards of three-hundred voluntary stations. Terrestrial Magnetism and Seismology are associated with Meteorology. The reports are, however, so voluminous that a brief historical retrospect may be acceptable, and is therefore given here. It is necessary to go into some detail because the subject ultimately under consideration is the application of Meteorology to Agriculture, and in such a case application means that the agriculturist must be in a position to receive and use the information which the meteorologist has to give, and this requires much preliminary work, first, to put the meteorologist in possession of the necessary facts and principles, and secondly, to enable the agriculturist to understand the technical language and ideas without which communication is meaningless.

Marine Meteorology.

1. The Office was started in 1854 as the Meteorological Department of the Board of Trade, under Admiral R. FitzRoy, on the recommendation of an International Maritime Conference held

at Brussels in 1853. The sole purpose of the department was the supply of meteorological instruments to the navy and mercantile marine, and the collection and discussion of meteorological observations from ships.

Those duties still remain in much the same form. They are undertaken partly by the Instruments Division and partly by the Marine Division of the Office.

Daily Weather Study.—Telegraphic Reporting and Anemograph Stations.

2. Moved especially by the loss of the "Royal Charter," in 1860 Admiral FitzRoy in co-operation with Le Verrier, and with the support of the Prince Consort, began daily telegraphic reports from stations in this country, and subsequently from France. With the aid of charts prepared from the observations, he commenced the issue of "forecasts" and "storm-warnings." This was the first beginning of what is now the Forecast Division of the Office. The procedure was sharply criticised by the scientific authorities of the time, and upon FitzRoy's untimely death in 1865 the Board of Trade took the matter up with the Royal Society. Upon the report of an inter-departmental committee (Board of Trade and Admiralty) a new departure was taken, viz. :—

Observatories of the First Order.

3. In 1867 a grant-in-aid of £10,000 was assigned to a Meteorological Committee (unpaid) to be appointed by the Royal Society, with enlarged duties, viz. :—

- (a) To continue the work in marine meteorology of the Meteorological Department of the Board of Trade.
- (b) To continue the study of weather by means of daily telegraphic reports, but not to issue forecasts or storm-warnings. (The storm-warnings were replaced by request of the Board of Trade, but the forecasts remained in abeyance till 1879.)
- (c) To bring to the assistance of the study of weather, the records obtained from self-recording instruments at seven special observatories on land established for the purpose. (This marks the introduction of observatories into the Meteorological Office system which are now represented by five meteorological observatories, two of which include magnetism and seismology, and a central observatory for the study of the upper air.)

Climatology and the Meteorology of the Globe.

4. In 1872 an International Conference of Meteorologists was held at Leipzig, which was followed by official international congresses of duly accredited representatives at Vienna in 1874 and ultimately at Rome in 1879. These international meetings concerned themselves partly with the exchange of information by telegraph between countries in Europe, and also with the study of climate, which is primarily of local or national importance, but ultimately has to do with the meteorology of the globe.

Exchange of Publications.

They also led to the organisation of an elaborate exchange of publications, so that a meteorological office has become the most cosmopolitan of all institutions and is in direct communication with every civilised country.

The international meetings not only brought an accession to the importance of the daily weather exchange, but introduced a new subject, climatology, into the work of the Office, which in England and Scotland had been the care of voluntary societies.

Thereupon the Scottish Society, through representatives in Parliament, demanded a subvention, and failing that, an inquiry into the administration. There was also much dissatisfaction about the marine work, and the inquiry was granted by the Treasury, who appointed a committee of inquiry under the Chairmanship of Sir William Stirling Maxwell.

Statistical Division.—Special Researches.

5. Upon the report of that Committee in 1877 the Treasury decided to revise the constitution, to place the actual direction as well as the general control of the Office in the hands of a paid Council appointed by the Royal Society with the sanction of the Treasury. The grant became £14,500. Climatological work was added to the obligations of the Office, and is now represented by the Statistical Division of the Office, which concerns itself with the publication of the official Year Book. Also by the same instrument "special research," which included experimental work of various kinds, was recognised as a legitimate object of expenditure.

Daily Information for Newspapers.—Evening Telegraph Service.

6. In 1879 the study of weather with the aid of daily telegrams and of self-recording instruments at observatories was pronounced to be sufficiently far advanced to justify the issue of forecasts, and they were accordingly issued at 11 a.m. daily to public offices and newspapers gratis, and to "subscribers." But "The Times" newspaper desired also an evening issue that might be printed in the morning paper. For some time the money necessary for the additional service was provided by "The Times" and subsequently by a syndicate of newspapers. Then the Government accepted the obligation and increased the grant first by £500 and subsequently by £300 more on that account. The Office was accordingly charged with a new duty—the supply of weather information in the evening to newspapers. It is now associated with evening duty for the Admiralty and Military Air Stations.

7. From 1880 things went on without change for more than twenty years, but in 1903 the Scottish Members of Parliament again demanded an inquiry on account of the failure of the Scottish Society to obtain a subvention sufficient to maintain the Observatory on Ben Nevis from the grant made to the Meteorological Office. Another inquiry was set on foot by the Treasury,

and a committee appointed under the Chairmanship of Sir Herbert Maxwell. This Committee reported in 1904, and resulted ultimately in the Treasury Minute of 20th May, 1905, already referred to.

Réseau Mondial.—Library.

In the meantime the library had become a most important matter, and the compilation of information about climate and weather in the various parts of the British Empire practically constituted a new department of activity. The pressure on the one hand of the International Meteorological Committee and on the other hand of the study of Solar Physics, has gradually led to the recognition of an obligation towards a *réseau mondial* as specially incumbent upon the Meteorological Office as the central institution of its kind for the Empire. This has become part of the duty of the Secretarial and Library Division of the Office.

Investigation of the Upper Air.

Since the Meteorological Committee was constituted in 1905 many changes have supervened; telegrams from Iceland, wireless telegrams from ocean steamers, the air departments of the navy and the army, the absorption by the Office of the whole duty as regards climatology, previously discharged by the Societies with the aid of a subvention. The Office has also become the central institution for the meteorological investigation of the upper air. It has taken over the direct control of observatories which were previously under separate authorities, and this step has brought with it the responsibility of the Office for certain aspects of terrestrial magnetism, as well as of atmospheric electricity and seismology. These changes have been associated with an increase of the grant to £20,000.

