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ANNUAL REPORT

of the Director of the

METEOROLOGICAL OFFICE

presented by the Meteorological Committee
to the Air Council

For the Year ended
March 31
1939

The Eighty-Fourth Year of the Meteorological Office

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LONDON

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METEOROLOGICAL COMMITTEE

1938-9

Appointed by the Air Council

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Vice-Chairman :—Colonel Sir HENRY LYONS, F.R.S. Nominated by the Royal Society.

Mr. J. B. ABRAHAM, C.B., Principal Establishment Officer, Air Ministry. Nominated by the Air Ministry. (To December 31, 1938.)

Mr. W. G. NOTT-BOWER, C.B.E., Principal Establishment Officer, Air Ministry. Nominated by the Air Ministry. (From January 1, 1939.)

Professor S. CHAPMAN, F.R.S. Nominated by the Royal Society.

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Mr. L. F. SCHOOLING, Assistant Secretary, Air Ministry. Nominated by the Air Ministry. (To February 21, 1939.)

Mr. W. G. CLEMENTS, M.C., Assistant Secretary, Air Ministry. Nominated by the Air Ministry. (From February 22, 1939.)

Mr. P. J. G. ROSE, C.B., Assistant Under-Secretary of State for Scotland. Nominated by the Scottish Office.

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Sir GEORGE C. SIMPSON, K.C.B., C.B.E., F.R.S., Director, Meteorological Office. (To September 2, 1938.)

Mr. N. K. JOHNSON, D.Sc., A.R.C.S., Director, Meteorological Office. (From September 3, 1938.)

Sir D'ARCY W. THOMPSON, C.B., LL.D., F.R.S. Nominated by the Royal Society of Edinburgh.

Secretary :—Miss D. G. CHAMBERS, M.B.E.

The Committee met on July 5 and November 29, 1938.

COMMITTEE OF THE METEOROLOGICAL OFFICE,
EDINBURGH, 1938-9

Chairman :—The Director of the Meteorological Office.

Professor E. T. WHITTAKER, Sc.D., LL.D., F.R.S. Nominated by the Royal Society.

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Professor J. A. CARROLL, Ph.D. Nominated by the University of Aberdeen.

Mr. A. STEVENS, M.A., B.Sc. Nominated by the University of Glasgow.

Secretary : Mr. A. H. R. GOLDIE, M.A., D.Sc., F.R.S.E.

The Committee met on June 29, 1938.

THE GASSIOT COMMITTEE, 1938

Appointed by the Royal Society in accordance with Treasury Letter of February 26, 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.

The President of the Royal Society (Sir WILLIAM H. BRAGG).

Sir HENRY LYONS (*Chairman*).

The Astronomer Royal (Dr. H. SPENCER JONES).

The President of the Royal Astronomical Society (Dr. H. SPENCER JONES).

The Director of the Meteorological Office (Sir GEORGE C. SIMPSON).

Sir GERALD LENOX-CONYNGHAM.

Sir GILBERT WALKER.

Professor S. CHAPMAN.

Dr. G. M. B. DOBSON.

Professor G. I. TAYLOR.

Sir FRANK DYSON.

The Committee met on July 21, 1938.

ANNUAL REPORT of the Director of the Meteorological Office presented by the Meteorological Committee to the Air Council for the year ending March 31, 1939 (the eighty-fourth year of the Meteorological Office).

1. GENERAL

The year under review has been an exceptional one for the Meteorological Office from several points of view. In the first place a large number of additional meteorological stations have been established at aerodromes, and new staff has been recruited and trained as rapidly as possible to man them. The year has also been abnormal owing to the international crisis in September which emphasized the importance of providing a reserve of trained personnel to cope with the additional demands which arise at such a time. Action is being taken to deal with this problem by forming a Meteorological Section of the Royal Air Force Volunteer Reserve into which suitable civilians will be recruited and trained in time of peace. A third respect in which the year has been exceptional is in the large number of changes that have taken place among the senior personnel in the Office; the occupants of more than half of the twelve senior posts have been changed by new appointments or promotion in the course of the year.

A new departure was made during the latter part of the year by the decision to introduce organised research into the normal work of the Meteorological Office. Hitherto, research has been left largely to the individual efforts of the staff and has been performed in their own time. Although the Meteorological Office can never become a research department in the full sense of the term, it is considered that some official action is required to provide solutions to the many meteorological problems, the lack of answers to which prevents the Office from functioning as effectively as it otherwise might. Up to the present it has been possible to make only a beginning with this project. A list of problems has been drawn up and classified, whilst steps have been taken to form a Meteorological Research Committee to advise and assist in the conduct of this organised research. It is believed that an appreciable amount of investigational work can be carried out with the resources already available in the Meteorological Office, although it may prove necessary later on to make special provision for urgent and important investigations which would otherwise have to remain in abeyance.

Among the technical problems which have received attention during the year, mention may be made of the development of the "radio-sonde" technique for ascertaining the meteorological conditions in the upper atmosphere at all times—even when the sky is covered with cloud. Another problem of particular importance to aviation is the dissipating of fog by artificial means, and trials are in progress to explore the possibility of this idea. Lastly, reference may be made to investigations which have been set on foot to ascertain why certain of the day-to-day weather forecasts have been lacking in accuracy. In this way it is hoped to discover the factors which affect certain meteorological situations which are at present imperfectly understood, and thus reduce the number of occasions on which satisfactory forecasts cannot be made.

2. ORGANIZATION

(a) LONDON

The internal organization of the Meteorological Office latterly in force was laid down in 1921, when the size of the Office was a small fraction of what it is now. The recent development of aviation, and the resulting growth in the importance of synoptic meteorology, have rendered a change in the organization necessary. The Meteorological Office has, therefore, been re-organized under the following three main headings :—

- (1) Synoptic meteorology.
- (2) Climatology.
- (3) Observatories and geophysical research.

Each of these sections has been placed under an Assistant Director who is responsible for the administration of the Divisions which fall within that group. The new organization is shown diagrammatically in Appendix I.

The Synoptic Section comprises three Divisions. The Forecast Division is responsible for forecasting duties at Headquarters and also for meeting the requirements of Civil Aviation. In view of the importance and magnitude of the demands of the Royal Air Force at home, a new Division has been formed to deal entirely with this aspect of the work. The Overseas Division, which has not been modified, completes the Synoptic Section.

On the Climatology side, the British and World Climatology Divisions have been combined into a single Climatology Division. The Marine Division, the work of which consists largely of marine climatology, is grouped with it to form the Climatology Section.

In order to give effect to the new research policy, the Assistant Director who has hitherto worked at Kew Observatory has been brought to Headquarters, and a new post of Superintendent has been created for the administration and direction of the work at Kew. The observatories in Scotland continue to be administered by the

Edinburgh Branch Meteorological Office, whilst the Superintendent at Edinburgh is now responsible to the Assistant Director in charge of observatories.

The changes in organization outlined above give the three Assistant Directors a larger share in the administration of the Meteorological Office, whilst Superintendents of Divisions now report to their respective Assistant Directors and not to the Director as in the past. It is believed that these changes will help the Office to meet the greatly increased demands which are now being made upon it.

(b) BRANCH METEOROLOGICAL OFFICE, EDINBURGH

The Edinburgh Office has continued to act as a centre for the organization of the climatological and rainfall stations in Scotland and for the administration of the three Observatories at Eskdalemuir, Lerwick and Aberdeen. The telegraphic reporting stations and such auxiliary reporting stations as are not attached to aerodromes are also administered by Edinburgh.

Climatological, Rainfall and Telegraphic Stations.—The numbers of stations of various types in different districts of the British Isles are shown in Appendix II. The Edinburgh Office receives the monthly registers and autographic records from the stations in the Scottish districts and carries out the systematic examination and checking of them and the extraction of data in a form ready for publication.

A number of new climatological and rainfall stations has been set up in districts which hitherto have been inadequately represented, and the inspection of stations of all types has been carried out in accordance with the normal programme.

Reports for the Registrar General for Scotland.—A monthly summary of the weather in Scotland, together with statistics for the principal towns, has been prepared as usual for the Registrar General.

Work connected with Observatories.—In addition to the general administration of the three observatories in Scotland, Edinburgh has prepared the Scottish sections of the *Observatories Year Book*, 1937, which were completed for press during the year, and the proof reading was carried through.

Computations of the daily magnetic activity as recorded at Eskdalemuir and Lerwick have been kept up to date and forwarded quarterly to De Bilt according to international arrangement.

Services for Aviation.—Meteorological reports were prepared on a number of proposed aerodrome sites in Scotland and the islands.

An additional auxiliary reporting station for aviation purposes was established at Earraid (Mull).

A meteorological exhibit was set up, and staff were in attendance, at the Royal Air Force Aircraft Exhibition held in the Waverley Market, Edinburgh, from February 14 to 25, 1939. The number of visitors to the Exhibition was about 180,000, and inquiries at the Meteorological Exhibit were numerous.

3. SYNOPTIC METEOROLOGY

(a) HEADQUARTERS FORECAST DIVISION

Organization.—The work of this Division may be summarized under the following main heads :—

1. The regular collection of information relating to current weather from reporting stations situated in the Northern Hemisphere.

2. The supply of information relating to current weather in Great Britain and Northern Ireland, and its distribution to other countries in accordance with an internationally agreed plan.

3. The drawing of synoptic charts, and the preparation and distribution of forecasts based on the current weather data collected.

4. The supervision of a number of subsidiary forecasting and other centres for the supply of information to civil air lines (*See Section 3 (b)*).

5. The distribution of meteorological observations as a basis for local forecasts at Royal Air Force stations.

6. The examination in meteorology of candidates for the various types of civil air pilots' licences.

The organization and control of the machinery necessary for the work of the Division is centred in a Headquarters service. This service at the beginning of the year was moved from Adastral House to more commodious quarters in Victory House, Kingsway. The expansion has fully tested the new accommodation.

Communications.—The system of teleprinter communication between Headquarters and the subsidiary outstations was extended. The number of outstations linked with the meteorological teleprinter circuits is now 25 as against 12 at the beginning of the year. In general, each outstation is responsible for the local collection of weather reports from stations in its neighbourhood. The collected reports are transmitted to Headquarters at fixed times. The increase in the number of teleprinter circuits has resulted in an increased speed of collection and transmission of information. Synoptic weather reports are broadcast over the teleprinter system to all connected stations and the increased speed has proved of great value. Longer broadcast messages are possible by teleprinter, and the more detailed information available at the outstations has proved very beneficial generally. The information also becomes available at the outstations by teleprinter more quickly than by wireless telegraphy,

for the time of transmission is not governed by a fixed time table such as is necessary for transmissions by wireless telegraphy. The teleprinter room at Headquarters has been fitted for automatic transmission, and this will still further increase the rate at which reports can be broadcast.

Reports from Ships.—The “selected ship” service for supplying meteorological observations from the sea by means of wireless has continued to operate satisfactorily. Two hundred and seventy-six ships co-operate in this way, and their task of maintaining an adequate supply of wireless weather reports has been assisted by supplementary reporting ships in those parts of the world where a sufficient number of “selected ships” is not always available.

Distribution of Information.—The system of hourly broadcast by radio-telephony of reports for aviation which was fully described in the report for last year was maintained during the year under review. The number of stations which now contribute hourly reports from 0700 to 1800 number 93, an increase of 6 over last year. In addition a number of stations contribute reports at less frequent intervals. Forty-seven stations continue reporting from 1900 to midnight. From June 7, available reports of wind measurements at 6,000 ft. have been broadcast in addition to those at the 2,000 ft. level. Estimates of the winds at these levels are now also included in the forecasts issued at intervals during the day. Only one interruption of the Service occurred during the year. This was in consequence of the breaking of the aerial at Borough Hill, Northampton, during the gale of November 22. The aerial was very quickly repaired and during this time the reports were broadcast in code on the teleprinter circuit.

From April 4 the issue of reports from some auxiliary stations by Air Ministry wireless at 0750 G.M.T. in summer and 0905 G.M.T. in winter was replaced by an issue of the upper air temperature reports received from Mildenhall and Aldergrove. From April 10 European collective messages were issued by wireless for the hours 0100, 0400, 1000, 1600 and 2200. The issues at 0100, 1000, 1600 and 2200 have since increased in length, and the time allotted for the transmission has been increased by fifty per cent.

