

M.O. 586

ANNUAL REPORT
OF THE DIRECTOR OF THE
METEOROLOGICAL OFFICE
PRESENTED BY THE METEOROLOGICAL COMMITTEE
TO THE SECRETARY OF STATE FOR AIR

FOR THE YEAR
APRIL 1, 1953 TO MARCH 31, 1954



LONDON : HER MAJESTY'S STATIONERY OFFICE
1954

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Vice-Chairman :—Professor G. M. B. Dobson, C.B.E., F.R.S. (Royal Society) (to October 1953)

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 Sir David Brunt, F.R.S. (Royal Society) (from October 1953)
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 Mr. W. Lewis (Scottish Office) (from November 1953)
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 Professor H. S. W. Massey, F.R.S. (Royal Society)
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 Professor P. A. Sheppard (British Universities)
 Mr. H. R. Smith, C.B. (Scottish Office) (to November 1953)
 Mr. G. W. Stallibrass, O.B.E. (Ministry of Transport and Civil Aviation) (to June 1953)
 Dr. O. G. Sutton, C.B.E., F.R.S. (Director, Meteorological Office) (from September 1953)
 Dr. O. H. Wansbrough-Jones, C.B., O.B.E. (Ministry of Supply)

Secretary :— Mr. R. J. Williams

The Committee met on May 28, 1953.

METEOROLOGICAL RESEARCH COMMITTEE

Appointed by the Secretary of State for Air

Chairman :—Sir David Brunt, F.R.S.

Members :— Dr. G. E. Bell (Ministry of Transport and Civil Aviation)
 Instructor Captain P. Bracelin, O.B.E., R.N. (Admiralty)
 Squadron Leader P. H. J. Buddery (Air Ministry) (from January 1954)
 Professor S. Chapman, F.R.S.
 Squadron Leader A. A. B. Cleaver, D.F.C. (Air Ministry) (to December 1953)
 Professor G. M. B. Dobson, C.B.E., F.R.S.
 Sir Nelson Johnson, K.C.B. (Director, Meteorological Office) (to August 1953)
 Sir Charles Normand, C.I.E.
 Professor P. A. Sheppard
 Dr. O. G. Sutton, C.B.E., F.R.S. (Director, Meteorological Office) (from September 1953)
 Dr. O. H. Wansbrough-Jones, C.B., O.B.E. (Ministry of Supply)

Secretary :— Mr. R. Frost

The Committee has met twice during the period covered by this report.

ADVISORY COMMITTEE ON METEOROLOGY FOR SCOTLAND

Appointed by the Meteorological Committee

- Chairman** :—Sir Nelson Johnson, K.C.B., D.Sc. (Director, Meteorological Office) (to August 31, 1953)
 Dr. O. G. Sutton, C.B.E., F.R.S. (Director, Meteorological Office) (from September 1, 1953)
- Members** :— Sir Edward Appleton, G.B.E., K.C.B., F.R.S. (University of Edinburgh) (from October 1953)
 Dr. A. E. M. Geddes, O.B.E., F.R.S.E. (University of Aberdeen)
 Professor W. M. H. Greaves, F.R.S. (Royal Society)
 Dr. D. Jack, F.Inst.P., F.R.S.E. (University of St. Andrews)
 Mr. J. S. Munrow (Fisheries Division, Scottish Home Department)
 Mr. J. Paton, M.A., B.Sc. (Royal Meteorological Society)
 Dr. R. J. Peters (Department of Health for Scotland)
 Professor W. M. Smart, D.Sc. (University of Glasgow)
 Mr. A. R. Wannop, O.B.E. (Department of Agriculture for Scotland)
 Sir Ernest Wedderburn, O.B.E., D.Sc., LL.D. (Royal Society of Edinburgh)
- Secretary** :— Mr. R. A. Watson (to January 31, 1954)
 Mr. R. Cranna, M.A., B.Sc. (from February 1, 1954)

During the year Sir Ernest Wedderburn resigned and Mr. J. Paton replaced him as representative of the Royal Society of Edinburgh. Sir Charles Normand, C.I.E., D.Sc. was nominated by the Royal Meteorological Society to be their representative in place of Mr. J. Paton.

The Committee met on June 11, 1953.

GASSIOT COMMITTEE

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, namely Meteorology, Terrestrial Magnetism, Atmospheric Electricity, Seismology and the cognate subjects.

- Professor H. S. W. Massey (Chairman)
 Professor D. R. Bates
 Sir David Brunt
 Professor S. Chapman
 Professor T. G. Cowling (to December 31, 1953)
 Professor G. M. B. Dobson
 Mr. E. Gold
 Sir Charles Normand
 Professor F. A. Paneth
 Mr. J. A. Ratcliffe (from January 1, 1954)
 Professor P. A. Sheppard
 Dr. O. G. Sutton (Royal Society member to August 31, 1953, subsequently as Director, Meteorological Office)
 Dr. T. W. Wormell
 The Astronomer Royal
 The President of the Royal Astronomical Society
 The President of the Royal Meteorological Society
 The Director of the Meteorological Office

The Committee met on April 17 and October 20, 1953.

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ANNUAL REPORT

OF THE DIRECTOR OF THE METEOROLOGICAL OFFICE PRESENTED
BY THE METEOROLOGICAL COMMITTEE TO THE SECRETARY OF STATE
FOR AIR FOR THE YEAR APRIL 1, 1953, TO MARCH 31, 1954

§ 1. FUNCTIONS OF THE METEOROLOGICAL OFFICE

The Meteorological Office is the State Meteorological Service. It forms part of the Air Ministry, the Director being responsible to the Secretary of State for Air through the Permanent Under Secretary of State.