Colonial Observations.

The Office has also become an advisory centre for the Colonies which have no separate meteorological organisation and it also assists the Meteorological Institutes of the Dominions in the selection and purchase of instruments.

British Rainfall Organization.

Thus the horizon of the work of the Office, which was originally limited to the collection and discussion of observations from the sea, has now become very wide: still it does not include all the British meteorological interests. The important subject of rainfall in the British Isles is still the care of a private organisation—"The British Rainfall Organization." The Meteorological Office makes no attempt at the detailed representation of rainfall, and only deals with rainfall as part of climatology.

When, therefore, the application of meteorology to agriculture is considered, so far as the Meteorological Office is concerned, anything which is dependent upon the detailed study of the distribution of rainfall is not necessarily included.

In a recent communication to the Treasury, the purposes which the Office keeps in view have been defined in the following terms:—

- “(i) The collection of observations from ships on all oceans, together with the discussion and publication of meteorological results, for the benefit of sailors, and as a contribution to the meteorology of the globe.
- “(ii) The collection and publication of reports received by telegraph, and the issue of forecasts and storm-warnings based upon them.
- “(iii) The maintenance of observatories and anemograph stations to furnish material for the scientific study of the phenomena of weather as exhibited on the daily charts, and the application of the study to the improvement of forecasting, and other purposes.
- “(iv) The organisation and maintenance of a trustworthy public memory of the weather, which is available for reference at any time by all classes of the community, and which forms a basis for the study of the climatology of the United Kingdom in comparison with that of other countries, and in relation to agriculture, public health, and other public purposes; the discussion of the observations with a view to the definition of climatic factors for this country in comparison with others, and ultimately to the relationships of seasons and the establishment of more general laws of climate and weather that should lead up to a reasoned forecast of coming seasons.
- “(v) Co-operation with the British Dominions and foreign countries for improving the organisation and the instruments by which the purposes enumerated above are to be pursued, and for the effective representation of the meteorology of the globe.”

Apart from the question of special researches by individuals at the Central Office or at the Observatories, the means which are adopted by the Committee for securing these objects are set out in the Circular 001 of which a copy is annexed, together with a copy of the latest report of the Committee, which gives on pp. 6-8 the names of the staff, consisting of about 80 persons.

These facts will enable His Excellency to form an opinion as to the rather complicated structure which is represented by the meteorological organisation of this country. References are given to the original documents which form the material through which the gradual development of the structure can be traced. It consists of a central office, with branch offices, observatories, and stations. The work of the central office is in five divisions, viz.:—

1. Marine Meteorology.
2. Forecasting, Storm-warnings, and Dynamical Meteorology.
3. Climatology and Statistics.
4. Instruments and equipment for observatories and stations.
5. Library, Inquiries, and Réseau Mondial.

Meteorology and Agriculture.

Some addition is necessary with regard to the important and difficult question of *la météorologie agricole*. It is really an open question whether the responsibility for the application of meteorology to agriculture belongs to the Meteorological Office or to the Board of Agriculture and Fisheries in England and the corresponding departments in Scotland and Ireland. The traditional attitude of the Meteorological Office is that it collects and digests meteorological information which the agriculturist can apply if he wishes, and from that point of view the following issues of the Meteorological Office are regarded as suitable.

Forecasts.

1. The *Daily Weather Report* with the provisions set out for telegraphing forecasts for a small fee to those who are willing to pay for the telegrams. Circular 001 (A-H), p. 9.

Forecasts are prepared throughout the year each morning at 10 a.m. and each evening at 7 p.m., and during the harvest season—June to September—in the afternoon, specially for agriculturists. Circular 001 (A-H) p. 13.

Statistics.

2. The *Weekly Weather Report*, which was projected especially with a view to agriculture and public health, gives a summary of the pressure, temperature, sunshine, and wind in a form which was designed to be especially suitable for agricultural purposes. This report has now been continued for 36 years, and forms a homogeneous body of statistics week by week which is, for that purpose, probably unrivalled in the world. But it has a very small circulation outside official circles.
3. The *Monthly Weather Report* which gives the usual climatological information for about 300 stations in the British Isles.

In actual practice these provisions are very little used by agriculturists. Many persons are willing to receive forecasts by telegraph but are unwilling to pay for the telegrams; it is entirely contrary to the instinct of the British race to pay for anything until its value has been made undeniably clear, so that the farmer and the Government are both waiting for the utility of the forecasts to be demonstrated beyond cavil. Yet that can only be done by trial, and nobody has yet been found who is willing to pay the cost of an adequate trial on a large scale. The Meteorological Office could, if the Committee wished, undertake that experiment, but it would mean diverting some of its funds from meteorological study to meteorological applications. It is naturally disposed to make quite sure of success before it embarks on a speculation of that kind, and certain success is the reward of careful study. No institution with scientific instincts is disposed to commit itself

to the position that its knowledge is complete and that it can forego any further investigation, especially in such a subject as the study of weather.

The climatological aspect of *la météorologie agricole* is a matter of the greatest difficulty. The practical farmer has made his own study of weather and used it in his own way without committing the results to writing. The Meteorological Office commits a vast number of figures to print without knowing what their precise application to agriculture is. All are agreed that agriculture depends upon weather, but to ascertain the manner in which the figures of the meteorologist can be applied to supplement the farmer's practical experience of weather is a matter requiring something that approaches to genius.

The relations between the Meteorological Office and the Boards of Agriculture in the United Kingdom are of the happiest, but neither side knows exactly how or where to begin. Some progress has, however, been made in this country. Some years ago the Meteorological Office issued a note about the wheat crop in relation to the rainfall of the previous autumn, and this was taken up by a member of the staff of the Board of Agriculture, who produced a most valuable discussion by modern statistical methods of the relations of weather and crops for one district of England.

Education.

The further development of the application of meteorology to agriculture is largely dependent upon education in the rural schools. The study of weather is now becoming a part of education in many schools, rural as well as urban, so that the prospect of more effective organisation is good. The provision for this is shown in Circular E.03.