The wireless telegraphy collective issues for the Royal Navy (Fleet Synoptic Messages) were continued during the year. These messages contain an analysis of the synoptic charts for 0100 and 1300 G.M.T. for western Europe and the north-east Atlantic together with reports from land stations in that area or reports from ships at sea made at 2400 and 1200. The time of issue of these messages has been advanced from 0600 and 1700 to 0500 and 1645 respectively.

Full particulars of the transmissions by wireless telegraphy and radio-telephony will be found in Meteorological Office Publication No. 252.

Forecasting Procedure.—The method of preparing synoptic charts has been maintained unchanged during the year. The preparation of these charts was fully described in the previous report. They are analysed according to generally accepted principles, and advantage has been taken of the increase in the teleprinter system of communication to broadcast daily to the main subsidiary stations the results of the analysis of the 0700 chart. This analysis is used as the basis of locally issued forecasts.

The publication of the *Daily Weather Report* was continued. H.M. Stationery Office printing presses were moved in February to Cornwall House, Stamford Street, and during the period until the re-assembly in March the printing was put out to contract.

Forecasts and reports to the daily press were continued without material change as were also the forecasts issued daily to the British Broadcasting Corporation. These forecasts include forecasts of visibility and wind for shipping in the waters round the British Isles, and special forecasts at times for fishing fleets.

Forecasts for shipping in home waters were also issued twice daily as in previous years by wireless telegraphy from the long wave G.P.O. station at Rugby and also from four G.P.O. coastal wireless telegraph stations.

Gale warnings were issued as necessary by wireless and radiotelephony from G.P.O. stations and the British Broadcasting Corporation. Particulars of the warnings issued in 1938 are given in Appendix III.

Inquiries and Special Work.—Reports were prepared on the general meteorological conditions prevailing at 15 proposed aerodrome sites in Great Britain. Other inquiries dealt with at Headquarters included a detailed report on visibility in the Valleys of the Thames and Medway.

Monthly percentage frequency summaries of surface and upper winds over the British Isles between the years 1920 and 1934 were prepared. Proofs were revised and passed for printing. Monthly percentage frequencies of cloud amounts and heights were also prepared.

Forecasts for special purposes covered a wide field, and included forecasts of thunder in east and south-east England for the Central Electricity Board. Forecasts of snowfall in London were also prepared for the Director of Public Cleansing, Highways Department, Westminster City Council, and daily forecasts of anticipated changes in absolute humidity in England and Wales and south Scotland were supplied to the Danish Bacon Company.

(b) SERVICES FOR CIVIL AVIATION

Organization.—The work in connexion with civil aviation increased steadily during the year. This work is divided between

the Headquarters service and the subsidiary stations at civil aerodromes. At the beginning of the year subsidiary stations were situated at Croydon, Manchester, Bristol and Lympne. A new forecasting centre was opened at Heston, and a new station associated with Manchester (Barton) was opened at Ringway in June. As in previous years services for civil aviation were also provided by the meteorological stations situated at the R.A.F. aerodromes at Mount Batten, Calshot, Aldergrove and Abbotsinch.

The application of the report of the committee held under the Chairmanship of Sir Henry Maybury has occupied attention throughout the year. Consideration has been given to the accommodation required at the various types of stations for meteorological staff and equipment. Plans for this accommodation were approved for stations at Birmingham, Belfast, Inverness, Liverpool and Southampton.

Consideration was also given to the reception of weather reports at Croydon in order to cope with the increased range of civil machines. Arrangements were made for additional reports to be received from Hamburg, Hanover, Frankfort, Berlin, Nancy and Zürich.

In order to reduce the time which elapses between the preparation of a report and its reception by the pilot of a machine in flight, a trial has been made at Croydon of a scheme whereby an observer is placed in the Control Tower during periods when the rules governing flying in bad visibility are in force. The scheme has proved of great value. Arrangements were also made for measuring the height of the top of fog by means of a tethered balloon carrying a meteorograph.

Following on the attention which has been given by the International Aeronautical Conference to the subject of forecasts of the weather anticipated for landings at specified times at terminal aerodromes, arrangements were made for the exchange of such forecasts between Croydon and Zürich in November. A similar exchange of forecasts between Croydon and Le Bourget has also been arranged. Forecasts of the weather anticipated at landing times are also provided by Croydon for the services operating between Croydon and Baldonnel.

Examinations and Instruction.—Two hundred and thirteen candidates were examined for the Civil Pilots " B " licence during the year, and lectures were given and examinations held in meteorology in connexion with four courses for Air Traffic Control Officers.

On four occasions meteorological instructors at Schools of Navigation for the training of civil pilots visited Headquarters to discuss questions relating to the examinations for 1st and 2nd Class Navigators' Licences. A visit was also made by instructors at the School of Air Navigation (Manston) and the School of General Reconnaissance (Thorney Island) with the same object.

(c) ROYAL AIR FORCE DIVISION

Organization.—For the first nine months of the year, as during the previous $3\frac{1}{2}$ years, the provision of services for the Royal Air Force formed part of the responsibility of the Synoptic Division. In consequence of the great expansion of this section of the work a separate Division was created, on January 1, 1939, to deal with the requirements of the Royal Air Force (Home Commands) and to supervise and control the work of the meteorological stations at R.A.F. establishments and stations in Great Britain and Northern Ireland.

The many aspects of the meteorological requirements of the Royal Air Force were kept closely under review by the Royal Air Force Meteorological Policy Committee, to which reference was made in the Report for 1937–8. Certain modifications and extensions were necessitated in the arrangements adopted in 1936 for the expanded meteorological organization.

During the year, as additional trained staff became available, the number of meteorological stations—of different categories—attached to the R.A.F. was increased from 31 to 68, and at several stations the staff was increased. The organization of stations in a group system, consisting of main forecasting centres and associated subsidiary stations, as briefly described in the introduction to the *Annual Report* for the year 1936–7, was considerably advanced. By the end of the year a continuous day and night service was in operation at the existing main forecasting centres. Senior officers were appointed to act as meteorological advisers at certain Command Headquarters.

Special staffing and other arrangements were made on several occasions to provide services in connexion with R.A.F. exercises and a forecasting station was maintained throughout the summer months at a temporary R.A.F. camp for Army Co-operation work.

Communications.—As already mentioned, further progress has been made in the teleprinter communication system for the collection and distribution of basic meteorological information between aerodromes and the Headquarters Forecasting Division. At the end of the year arrangements for the distribution by teleprinter of hourly reports of weather to practically all R.A.F. Stations and the extension of this service to a 24-hour basis were under consideration.

On account of the increased number of R.A.F. stations, the increased amount of flying and the range of flights, the procedure for the rapid distribution of aviation storm warnings was revised.

Observational Procedure.—The installation of vertical-beam searchlights for the rapid determination of the height of the base of low cloud in darkness was continued. Forty-seven such searchlights were in operation at R.A.F. aerodromes on March 31.

Reliable information as to the range of horizontal visibility during the hours of darkness is of great importance in the practice of forecasting and of aviation, but the determination of visibility at night presents difficulties. Provisional specifications of the powers and distances of lights to be used in night observations were adopted by the International Meteorological Organization in 1935. A number of aerodrome stations are now testing a meter of simple and ingenious design which, when used in conjunction with suitable lights at known distances, enables visibility to be determined in accordance with the international specifications. (*See Section 6, p. 30.*)

Meteorological Instruction to Pilots.—The transfer, foreshadowed in the previous Report, of instruction in elementary meteorology at flying training schools from Meteorological Officers to Officers of the R.A.F. Educational Service took effect in the course of the year. Regular courses of lectures in advanced meteorology were given by Meteorological Office lecturers at the School of Air Navigation, the School of General Reconnaissance, the School of Naval Co-operation, the Cadet College and the Central Flying School. The number of lecturers at the School of Air Navigation was increased to three. Many lectures and a considerable amount of other instruction were given to flying personnel by the meteorological staff at the various stations.

An official publication, "Meteorology for Aviators," written by Dr. R. C. Sutcliffe, a member of the Office staff, was issued towards the end of the year. This manual is designed to meet the requirements of the training courses for service pilots and those of candidates for First and Second Class Civil Air Navigators' Licences.

The Meteorological Flights.—The Meteorological Flights of the Royal Air Force at Mildenhall and Aldergrove continued in full regular operation, and provided invaluable observations of temperature and humidity and of the distribution of cloud up to heights of 20,000 ft. or above. Many flights additional to the prescribed normal routine were made. The highly meritorious achievement of the Mildenhall Flight in maintaining an uninterrupted series of scheduled ascents throughout a period of two years was made the occasion of a special descriptive broadcast by the British Broadcasting Corporation on November 22, 1938. Observations from ground level, of the motion of smoke puffs discharged from aircraft during meteorological flights at Mildenhall has permitted accurate determinations of the upper wind on suitable occasions.

(d) OVERSEAS SERVICES

The Overseas Division is concerned with the meteorological organization on the Empire Air Routes, the trans-Atlantic Air Routes, and on all British overseas air routes. It is also responsible for meeting the meteorological requirements of the Royal Air Force

overseas, and it controls the overseas stations maintained by the Meteorological Office, through which co-operation is effected with the Royal Navy and other services. During the period under review steady progress has been maintained; a considerable amount of work has also been accomplished in connexion with the organization of projected routes which have not yet been developed. On March 29, the Superintendent of the Division completed his fifth overseas tour, having left England on January 7 in order to attend a meeting in Montevideo of the Third Regional Meteorological Commission of the International Meteorological Organization. The opportunity was taken to visit the Meteorological Services at Uruguay, Argentina and Brazil, and, incidentally, to investigate the meteorological organization which would be required in South America in connexion with the projected air service between England and that continent.

The Empire Airways.—As in previous years close liaison has been maintained with the different meteorological authorities responsible for the provision of facilities along the Empire Airways, and further assistance has been given in the selection and training of staff, the purchase of equipment, and the general development of the meteorological services. Co-operation has been facilitated by visits from the Directors or representatives of certain services during the year, the visitors including the Director of Civil Aviation, Palestine, and representatives of the meteorological services of Iraq, British East Africa, New Zealand, the Sudan and British West Africa. The Director of the Iraqi Meteorological Service visited Egypt in March in order to discuss the meteorological organization on the Alexandria-Basra air route.

An experimental code for the transmission of weather reports from aircraft to ground stations for the information of the meteorological services was brought into operation on the routes between the Mediterranean, British East Africa and India in October.

Details of other developments during the year are given below :—

The Empire Air Base at Hythe (Southampton).—A combined meteorological and radio building, situated on the breakwater near the Imperial Airways hangar and offices was completed in May, and the temporary meteorological office has now been vacated. In February, the Air Ministry radio station was transferred to Southampton Airport where the reception of meteorological messages from the continent has since been carried out, the data being passed to Hythe by teleprinter.

Since the beginning of the period under review the Imperial Airways aircraft have started from Southampton Docks instead of from Hythe as formerly, and before departure of the flying boats the duty forecaster proceeds by launch from Hythe to the Docks in order to discuss with the Commander of the aircraft the meteorological situation as affecting his flight and to provide him

with the necessary information. As from April 10, 1938, the aircraft commander has been furnished with a detailed forecast covering the day's flying—from Southampton to Athens during the summer months but only as far as Rome during the winter—together with the latest weather and upper wind reports and also a copy of the latest synoptic weather chart. Later information is supplied by the appropriate meteorological services at the scheduled stopping places in France (Marseilles) and Italy (Lake Bracciano, Rome and Brindisi), in addition to the normal supply of information by radio during flight. In order to provide information for incoming aircraft, weather reports from Hythe have been included in the Croydon regional broadcast messages, but as from March 7, 1939, messages have been broadcast from Southampton at half-hourly intervals from 0715 to 1815 G.M.T. daily, in conformity with the European regional system. The messages include weather reports from Hythe, and also from surrounding coastal stations in southern England and the Isle of Wight, upper wind reports and forecasts covering that portion of the route lying over the English Channel.

In addition to the supply of information for the Empire services, local forecasts for Southampton Water are supplied twice daily for the safeguarding of flying boats moored out or being towed, launched or beached.

Forecasts and other information were supplied for non-stop Christmas mail flights direct from England to Egypt.