General policy is controlled by the Meteorological Committee of which the Parliamentary Under Secretary of State for Air is Chairman. Almost all those Government Departments to which the Meteorological Office regularly provides services are represented on the Committee, and there are also representatives of the Royal Society, the Royal Society of Edinburgh, and the British Universities.

The general functions of the Meteorological Office are :—

- (i) Provision of meteorological services to the Army, Royal Air Force, Civil Aviation, Ministry of Supply, the Merchant Navy and Fishing Fleets.
- (ii) Liaison with the Naval Weather Service of the Admiralty and provision of basic meteorological information for use by that Service.
- (iii) Meteorological services to other Government Departments, public corporations, local authorities, the Press and the general public.
- (iv) Organization of meteorological observations in Great Britain and Northern Ireland, and in certain colonies.
- (v) Collection, distribution and publication of meteorological information from all parts of the world.
- (vi) Maintenance of certain British observatories, and publication and distribution of magnetic and seismological information obtained from them.
- (vii) Research in meteorology and geophysics.

The Meteorological Office also takes a leading part in international co-operation in meteorology.

The cost of the Meteorological Office is borne on Air Ministry Votes. Appendix IV shows the provision made in the Air Estimates for expenses and receipts of the Meteorological Office for the financial year 1954–55.

§ 2. FORECASTING SERVICES RENDERED BY THE METEOROLOGICAL OFFICE

(1) Organization for Forecasting

(a) **Central Forecasting Office.**—The headquarters of the forecasting service and the main communications centre of the Meteorological Office are situated at Dunstable. The organization of the Central Forecasting Office, into Divisions and Branches under a Deputy Director, is shown in Appendix I.

The functions of the Central Forecasting Office are :—

- (i) To collect meteorological data required for forecasting both at Dunstable and at outstations.
- (ii) To disseminate the data to meet the needs of outstations and in accordance with international requirements.
- (iii) To provide basic analyses and prognostic analyses covering a wide area for the guidance of forecasters at outstations and for the information of foreign meteorological services.
- (iv) To provide the forecasts, weather warnings and other information on current weather required by Government Departments, public services and the general public.
- (v) To prepare and keep up to date the forms, handbooks and other publications relating to the services provided.
- (vi) To carry out research work on forecasting problems with the object of increasing the accuracy of the forecasts and extending the period for which they can be provided.

No important changes were made during the year.

(b) Reporting stations.—The network of surface weather reporting stations continued to operate without major change. Reports in the full synoptic code were received from 79 stations, of which 21 were manned by part-time observers normally engaged in other walks of life. Abbreviated (AERO) reports were received from a further 27 stations, similarly manned by part-time observers including coastguards, light-house keepers, schoolmasters and others interested in meteorology as a hobby. A high standard of interest and accuracy was maintained by these observers. Observations were also furnished by a number of Royal Naval Air stations and by United States Air Force stations in this country. The total number of stations from which regular coded reports were received was 180.

(c) Ships' reports.—*Voluntary observing ships.*—The organization of voluntary observing ships is described on p. 22. About 148 reports were received daily in the Meteorological Communications Centre at Dunstable from "selected" ships in the eastern North Atlantic (north of 35° N., east of 40° W.). Of these, 129 were from British ships and 19 from foreign ships; 55 per cent. of these messages were received within one hour and 78 per cent. within two hours of the time of observation. Reception was facilitated by a direct teleprinter line between the Post Office wireless station at Burnham-on-Sea and the Central Forecasting Office.

Ocean weather ships.—The British weather ships on duty at two stations in the North Atlantic carried out a full programme of surface and upper air observations, which were communicated to the Central Forecasting Office by point-to-point W/T communications. Radio weather messages from ocean weather ships operated by other nations in the North Atlantic were received regularly throughout the year.

(d) Meteorological flights.—R.A.F. Hastings aircraft based on Aldergrove continued to perform routine meteorological reconnaissance flights over the eastern Atlantic about two or three times a week. By special efforts this

programme was maintained during the employment of some of the meteorological flight aircraft on relief work following the Greek earthquake in October 1953.

Vertical ascents were made daily in the United Kingdom by Spitfire aircraft flown by a civilian contractor under the direction of R.A.F. Home Command. Most of the ascents were made near Worcester, but for a period in July and August the location was changed to Camphill in Derbyshire, where the ascents provided valuable information for the National Gliding Contest.

A R.A.F. aircraft was available at Singapore for vertical ascents and short-range reconnaissance flights. These were made on a non-routine basis and were flown as the prevailing weather situation required.

(e) **Radio-sonde and radar wind stations.**—The United Kingdom network of eight radio-sonde and radar wind stations was maintained. From April 27 routine ascents were made at the radar-sonde theodolite site at Crawley instead of at Larkhill. Observations of upper wind by radar were obtained at 0300, 0900, 1500 and 2100 G.M.T. at each station and on the two British ocean weather ships, while measurements of pressure, temperature and humidity were made twice daily at 0300 and 1500 G.M.T. At eight overseas stations under British control two ascents, at 0300 and 1500 G.M.T., were made daily for both temperature and wind observations. Measurements of temperature were made to an average height of 56,500 ft., wind observations being terminated at a slightly lower average level.

The principles of the new radar-sonde theodolite equipment, installed at Crawley, were explained to the Press in August 1953. Flight trials of the wind-finding apparatus were made. Approval was given for radar-sonde theodolites to be installed at Hemsby and Fazakerley, subject to the satisfactory completion of trials at Crawley.

(f) **Thunderstorm location.**—The "sferic" system used for the location of thunderstorms continued without change, the four direction-finding stations being located at Hemsby (Norfolk), Camborne (Cornwall), Leuchars (Fife) and Irvinestown (Northern Ireland).