But thus far as regards organisation, at present the formal responsibility of the Office is limited to preparing forecasts, and compiling statistics which will be indispensable when further investigation has so far developed the laws of weather, as to allow of forecasting coming seasons.

That is one of the avowed objects of the *réseau mondial*, and the work thereupon must therefore also be regarded as a contribution to *la météorologie agricole*, although the practical farmer would probably not so regard it.

Answers to Inquiries.

Perhaps the most valuable provision of the Meteorological Office at the present stage is the provision for answering inquiries about the weather on the part of the general public. Any public department and any private person may ask any question that can be answered by a knowledge of the facts and laws of weather, and to such questions answers are given with all the intelligence that the Office can command. Many inquiries are answered, and the inquirer often finds the Office to be possessed of information of which he was unaware.

This provision allows inquiry to be directed along the lines which the agriculturist opens; among the subjects which have already been the subject of inquiry may be mentioned—spring

frosts, and the protection of vegetation by "smudging;" autumn frosts; the effect of gun-fire upon rainfall, particularly during harvest; spells of fine weather for harvest; temperature in relation to sugar-growing; the limits of forestation prescribed by temperature; atmospheric humidity in relation to brewing.

By watching the trend of these inquiries, and by the organisation of the means of preparing intelligent replies, the Meteorological Office hopes to approach the question of *la météorologie agricole* on lines suggested by agriculturists themselves, and at the same time by encouraging the development of weather study in schools to lead up to the spontaneous use of the information compiled in the Office.

If necessary, the form of the information which meteorologists have hitherto put forward as representing the main features of climatology will be altered so as to meet the needs of the agricultural inquirer.

In fine, it may be said that at present the Meteorological Office is more concerned with the means for organising *la météorologie agricole* on a satisfactory basis than with any organisation actually in operation.

W. N. SHAW.

Meteorological Office,

London, S.W..

22nd December, 1914.

List of References to accompany Memorandum on the Organisation of the Meteorological Office in London, with special reference to Agricultural Meteorology:—

1. Abstract of Copy of Report of Conference held at Brussels respecting Meteorological Observations—1854.
2. Report of a Committee appointed to consider certain questions relating to the Meteorological Department of the Board of Trade—1866.
3. Report of the Treasury Committee appointed to inquire into the conditions and mode of Administration of the Annual Grant in Aid of Meteorological Observations—1877. (C.—1638.)
4. Report of the Committee appointed to inquire into the Administration by the Meteorological Council of the existing Parliamentary Grant—1904. (Cd.—2123.)

List of Enclosures to accompany above Memorandum:—

1. Copy of Treasury Minute, dated 20th May, 1905.
2. Circular 001 (A.—H.): Meteorological Office—Statement of Provisions for the Supply of Information to the Public—General Provisions.
Circular 001 (J.): List of Ships, Observatories and Stations in connexion with the Meteorological Office.
Circular 001 (K.—L.): List of Publications issued by the Meteorological Office, &c.
3. Ninth Annual Report of the Meteorological Committee to the Lords Commissioners of His Majesty's Treasury—1914. (Cd. 7530.)
4. Circular E.03: Meteorological Office—Arrangements for the Supply of Copies of the Daily Weather Report for use in Schools, and other Educational Provisions.
5. Specimen Copy of the Daily Weather Report.
6. Specimen Copy of the Weekly Weather Report.
7. Specimen Copy of the Monthly Weather Report.

3. CLIMATOLOGICAL STATIONS AND LOCAL AUTHORITIES.

MEMORANDUM BY THE DIRECTOR OF THE METEOROLOGICAL OFFICE.

In the present emergency in national affairs the Meteorological Committee desire to call attention to the position of the Meteorological Office in relation to the collection of observations from what are technically known as "climatological stations"; that is to say from stations which are maintained, not by the Office in connexion with the public daily service of forecasts and gale warnings, but by local authorities or private persons. They contribute observations to be used by meteorologists for the study of the details of climate and weather in the British Isles, and by the public who require information about the weather for various purposes.

The Meteorological Office is a central depository of transcripts of meteorological observations of various kinds in every part of the British Isles, of the British Empire, and, indeed, of the whole world, not because the information is essentially necessary for, or immediately applicable to the work of forecasting and the study of daily weather which, so far as observations on land are concerned, are its primary duties, but because an organised central storehouse or memory of the experiences of weather for a long series of years is of great public utility and more effective than any compilation which otherwise individuals would be able to make for their own use. By agreement between the office and the Scottish Meteorological Society, the Meteorological Office, Edinburgh, discharges a similar duty with special reference to Scotland.

In the course of the past 20 years, a large amount of valuable information has been compiled, the existence of which is hardly realised. It is still far from complete, but I may be permitted to illustrate the usefulness, or at least the appositeness, of an efficient public memory by recalling a report which I happened to see some years ago in "The Westminster Gazette" of a law-suit in which a tobacconist sued his neighbour for damage to a case of cigarettes, alleged to be due to rain coming through a broken skylight. It was acknowledged that the skylight was broken by the neighbour's son and, according to the report, "all went well until a mild-mannered gentleman from the Meteorological Office" proved that it had not rained since the skylight was broken, and the plaintiff's case had to be abandoned.

In order to be effective the collection of information should be carefully organised. The preservation of a trustworthy and sufficient memory of past weather is primarily a matter of urgent local importance. The weather is an element in the profit and loss account of every individual, of every parish, of every district, whether urban or rural, of every county and of every state; and the preservation of an efficient record of these events is just as important for the persons or authorities concerned as the record of the money transactions in which they are engaged. The difference between the two sets of experiences is that one is beyond the control of the individual or local authority and the other is not;

but no steward of his own or other people's interests would be regarded as wise if he left out of account the gains and losses which he could not control.

The question of meteorological observations, or weather records, may be put in this general form: Here is a spell of rain, which the house-gutters, the local drains, the roads, gulleys and streams have to carry away, a snow-storm which may make the neighbourhood impassable, a hail-storm which damages the crops, a drought, or a long frost which endangers the water supply, a wind which brings down all the loose tiles and chimneys. Are these events to be regarded as normal and to be provided against by suitable precautions, or are they outstanding risks which should be left to chance?