Developments in the Empire Air Services during the year have necessitated an extension of the routine to cover the twenty-four hours and a corresponding increase in staff.

Malta.—A meteorological station was opened at Ta Qali on November 17, in time to deal with the Imperial Airways Christmas landplane services.

Greece.—Correspondence has taken place with the Director of the Greek Meteorological Service with a view to improving the meteorological facilities in that country for British aircraft operating on the Empire Airways.

Egypt.—Little progress has been made towards reaching agreement as to the best method of transferring the aviation meteorological service from the Air Ministry to the Egyptian Government. The Ministry of Communications is proceeding in the meantime with the development of its own Meteorological service. Three Egyptian graduates, after completing a University course in Meteorology in London, were attached to the Meteorological Office till September, when they were attached to Heliopolis for further training.

Forecasts for these services continue to be issued from Heliopolis which also supplies all information for other civil air services operating through Egypt, as well as for the Royal Air Force and the Royal Egyptian Air Force.

Palestine.—As from January 1, the Palestine Meteorological Service assumed responsibility for the issue of all forecasts required for air services operating through that country; the forecasts had been supplied previously by Heliopolis.

Iraq.—The Iraqi Meteorological Service has now assumed control of all meteorological stations in Iraq, other than those maintained for the Royal Air Force, with the exception of the station at Diwanayah which is expected to be taken over shortly. The Air Ministry station at Habbaniyah supplies information to Imperial Airways flying boats alighting on Lake Habbaniyah but otherwise all meteorological information for civil aviation is supplied from Baghdad.

India.—In order to meet the requirements of the Empire flying boat route through India, the meteorological station at Gwadur was closed on October 24 and a new station opened at Jiwani.

Trans-Atlantic Air Routes. —The meteorological station at the Shannon, which has continued to be operated by the Meteorological Office on behalf of the Meteorological Service of Eire, on an agency basis, was maintained throughout the year. The only trans-Atlantic flight to take place was that of *Mercury*, the upper component of the Short-Mayo Composite Aircraft, which flew from the Shannon to Montreal in July, afterwards proceeding to New York, and then returning via the Azores to Southampton. The meteorological organization which had been recommended at the Trans-Atlantic Conference held in Dublin in March, 1938, was brought into operation on all sections of the route between Hythe and New York and proved satisfactory.

Assistance was also given in connexion with the flights from Berre to Foynes, and from Foynes to Biscarosse of the flying boat *Lieutenant de Vaisseau Paris* of Air France Transatlantique in the same month.

In accordance with a recommendation of the Dublin Conference, March, 1938, experimental codes were prepared for the exchange between the Shannon and Botwood of route forecasts and of analysis messages.

During the last three months assistance has been given to the Meteorological Service of Eire in providing courses of training at the Shannon for Irish meteorological officer cadets and for assistants. The former course was commenced on January 16, and the assistants' course on March 27.

Three Atlantic Meteorological Reports were published during the year :—

Report on a year's meteorological investigations on the North Atlantic Ocean.

Greenland from the standpoint of Synoptic Meteorology.

Upper winds over the North Atlantic.

Other Routes and Areas.—*Trans-Tasman Air Route.*—At the request of Union Airways, New Zealand, copies of the trans-Atlantic Meteorological Organization were supplied for a conference held at Sydney in December to discuss the meteorological and radio organization required for the trans-Tasman service. The meteorological organization agreed upon at this conference was based on that which had proved successful in Atlantic flights.

South Atlantic Route.—Preliminary consideration was given to the meteorological organization which would be required in connexion with the projected British air service from England to South America via west Africa. A discussion took place in Lisbon on January 10 with the Director of the Marine Meteorological Service of Portugal regarding the arrangements for flights between England and Lisbon.

Consideration was given to the question of arranging for regular weather reports from certain islands in the South Atlantic under British Control to be transmitted for the benefit of interested services, and towards the end of the year preliminary steps were taken for one report daily from St. Helena and Ascension to be transmitted by cable to Freetown for inclusion in the collective messages issued from Dakar.

British West Africa.—Additional staff have been posted to the British West African Meteorological Service during the year and the organization which was accepted by the West African Governments in 1937 is now nearing completion.

British Somaliland.—Advantage was taken of the presence on leave in the United Kingdom of Mr. Grinsted of the British East African Meteorological Service to arrange for him to visit British Somaliland on his return to Kenya Colony in order to advise the Government with regard to equipment of meteorological stations in that territory and arrangements for the transmission of weather reports from certain stations.

Meteorological Arrangements for Long Range Flights.—Special meteorological organizations were arranged for flights of the Royal Air Force Long Range Development Unit and of *Mercury*, the upper component of the Short-Mayo Composite Aircraft. In connexion with the former a special meteorological unit was established at Cranwell in July to provide the necessary advice for a flight to Ismailia via the Persian Gulf. For the return flight to England a temporary meteorological station was established at Ismailia from July 18 to 21. Special arrangements were again made in October for the flight from Upper Heyford to Ismailia via Malta, a special unit being established at Upper Heyford for the purpose.

For the record flight from Ismailia to Australia in November a special station was again established at Ismailia. The meteorological organization along the route was drawn up after discussion with the Officer Commanding, Long Range Development Unit, in consultation with the meteorological services concerned.

In connexion with the flight of *Mercury* from Dundee to the Orange River in October, a special meteorological unit was established at Dundee in order to advise the pilot and operations personnel.

Overseas Stations.—The work of the overseas stations maintained by the Meteorological Office has continued on the lines of previous years. A brief account of their work is given below.

Gibraltar.—On April 1, 1938, the station assumed responsibility for the routine meteorological observations which had hitherto been made by Naval personnel. At the same time the observation routine was expanded, observations now being made at 0100, 0700, 1000, and 2200 G.M.T. Tabulations and computations of all the meteorological elements are made at the station and annual meteorological summaries are supplied to the Colonial Secretary and to the Medical Officer of Health.

On September 1, the broadcast issue of Mediterranean Fleet Synoptic Messages was increased from one to three daily, at 1030, 1600 and 2130 G.M.T. In addition to these messages, forecasts are issued twice daily to the Naval, Military and Port authorities. An important branch of the work is the supply of "Meteor" telegrams and calibration reports to the Royal Artillery.

Malta.—Regular meteorological information is supplied to the three defence services, the Port authorities, Fisheries, Broadcast Relay Service and the press, while occasional requests for information are received from the local Civil Government, H.M. Dockyard, Merchant Shipping and the general public.

A twenty-four hour observation routine was introduced on April 1. The forecast routine has been maintained from 0430 G.M.T. to 2100 G.M.T. on week-days and from 0700 G.M.T. on Sundays.

The system of warnings of gregales, gales and squalls remained in force. Mediterranean Fleet Synoptic messages have been issued three times daily as at Gibraltar. Special forecasts are added to these messages to meet special requirements.

Special forecasts have been issued to Royal Air Force units for flights to the United Kingdom and to Egypt. Since November 1 forecasts and other information have been issued to the Ala Littoria S.A. at Malta in addition to the reports sent to Tripoli, Syracuse, Marsala and to aircraft in flight.

Among investigations which have been undertaken mention may be made of an analysis of ten years' upper air temperature observations at Malta which was completed.

Middle East Area.—A substantial increase has occurred in all branches of the work due to expansion in air services and to the training of Egyptian personnel.

From April 1 a modification was introduced into the observing routine, observations now being made at 0200, 0400, 0600, 0900, 1200 and 1800 G.M.T. Collective messages are broadcast from Ismailia at 45 minutes after each of these hours. At 0245 and at 0645 observations from Iraq are included in the messages. In addition to the reports from Meteorological Office stations at Heliopolis, Aboukir, Ismailia, Ramleh and Amman, observations are received from the Egyptian Physical Department's stations, from Mirabella (Imperial Airways), Landing Ground H4 (Iraq Petroleum Co.), Bair, Mudawara, Ma'an and Akaba (Arab Legion, Trans-Jordan).

In order to cope with the increased number of messages passing between Heliopolis and Almaza, the main Egyptian airport, a direct telephone line has been installed.

Instruction in Meteorology has been given regularly at No. 4 Flying Training School, Abu Sueir. Meteor reports are frequently supplied to British and Egyptian Artillery and anti-aircraft units.

Iraq.—The main function of the stations maintained at Habbaniyah and Shaibah is to supply meteorological information to Royal Air Force units stationed in Iraq. Close liaison is maintained with the Iraqi Meteorological Service, and certain information is supplied by arrangement with that service to Imperial Airways at Habbaniyah as mentioned on p. 17. The meteorological office is open throughout the twenty-four hours so that weather reports are available at any time.

In addition to the supply of weather reports and forecasts, lectures in meteorology are given as required to the personnel of the R.A.F. squadrons. Investigational work included frontal analysis of interesting synoptic charts for Iraq for previous years, the development of revolving storms in the Persian Gulf, the incidence of sandstorms and thunderstorms, and the time interval between the passages of fronts at Habbaniyah and Shaibah.

General.—At Headquarters, meteorological sections of Aircraft Route Books have been prepared for the Air Staff. During the year, 134 inquiries relating to meteorological conditions affecting aviation overseas were dealt with on behalf of the Air Staff and the Department of Civil Aviation. Several of these inquiries were associated with developments on the Empire Airways or with projected new routes.

Assistance has been rendered in the preparation of two instructional films on Ice Accretion and on Air Pressure and Temperature.

4. CLIMATOLOGY

(a) BRITISH CLIMATOLOGY

One section of the Climatology Division is responsible for the administration of the climatological and rainfall stations in the British Isles. There are approximately 360 stations of the former

type, whilst rainfall stations number about 5,570. The records from all these stations are collected, analysed and published in the various publications referred to below.

The section deals with all inquiries relating to the past weather and climatology of the British Isles, an important part of this work consisting in the determination of the mean rainfall on specified areas, which is required in connexion with water schemes.

The growth of public interest in the climate of British health resorts has been reflected in the desire of many towns to have their records included in the *Monthly Weather Report*. The number of towns for which observations are published in this way, has been increased by 51 during the year.

Distribution of Stations.—The stations vary greatly in equipment and personnel and may be roughly divided into six classes :

(i) Observatories (see pp. 31–6) where continuous records of all meteorological elements are obtained. These are staffed by Meteorological Office personnel.

(ii) Distributive stations, which are established to distribute information for civil aviation, the Royal Air Force and the Army, at which—with but few exceptions—synoptic charts are prepared daily. These are also manned by Meteorological Office personnel.

(iii) Telegraphic reporting stations. These stations have been established to take observations and report them immediately by telegraph. The observers are not members of the Meteorological Office staff, being frequently coastguards, lighthouse keepers or others with permanent posts giving them facilities for taking meteorological observations at all hours.

(iv) Crop weather stations are maintained at certain agricultural colleges and research institutions in connexion with the study of the relations between the weather and growing crops. They report partly to the Meteorological Office and partly to the Ministry of Agriculture and the Department of Agriculture for Scotland, and the arrangements for the observations are under the general control of a committee on which the Office is represented.

(v) and (vi) Climatological and Rainfall stations. These are maintained by private observers, or by municipal or other local authorities without payment by the Office. Great public spirit is shown by those who maintain these stations and forward their records and observations for incorporation in the official weather reports, and for preservation in the Office, where they are available for the benefit of the community.

The number of stations of each of the above types in each of the 16 divisions into which the British Isles is divided for meteorological purposes is shown in Appendix II (p. 43). In that table also is given the number of stations which maintain instruments for the

continuous record of certain specified meteorological elements. Only such autographic records as are regularly received in the Office are included in the table.

Presentations to Observers of Long Standing.—As a mark of appreciation the names of the following rainfall observers who have maintained records covering over 40 years, have been added to the free issue list of *British Rainfall* :—

Mr. W. Garden, of Selly Oak.

Mr. W. Coles Finch, Chatham Water Works.

Mr. A. F. Pine, Codnor Cross Hill, Derbyshire.

The services of the following observers at climatological stations, whose observations have extended over unusually long periods have been acknowledged by the presentation of appropriately inscribed aneroid barometers :—

Mr. George Reid, of Crieff.

Mr. C. Dales, of Bournemouth.

Mr. C. L. Brook, of Meltham.