The control station at Dunstable was equipped with one of three new sets of cathode-ray-direction finding equipment received during the year, and although observations were not normally made at the control station, the equipment was most useful for monitoring the network, for training, and for demonstrations. The new equipment, including two sets as spares for the network and for emergency use, was designed by the National Physical Laboratory. It is suitable for use in the tropics, and is simpler and less expensive than the original sets. An order for three sets was placed by the Sudan Government, through the Meteorological Office.

(g) **Meteorological communications.**—*Land-line communications.*—Four teleprinter broadcasts continued to be made from Dunstable. The main broadcast (Channel 1) supplied basic data to approximately 190 stations, a small increase over last year's figure. A second teleprinter broadcast network (Channel 2), for the issue of supplementary data, was connected to about 90 stations compared with 75 last year, the increase being due to the addition of United States Air Force and R.A.F. Fighter Command stations. A third broadcast, of

North American and North Atlantic data, continued to be made to 17 stations concerned with transatlantic and other long-period forecasts. A fourth broadcast supplied selected data to meteorological communications centres connected to the western European teleprinter network. The information included in the broadcasts was kept under continuous review to ensure that the changing requirements of recipients were met as fully as possible.

The meteorological communications system was used from September 15 onwards for the rapid collection and transmission to the Central Forecasting Office of tide-gauge readings made by Harbour Masters in connexion with the East Coast Flood Warning Scheme.

Reorganization of the west European teleprinter network was effected on January 4. The Federal German meteorological service assumed full responsibility for the Frankfurt centre which superseded the two separate centres at Bad Eilsen and Rhein Main. The new teleprinter circuits operated satisfactorily, and the reorganization and introduction of new schedules worked out as planned.

Radio communications.—The three W/T broadcasts (continental, sub-continental and national) were continued with no substantial change. Additional aerial installations at Dunstable, expected to improve reception of some distant transmitting stations, were practically completed.

During periods of adverse radio propagation, reception of North American data was often impossible, either by radio-teleprinter via the New York–Azores–Paris circuit or by direct W/T interception. During break-downs of the usual channels of meteorological communications between Europe and North America in December 1953 and February 1954, arrangements were made for European observations to be sent from Dunstable to New York via Birdlip W/T station.

Following satisfactory trials, experimental radio-facsimile broadcasts from Dunstable were maintained, to a regular timetable, for reception at Prestwick, Bawtry, Duxford and Hullavington. Reports received from these stations indicated that the MUFAX recorders required very little attention. Authority was given for six additional recorders to be obtained for use at stations connected by land-line with Dunstable. These recorders will be fully automatic in operation.

A special service of weather charts and upper air information was provided by radio-facsimile process for the British Gliding Association Meeting at Camphill, Derbyshire, at the end of July and beginning of August 1953.

(2) Supply of Forecasts for the General Public, Government Departments, etc.

The following are among the services rendered by the Meteorological Office :—

(a) **General public, shipping, etc.**—Numerous forecasts were supplied to the general public, on request and by previous arrangement, by the meteorological offices specified in the Post Office Guide. These forecasts included many connected with sporting and recreational activities.

The British Broadcasting Corporation included daily weather bulletins and forecasts for shipping in the Home and European Services. Arrangements were made for the issue of warnings of persistent fog in selected industrial areas.

The areas covered by forecasts prepared for television broadcast were further extended as, with the installation of additional transmitters, reception has become possible over most of the country. From January 11, 1954, the presentation of television forecasts was made daily in the studio by a forecaster of the Meteorological Office, instead of by a B.B.C. announcer. An analysis of the reactions of the general public to this type of presentation, made by the B.B.C. Listener Research Unit, showed that the new service is popular. Negotiations have also been completed for an improved service on sound radio.

(b) **Railways.**—Forecasts and warnings of snow, frost, fog and thunderstorms continued to be issued as in the previous year. Forecasts of icing on the conductor rails or cables of electrified railways were again provided between October and March.

(c) **British Electricity Authority.**—Daily forecasts of meteorological conditions affecting electricity loading were issued to Grid Control Centres. The supply of special week-end temperature forecasts was continued, and a broad outlook for four days ahead was supplied to the Authority bi-weekly. The meteorological unit at the British Electricity Authority Headquarters was maintained.

(d) **Gas undertakings.**—Warnings of expected changes in meteorological elements affecting day-to-day requirements of gas were issued as in previous years.

(e) **Agriculture and horticulture.**—Many special forecasts and warnings were supplied to growers. The fine-spell notification service was used extensively by farmers and others.

(f) **River Boards, etc.**—From September 15, 1953, daily collaboration was maintained between the forecasting staff of the Central Forecasting Office and Officers of the Admiralty Hydrographic Department working at the Meteorological Office, in connexion with the issue of tidal warnings to River Boards and Police Authorities.

(g) **Docks and Inland Waterways Executive.**—Warnings of persistent frosts likely to produce ice on canals in the Wolverhampton area were supplied.

(h) **Road engineers and automobile clubs.**—Warnings of the onset of meteorological conditions likely to cause bad road conditions were supplied to various Government Departments and motoring associations. A further increase occurred in the number of local authorities utilizing snow warnings in connexion with snow-clearance schemes.

(i) **Factories and other commercial undertakings.**—Special forecasts were supplied, as in previous years, of weather conditions affecting industrial processes. In connexion with arrangements for effecting economies in factory heating, extensive use was made by industrial subscribers of a special multi-address telegraph service providing mean week-end temperature forecasts.

(j) **Belfast Harbour Power Station.**—Special week-end temperature forecasts were issued throughout the year to assist in estimating the consumption of electricity.