Only by an adequate public memory can an answer be given, and hitherto the provision of the material for an answer has been left mostly to private enterprise. The claims of Science have usually been urged as an encouragement to private enterprise, and without doubt, such observations are indispensable for the scientific study of weather; but they are equally indispensable for the proper conduct of the ordinary affairs of life. Since the study of weather began to be organised on a scientific basis, circumstances have changed. The life of the individual and of the community is not nearly so self-contained now as it used to be; it is much more dependent upon facilities for communication with the rest of the world; the increase of those facilities enables the experience of many to be used for the advantage of each in a far greater degree than was possible in the olden days.

To take an example, the practice of insurance is far more widely spread than it used to be. Taking the case of insurance against hail, the premium should be different according to the locality; but so far as is known, the localities in their corporate capacity keep no records, and in consequence the premium is fixed for them upon information privately compiled by the insurance companies—that is to say, by one of the parties to the bargain. Many other forms of insurance against weather are possible, but only when the risk can be properly computed by means of ascertained facts. This Office has recently been concerned in a legal dispute as to whether damage to property during a squall of wind accompanied by incessant lightning was directly due to the wind or to the lightning: a fine distinction, upon which the validity of the insurance turned, and which suggests some revision of the practice of insurance in the light of recorded experience of weather.

Local authorities have given little consideration to these matters, and individual farmers and others have trusted to their own reminiscences. It is, in fact, apparent that the balance of prosperity has been so large that it has not hitherto been felt necessary to pay much attention to the profits to be made out of the weather, or to economise the losses which it causes. But when the pinch of adversity comes, as it must come after the squandering of so much of the world's wealth in the war, the reduction of any risk by the use of organised knowledge is at least worthy of consideration. The stress of war is therefore a

reason for organising the study of weather, not a reason for postponing organisation to a more prosperous season.

No one will deny that a careful record of the weather regularly compiled from day to day on a definite plan is in the long run a better basis of action than the longest stretch of personal reminiscences, just as a daily record of river-level is better than an occasional mark on the parapet of a bridge. With the change of circumstances, from the comparative independence of the homestead to mutual dependence of town and country, and from the abundant prosperity of past years to the adversity that lies in front of us in the near future, the preservation of an adequate record of the events of weather for comparison with past times and with other localities has also changed from being a matter of scientific and personal curiosity to a necessity for the community. It is from that point of view that it should be regarded; the additional advantage that may accrue from scientific meteorological study is all to the good, but it is another matter.

The unanimity with which the health resorts have made provision for careful records of weather show that a knowledge of the weather must be looked upon as a valuable asset, and it is equally so for any other locality. A contractor who undertakes work for a local authority must either know something about the weather or allow a wider margin for contingencies than is really necessary; the locality must either supply the information or provide the margin.

Hitherto the observations upon which we depend for supplying information about the weather in all parts of the British Isles have been largely those of country clergy and landowners; but the drain upon their resources, particularly in men, has begun to diminish the number of observations available. Already in Ireland the observations are altogether inadequate, and when, for example, questions are put as to the parts of the country where climatic conditions are favourable for afforestation, we cannot give a satisfactory answer, because the localities have made no record of their experience. Moreover the distribution of observing stations depends not upon the present and future requirements of the public, but upon the existence of a local volunteer.

It is submitted, therefore, that the Local Authorities should give serious consideration to the question of an adequate record of weather. The Meteorological Office has been active in collecting and organising the meteorological information that was known to be available. This has given the impression that the Office, as the creation of the central Government, ought itself to provide any observations that may be found necessary for any purpose whatever; but such an impression is quite erroneous. Out of 500 Observatories and Stations which contribute observations to the Office for the benefit of the public, only 36 are maintained or subsidised out of Office funds. A considerable number are maintained by local or statutory authorities and the remainder by private persons at their own expense. It is natural, and perhaps laudable, that in the matter of weather the City of Westminster should rely upon the Meteorological Office, instead of itself, for

its memory; and it is not unreasonable that the Office of Works, in a dispute over a contract, should apply to the Office (unsuccessfully, I fear) for details of weather between Avonmouth and Bristol, and their relation to the average; but it would be absurd, for example, for the Council of the County of Warwick to rely upon London to know what weather had been experienced in Warwickshire; or for residents at Hindhead to live in ignorance of their own climatic conditions until the Government provides the information. The natural order is just the reverse; the Meteorological Office should naturally appeal to the localities to know what has transpired there, and it is a matter for surprise how many of the County Councils, when appealed to, would be unable to say what the weather had been in their county since it was under their charge. The whole situation arises from the mistaken notion that to satisfy the condition of utility at all, knowledge must be useful here and now, and that nothing need be preserved for which the officials of to-day have no obvious and immediate use. It is the memory which goes back longest that is the most effective, and therefore most useful.

It ought, in fact, to be the function of the Meteorological Office to reduce, rather than to multiply, meteorological observations, by proper organisation and by the suggestion of co-ordination, where co-ordination is economical. The following guiding principles seem to be applicable: for keeping its water-supply and drainage properly under observation, every parish ought to have its raingauge, and the Parish Council might see to that. A District Council might keep a regular record of temperature and weather as well, for its own district; while in every county there should be, for official purposes, a proper number, and no more, of fully equipped climatological stations which should be centres of information about the weather and its ways for all concerned.

W. N. SHAW.

April 27th, 1915.

4. CENTRAL OBSERVATORY FOR THE INVESTIGATION OF THE UPPER AIR.

(Report drawn up for the consideration of the Meteorological Committee in October, 1914.)

1. *The present provision for the Investigation.*—Since 1905 a sum of £450 has been assigned by the Meteorological Office for the experimental investigation of the Upper Air in this country. The work has been in the charge of Mr. W. H. Dines, F.R.S.

A number of other institutions and private persons have been active in co-operation with Mr. Dines, and the scientific results obtained by the co-operation are a subject for warm congratulation. The published work of Mr. Dines, Mr. Cave, Mr. Gold, Miss White and others, take high rank among the publications on the subject. It includes three reports on the Free Atmosphere of the British Isles, and Mr. Gold's prize essay on the International Kite and Balloon Ascents published by the Office; one

paper in the Philosophical Transactions and one in the Proceedings of the Royal Society; a book, and a lecture before the Royal Institution; a paper in the Proceedings of the Royal Society of Edinburgh, and one in the Journal of the Scottish Meteorological Society; numerous papers in the Quarterly Journal of the Royal Meteorological Society, with one Presidential Address.