Publications.—*The Monthly Weather Report.*—With the issue for January, 1939, some changes were made in the *Monthly Weather Report*. Owing to the increasing interest in meteorology, the number of climatological stations in this country continues to grow. It has been decided to publish the records from all stations which conform to scientific standards, except where they are practically adjacent to one another. This has resulted in an increase of 51 stations, from 309 to 360, necessitating the addition of two more pages of tables. The opportunity was taken to simplify production by reproducing the two pages of maps in black and white instead of in blue as hitherto.

The Weekly Weather Report, 1937-8, was signed for press on July 11, and published on August 30, 1938.

British Rainfall, 1937, was published on July 28. The volume follows the usual lines. The normal values used for comparison in the tables and text refer to the period 1881-1915, but in order to give effect to the Resolution of the International Meteorological Conference at Warsaw in 1935 by which the period 1901-30 was adopted as the standard for climatological normals, the volume includes a comparison of the monthly, seasonal and annual normals of rainfall for 1881-1915 with those for 1901-30, and tables of normals for the latter period at selected stations.

Observatories' Year Book.—The Climatology Division is responsible for collecting the geophysical records from the observatories and for supervising their publication in the *Observatories' Year Book*. The demand for the 1937 volume was placed on May 12 and final copies should have been delivered by February 15 according to

contract. The printer, however, fell seriously behind and the volume was still in the revise stage on March 31.

Returns for Registrar-General.—Weekly summaries of the weather at certain large towns are prepared for the Registrar-General for England and Wales. Quarterly and annual summaries are also prepared. Similar information is supplied quarterly to the Governments of Northern Ireland and Eire.

Investigations and Special Work.—The number of inquiries relating to British climatology continues to increase and this year reached the figure of 3,061. The sources from which inquiries emanate show that public utility and industrial undertakings are gradually realising the importance of taking meteorological factors into consideration.

In this connexion, it has to be recorded that the Superintendent of the Climatology Division represented the Meteorological Office on the Agricultural Meteorological Committee of the Ministry of Agriculture and Fisheries and also on the Inland Water Survey Committee of the Ministry of Health. The Office was similarly represented on the Building Research Committee of the Department of Scientific and Industrial Research, and on the Hydrology Subcommittee of the International Union of Geodesy and Geophysics.

Long Range Forecasting.—Further consideration was given to the problem of preparing general forecasts for a month or more ahead, of the deviation of pressure from normal over the northern hemisphere. A series of such charts was prepared covering 57 years and these are being studied in detail. It seems probable that the factors influencing the general type of weather, as contrasted with the day-to-day changes, are two-fold; one group, which is best developed in middle and low latitudes, has its seat in the upper atmosphere at a comparatively high level, while the other group, which is most effective in high latitudes, is related to surface phenomena such as ocean currents and movements of Arctic ice. In order to study the first or high-level group, a series of charts is being constructed to show the deviations of pressure from normal, month by month for ten years at a height of 3 Km.

Maximum Velocity of the Wind in Gusts.—At the request of the Building Research Committee of the Department of Scientific and Industrial Research a memorandum was prepared on the incidence of the highest gusts of wind hitherto recorded in different parts of the British Isles. The memorandum was illustrated by a map showing the maximum wind velocity to be expected in any area.

Inland Water Survey Committee of the Ministry of Health and Scottish Office.—Details of the monthly rainfall at representative stations and estimates of the general monthly rainfall were supplied

for certain areas for inclusion in "Surface Water Resources of Great Britain," second report, 1936-7.

Computation of Humidity.—As from January 1, 1939, relative humidity has been computed with reference to saturation over ice, when the air temperature is below freezing point. Also, when the vapour pressure is below that corresponding to saturation at 32° F., the temperature of condensation from vapour to ice, strictly the "hoar-frost point," has been tabulated as the dew point. That is to say, the dew point is now taken as the temperature at which the existing vapour pressure is equal to the saturation pressure over ice. This change of procedure has necessitated amendments to the "Hygrometric Tables" for temperatures below freezing point. At the same time, the opportunity was taken to revise the tables for the computation of relative humidity from upper-air observations of dry-bulb and wet-bulb temperature. These tables, like those used for surface observations, now refer to an ice-covered wet-bulb when the temperature is below freezing point.

(b) WORLD CLIMATOLOGY

Meteorological Returns from British Colonies.—Many of the British Colonies and Protectorates which have no organised meteorological service nevertheless maintain one or more meteorological stations, and publish the observations in their annual blue-books. The Meteorological Office collects reprints of these summaries and circulates them in sets to nearly 200 recipients in all parts of the world. During the year 1938-9 reprints from 35 Colonies were issued in this way, containing data for 635 stations.

In several small Dependencies, mostly on oceanic islands, climatological stations are maintained directly by the Meteorological Office. Summaries of the observations at six of these stations—Amman (Trans-Jordan), Ascension Island, Fanning Island, Funafuti, Ocean Island and St. Helena for the year 1936 were printed and included with the summaries for other Colonies.

Climatological returns were received in manuscript from a number of other stations in the Colonies and in foreign countries where no regular meteorological service exists; summaries for some of these stations are included in the *Réseau Mondial*. Returns were received for a new station at Mukalla in the Aden Protectorate from April, 1938, onwards. The total number of stations for which manuscript returns were received in 1938 was 50.

Two series of observations in the island of Chios, eastern Mediterranean, for the years 1898-1917 and 1928-38 were received by courtesy of Mr. P. Argenti. A summary of these was published in the *Quarterly Journal of the Royal Meteorological Society* for January, 1939.

Réseau Mondial.—The annual volume of data known as the *Réseau Mondial*, which includes as far as possible summaries of pressure, temperature and precipitation for the whole world, was published for the year 1931. The volume was incomplete, no data having been received for Brazil and most of the U.S.S.R., while owing to insufficient reports it was necessary to omit all the values for marine five-degree "squares." The volume for 1932 was held up for some time in the hope that the missing data for that year would be received, but has now been sent to press without them.

Admiralty Pilots.—The meteorological sections of six Admiralty pilots were revised during the year. In conjunction with the Naval Meteorological Branch of the Hydrographic Department of the Admiralty, a new form of climatological table for printing in the Pilots was devised. The table provides space for giving monthly means for morning and afternoon hours separately of the following elements:—relative humidity, cloud amount, average wind force (or speed), percentage frequency of wind direction.

Naval Handbooks.—Work on the Naval Handbooks of the East Indies Stations and the Home Station has proceeded during the year, the volumes dealing with local climatology and forecasting being in course of preparation.

Investigations and Special Work.—Demands for information relating to world climatology show an increase upon the corresponding numbers last year, the total being 586. Steps have been taken to prepare for publication, tables giving averages of temperature, rainfall, humidity and sunshine for the chief cities of the world. It is evident that such a publication is needed.

Among the general inquiries may be mentioned the calculation of heights during a journey across Greenland in June to July, 1938, for the Scott Polar Research Committee, Cambridge, and the preparation of a map of Africa showing the regions where maximum temperatures between specified limits might be expected, for the London School of Hygiene and Tropical Medicine.

Effect of Climatic Conditions on Locust Outbreaks.—On behalf of the Committee on Locust Control of the Economic Advisory Council an investigation has continued into the climatic conditions in Africa at the times of outbreak of locust swarms. The collection of monthly data of temperature, humidity, and rainfall for certain stations has been completed as far as possible with the continued assistance of the various Meteorological Services. Charts of rainfall and raindays for each month of the period 1925–36 have been constructed, and the corresponding maps of mean maximum and minimum temperature are being drawn.

(c) MARINE CLIMATOLOGY

Organization.—Information regarding the meteorological conditions over the oceans is obtained primarily through the co-operation of the Merchant Navy, although valuable returns are also supplied by the Royal Navy. The Marine Division of the Meteorological Office is responsible for securing the co-operation of the Commanders and Officers of the Merchant Navy, and for their organization in the Voluntary Corps of Marine Observers. The services rendered by the Merchant Navy in this way are of the greatest value, whilst the most cordial relationship exists with the Meteorological Office.

Throughout the year the Regular Voluntary Observing Fleet has been maintained at 360 ships. In addition, there are 563 supplementary ships, making a total of 923 ships of the British Merchant Navy co-operating with the Meteorological Office. The greater portion of these ships assists in the supplying of observations for synoptic purposes, and reference is made to this aspect of the work in Section 3 (a) p. 10. Fairly complete meteorological information has now been accumulated over many years for most parts of the oceans, and full meteorological logs are now kept only by a limited number of ships whose routes take them through those regions for which sufficient observations have not yet been collected.

Liaison with these ships is maintained by two members of the Meteorological Office staff who hold appointments as Port Meteorological Officers at London and Liverpool. In addition, the Meteorological Office has Merchant Navy Agents at Southampton, Glasgow, Hull, Newcastle and Leith. Two other agencies at Hong Kong and Sydney were closed down during the year, the reduction in the number of log-keeping ships rendering them no longer necessary.

Eighteen Lightvessels and Coast Stations in Home Waters and two Lighthouses abroad have regularly returned observations. Since January, 1939, four of the above Lightvessels situated off the Irish coasts have been transferred to the Irish Meteorological Service.

The Marine Division collaborates with the Officers' training ships *Conway* and *Worcester* and the Nautical College, Pangbourne, in the training of cadets in weather observation. The standard of training is highly satisfactory, and is reflected in the subsequent work of the cadets when they later become officers in the Merchant Navy.

Reduction of observations.—The collecting of meteorological observations over all the oceans of the globe has been in progress since 1855, and steps are now being taken to analyse the mass of information which has been accumulated.

The statistical analysis of the data is being carried out by means of the Hollerith process. The observations from the ships' log books are transferred to cards by punching holes in positions governed by a

pre-arranged plan. The passage of the cards through an automatic electrical counting and sorting machine then enables totals and averages of any meteorological element to be determined rapidly. The number of sets of observations which are being treated in this way is 2,463,000. Approximately 365,000 sets of observations were extracted in the course of the year, and there now remain only about 135,000 still to be punched. The meteorological elements which are being analysed include wind force and direction, barometric pressure, air and sea temperatures, humidity, cloud formation, weather and sea disturbance. The system to be employed in the analysis of each element has been agreed upon in consultation with the Board of Trade and the Admiralty, and the manner in which the final results are to be shown in a series of atlases has also been decided upon. The complete programme will occupy some years, and it has consequently been necessary to arrange an order of priority in which the various oceans and the various meteorological elements shall be dealt with. When complete the charts will be of the greatest practical value to all ships, and they will also constitute a basis on which to found a scientific investigation of marine climatology and its relationship to land climatology.

The observations recorded in ships' logs can also be used for determining ocean currents. An atlas of currents for the North Atlantic has already been published, and a second atlas for the South Pacific was completed during the year and is about to be published. Work has been commenced on the revision of the North Atlantic atlas mentioned above. The charting of the currents of the South Atlantic has been commenced with a view to its completion simultaneously with the revised North Atlantic atlas. The south-eastern portion of the North Atlantic and Mediterranean basin is being re-charted and will be published in the *Marine Observer* during the coming year.

In the course of the past year information relating to currents has been supplied to the Admiralty for the revision of five Admiralty Pilots and Sailing Directions.

5. SERVICES FOR NAVY AND ARMY

(a) NAVY SERVICES

As was explained in the last *Annual Report*, the meteorological requirements of the Navy are now catered for by the Naval Meteorological Branch of the Hydrographic Department of the Admiralty. Close liaison has been maintained with the Chief Superintendent of Naval Meteorology. Two members of the Meteorological Office staff have been lent for training Naval officers in meteorology, and for advising upon technical problems.

Reference has been made in Section 4 to the preparation and revision of Naval Handbooks and Admiralty Pilots which are being carried out in close collaboration with the Naval Meteorological Branch.

In the construction by the Marine Division of ocean current atlases, and more particularly ocean meteorological atlases, the Admiralty's requirements have been fully ascertained and the programme for this work has been concurred in by them.

The loan to the Admiralty of a scientific officer for investigating the forecasting of visibility at sea has continued. Satisfactory progress is being made in this somewhat difficult problem.

(b) ARMY SERVICES

The rearmament of the country and preparations for defence have caused considerable pressure in the work of the Army Division both at Headquarters and at the outstations. At Larkhill the experimental work on radio wind finding, described under the headings of Instruments, has occupied much time. In addition to this, and the normal work of the station for the School of Artillery, special researches have been undertaken for the Army.