(k) **Film companies.**—Special weather forecasts for the Greater London area were supplied twice daily throughout the year, and for other areas on request.

(l) **Department of Scientific and Industrial Research.**—Information on upper air temperatures was supplied daily to the Radio Research Station, Slough, for investigations into television reception.

Forecasts and warnings of drifting snow and ice formation on roads were supplied to the Road Research Laboratory as in previous years.

(m) **Ministry of Fuel and Power.**—Warnings of sharp falls in barometric pressure were issued to certain collieries, in connexion with experiments on a colliery warning system.

(n) **University Research Departments.**—A number of forecasts were issued to University Research Departments in connexion with experimental high-altitude balloon ascents.

(o) **Ceremonial occasions.**—Forecasts for State ceremonial and pageant occasions were issued as required. In particular, numerous requests were met for the provision of forecasts at the time of the Coronation of Her Majesty the Queen.

(3) Services for the Royal Air Force

(a) **Organization.**—There was no important change in the organization of meteorological services to the Royal Air Force. Staffing limitations prevented the manning of some meteorological offices requested by the Royal Air Force, and in some cases the necessary meteorological facilities were provided by telephone from a nearby meteorological office.

In the British Zone of Germany, German forecasters and assistants continued to be employed in our meteorological offices under the supervision of British staff.

Little change of organization occurred in the Mediterranean, Middle East and Far East areas, although requirements for meteorological facilities continued to increase at many places.

The main meteorological offices at Gloucester, Uxbridge and Watnall, and also those at Malta and at Ismailia (Canal Zone Egypt), continued to provide meteorological information and advice to the associated Air Traffic Control Centres.

(b) **Facilities.**—In addition to the normal meteorological service, special facilities were provided for large-scale R.A.F. and Joint Exercises, for the Coronation Fly-Past, for the Royal Review of the Royal Air Force, for long-range training flights by pilots of the R.A.F. Flying College at Manby and of the Central Navigation and Control School at Shawbury, and for flights by jet aircraft across the Atlantic, to overseas Commands and to South Africa. A special meteorological organization was provided for the London–New Zealand Air Race in October 1953.

Mobile meteorological units were provided during Allied Exercises in western Europe.

R.A.F. broadcasts of weather reports and landing forecasts by Gloucester, Watnall (on a restricted scale) and R.A.F. stations in the Middle East Air Force Command were maintained.

In the Far East additional meteorological facilities continued to be provided for the military forces in Malaya and Hongkong.

(c) Royal Air Force Meteorological Policy Committee.—The 30th meeting of the Royal Air Force Meteorological Policy Committee was held on November 30, 1953, when discussions were held on the meteorological requirements of Fighter Command. It was agreed that a report should be prepared on methods of conveying meteorological information to aircrews, including the graphical representation of weather ; and that further consideration should be given to the provision of meteorological forecasting offices at Sector Operation Centres in addition to those at present provided at Fighter Command Stations.

(d) Miscellaneous activities.—The Royal Air Force co-operated in the investigations of jet streams, turbulence, ice formation on aircraft and certain aspects of condensation trails formed by jet aircraft. As opportunity offered they also provided reports on the position and extent of the ice fields off the coast of Greenland. These observations were useful not only to the Meteorological Office but also to the Ministry of Agriculture and Fisheries.

Flights by R.A.F. jet aircraft between Habbaniya and Bahrein in order to investigate the wind profile at high levels in that region were continued.

Trial receptions of the experimental facsimile broadcasts of surface and upper air weather maps, analyses, etc. broadcast from the Central Forecasting Office, Dunstable, were made at four meteorological offices.

(e) Meteorological instruction for the Royal Air Force.—Meteorological instruction was given at a large number of schools in Flying Training Command, at Operational Conversion Units and at other R.A.F. units at home and overseas.

A new handbook, "Elementary meteorology for aircrew", on the same lines as the revised syllabi of meteorological instruction in Flying Training Command which have been approved during the year, was in course of preparation and will replace "Meteorological handbook for pilots and navigators".

A new film strip, "Arctic meteorology", and the accompanying lecture notes were prepared and distributed.

(4) Services for Civil Aviation

(a) Organization.—Meteorological facilities were provided in the United Kingdom and overseas in conformity with the recommendations of the International Civil Aviation Organization.

The main meteorological offices at Prestwick, Preston and Uxbridge continued to provide information to the associated Air Traffic Control Centres. Broadcasts by radio-telegraphy of weather reports and forecasts were maintained at these centres for the information of aircraft in flight. Increased use was also made of radio-telephony for broadcasts of weather reports and for obtaining information on request.

British European Airways and British Overseas Airways Corporations continued to co-operate in arranging flights by meteorological office staff for the purpose of gaining first-hand experience of conditions on the routes for which they provide meteorological service. Facilities for such "familiarization flights" were extended to forecast staff at certain overseas meteorological offices.

Standard altimeter-setting procedures were introduced on North Atlantic routes on March 1, 1954, whereby all flights in the oceanic areas of the North Atlantic region are made at levels related to an altimeter setting of 1013.2 mb. To enable the Oceanic Area Control Centre at Prestwick to ascertain the lowest usable flight level, the Meteorological Office has supplied periodic forecasts of lowest mean-sea-level pressure for the area concerned.

(b) Aeronautical Research Council.—The Meteorological Office was represented at a meeting of the Civil Aviation Research Committee at which the effect of the proposed withdrawal of the American ocean weather stations was discussed.

(c) Services provided in the United Kingdom.—Meteorological offices were maintained at 24 civil aerodromes, an increase of one during the year due to the transfer of Inverness (Dalcross) aerodrome from the R.A.F.