Out of the £450 a year Mr. Dines has received £200 as honorarium, and the remaining £250 has been spent at his discretion, the greater part of it being required for the payment of a mechanical assistant, who now makes the special apparatus for aerological work.

2. *The development of the Investigation.*—When the Investigation was commenced in 1905 the chief instrument of investigation was the kite, with which it is possible to explore the atmosphere and ascertain the temperature, humidity, and wind velocity up to about 6 kilometres (20,000 feet). Subsequently the registering balloon was adopted in addition, by which temperatures, and to a certain extent humidity, could be ascertained up to 20 kilometers or more (70,000 to 80,000 feet); and now the pilot balloon watched by theodolites has become the usual means for determining the direction and velocity of air currents at different levels.

The most striking result of the investigation of the upper air is the division of the atmosphere into two layers with characteristic properties; the inner or lower layer, the troposphere, about 10 to 15 kilometres (30,000 to 45,000 feet) thick, comprising about three quarters of the whole atmosphere, and the upper layer, the stratosphere, above the highest cloud level. The investigation of the strata on either side of the boundary between the troposphere and the stratosphere, the region of transition, has become a very attractive subject of research for which registering balloons are a necessity, and pilot balloons are occasionally useful. It is, however, outside the ordinary range of the aeroplane and the manned balloon, and consequently the investigation of the higher regions, which is of primary importance for meteorological science, has to be distinguished from the investigation of the lower regions, which has its immediate practical application in the flying schools. For this latter pilot balloons are frequently in use. Kites might be used, but as a means of aerological research kites have fallen into disuse in this country, partly from the fact that the results for the elements which are most easily registered, temperature and humidity, have been found not to lend themselves effectively to classification, but mainly from the risk which is run with a great length of steel wire either in the path of an aeroplane or across a line of route of motor cars.

3. *The Aeronautical and Aerological Aspects of the Inquiry.*—The investigation of the lower strata for the Meteorological Office in accordance with international programme by means of pilot balloons, has now become part of the routine of the observations at South Farnborough, Falmouth, Eskdalemuir, and Aberdeen. The investigation of the turbulence of atmospheric motion is also a proper subject for these stations. The investigation of the upper strata is the special concern of meteorologists, and has only an indirect application upon the practice of the flying school.

4. *Requirements of Site and Equipment.*—A most important consideration is the locality to be chosen for the Observatory, because the inquiry is conducted by means of instruments carried by registering balloons which are lost altogether if they drop into the sea, but are returned by the finder, as a rule, if they fall on land. No direction of drift can be ruled out as beyond the limits of possibility, and consequently the site which is as distant as possible from the sea in any direction is *primâ facie* the best.

The essential elements of an aerological observatory are a workshop for the manufacture, repair, and adjustment of instruments, a laboratory for the manipulation of hydrogen balloons and the calibration of the instruments, a computer's office for storing, tabulating, and computing the records, and open space for manipulating the balloons, and theodolites for watching them. The site selected must be at a sufficient distance from the sea in every direction, and it is a great advantage for it to be outside the atmospheric influences of large towns.

The auxiliary equipment of such an Observatory consists of:—

- (1) The usual equipment of a Meteorological Observatory for ascertaining the surface conditions during the various soundings. A free exposure for wind is specially desirable, and also a free outlook for the observation of balloons as well as of clouds, their motion and transformations.
- (2) Kite gear and other appliances for examining the conditions of the atmosphere for at least the first kilometre of height (3,300 feet). Up to this height kites may be worked without serious risk to motor cars and other road traffic, but the kite wire remains an invisible danger to aeroplanes.

5. *The Site proposed by Mr. Dines.*—Mr. Dines began his aerological work with investigations by means of kites, using his house and premises at Oxshott as his base. In 1906 he moved to Pyrton Hill, Watlington, on the north-western slope of the Chiltern Hills, and has now acquired for the purpose a property at Benson, in Oxfordshire, which is in the plain of the Upper Thames near its confluence with the Thame, 3 miles from the Great Western Railway Station at Wallingford, on the high road from Henley to Oxford, and about 12 miles distant from either of those towns. He now desires an expression of the views of the Meteorological Committee as to the establishment there of an aerological station which would be permanent; that is to say, which could be carried on by the Office independently when the time comes for the present personal arrangement to be terminated. For this purpose an understanding as to ownership and occupation of the property would be necessary.

6. *Consideration of the Benson Site.*—For a satisfactory answer to this question a number of considerations must be taken into account.

First, the proposal must be put into a more definite form. The property which Mr. Dines has acquired is shown in the 25-inch ordnance map. It consists of a house and garden (with a cottage between them and the high road) and a 5-acre field in the rear.

It is proposed that the buildings forming the Observatory should be placed in this field; a workshop, gear-shed, and anemometer tower are already in use or in course of erection. Access to the field is obtained from the garden, or independently from a drift-way leading from the high road to a dairy farm, the land of which surrounds the field on the south and east, and is accessible at present for the purposes of the Observatory. The proposition is for Mr. Dines to retain the use of the house, cottage, and garden, and to undertake to make over to the Office when called upon the right of occupation of the field at £10 a year. Mr. Dines is further willing to give the Office the option of acquiring the whole property after the death of himself and his wife, at a valuation based on £1,700 as the present value. To complete the Observatory buildings in the sense indicated above, the workshop, which has been erected at a cost of about £60, would have to be supplemented by two similar erections for a laboratory and an office respectively. Certain domestic offices would also be necessary.