The number of Artillery practice camps to which meteorologists are sent during the summer months increased once again, and the posting of the necessary men from Shoeburyness seriously taxed the resources of that station. It was decided to send an experienced officer from Shoeburyness to visit all the camps and give instructions where necessary. Although it was found that the work was, in general, being carried out in a satisfactory manner, the visit proved stimulating to all concerned, and it is proposed to make similar arrangements in future years. During the period when the staff at Shoeburyness was at full strength, research work both for the Army and for other branches of the Meteorological Office was undertaken.

6. METEOROLOGICAL INSTRUMENTS

The year has been one of abnormal activity in the issue of instruments to new stations. Forty new observing stations on aerodromes have been opened and equipped with meteorological instruments. Fifty-two searchlights have also been issued to aerodromes for obtaining cloud height at night, and barometers and thermometers have been supplied to numerous R.A.F. aerodromes. This activity is reflected in the cost of equipment purchased during the year, which has risen to the unprecedented figure of £30,000, which may be compared with the average figure of £7,500 during the three-year period 1932 to 1934. The abnormal increase in the demand for instruments has occasioned some difficulty in obtaining supplies from the makers, particularly in the case of the more expensive instruments, in the making of which much skilled labour

is employed. With the co-operation of the makers, these difficulties have been surmounted and all urgent demands for instruments have been met.

The most important instrumental problem pursued during the year has been the development of the so-called "radio-sonde" method of measuring the temperature, pressure and humidity of the atmosphere up to heights of 10 miles or more. This information is of great importance in the modern technique of weather forecasting, and it is hoped that in the near future a complete network of upper-air observing stations will be established, extending over the greater part of Europe. The apparatus under trial in this country has been developed in collaboration with the National Physical Laboratory. The instrument is carried by a free balloon and transmits radio signals which are modulated according to the value of the temperature, pressure and humidity at any height. Fifty such ascents have been made, in most of which a Dines meteorograph was attached to the radio-sonde, so that eventually the temperatures given by the wireless signals would be compared with those determined from the record inscribed on the metal plate of the meteorograph. A number of minor technical difficulties have been encountered which introduced a degree of uncertainty into the readings given by the radio-sonde. It is hoped that most of these defects have been eliminated, and that a new set of instruments now being manufactured will prove satisfactory.

One of the most successful types of radio-sonde developed abroad is the instrument designed by Prof. Väisälä of Helsingfors. Prof. Väisälä agreed to supply a number of his instruments for trial in this country, and arrangements were made for a member of the Meteorological Office staff to spend two weeks in Helsingfors learning the technique. The instruments, with the necessary ground equipment, were received in March, 1939. The Väisälä design appears to be very good, particularly as regards lightness and simplicity, and the results of comparative trials with the N.P.L. model will be awaited with great interest.

Work has also continued actively on the radio method of measuring the upper wind, to which reference was made in the last *Annual Report*. A balloon carrying a small radio transmitter is released, and its movement followed by two radio direction-finding stations at the ends of a base line. A five-mile base was laid out in the neighbourhood of Larkhill, Salisbury Plain, and numerous trials have been carried out during the year, the balloon being followed not only by radio means, but also by pilot balloon theodolites, on occasions when conditions permitted this. A check on the accuracy of the method was thus obtained. It is known that radio signals are deflected by surface obstacles, and each site has therefore to be calibrated to ascertain the errors in radio bearings in different directions. A good deal of time has been spent on this calibration work. The results

obtained show that the wind can be determined to a moderate height with a considerable degree of accuracy by means of the existing equipment in the case of light or moderate winds. On occasions of strong wind the balloon is rapidly carried to so great a distance from the observing stations that accurate triangulation becomes difficult, and the calculation of the wind correspondingly uncertain. In order to overcome this difficulty a longer base line is being laid out, and improved direction-finding apparatus is being installed. As radio bearings provide no indication of the height of the balloon, it has been necessary to calculate this from the assumed rate of ascent. Experience has shown that this method may lead to considerable errors, and it is therefore proposed to combine the radio wind finding with the radio-sonde work which has been developed at Kew Observatory, in which the height of the balloon can be calculated from the observations of pressure and temperature emitted by the radio meteorograph.

Work has been continued on the design of the searchlights used to throw a vertical beam at night on to the lower side of a cloud sheet to determine its height. The angular elevation of the light spot measured from a nearby point gives a measure of this height. For this purpose a maximum concentration of light in a beam of minimum cross section is necessary, and research has shown that searchlight bulbs of much lower power than those formerly employed are efficient if the dimensions of the filament are kept down to a minimum. It has been found that a 100-watt bulb may give a light spot which is more easily visible than one of 500 watts, owing to the increased concentration of the beam obtainable from the smaller filament. Experiments on bulbs of even lower rating are now in progress, in co-operation with electrical firms.

Since aviation has become a recognised mode of transport, visibility has been one of the most important elements which a meteorological reporting station is called upon to observe. No difficulty is experienced in making observations in daylight. A series of objects, as near as possible to certain defined distances from the observation point is chosen for each station, and the most distant object which can be seen at the time of observation forms a measure of the visibility which is reported in accordance with an international code. During the hours of darkness the observation presents greater difficulties. It is seldom that suitable lights can be found at the specified distances, and further, the distance at which a light is visible on any occasion depends not only upon the clearness of the atmosphere, but also upon the brightness of the light. Need for some more precise means of measuring the visibility of night has long been felt. During the past year, Mr. E. Gold, F.R.S., Assistant Director, in collaboration with the Instruments Division, has designed a visibility meter which consists essentially of a strip of blackened glass, the density of which is graded from clear glass at one end of the strip to a high degree of opacity at the other, with a

suitable scale mounted alongside it. The degree of opacity required to extinguish a light of known candle power at known distance from the point of observation, forms a measure of the opacity of the atmosphere, and this can be determined with extreme readiness by the new visibility meter. A simple table can be prepared when the strength of the light and its distance are known, to convert readings on the meter to visibility on the international scale. Forty of these meters have been purchased during the year and issued to stations for trial. Advantage will be taken of the experience thus gained to introduce any desirable modifications into the design before bringing the meter into general use.

A large number of pilot balloon theodolites of the design recently developed in the Meteorological Office have been purchased and issued to stations during the year. Some minor improvements in the design have been suggested, and are being incorporated. In particular, it has been found that by means of a reading lens fixed to the theodolite, the readings of altitude and azimuth can be taken with the necessary precision from the scales on the main circles by interpolation without the need of verniers or other devices. This will considerably facilitate the work of the observer.

Attention has been devoted to the specification and method of storage of pilot balloons with a view to obtaining balloons of superior quality for use in hot climates, where rubber tends to deteriorate rapidly.

It has been found that the tendency of grass minimum thermometers to develop errors owing to spirit evaporating from the main column and condensing in the tube, can be overcome if the end of the tube remote from the bulb is covered with a blackened sheath. On days of sunshine this sheath is heated considerably above the temperature of the rest of the thermometer and the condensed spirit is driven back to the main column. Such a sheath not only prevents the formation of errors, but has been proved to remove errors in thermometers which have already developed them. It is proposed to issue this device to observing stations, in order that it may be given an extended trial.

7. OBSERVATORIES

(a) KEW

Atmospheric Electricity.—The exploration of the electric field in thunderstorms by means of alti-electrographs carried by free balloons was continued during the year, useful results being obtained in two storms in which the numbers of soundings were eight and six respectively. Systematic observations of potential gradient, electricity of rain, point discharge and conductivity of the atmosphere were continued.

Mr. Hogg of the Solar Physics Observatory, Canberra, completed the two important investigations in which he had been engaged on the nature of "intermediate ions" and on the "electrode effect" of the air-earth current. Accounts of his work will be published in Canberra.

Seismology.—Since the transfer of the seismographs to the new underground house the records have been almost entirely free from the effects which were previously caused by the wind.

A notable event was the occurrence on June 11, 1938, of an earthquake which was felt over a great part of England. The epicentre of this earthquake was in Belgium, near Ghent. At the Observatory, the best record of the initial phases of the earthquake was obtained with a newly-constructed vertical seismograph.

November, 1938, was remarkable for showing more seismic activity than any other month since the Galitzin seismographs were first set up in Great Britain at Eskdalemuir in 1910. The total number of shocks was 52 and six of them were important earthquakes.

Exploration of the Upper Air.—The principal task of the Upper Air Section has been to co-operate with the National Physical Laboratory in developing the method of radio-sounding referred to in Section 6. Ordinary soundings with the balloon meteorograph have been relatively few, but the following numbers of satisfactory ascents into the stratosphere were made :—

Above 20 Km.	...	...	...	2
Between 15 and 20 Km.	...	...	...	11
Between 10 and 15 Km.	...	...	...	14

Efforts have been made for some time past to obtain samples of the upper atmosphere in a specially designed glass vessel carried by a small free balloon. In this way it was hoped to be able to determine the water vapour content in the stratosphere. The difficulties imposed by the necessary limitation of weight have caused this method to be abandoned in favour of collecting samples from a high-altitude aircraft. Preliminary work has been carried out on the design of a semi-automatic apparatus containing nine sampling vessels. The determination of the quantity of water vapour in the air collected in these vessels will be made by the technique developed by Dr. Glückauf at the Imperial College of Science in collaboration with whom the investigation is being carried out.

Six attempts were made during the year to obtain samples of the air from heights above 20 Km. for the determination by Prof. Paneth

of the amount of helium, but only in one case was an analysable sample obtained.

(b) **ESKDALEMUIR**

General.—There were no major changes in the work. The allotment of time to various sections remained as last year and, as in previous years, much of the magnetic tabulation was done at the Edinburgh Office, the Eskdalemuir portion being restricted to measuring the traces and compiling the first tables of results.

Outstanding features of the year were the successful recording of the very large magnetic disturbances accompanying the sunspot maximum, the re-standardization of the absolute instruments, some improvements in instruments, and the systematization of the Office and Library arrangements.

Terrestrial Magnetism—Absolute observations of declination and horizontal force were made on most week-days using the Kew magnetometer and the Schuster-Smith coil while dip was determined on two or more days weekly with the Schulze Inductor. These observations served to standardize the autographic records of the variometers. Determinations of horizontal force by means of the Kew magnetometer were continued twice a month as a check on the electrical methods.

All the great disturbances during this year of sunspot maximum were recorded completely by the la Cour variometers and it was not necessary to have recourse to the auxiliary low sensitivity magnetographs. The storm of April 15, 1938, showed the remarkable range in declination of $6^{\circ} 25'$. Scale tests were made twice monthly, and checks were provided on horizontal force (H) and vertical component (V) by the auxiliary instruments which were reduced in sensitivity so as to bring the records of large disturbances within the limits of the charts. Warnings of the probability of disturbances associated with exceptional sunspot activity were made available by the courtesy of the Astronomer Royal, and governed the switching up of the recorder lights.

A detector, to give audible warning of large disturbances, and automatic voltage increase at the recorder lamps, was designed and tested in co-operation with the Physics Department of Edinburgh University. It gave promising results.

The use of a permanently suspended magnet for determinations of declination, referred to in last year's report, was abandoned after extended test. It was found that the instantaneous readings, when

used to standardize recording instruments of small time scale, gave a considerably greater scatter in results than did the means of readings taken in the old way over a period of five or ten minutes.

Improvements in the records of the vertical component (V) were made by attending to the internal optical system of the instruments. Subsequently contact prints were supplied to inquirers instead of tracings.

Character figures, representing the magnetic character of each day, were sent to Edinburgh quarterly for transmission to the international Union of Geodesy and Geophysics, and records for the Polar Year were lent to Dr. la Cour. Hourly values of declination were contributed regularly to weekly mining journals as in previous years, whilst 43 copies of records were supplied to mining companies, surveyors and mining schools. Reports to the National Physical Laboratory of disturbances exceeding certain limits were continued, and arrangements were made for sending notification of occurrence of aurora to Dr. Ratcliffe of Cambridge.

A small amount of preliminary examination and experimental work was carried out with the records obtained in 1926 from the vertical force coil laid on the moor.

Co-operation was arranged with Edinburgh University in their work on photographing aurora.

Routine meteorological observations were made as usual. In addition, observations of solar radiation with the Ångström pyrheliometer were obtained when opportunity occurred, the results being sent to Kew for passing to the International Commission.