London Airport and Prestwick continued to provide facilities for the North Atlantic and other trunk routes. With the increasing use of London Airport by airlines, and to meet the needs of early Comet development flights and ultimately commercial flights on North Atlantic routes, the organization was strengthened and developed with particular emphasis on expanding the work on upper air charting and forecasting. Charts for the 200-mb. level (approximately 38,000 ft.) are now drawn as routine for the whole of the North Atlantic and eastern half of North America.

The office at Northolt continued to supply information for a large number of services to destinations in Europe and within the United Kingdom.

There was also a marked increase in work at Bovingdon because of the introduction of new services by charter operators.

In order to meet the needs of charter operators Blackbushe was upgraded to a forecasting office.

Ringway was required to provide a limited meteorological service for the Sabena (Belgian Air Lines) transatlantic operators from Brussels to New York via Ringway.

A marked increase in meteorological requirements for aviation in the Cardiff area led to arrangements for a meteorological office at Cardiff (Rhoose) to be opened in April 1954.

The Minister of Transport and Civil Aviation approved many applications, made by independent airlines, for the operation of new public air services. Advice concerning the meteorological facilities available for these services was given to the Ministry of Transport and Civil Aviation and to airline operators.

Close liaison was maintained with the States of Jersey Meteorological Service in matters of mutual interest concerning the organization of meteorological facilities for aviation.

(d) Services provided overseas.—Meteorological service for civil aviation continued to be provided at a number of joint-user airfields in the Middle East Command.

Liaison was maintained with colonial and foreign meteorological services along trunk routes ; in particular an organization, based on experience gained in providing meteorological service for British Overseas Airways Corporation Comet flights, was agreed with the French Meteorological Service for Comet flights by a French operator through Idris.

(e) Examinations.—Examinations were held in meteorology for the Commercial Pilot Licence and Instrument Rating, Senior Commercial Pilot, Airline Transport Pilot and Flight Navigator Licences, and for the Air Traffic Control Officers' primary courses ; 1,023 candidates were examined during the year.

Under the scheme of training instituted in 1951 a number of Air Traffic Control and Executive Officers at Ministry of Transport and Civil Aviation aerodromes were given instruction in the making and reporting of weather observations, so that they could undertake the provision of aerodrome weather reports when stationed at an aerodrome where there was no meteorological office. Arrangements were made for extending the scheme to aerodrome controllers at certain non-state aerodromes.

(f) Special work.—Meteorological staff gave evidence at the public inquiries into aircraft accidents which occurred at Belfast (Nutts Corner) on January 5, 1953, near Birmingham on January 1, 1953, and between the Azores and Newfoundland on February 2, 1953. Reports on the meteorological aspects of a number of other accidents, including that to the Comet off Elba on January 10, 1954, were prepared for the Accidents Investigation Branch, Ministry of Transport and Civil Aviation.

Basic meteorological information was supplied daily to Malham Tarn during the period of a meteorological course organized by the Royal Meteorological Society.

A small meteorological unit was equipped at Camphill with facsimile apparatus for reproducing charts made at Dunstable, and gave service for the National Gliding Championships organized by the British Gliding Association.

Information on pressure gradients was supplied to the Ministry of Transport and Civil Aviation to assist in a study of altimeter-setting procedures.

Special arrangements were made to meet the meteorological requirements for the London–New Zealand Air Race in October 1953, in co-operation with Commonwealth and foreign meteorological services along the route. Special arrangements were also made in co-operation with the Icelandic, Canadian, United States and British Caribbean Meteorological Services for the flight of Her Majesty the Queen and the Duke of Edinburgh from London to Bermuda in October, 1953. Meteorological service was provided for various other special flights, including flights by Royalty to Oslo and Rhodesia, and notable high-level flights to North America, Iceland, Cairo, Khartoum and South Africa.

Arrangements continued for the collection of aircraft reports for the investigation of icing and turbulence. Relevant reports of turbulence were provided to the United States Weather Bureau in connexion with the investigation of clear-air turbulence being undertaken on behalf of the International Civil Aviation Organization.

Investigations continued at certain civil airports into the relationship between horizontal visibility and visibility from air to ground during mist and fog. Other experiments on visibility in mist and fog continued at London Airport.

Investigations of standing waves in the atmosphere were continued at Northolt with the co-operation of British European Airways Corporation.

The meteorological offices at London and Prestwick co-operated with airline operators in special trials connected with load planning, and with the selection of least-time tracks on North Atlantic routes.

Planning was continued for meeting the meteorological needs of civil aviation in the London area for the next 10 years on the basis of estimates of air traffic. Proposals for meeting the requirements of the London Air Traffic Control Radar Section were agreed with the Ministry of Transport and Civil Aviation.

Meteorological service was provided for flights made by aircraft of the United States Navy from London Airport and Blackbushe.

(5) Services for the Royal Navy*

Certain meteorological offices overseas continued to provide weather forecasts and other information for units of the Royal Navy. Close liaison was maintained with the local Naval authorities at Malta, in the Suez area, the Persian Gulf and in the Far East.

Special meteorological facilities were provided for joint R.N. and R.A.F. Exercises, including forecasting units at the Maritime Headquarters at Mount Wise, Chatham, Londonderry and Pitreavie. In accordance with current policy Officers of the Naval Weather Service were attached as Liaison Officers for the briefing of Naval Staff Officers during joint Exercises.

(6) Services for the Army

The meteorological office at the School of Artillery, Larkhill, was maintained.

Meteorological information needed at Artillery Practice Camps was provided either by Meteorological Office staff attached to the camps or by nearby meteorological offices. Arrangements were made for some Army officers and other ranks to be trained at Larkhill in making meteorological observations and computations required in artillery work, which will enable certain Practice Camps to supplement the information provided by meteorological offices.