7. *Estimate of establishment and annual expenditure of an Aerological Observatory.*—Having regard to the high qualifications necessary, and the other duties which are indicated later, the staff required for such an establishment would be:—

	£
(1) A <i>Director of Investigations</i> of the Upper Air for the Meteorological Office, at a salary of from £500 to £650 a year	500-650
(2) A <i>Professional Assistant</i>	125-200
(3) A <i>Mechanical Assistant</i> , who (in special circumstances) would be graded on the Office staff, with a maximum of £200 a year, with the usual superannuation provision ...	130-200
(4) A <i>Clerk Computer</i> , who would also be on the graded staff, say £75-£110, beginning perhaps with a boy at 14s. to 20s. per week ...	40-110
(5) Some provision, say 5s. to 10s. per week, for attendance, which could be arranged locally ...	13-26
(6) At present about £100 is available for consumable stores and incidental expenses: this has been supplemented by the proceeds of the sale of apparatus. The use of Mr. Dines's premises has been an exceptionally economical arrangement. The vitality of the institution depends upon this item, and the allowance, inclusive of upkeep, lighting, heating, &c., ought to be	250

The cost of an Observatory on this scale might therefore be estimated at from, say £1,050 to £1,450. Ultimately the house and cottage would be available for the accommodation of part of the staff, and additional accommodation could easily be found in the village of Benson.

8. *Other purposes of an Observatory at Benson.*—The primary purpose of this establishment would be the investigation of the upper air, particularly the layers above 4 kilometres (14,000

feet), which are beyond the range of ordinary aeronautical work. The region in question is known to have a dominant influence upon the distribution of pressure at the surface, and therefore in a general sense controls our weather. The investigation must therefore be regarded as an essential part of general Meteorology.

There are, however, other meteorological investigations for which the establishment proposed would afford a suitable base.

- (1) The site is in a wide river plain in an agricultural region where the phenomena of ground frosts, and alternatively, land fog, can be studied with greater freedom from the influence of large towns than at any other of the establishments of the Office.
- (2) The introduction of wireless apparatus has made it possible to obtain indications of distant lightning, and an organised investigation is called for into the phenomena of thunderstorms, as affecting trees and lightning conductors, with their accompaniment of hail and other striking phenomena. For the time being the association of this work with the investigation of the upper air under the guidance of a fully competent meteorological investigator is the most suitable means of getting an insight into the problem for the following reason. One of the most noticeable characteristics of the occurrence of thunderstorms is their wide sporadic distribution on many occasions, in spite of their very local character. They occur in different parts of the country on successive days, though the localities of occurrence on successive days cannot be regarded as connected by "travelling" in the ordinary sense. The best indication of the probability of a thunderstorm in any locality at present is that a thunderstorm has already been noted somewhere else on the map. This points to some general characteristic difference between the upper and lower layers on otherwise similar occasions which ought to yield to skilful investigation.

The Benson Observatory would be the best of the Office establishments for the special investigations here mentioned. The other establishments are as follows:—

Kew Observatory.—The central establishment and weather station for London.

Eskdale Observatory.—The magnetic observatory and meteorological establishment for moorland conditions at 800 feet.

Valencia Observatory.—For the study of atmospheric conditions on the Atlantic seaboard.

Falmouth Observatory.—For the study of atmospheric conditions at the mouth of the English Channel, and of the application of meteorology to the needs of seaports and seamen, particularly yachtsmen and coasters.

Aberdeen Observatory.—For the study of atmospheric conditions in the North Sea.

South Farnborough.—For the study of the turbulence of atmospheric motion, and for the application of meteorology to the needs of aircraft.

None of them is so well suited as Benson for the study of the upper layers of the atmosphere, and of the application of meteorology to agriculture. In this case the application of meteorology should be understood to include the distribution of information for the benefit of farmers, just as at Falmouth the study of the application of meteorology to the needs of seaports includes the exhibition of forecasts and the critical observation of the work of the Office in that direction by a member of its own staff.

9. *The application of Meteorology to Agriculture.*—In this case the work would be connected with that of the Statistical Division of the Office, and the use of statistical methods, as well as with the work of the Forecast Division.

The establishment of such a relationship with the Statistical Division would be specially appropriate, because Mr. Dines has found that statistical methods furnish the most effective way of dealing with the observations of the upper air, and has obtained thereby results which are of the highest importance, and compare most favourably with those obtained in other countries at much greater cost.

In the earlier stages of the history of the Office, provision for collecting information was alone considered, but now after many years of collection the study of the application of the information with a critical examination by a member of the staff may be frankly recognised as desirable with a view to the success of the office work. Circumstances have recently pointed to the practical necessity for an office in Liverpool to study the distribution to ships of the information collected by the Marine Division, and its application. Such an office, which might be in some sort of connection with the Liverpool Observatory, would with Benson, complete the organisation for the study of these applications: Kew and South Kensington representing the application of Meteorology to the life of large towns, Falmouth to seaports, South Farnborough for aircraft, Benson for agriculture, and Liverpool for ocean-going steamers.

For the purpose of the local distribution of information about the weather, the observatory should be in communication with the general telephone system. We have applied from time to time for assistance in distributing forecasts by telegraph to rural villages. So far we have been unsuccessful in obtaining the means for carrying out the project. Benson is a typical rural community, and the regular exhibition of a forecast there would elicit an answer to the question whether it is desirable to pursue the matter further. In course of time the local farmers would either come to use it or decide to disregard it, and the observation of an expert meteorologist on the spot would supply the reason for the conclusion and suggest a more effective method of treatment.

The opportunity which Benson affords for the study of atmospheric conditions specially affecting agriculture, and of the work of the Office in relation to agriculture, may be held more than to counteract the disadvantage of its lack of elevation. For an

Aerological Observatory some commanding eminence has generally been sought, but a commanding situation, though very impressive for the visitor, is not really necessary for the investigator. So far as investigations with kites are concerned the site of Eskdalemuir could hardly be improved upon, and for registering balloons, or pilot balloons, a clear atmosphere is necessary, and the absence of obstruction which subtends a greater angle than 5° is sufficient, and these the locality of Benson will afford.

One objection may be taken to its position, and that is, that it is not sufficiently far from the South Coast. From that point of view, a position further to the north-west, such as the neighbourhood of Birmingham or Shrewsbury, would be preferable. Birmingham has been ruled out on account of atmospheric pollution. No site is offered near Shrewsbury, but in this connexion it may be remarked that there is a station at Shrewsbury which is in urgent need of reorganisation, and perhaps some chance of co-operation might be developed.