An examination of the incidence of heavy rainfall was completed, and is in course of publication. Work on synoptic situations associated with cloud down on the Border Hills is in progress.

Atmospheric Electricity—Autographic records of the electrical potential gradient have been maintained, absolute determinations being made as necessary to standardize the scale value of the recording instruments.

Year Book.—The text and completed tables for the Year Book were sent to Edinburgh on June 30, and the final corrected proofs in November. As in previous years, the absolute observations made at Valentia were compared with those made at Eskdalemuir in order to settle doubtful points before publication.

Office Arrangements—The equipment on charge was arranged systematically, and measures taken for maintaining the arrangement. The library books and pamphlets were arranged in order, and the cataloguing of pamphlets on the South Kensington system was

nearly completed. A more systematic arrangement of office equipment and files was also nearly complete at the end of the year. A detailed account of the Observatory procedure was compiled and indexed. It was designed to enable anyone from a general acquaintance with the work (e.g., an incompletely trained man, or an old one fallen out of touch with details) to perform step by step unassisted the observations, chart changing, tabulation, preparation of returns, office procedure, etc., on any occasion when he might be required to do so.

Works, Services, etc.—The buildings require partial repetition of the major overhaul of 1929-30, the mastic pointing having become absorbent generally and the porous stone again in need of treatment.

Some autumn and winter thinning and replanting of trees was done by the handyman. Many of the trees thinned out last year were sold locally and the cash credited against the cost of the outside labour employed for the work.

The electric heaters in the underground chambers continue to maintain these in a very satisfactory dry state except at the height of the summer season when condensation was very heavy. One of the control thermostats has gradually changed its constants and has now to be set 2° C high.

(c) LERWICK

Terrestrial Magnetism.—The variometers recorded very satisfactorily throughout the year, any breaks in the standard records being covered by the supplementary traces. The records were standardized by regular observations with the Kew magnetometer and the Dip inductor. Measurements of the vertical component of magnetic force have also been made four times a week with the B.M. magnetometer; analysis of the results shows a remarkably consistent behaviour, subject to a residual temperature coefficient of 1.8γ per 1° C. The instrument was taken to Abinger and Eskdalemuir at the turn of the year for comparison tests and restandardization. The latter shows that the fundamental constants have not changed appreciably over a period of two years.

A new non-magnetic hut was constructed to house the modified Smith coil and the Cambridge inductor; the Kew magnetometer and the B.M. magnetometer now occupy the old hut.

Aurora.—The customary watch has been maintained. During the winter, in co-operation with the Physics Department of

Edinburgh University, Eskdalemuir Observatory and some other stations on the mainland, arrangements were made for the exchange of notifications when aurora suitable for photographing could be seen and for simultaneous photographs to be taken at fixed times.

Atmospheric Electricity—The Benndorf electrograph has recorded with only a few minor breaks, and the normal routine for tests and absolute observations has been followed. The duralumin holder for the polonium collector which had been liable to rapid corrosion in the salt air was replaced by a copper holder in May, 1938, with satisfactory results.

Meteorology.—The usual 0900 observations and the autographic records have been maintained. As from January, 1939, data from the Observatory have been used in Table III of the *Monthly Weather Report*, in the *Réseau Mondial* and in the "climat" broadcasts. Frequent reports of wind speed and direction were supplied to Sumburgh Airport.

(d) ABERDEEN

Work during the year proceeded on the usual lines. In addition, regular daily weather reports at 0700 have been sent to Abbotsinch aerodrome from May 1, 1938. Inquiries, mainly for aviation purposes, showed an increase over the number in the previous year.

Summaries of upper winds, visibilities, cloud height and form at Aberdeen were prepared, and an investigation was carried out on the exposure of anemometers.

8. INTERNATIONAL CO-OPERATION

The work of the three main organizations, through which the Meteorological Office participates in international work, during the past year is summarized in the following paragraphs:—

(a) **The International Meteorological Organization**.—(i) *The Commission for Maritime Meteorology* met at De Bilt (Utrecht) in July, 1938. The meeting was attended by Capt. Garbett, Chief Superintendent of Naval Meteorology and Mr. F. Entwistle, the Secretary of the Commission for Aeronautical Meteorology.

The principal resolutions concern:—

(1) The publication in international weather reports of the data received in wireless reports from ships.

(2) Improvements in the synoptic organization of ships' reports through the development of a system of four observations daily in the Atlantic, by the introduction of a single universal code for ships' observations, and by an extension of the system under which certain ships collect the messages from other ships and transmit them to coastal stations.

(ii) *Regional Commission III (South America)*.—This Commission met at Monte Video, Uruguay, in February, 1939, under the Presidency of Ing. A. Galmarini. It was attended by Mr. F. Entwistle.

The principal recommendations concern :—

(1) The improvement of the organization of synoptic meteorology by arranging for regular observations in all countries of South America three times daily from September 1, 1939, with a fourth observation in the early morning as soon thereafter as practicable.

(2) Improvements in the arrangements for obtaining ships' observations and observations from Islands in the South Atlantic.

(3) The selection of stations for the provision of a network of radio-sonde observations in South America and an increase in the number of stations from which observations of upper wind by pilot balloons and upper air temperatures by aeroplanes are obtained.

(4) A scheme of co-ordination between the meteorological stations maintained by the three principal groups of Aviation Companies—Pan-American Airways, Condor (Lufthansa) Syndicate, and Air France—and the official Meteorological Services of the different countries.

Other resolutions concern the application in South America of the international codes for wind force and visibility, agreement upon the levels to which barometer observations should be reduced, the introduction of a section for agricultural meteorology, and the translation into Spanish of books which are of particular meteorological interest.

There have been no meetings of other Commissions of the International Meteorological Organization during the past year, but the Atlantic Committee of the International Commission for Aeronautical Meteorology held meetings at Copenhagen in April and at De Bilt in July, 1938. At the meeting in Copenhagen joint meetings were arranged with the representatives of the Oceanographical Association of the International Union of Geodesy and Geophysics, to ensure co-ordination between meteorological and oceanographical investigations in the North Atlantic, particularly in view of the oceanographical expedition to the North Atlantic which had been organised for May, 1938.

(b) *International Union of Geodesy and Geophysics*.—There has been no meeting of the Union this year.

(c) *International Commission for Air Navigation*.—A meeting of the Meteorological Sub-Commission of this Commission was held in

Paris in November, 1938, under the Presidency of Mr. E. Gold. The main resolutions concern :—

(1) Improvement in the arrangements for co-ordinating the meteorological and control services on aerodromes, in connexion with the institution or suspension of control, under conditions of bad visibility.

(2) Meteorological reports from aircraft in flight; particularly reports of formation of ice, banks of fog, duststorms and other dangerous phenomena.

(3) Specification of the information to be included in reports handed to pilots before departure, including essentially a description of the meteorological situation in the region concerned, a forecast of the changes anticipated which are likely to concern the flight, and a forecast of landing conditions, together with tables giving observations of upper wind and a selection of surface observations.

(4) The desirability of maintaining in the specification of the "standard atmosphere" that value for the basic pressure in millibars which is in conformity with the relation adopted in meteorological practice between the millibar and the millimetre of mercury under standard conditions of temperature and gravity.

International Aeronautical Conference.—The 39th Meeting of the International Aeronautical Conference was held at the Hague in May, 1938. Mr. R. Corless attended the meeting of the Meteorological Commission. Seventeen resolutions were adopted; the principal recommendations concern :—

(1) The meteorological arrangements necessary to meet the seasonal changes of time-table.

(2) The development of an international forecast code designed for forecasts of landing conditions.

(3) Improvements in the arrangements for warnings of thunderstorms.

(4) The initiation of a trial system of reports of meteorological conditions from aircraft in flight.

In addition a number of minor difficulties or variations in practice were examined and steps taken to effect the necessary improvement and co-ordination.

9. STAFF

In the course of the year the number of staff has risen from 586 to 763. This increase has been due in part to the expansion of the Royal Air Force and also to the implementation of the recommendations of Sir Henry Maybury's Committee, by which the Government assume responsibility for providing the meteorological services at

civil aerodromes. In spite of the universal demand for technical personnel, it has been found possible to recruit new staff at the rate required. Instructional classes for new entrants have been maintained in continuous operation for both professional and subordinate grades, with the result that, notwithstanding the large degree of dilution which has taken place, a satisfactory standard of technical proficiency has been maintained throughout the Office.

It is thought to be of some interest to record in the following table the numerical strength of the Meteorological Office during the past 20 years.

Year	1919	1925	1930	1935	1937	1939
No. of Staff ...	161	270	330	369	456	763

As already mentioned, the past year has been a notable one owing to the changes in the senior staff. Within a few months the retirement has taken place of the Director (Sir George Simpson, K.C.B., F.R.S.), two Assistant Directors (Mr. R. G. K. Lempfert, C.B.E., M.A., and Mr. F. J. W. Whipple, M.A., Sc.D.) and the Marine Superintendent (Capt. L. A. Brooke Smith, R.D., R.N.R.). The nearly simultaneous loss of all this accumulated experience has imposed a heavy strain upon the Office; but its severity has been minimized by the loyal efforts of the whole of the staff. Mr. R. Corless, O.B.E., M.A., and Mr. A. H. R. Goldie, M.A., D.Sc., have been selected to fill the two vacancies in the Assistant Director grade. Capt. C. E. N. Frankcom has been appointed Marine Superintendent, whilst Dr. C. E. P. Brooks and Mr. H. W. L. Absalom have been promoted to Principal Technical Officers.

Consequential promotions and the creation of new posts have led to the appointment of eight new Senior Technical Officers during the year.

The valuable services which Miss D. G. Chambers has rendered to the Department were accorded recognition in the New Year's Honours by the conferment upon her of an M.B.E.

10. LIBRARY AND PUBLICATIONS

Library. —The increased activity of the Library recorded in recent reports was maintained during 1938–9. 776 new books and pamphlets, 4,265 periodicals and 11,465 daily weather reports were received in the year. In addition to the books, etc., consulted in the Library itself, over 3,515 publications were issued on loan. Arrangements have been made to obtain additional copies of certain books which are in greatest demand.

A count of the publications in the Library was made during 1938 and by means of two numbering stamps taken into daily use in January, 1939, a record of the number of volumes and pamphlets is being automatically kept up to date. The contents of the Library on March 31, 1939 included 28,145 volumes and 7,100 pamphlets.

Co-operation was maintained with the National Central Library, and some information was supplied to the Association of Special Libraries and Information Bureau.

International relations were maintained and extended where possible. Over 600 classified bibliographical references (with abstracts in many cases) to meteorological books and papers published in the British Empire during 1937 were prepared and sent to Paris for inclusion in the International Bibliography of Meteorology for that year. In accordance with the request of the Bibliography Commission of the International Meteorological Organization, efforts were also made to secure better co-operation in this work from other parts of the world.

Exchanges of publications were arranged for the first time between the Meteorological Office and the following institutions :—

Osservatorio Meteorologico-Geodinamico, Montecassino ;
Bernard Price Institute, Johannesburg

and the exchange with Central Weather Bureau, Moscow, was extended.

Assistance was given to Dr. T. Bergeron, the well-known meteorologist, in the German-English section of a comprehensive international dictionary of meteorological terms which he is compiling.

Commissions and Committees.—Dr. C. E. P. Brooks continued to act as the Secretary of the Bibliography Commission of the International Meteorological Organization, and attended a meeting of the Commission at Utrecht on May 22, 1938. Dr. Brooks also represented the Meteorological Office at the International Conference on Documentation held at Oxford on September 21-6, 1938.

Publications.—The past year has been noteworthy for the appearance of two meteorological text books. Both have been written by members of the Meteorological Office staff, one being "Meteorology for Aviators" by Dr. R. C. Sutcliffe and the other "The Admiralty Weather Manual" by Dr. A. G. Forsdyke. Dr. Sutcliffe's work is intended principally for the benefit of Royal Air Force personnel and pilots engaged in civil aviation. It is used as the textbook for the meteorological courses at the Royal Air Force training establishments. Dr. Forsdyke's book, on the other hand, is written essentially from the point of view of the meteorological officer in the Royal Navy, and deals with the problems which are peculiar to weather forecasting at sea. It constitutes the textbook of the Naval Meteorological Branch.