Meteorological facilities for the Army continued to be provided in overseas commands.

The Meteorological Office was represented on a number of War Office Committees.

* The Director of the Naval Weather Service submits an *Annual Report* to the Board of Admiralty.

(7) Services for the Ministry of Supply

Meteorological offices were maintained at a number of Ministry of Supply research experimental establishments. The Meteorological Office was represented on a number of Ministry of Supply Committees and dealt with various special inquiries from Ministry of Supply Branches.

(8) Services for the Merchant Navy and Fishing Fleets

The Central Forecasting Office maintained the service of gale warnings and forecasts for shipping as in former years. These warnings and forecasts for coastal sea areas of the British Isles were disseminated in B.B.C. radio programmes and by G.P.O. coastal radio stations. In the B.B.C. Light Programme gale warnings were read out within a few minutes of issue. They were repeated at the beginning of each weather bulletin in the Home Service, at 6.55 a.m. (except Sundays), 7.55 a.m., 12.55 p.m., 5.55 p.m. clock time. The forecasts for shipping were given in the same bulletins. By arrangement with the Ministry of Transport and Civil Aviation through the Coastguard Services visual gale-warning signals in the form of canvas cones were exhibited at many points on the coast.

The North Atlantic shipping bulletin, broadcast twice daily by the Portishead Radio at 0930 and 2130 G.M.T., included storm warnings and forecasts for the north-eastern Atlantic Ocean. An analysis of pressure and frontal systems for the use of shipping was broadcast daily at 1130 G.M.T. Forecast centres near ports issued on request local forecasts or weather reports to masters of ships and others concerned with the movements of shipping or with the loading and discharging of cargo.

(9) Services for the Commonwealth

(a) Middle East area.—Malta.—The Meteorological Office continued to maintain a forecasting service at Luqa and a radio-sonde/radar wind unit at Qrendi. In order to meet the growing requirements of aviation meteorological services on a considerably increased scale were provided. The exchange of meteorological information with neighbouring countries was maintained.

Cyprus.—The forecasting service and a radio-sonde/radar wind unit at Nicosia provided meteorological facilities for military and civil aviation. An agreement was reached with the Cyprus Government for the forecasting service to be extended to cover 24 hours daily to meet increased demands by civil aviation.

Aden.—A forecast service and a radio-sonde/radar wind unit were maintained at Khormaksar to meet the requirements of the R.A.F., of shipping, and of civil aviation. Routine and special meteorological reports were provided from stations along the south Arabian coast and on Kamaran Island.

British Somaliland.—The Meteorological Office continued to exercise technical control over the reporting station at Hargeisa, and advised the Somaliland Government regarding improvements in facilities. Weather observations were made by stations operated by the Desert Locust Survey.

Pakistan.—A forecasting service was maintained at the R.A.F. Staging Post Mauripur, to meet the requirements of the Royal Air Force and the Royal Pakistan Air Force. From January 1954 some of the assistant staff were supplied by the Royal Pakistan Air Force.

(b) **Far East area.**—*Ceylon.*—The Meteorological Office continued to provide a small forecasting unit at Negombo, basic data and technical assistance being obtained from the Ceylon Meteorological Service. An agreement was reached for the provision of assistant staff at Negombo by the Ceylon Meteorological Service.

Male.—Meteorological equipment, previously loaned to the synoptic and upper wind reporting station at Male, was transferred to the Maldivian Government.

Malaya.—The Meteorological Office was responsible for meeting the requirements of the R.A.F. in Malaya through offices at Changi, Tengah, Seletar and Butterworth. Routine wind observations by radar continued to be made from a site near Singapore with Army assistance until August 1953. The commencement of these wind observations by the Malayan Meteorological Service obviated the need for further observations by Meteorological Office staff.

Nicobar Islands.—A meteorological reporting station continued to be maintained at Car Nicobar.

Hongkong.—A small complement of Meteorological Office staff assisted the Royal Observatory in meeting the requirements of the Army and Royal Air Force. Forecasting facilities continued to be provided for the R.A.F. at Sekkong.

(c) **British West Indies.**—The British Caribbean Meteorological Service continued to be staffed mainly by Meteorological Office forecasters, although, in accordance with the policy mentioned in last year's Report, their replacement by forecasters of the Caribbean Meteorological Service had begun.

(d) **Falkland Islands.**—The Meteorological Office continued to maintain a radio-sonde/radar wind unit at Port Stanley.

(e) **Ascension Island.**—A pilot-balloon station, operated by staff of Cable and Wireless Ltd, was set up to make two upper air observations a day, and routine synoptic reports were increased in frequency to 4 a day at standard hours.

(10) Services in Foreign Countries

(a) **European area.**—*Germany.*—The Meteorological Office continued to be responsible for the provision of meteorological services in the British Zone of Germany to meet the needs of British Forces and of the High Commission.

The Chief Meteorological Officer 2nd Tactical Air Force continued to undertake the duties also of Chief Meteorological Officer 2nd Allied Tactical Air Force and of British representative on the Allied Meteorological Board under the General Committee of the Allied High Commissioner.

Close liaison was maintained with the Federal German Meteorological Service.

Austria.—A meteorological office was maintained at Schwechat (Vienna) during 1953 with a British meteorological officer in charge of Austrian staff. From January 1, 1954, the service was provided directly by the Austrian authorities under the supervision of the British meteorological officer.

(b) **Middle East area.**—*Libya.*—Technical control of meteorological services in Libya continued to be exercised by the Director of the British Meteorological Office through the Chief Meteorological Officer, Middle East Air Force. Meteorological Office staff continued to fill posts for which suitably trained staff of local origin were not available. Forecasting offices at Idris and El Adem were linked with small networks of reporting stations in Tripolitania and Cyrenaica, while forecasts at Benina airport were supplied from El Adem or Malta.