10. *Relation of the Aerological Observatory to other Observatories.*—Benson is in the Thames valley, 45 miles from London and 12 miles from Oxford. Kew is also in the Thames valley, and the relation of the proposed observatory to both Oxford and Kew needs consideration. The University of Oxford makes no provision for the study of Meteorology, but the Radcliffe Trustees, a corporation independent of the University, maintain the Radcliffe Observatory for astronomical work, and like other astronomical observatories it has maintained for nearly a century regular meteorological observations. Since the time when Mr. E. J. Stone was a member of the Meteorological Council the Radcliffe Observer has had in operation the spare set of self-recording instruments obtained in 1868 for an eighth observatory of the Kew type. A telegraphic reporting station, somewhat short of complete, was maintained at the Radcliffe Observatory from the commencement of the Office work until the end of 1912, when it was given up because it could not undertake observations at 7 a.m. or 6 p.m.—the official hours. The payment to the observer—£16 3s. a year, a perennial subject of discussion between the Observatory and the Office, has been continued for the time being in consideration of the Observatory continuing its contributions to the Weekly and Monthly Reports. The Office is peculiarly vulnerable with regard to the Weekly Report, because it has compiled a body of *statistics for districts*, and the discontinuance of a station without an equivalent substitute implies a fatal break in the continuity of the statistics. But Benson would be a proper equivalent for Oxford, and if thought fit the subvention might be diverted.

At the same time it is clear that Kew, Benson, and Oxford ought to be brought into co-operative relation, and if Benson continues to be served by a Meteorologist of the first rank, negotiations ought to be opened with the University with a view to getting the subject recognised there by a Professorship, or in some other manner.

The relations with Kew may be left to be evolved by the direction of the Office as circumstances indicate.

APPENDIX II.

KEW PHOTOHELIOGRAPH.

Memorandum by the Superintendent of the Observatory.

The Report of the Kew Committee presented to the Council of the British Association June 27th, 1855, describes the construction of the apparatus as follows:—

“The apparatus suggested by Sir John Herschel for photographing the spots on the sun’s disk is progressing under the superintendence of Mr. Warren De la Rue. The Solar Photographic Telescope is promised by the maker complete in three months. . . . The diameter of the object glass is 3·4 inches, and its focal length 50 inches; the image of the sun will be 0·465 inch, but the proposed eyepiece will, with a magnifying power of 25·8 . . . , increase the image to 12 inches. . . . The object glass is under-corrected in such a manner as to produce the best practical coincidence of the chemical and visual foci. . . . It was originally intended to place the telescope in an observatory 12 feet in diameter, provided with a revolving roof. . . . It has, however, been found possible to somewhat alter the construction of the tube, so as to reduce its length sufficiently to allow of the telescope being placed under the dome of the Kew Observatory, which is only 10 feet in diameter.”

The Report of the Kew Committee for 1856-57 contains the following statement:—

“On the 20th of May, 1854, Benj. Oliveira, Esq., F.R.S., placed the sum of £50 at the disposal of the Council of the Royal Society, to be appropriated during that year in any manner the Council might consider most in harmony with the interests of Science. Mr. Oliveira further stated, that he might probably in future years offer a similar sum if the mode of its disposal appeared to him eligible; and an application having at the same time been made by the Kew Committee for the sum of £150, in order to erect a Photographic Apparatus for registering the position of the spots in the Sun’s disc, as suggested by Sir John Herschel, the Council of the Royal Society devoted to this purpose the donation of Mr. Oliveira, and proposes, should it be continued, to apply it for the next two years in replacement of the sum of £100 which the Council in the meantime advanced from the donation fund of the Royal Society, in order that the undertaking might not be delayed. This arrangement was approved by Mr. Oliveira, and the apparatus has, under the direction of Warren De la Rue, Esq., F.R.S., been completed by Mr. Ross at the cost of about £180.”

The report finishes with a description of the telescope and clock.

The Kew Committee Report for the year 1858-59 also refers to the Photoheliograph. It says: . . . "Since the last meeting of the Association the unfortunate death of Mr. Welsh has retarded the experiments with the Photoheliograph, but from time to time they have been gone on with, at first by Mr. Chambers . . . and latterly by Mr. Beckley . . . ; and in order that they might be prosecuted more continuously, the Committee have fitted up a Photographic room in close contiguity to the instrument." This refers presumably to the wooden structure on the roof, which continued to be known as the "Sun Room" until its demolition in 1913.

The report goes on to state that the best photographic definition was obtained when the sensitized plate was from $\frac{1}{10}$ to $\frac{1}{8}$ of an inch beyond the visual focus in the case of a 4-inch picture, and that in this position beautiful pictures of the sun 4 inches in diameter were obtained which bore magnifying with a low-power lens. In this way considerable detail was shown on the sun's surface, while the spots were well defined. The report proceeds: "Mr. De la Rue, by combining two pictures obtained by the Photoheliograph at an interval of three days, has produced a stereoscopic image of our luminary which presents to the mind the idea of sphericity. Under Mr. De la Rue's direction, Mr. Beckley is making special experiments having for their object the determination of the kind of sensitive surface best suited for obtaining perfect pictures. . . . Now that the photographic apparatus has been brought to a workable state, Mr. De la Rue and Mr. Carrington, joint Secretaries of the Astronomical Society, propose to devote their attention to the best means of registering and reducing the results obtained by the instrument, provided the funds which may be necessary are placed at their disposal."

The Kew Committee Report for 1859-60 says:—

"The Photoheliograph has been an occasional source of occupation to the mechanical assistant; but before daily records of the sun's disk can be obtained it is absolutely requisite that an assistant should be appointed to aid Mr. Beckley. . . . Unfortunately, the funds at the disposal of the Committee are quite inadequate for this purpose, and unless a special grant be obtained the Photoheliograph will remain very little used. At present Mr. Beckley is preparing the instrument, under Mr. De la Rue's direction, for its intended trip to Spain for the purpose of photographing the eclipse which takes place on July 18th. The expenses of these preparations, and of the assistants who will accompany Mr. De la Rue, will be defrayed out of the grant of the Royal Society for that object."