The *Meteorological Magazine* and the *Marine Observer* were issued regularly during the year. In February, 1939, the first number of a new volume, changes were made both in the appearance and contents of the *Meteorological Magazine*. Thanks to the co-operation of H.M. Stationery Office, the magazine is now printed in bolder type on a paper of better quality, while the stiffer cover carries a simplified design. The nature and arrangement of the contents have also been modified. Certain features of little general interest are omitted, as well as all highly technical matter; these are replaced by authoritative articles which discuss meteorological subjects as simply as possible. Among the articles published in the issues for February and March may be mentioned:—

The film as a meteorological instrument, by J. S. Farquharson.

The evolution of the earth's atmosphere, by Dr. H. Spencer Jones.

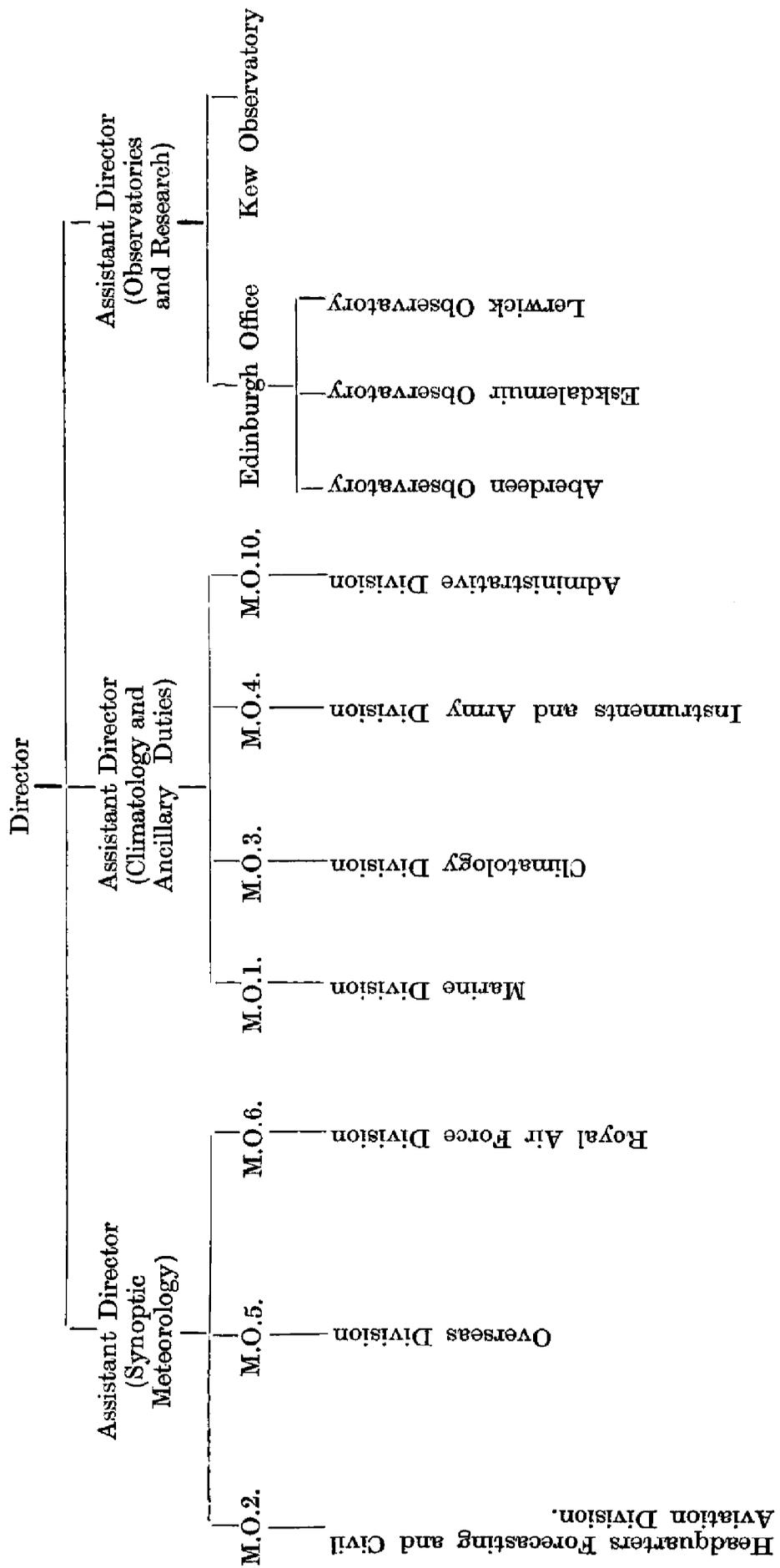
The composition of the atmosphere through the ages, by G. S. Callendar.

Climatology and forecasting, by S. T. A. Mirrlees.

The publications which contain the climatological returns from the network of British stations and observatories are dealt with in Section 4 (a) of this report.

A complete list of the publications emanating from the Meteorological Office during the past year is given in Appendix VI. Both the volume and the standard have been well maintained.

APPENDIX I
ORGANIZATION OF THE METEOROLOGICAL OFFICE



APPENDIX II

CLASSIFICATION OF BRITISH STATIONS WHICH REPORT TO THE CLIMATOLOGY DIVISION (see p. 21 for explanation).

DISTRICTS	STATIONS						AUTOGRAPHIC RECORDS					
	Observatories	Distributive	Telegraphic	Crop Weather	Climatological	Rainfall only	Sunshine	Rainfall	Wind	Pressure	Temperature	Humidity
0 Scotland, N. ...	1	0	4	0	13	125	13	1	3	5	0	0
1 " E. ...	1	1	1	2	32	348	26	7	2	2	1	1
6A " W. ...	1	1	1	1	25	404	21	7	3	3	3	1
2 England, N.E. ...	0	2	2	2	20	297	22	4	6	4	2	2
3 " E. ...	0	3	1	8	18	507	25	18	7	6	3	2
4 " Midlands	0	1	2	6	36	1104	34	22	2	3	2	1
5 " S.E. ...	0	7	3	4	39	914	44	22	10	9	10	8
London District...	2	0	0	0	10	47	10	4	2	2	3	1
8B England, S.W. ...	0	1	3	5	31	633	35	6	6	5	4	3
7A " N.W. ...	0	1	0	1	20	479	23	12	4	2	1	1
7B Wales, N. ...	0	2	0	1	6	202	6	4	3	2	2	2
8A " S. ...	0	0	1	2	9	227	14	5	2	1	1	0
9 Ireland, N. ...	0	1	2	0	8	132	7	2	2	4	1	1
10 " S. ...	1	0	2	0	11	121	9	2	3	3	0	0
6B Isle of Man ...	0	0	1	0	1	7	2	0	1	1	1	1
11 Scilly and Channel Isles ...	0	0	2	0	1	24	3	0	1	2	1	0
TOTAL ...	6	20	25	32	280	5571	289	116	57	54	35	24
Corresponding number for last year ...	6	20	24	32	288	5537	280	101	56	61	38	25

APPENDIX III

GALE WARNINGS ISSUED DURING THE YEAR 1938

DISTRICTS	Summary of occasions of gales		Summary of warnings issued			
	Total number of occasions when warnings were necessary	Percentage of occasions of gales effectively warned	Total number issued	Issues justified by gales, force 8 and above	Issues justified by strong winds, forces 6 and 7	Percentage justified by gales and strong winds
Scotland, N.E.	16	94	67	15	37	78
Scotland, E.	14	100	45	14	19	73
Scotland, N.W.	14	100	65	14	29	66
Scotland, W. and North Channel	20	90	58	18	26	76
Ireland, N.	30	97	73	29	26	75
Ireland, S.	10	100	61	10	37	77
Irish Sea	13	100	57	13	28	72
St. George's Channel	19	100	58	19	22	71
Bristol Channel	27	89	53	24	14	72
England, S.W.	19	100	43	19	10	67
England, S.	12	100	41	12	22	83
England, S.E.	9	100	35	9	18	78
England, N.E.	13	84	44	11	18	66
England, E.	18	94	39	17	16	85
TOTAL	234	96	739	224	322	74

APPENDIX IV

FINANCIAL STATEMENT

The year under review, 1938-9, is the eighteenth in which the cost of the Meteorological Office has been borne on Air Ministry Votes. The accounts are not yet closed, but the following tables give the approximate figures for the expenses and receipts of the Meteorological Office :—

APPROXIMATE STATEMENT OF EXPENDITURE AND RECEIPTS IN RESPECT OF METEOROLOGICAL SERVICES DURING THE YEAR 1938-9.

<i>Expenditure.</i>	<i>Amount.</i>
	£ £
Salaries and Wages—H.Q. Establishments	64,995
" " —Out-station Establishments	118,386

	183,381
Fuel and Light	652
Transport of Personnel and Equipment	9,023
Instruments, Equipment and Stores	28,455
Research	2,830
Minor Works Services, Rents, Repairs and Maintenance of Buildings	7,915
Telegrams, Telephones	
Subventions to reporting stations }	40,790
and miscellaneous charges }	
Grants towards Meteorological Services for Empire	
Air Routes	11,214
Superannuation	633

Total	<u>£284,893</u>
<i>Receipts</i>	
Receipts from War Office and Admiralty	2,053
Sale of Instruments, Carriage, etc.	12,580
Meteorological Information, Forecasts, etc.	2,376
Receipts from Royal Society	528

Total	<u>£17,537</u>

APPENDIX V

THE STAFF OF THE METEOROLOGICAL OFFICE, HEADQUARTERS, BRANCH ESTABLISHMENTS AND OBSERVATORIES, MARCH 31, 1939.

THE STAFF AT HEADQUARTERS

DIRECTOR

N. K. Johnson, D.Sc., A.R.C.S.

Assistant Directors E. Gold, D.S.O., F.R.S.; R. Corless, O.B.E., M.A.

ADMINISTRATIVE DIVISION

<i>Chief Clerk</i> ...	...	...	H. L. B. Tarrant, M.B.E.
<i>Assistant I</i> ...	...	...	Miss D. G. Chambers, M.B.E.
<i>Assistants</i> ...	...	...	8
<i>Typists</i> ...	...	...	2

HEADQUARTERS FORECAST AND CIVIL AVIATION DIVISION

<i>Principal Technical Officer</i> ...	...	...	E. G. Bilham, B.Sc., A.R.C.S., D.I.C.
<i>Senior Technical Officers</i> ...	...	...	C. K. M. Douglas, B.A.; S. F. Witcombe, B.Sc.
<i>Technical Officers</i> ...	...	...	J. Crichton, M.A., B.Sc., F.R.S.E.; R. A. Watson, B.A.; L. Dods, B.Sc.; M. J. Thomas, B.Sc.; F. H. Dight, B.Sc.; W. H. Bigg, B.Sc.; E. T. Eady, B.A.
<i>Assistants I</i> ...	...	...	W. Hayes; E. L. Clinch; A. A. Lovie; T. F. Twist; W. A. L. Marshall.
<i>Assistants</i> ...	...	...	38
<i>Draughtswomen</i> ...	...	...	8
<i>Telephone Typists</i> ...	...	...	6
<i>Teleprinter Operators</i> ...	...	...	8

ROYAL AIR FORCE DIVISION

<i>Principal Technical Officer</i> ...	...	...	H. W. L. Absalom, B.Sc., A.R.C.S., D.I.C.
<i>Senior Technical Officer</i> ...	...	...	C. S. Durst, B.A.
<i>Assistant I</i> ...	...	...	F. M. Dean.
<i>Assistants</i> ...	...	...	4

OVERSEAS DIVISION

<i>Principal Technical Officer</i> ...	...	...	F. Entwistle, B.Sc.
<i>Senior Technical Officer</i> ...	...	...	S. P. Peters, B.Sc., A.Inst.P.
<i>Technical Officers</i> ...	...	...	J. S. Farquharson, M.A.; D. A. Davies, B.Sc.
<i>Assistant I</i> ...	...	...	B. G. Brame.
<i>Assistants</i> ...	...	...	4