A radio-sonde/radar wind unit continued to be maintained at Benina.

Liaison was maintained with the World Meteorological Organization Adviser who was appointed to the Libyan Federal Government in November 1953.

Egypt.—The British Meteorological Office retained responsibility for the provision of meteorological facilities for the British Military Forces in the Canal Zone.

Sudan.—The Sudan Meteorological Service assumed responsibility for R.A.F. requirements at Khartoum early in 1954, and the Meteorological Office staff was withdrawn.

Jordan.—Reporting stations were maintained at Amman and Mafraq under the control of the main meteorological office at Habbaniya (Iraq). Limited forecasting facilities were provided at Amman early in 1954.

A representative of the World Meteorological Organization was appointed as technical adviser to the Jordan Government in November 1953, and discussions on general meteorological requirements in Jordan were held with him.

Iraq.—The Meteorological Office continued to maintain forecasting offices at Habbaniya and Shaiba, and a radio-sonde/radar wind unit at Habbaniya.

Close liaison was maintained with the Iraqi Meteorological Service.

Arrangements whereby our meteorological officers at Habbaniya and Shaiba covered meteorological requirements for civil aviation at Basra for part of the day ceased in December 1953, at the request of the Iraqi Government who expressed appreciation of the services provided. All requirements at Basra from the beginning of 1954 were met by the Iraqi Meteorological Service.

Persian Gulf.—The forecasting service and radio-sonde/radar wind unit at Bahrein and the reporting station at Sharja were maintained. The staff at Bahrein was increased in order to allow for the provision of a continuous 24-hour forecasting service to meet the requirements of civil aviation.

§ 3. CLIMATOLOGY AND MARINE AND AGRICULTURAL METEOROLOGY

The Climatology Division, situated at Harrow, is concerned with British Climatology (including the British Rainfall Organization), World Climatology, Agricultural Meteorology, and Upper Air Climatology, and includes the Meteorological Office Central Library (see p. 44). Marine Meteorology is the responsibility of the Marine Branch, also located at Harrow.

The Edinburgh office collects and stores climatological records (including rainfall records) made in Scotland, and maintains the library of the old Scottish Meteorological Society. It deals with meteorological questions concerning or arising in Scotland, and acts as the centre for the administration of the climatological stations in Scotland and of such telegraphic and auxiliary reporting stations as are not attached to airfields. The magnetic records of the geophysical observatories at Eskdalemuir and Lerwick are analysed and prepared for publication and discussed in the Edinburgh office.

(1) British Climatology

(a) Organization and functions.—The British Climatology Branch is charged with the supervision, including periodical inspection, of all voluntary climatological and rainfall stations in Great Britain and Northern Ireland; with collecting, summarizing, and preserving permanent records of surface observations; and with replying to climatological inquiries from the general public, commercial and industrial firms, and Government Departments.

(b) Stations.—There are five classes of stations contributing climatological observations, being the observatories and synoptic, crop weather, climatological and rainfall stations. Appendix III shows how these stations are distributed among the 14 regions into which Great Britain and Northern Ireland are divided for climatological purposes. During the year 30 additional climatological returns were received, while 9 stations ceased to report including Cullompton (Devon) and Hutton (Lancashire) which commenced reporting in 1880 and 1912 respectively. Interesting new stations include those at Herstmonceux Castle (Astronomer Royal) and at Slaidburn (Fylde Water Board).

All these stations provide observations at 0900 G.M.T., while the synoptic stations forward climatological returns for at least the main climatological hours 0300, 0900, 1500 and 2100 G.M.T. Some stations provide hourly summaries of wind, rainfall and sunshine, and frequency tables of intense falls of rain.

Climatological and rainfall stations are maintained by private observers, local authorities, universities and other educational establishments, industrial firms, trusts and Government Departments. Great public spirit is shown by those who participate in the operation of these stations, often at personal inconvenience because of the necessity for daily readings at fixed times throughout the year, whatever the weather. Some of the climatological stations make additional reports for daily issue to the Press under a Health Resorts Scheme, while some forward weekly returns to enable the climatic variations over the country to be followed week by week.

Consideration was given to the distribution of pressure-tube anemographs with the object of improving the network of stations for which continuous and representative records of wind are obtained and subsequently analysed. It was decided to equip those stations in the windier parts of the country with an extended speed scale.

(c) British Rainfall Organization.—This organization, which was taken over by the Air Ministry in 1919, collects all rainfall reports and data on the duration and intensity of precipitation, droughts and rain spells, evaporation and percolation.

(d) **Publications.**—*The Monthly Weather Report*, which contains full monthly and annual summaries of observations at synoptic and climatological stations, was issued regularly. The format of the annual summary to the *Monthly Weather Report* was revised.

British Rainfall.—The volume for 1951 was published in November 1953, that for 1952 was sent to the printers, and that for 1953 was being prepared.

(e) **Training.**—Two short courses for observers at climatological and health resort stations were arranged in October ; there was an attendance of 41.

(f) **Special work.**—The preparation of rainfall averages for the period 1916–50 was continued. Following the inclusion in the *Monthly Weather Report* in January 1953 of averages for temperature and sunshine for the new period 1921–50, station averages of atmospheric pressure at 0900 were calculated for the same period and used from January 1954.

There were consultations with representatives of the Medical Research Council, and the London School of Hygiene and Tropical Medicine in respect of mortality from respiratory disease during various temperature, humidity and visibility conditions.

Arrangements were made for hourly values of dry-bulb and wet-bulb temperature to be tabulated at a number of stations so that these could be analysed in due course, thus providing more satisfactory data for application to cooling-tower and air-conditioning problems in connexion with which many inquiries were received.