The expedition proved a very successful one. The results obtained were discussed by Mr. De la Rue in the Bakerian Lecture for 1862 "On the Total Solar Eclipse of July 18th, 1860, observed at Rivabellosa, near Miranda de Ebro, in Spain." *Phil. Trans.*, Vol. 152, pp. 333-416.

The Kew Committee Report for 1861-2 mentions that amongst the exhibits sent from the Observatory to the great Exhibition in 1861 were some sun pictures taken by the Photoheliograph. A medal was awarded for these to Mr. Beckley.

The same report says the Photoheliograph was intended to be used for observing a transit of Mercury and a partial eclipse of the sun, but on both occasions the weather was bad. It refers to good sun-pictures obtained at Kew by Mr. Beckley in November and December. It adds: "The Heliograph was sent from Kew at the beginning of January to Mr. De la Rue's Observatory and Mr. Beckley attended at Cranford to assist in erecting and adjusting it to focus. . . . Altogether, up to the 12th of September, inclusive, 177 photographs have been taken on 124 days. . . . During the month of August Dr. Sabler, Director of the Observatory of Wilna, in Russia, resided at Cranford, and received instruction in Astronomical Photography. A Photoheliograph is being constructed for him, under Mr. De la Rue's superintendence, by Mr. Dallmeyer, and a micrometer by the Messrs. Simms. This Heliograph will embody all the . . . improvements suggested by the experiments with the Kew instrument. . . . The experience obtained during the past year has been such as to lead Mr. De la Rue to recommend that photographic records should be continued for a series of years at some public Observatory. The Committee . . . have come to the conclusion that the Heliograph might be worked at an annual expense of £200. . . ."

The Kew Committee Report for 1862-63 mentions that the Photoheliograph was brought back from Cranford to Kew in February, 1863, and again erected in the dome, and that since May 1st it had been continuously worked by a qualified assistant under Mr. Beckley's supervision. Apparently a grant of £150 had been made by the British Association in 1861 for sun-pictures, and an earlier grant of £90 had come from the same source for a photographic assistant. Early in 1863 a grant had also been obtained from the Royal Society.

The Report for 1863-64 mentions the employment of Mr. Loewy, "formerly assistant in the Flagstaff Observatory, Melbourne," in reducing the negatives obtained with the Photoheliograph. Use was made of a micrometer designed by Mr. De la Rue, and that gentleman, it is mentioned, was "having an arrangement made, by means of which the proportion of the sun's disk obscured by spots may be conveniently measured."

The Report for 1864-65 mentions the acquisition of valuable material intended for comparison with the records from the Photoheliograph. This consisted of Mr. Carrington's original drawings "in which the size and appearance of the spots are delineated with great fidelity," and also the long series of original drawings made by Hofrath Schwabe. The ultimate destination of the latter was apparently the Royal Astronomical Society. "In order to realise this generous bequest of Hofrath Schwabe, Mr. Loewy . . . went to Dessau, taking with

him a selection of duplicate negatives and prints of the sun, which he presented, in the name of the (British) Association, to that gentleman."

The Report for 1865-66 contains the copy of a letter from Mr. De la Rue to Father Secchi describing the Solar work at Kew: "The pictures taken by means of the Kew heliograph are all measured by means of my Micrometer; the positions of the spots are then reduced to distances in terms (fractional parts) of the sun's radius, and the angles of position corrected for any error in the position of the wires. Pictures of the Pagoda* are taken from time to time, and the measurements of the various galleries of the Pagoda serve to determine the optical distortion of the Sun's image and the corrections to be applied to the Sun-pictures. The helio-centric latitudes and longitudes of the spots are then calculated. The areas of the spots and the penumbra are also measured, and the areas corrected for perspective are tabulated in terms (fractional parts) of the area of the sun's disk. The areas of the spots, &c., on all of Carrington's original pictures have recently been measured."

The same Report mentions the publication at the expense of Mr. De la Rue of a memoir, "Researches on Solar Physics, by Warren De la Rue, B. Stewart and B. Loewy; first series; On the Nature of Sunspots," dealing with the earlier results obtained with the Photoheliograph. Abstracts of this and of a "second series" appear in the "Royal Society's Proceedings," Vol. 14, 1865. Subsequently, two long papers in the "Royal Society's Transactions,"—Vol. 159, 1869, pp. 1 to 110, and Vol. 160, 1870, pp. 389-496—by the same three authors, contained full particulars of the positions and areas of the sunspots observed with the Photoheliograph from 1862 to 1866.

A list including the above and several other papers relating to the Kew Photoheliograph, written by Mr. De la Rue, either alone or in conjunction with Messrs. Stewart and Loewy, will be found in the "History of the Kew Observatory" by Dr. R. H. Scott, Roy. Soc. Proc., Vol. 39, pp. 37-86.

The Photoheliograph seems to have continued in regular use until March, 1872, completing ten full years of observation.

The Report of the Kew Committee for the year ending October 31st, 1873, mentions that the Photoheliograph had been lent to the Astronomer-Royal for taking sun-pictures at Greenwich. The instrument seems to have remained at Greenwich until January 5th, 1876, when it was returned to Kew. Subsequent to this date, the instrument seems only to have been used for visual observations.

The work of measuring sun pictures went on at Kew Observatory for many years, Mr. De la Rue making an annual grant of £100 a year for the purpose from 1874 to 1880. According to Dr. R. H. Scott's "History," Mr. De la Rue's total disbursements in connection with the Photoheliograph exceeded £2,000.

* In the Royal Gardens.

In the Kew Report for 1882 we read: "The measurements and reductions of the sun spot positions as determined by means of the Kew Photoheliograph from 1864 to 1872 having been completed for Mr. De la Rue, he has deposited the manuscript with the Council of the Royal Society."

The instrument was used for many years for the purpose of taking drawings of sunspots after the manner of Schwabe. Eventually the question of the utility of the results so obtained was raised by the Superintendent in 1897. The Kew Committee applied for advice on the subject to several eminent astronomers, but the opinions expressed were somewhat diverse. A request was then addressed for a formal opinion to the Solar Physics Committee, and, in accordance with the reply received, the use of the Photoheliograph ceased at the end of 1897.

Not much had been done for many years previously to keep the instrument in repair, and except for an occasional cleaning of external parts nothing has been done since.

C. CHREE.

May 26, 1915.

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