APPENDIX V—*continued*

CLIMATOLOGY DIVISION

<i>Principal Technical Officer</i> ...	C. E. P. Brooks, D.Sc.
<i>Senior Technical Officer</i> ...	J. Glasspoole, M.Sc., Ph.D.
<i>Technical Officers</i> ...	Miss E. E. Austin, M.A.; Miss E. H. Geake, M.Sc.; G. R. Benwell, B.A.; J. Wadsworth, M.A.; Miss L. F. Lewis, B.Sc.
<i>Senior Professional Assistants</i>	Miss L. D. Sawyer, B.A.; Miss G. L. Thorman, B.Sc., A.K.C.
<i>Retired Naval Officers</i> ...	E. W. Woodruff, Cdr. R.N. (retd.); J. Pontifex, Cdr., R.N. (retd.).
<i>Assistants I</i> ...	A. T. Bench; A. G. W. Howard.
<i>Assistants</i> ...	38
<i>Draughtsman and Draughtswomen</i>	7
<i>Presskeeper</i> ...	1
<i>Telephone Operator</i> ...	1
<i>Typists</i> ...	3

MARINE DIVISION

<i>Superintendent</i> ...	C. E. N. Frankcom, Capt.
<i>Technical Officer</i> ...	J. Hennessy, Cdr., R.N.R. (retd.), R. D.
<i>Senior Professional Assistant</i>	E. W. Barlow, B.Sc.
<i>Assistant I</i> ...	H. T. Smith.
<i>Assistants</i> ...	22

ARMY AND INSTRUMENTS DIVISION

<i>Principal Technical Officer</i> ...	J. S. Dines, M.A.
<i>Senior Technical Officer</i> ...	E. V. Newnham, B.Sc.
<i>Technical Officers</i> ...	D. N. Harrison, D.Phil; R. Cranna, M.A., B.Sc.
<i>Assistant I</i> ...	P. N. Skelton
<i>Assistants</i> ...	12
<i>Draughtsman</i> ...	1
<i>Instrument Maker</i> ...	1
<i>Photographic Assistant</i> ...	1
<i>Storemen and Packers</i> ...	5
<i>Typists</i> ...	1

EDINBURGH BRANCH METEOROLOGICAL OFFICE

6, Drumsheugh Gardens, EDINBURGH, 3

<i>Principal Technical Officer</i> ...	A. H. R. Goldie, M.A., D.Sc., F.R.S.E.
<i>Technical Officer</i> ...	Vacancy.
<i>Assistant I</i> ...	H. E. Carter.
<i>Assistants and Clerk Typist</i> ...	6

APPENDIX V—continued

OBSERVATORIES

KEW OBSERVATORY, Old Deer Park, Richmond, Surrey

<i>Assistant Director</i>	...	...	F. J. W. Whipple, Sc.D., F.Inst.P.
<i>Technical Officers</i>	...	...	L. H. G. Dines, M.A.; A. W. Lee, D.Sc., A.R.C.S., D.I.C.; G. D. Robinson, B.Sc., Ph.D.
<i>Assistant I</i>	...	...	E. Boxall.
<i>Assistants & Observer</i>	...	6	
<i>Instrument Maker</i>	...	1	
<i>Mechanics and Carpenter</i>	...	3	
<i>Caretaker & Handyman</i>	...	2	
<i>Housekeeper</i>	...	1	

THE OBSERVATORY, ESKDALEMUIR, Langholm, Dumfriesshire

<i>Senior Technical Officer</i>	...	W. A. Harwood, D.Sc.
<i>Technical Officer</i>	...	D. D. Clark, M.A.
<i>Assistants</i>	...	3
<i>Mechanic & Handyman</i>	...	2
<i>Housekeeper and Domestic Servant</i>	...	2

THE OBSERVATORY, King's College, ABERDEEN

<i>Assistant I</i>	...	G. A. Clarke.
<i>Assistant & Observer</i>	...	2

THE OBSERVATORY, LERWICK, Shetland

<i>Technical Officer</i>	...	O. M. Ashford, B.Sc.
<i>Assistant & Observers</i>	...	3
<i>Caretaker</i>	...	1

PORT METEOROLOGICAL OFFICES

LIVERPOOL

<i>Senior Professional Assistant</i>	M. Cresswell, Cdr., R.N.R. (retd.).
<i>Clerk</i>	...

LONDON

<i>Senior Professional Assistant</i>	C. H. Williams, Cdr., R.N.R. (retd.).
<i>Clerk</i>	...

APPENDIX VI

PUBLICATIONS

The publications prepared by the Office are generally issued by His Majesty's Stationery Office as official publications. A complete list, with the prices at which they can be purchased through any of the Sale Offices or usual agents of the Stationery Office is sent free to any applicant.

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

PERIODICAL :—

The Daily Weather Report issued in three sections (to March 31) :—

1. The British Section.
2. The International Section.
3. The Upper Air Section.

The Monthly Weather Report with a summary for the year (to February, 1939).

Weekly Weather Report for the period February 28, 1937, to February 26, 1938. Particulars of temperature, rainfall and bright sunshine for each week. *7s. 6d.*

The Marine Observer (to March, 1939).

The Meteorological Magazine (to March, 1939).

Monthly Frequency Tables, being summaries of observations of horizontal visibility, height of base of low cloud and speed and direction of surface and upper winds in the form approved by the International Commission for Air Navigation (to January, 1939). *Not on sale.*

Seismological Bulletin. A diary of seismological disturbances recorded on the Galitzin Aperiodic Seismographs at Kew Observatory, Richmond (to February, 1939). *Not on sale.*

Réseau Mondial, 1931. Monthly and annual summaries of pressure, temperature, and precipitation based on a world-wide network of observing stations. *15s.*

British Rainfall, 1937. A report on the distribution of rain in space and time over the British Isles as recorded by over 5,500 observers. *15s.*

Southport Auxiliary Observatory. Annual Report and results of meteorological observations, 1937. By J. Baxendell. *Not on sale.*

OCCASIONAL :—

Decode for use with the International Code for Wireless Weather Messages from Ships adopted by the International Meteorological Conferences, 1929 and 1935. 6th edition, revised to September, 1938. *6d.*

Meteorology, Elementary, A Short Course in. By W. H. Pick, B.Sc., F.C.P., F.Inst.P. 5th Edition, 1938. *2s. 6d.*

Meteorology for Aviators. By R. C. Sutcliffe, Ph.D. *7s. 6d.*

Meteorology in Relation to Air Navigation. (Reprint of Chapter XVII of the "Manual of Air Navigation," Vol. I.) *1s.*

South Pacific Ocean Currents, Atlas of. *7s. 6d.*

APPENDIX VI—continued

Geophysical Memoirs :—

Vol. IX :—

76. The Travel-times of the Seismic Waves P and S. By A. W. Lee, D.Sc. 2s.
77. An Investigation of the lapse rate of temperature in the lowest hundred metres of the atmosphere. By N. K. Johnson, M.Sc., A.R.C.S., and G. S. P. Heywood, M.A., B.Sc. 3s. 6d.
78. Seismology at Kew Observatory. By A. W. Lee, D.Sc. 2s.
79. Depressions as vortices. By A. H. R. Goldie, D.Sc., F.R.S.E. 1s. 3d.

Professional Notes:—

Vol. VI :—

83. A comparison between the geostrophic wind, the surface wind and the upper wind derived from pilot balloons at Valentia Observatory, Co. Kerry. By L. H. G. Dines, M.A. 2d.
84. Dust-storms in Iraq. By F. E. Coles, B.Sc., D.I.C. 4d.
85. The relation between the blueness of the sky and (A) the polarity of the air, (B) the gradient wind (with an appendix on observations of the blueness of the sky at Aberdeen, Valentia and Kew. By J. S. Farquharson, M.A.). By J. H. Brazell, M.Sc. 2d.
86. Sea breezes at Worthy Down, Winchester. By S. P. Peters, B.Sc. 4d.
87. Upper Winds at Nicosia (Cyprus). By J. Durward, M.A. 4d.
88. Fog on the mainland and coasts of Scotland. By F. E. Dixon, B.A. 6d.

The publication of the following books or papers by members of the Staff may also be mentioned :—

By E. GOLD, D.S.O., F.R.S. :—

Uniformity in times of observation for forecasting and climatology. *Publ. Organ. met. int., De Bilt*. No. 34, 1938 (Reg. Comm. No. II (Far East), Hong Kong, 1937), pp. 75-7.

Some comments on occlusion and on Professor Brunt's remarks regarding it. *London, Quart. J. R. met. Soc.*, **64**, 1938, pp. 629-30.

Obituary notice of Prof. Dr. H. Hergesell. *London, Quart. J. R. met. Soc.*, **64**, 1938, pp. 655-9.

By F. J. W. WHIPPLE, M.A., Sc.D., F.Inst.P. :—

Modern views on atmospheric electricity. (Presidential address delivered before the Royal Meteorological Society on Jan. 19, 1938.) *London, Quart. J. R. met. Soc.*, **64**, 1938, pp. 199-213.

By E. G. BILHAM, B.Sc., A.R.C.S., D.I.C. :—

Sequences of dry and wet months in England and Wales. *London, Quart. J. R. met. Soc.*, **64**, 1938, p. 324.

The spring drought in the British Isles. *Nature, London*, **141**, 1938, pp. 902-3.

George James Symons, F.R.S., Born August 6, 1838; died March 10, 1900. *London, Quart. J. R. met. Soc.*, **64**, 1938, pp. 593-7.

The weather in Great Britain during 1938. *Nature, London*, **143**, 1939, pp. 106-7.

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By C. E. P. BROOKS, D.Sc. :—

The climate of Chios. *London, Quart. J. R. met. Soc.*, **65**, 1939, pp. 52–6.

By C. E. P. BROOKS, D.Sc., with Miss T. M. HUNT :—

G. J. Symons as a bibliographer. *London, Quart. J. R. met. Soc.*, **64**, 1938, pp. 597–9.

By F. ENTWISTLE, B.Sc. :—

Atlantic flight and its bearings on meteorology. *London, Quart. J. R. met. Soc.*, **64**, 1938, pp. 355–89.

The meteorological problem of the North Atlantic, *London, J. R. aero. Soc.*, **43**, 1939, pp. 69–96.

By C. S. DURST, B.A. :—

The wind structure beneath warm fronts. *London Quart. J. R. met. Soc.*, **64**, 1938, pp. 516–22, disc., p. 522.

By C. S. DURST, B.A., with R. C. SUTCLIFFE, Ph.D., B.Sc. :—

The effect of vertical motion on the “ geostrophic departure ” of the wind. *London, Quart. J. R. met. Soc.*, **64**, 1937 p. 240.

By J. GLASSPOOLE, M.Sc., Ph.D. :—

The rainfall of the British Isles. A review of the development of our knowledge. *Wat. and Wat. Engng.*, *London*, **40**, 1938, pp. 77–87.

By E. V. NEWNHAM, B.Sc. :—

Effects of floods in East Norfolk. *Nature, London*, **142**, 1938, pp. 257–8.

By Miss E. E. AUSTIN, M.A. :—

La vie météorologique en Grand-Bretagne. *Météorologie, Paris*, 1938, pp. 52–5.

By R. CRANNA, M.A., B.Sc. :—

The new pilot balloon theodolite of the Meteorological Office, *London, Quart. J. R. met. Soc.*, **64**, 1938, pp. 613–5.

By A. F. CROSSLEY, M.A. :—

Note on the variation of pressure accompanying a distortion of air flow. *London, Quart. J. R. met. Soc.*, **64**, 1938, pp. 477–80, disc., pp. 480–1.

By H. H. LAMB, B.A. :—

Industrial smoke drift and weather. *London, Quart. J. R. met. Soc.*, **64**, 1938, pp. 639–43.

By R. M. POULTER :—

Cloud forecasting; the daily use of the tephigram. *London, Quart. J. R. met. Soc.*, **64**, 1938, pp. 277–88, disc., pp. 289–92.

By R. C. SUTCLIFFE, Ph.D., B.Sc. :—

On development in the field of barometric pressure. *London, Quart. J. R. met. Soc.*, **64**, 1938, pp. 495–504, disc., pp. 505–9.

APPENDIX VI—*continued*

By J. WADSWORTH, M.A. :—

The Observatory at Apia, Samoa. *London, Quart. J. R. met. Soc.*, **65**,
1939, pp. 31-42.

By E. W. BARLOW, B.Sc. :—

The auroral display of January 25-6, 1938. *London, Quart. J. R. met. Soc.*,
64, 1938, pp. 215-9.