Records from the night-sky recorders, as published in the *Monthly Weather Report* Table III (a), were examined in detail and compared with hourly cloud and visibility observations.

Wind data and *Daily Weather Reports* were examined for as long a period as possible in order to advise Professor G. M. B. Dobson (as a member of the Waverley Committee) on any evidence for an increase in recent years in the frequency of strong winds over the North Sea likely to produce exceptionally high tides along our east coasts.

Hydrology.—The section working on hydrological problems maintained close contact with outside bodies, in particular with the Hydrological Research Group of the Institution of Water Engineers, the Ministry of Housing and Local Government, the Ministry of Agriculture and Fisheries (land drainage and River Board work) and the Road Research Laboratory of the Department of Scientific and Industrial Research (storm-water drainage).

Consultations with individual River Boards continued, and a number of them were advised about the extent of existing rainfall records in their areas and of any need for new observations. There was an increase in the information supplied regularly to River Boards.

Water-balance investigations were carried out for a number of catchment areas which are of importance for hydroelectrical or water-supply schemes. Greater use was made of the estimation from climatological data of evapo-transpiration losses.

There were discussions with the Road Research Laboratory of the Department of Scientific and Industrial Research and the Chief Engineer of the Ministry of Housing and Local Government with a view to securing more reliable information about rates of rainfall which might result in better designs of sewers.

Arrangements were made to take over the work of the Snow Survey of Great Britain which the British Glaciological Society had to discontinue following their annual report 1952-53.

Committees.—A representative of the British Climatology Branch served on the following committees :—

(i) Hydrological Research Group of the Institution of Water Engineers which prepared a hydrological symposium as reported in the *Journal of the Institution of Water Engineers* for May 1953, and an exhibition of hydrological instruments, in December 1953, in which the assessment of rainfall and evaporation was prominently featured.

(ii) Wind Power Generation Committee of the British Electrical and Allied Industries Research Association.

(iii) Hydraulics Committee of the Institution of Civil Engineers.

(iv) Study Committee on Basic Design Temperatures for Space Heating Installations of the Institution of Electrical Engineers, which prepared a report on the selection of external temperatures to be assumed in the design of space-heating installations in the United Kingdom which are designed for continuous operation.

(g) *Inquiries.*—As usual, a great many requests were received for climatological information in connexion with law cases, water supply and flooding problems, town planning, etc., and also with the work of industrial and research organizations, both within Government Departments and outside. The variety of inquiries which were dealt with is illustrated by the following selection of subjects for which data or advice were sought : fogs and danger to life, variations in week-end traffic in London, the effects of wind on passenger trains, the movement of sand dunes, causes of road accidents, damage to overhead conductors, deterioration of stored food and of electrical equipment, defective laying of wood-block floors and of variation in the consumption of gas and electricity ; meteorological aspects of the design of buildings, cooling towers, air-conditioning plants, street lighting and wind-screen wipers ; information for encyclopaedias and other books of reference ; medicine, oceanography, forestry, fire fighting ; safety in mines and entomology ; town and country planning and information to decide where to live or spend a holiday. Many of these inquiries involved considerable work and the presentation of data in a special form ; among such inquiries may also be mentioned the assistance given to the British Electricity Authority in designing suitable wind screens to protect high voltage insulators near the coast from salt spray during on-shore gales, and to local authorities in estimating the highest mean wind speed over one minute likely to occur in their areas in order to assess loads on buildings, etc., in accordance with the Model Byelaws, Series IV, Buildings, published by the Ministry of Housing and Local Government in 1952.

Rainfall data were supplied to Government Departments and to numerous engineering firms in connexion with water supply, drainage and hydroelectric schemes. In a number of cases in Civil Courts evidence was provided on aspects of climate or on particular weather records.

Monthly reports on the rainfall of the Thames and Lea Valleys were supplied to the Metropolitan Water Board and the Thames Conservancy and Lea Conservancy Boards. Weekly, quarterly and annual summaries of the weather were sent to the Registrar-General for England and Wales, and similar information was supplied for each quarter and for the year to the Government of Northern Ireland. Weekly summaries of the data from crop weather stations were prepared for circulation by the Ministry of Agriculture and Fisheries. Data for Northern Ireland were supplied regularly to the Irish Republic, on an exchange basis.

(2) World Climatology

The Branch dealing with World Climatology is responsible for collecting and summarizing climatological observations from a number of stations overseas, and for preparing reports, memoranda and tables on weather conditions in all parts of the world, for the use of Government Departments, industry and the general public as well as for research purposes.

(a) **Overseas stations.**—Stations in operation overseas at the end of 1953 numbered 76, distributed as follows: Europe 7, Africa 34, Asia 20, South America 1, Oceanic islands 14. Two new stations were opened in the Persian Gulf area while one station was closed in Ceylon. The manuscript returns from 6 stations in British West Africa and 10 islands in the Pacific Ocean were received by courtesy of the Directors of the British West African Meteorological Service and the Meteorological Service of New Zealand respectively.

“Notes on the meteorological observations in British Colonies and Protectorates, 1948” was published and issued with the reprints for that year. Copies of meteorological summaries for 1952 were received from 13 colonies; arrears were received from 8 colonies for 1951 and 6 colonies for 1949 and 1950.

(b) **Reseau Mondial.**—The material for the 1933 volume was prepared for printing and work was begun on the preparation of the 1934 volume.

(c) **Naval Handbooks.**—Work on the revision of the Mediterranean handbook was almost completed.

(d) **Falkland Islands and Dependencies.**—The survey of the meteorology in the region of the Falkland Islands and Dependencies, based on the observations during 1944 to 1950, was continued and the final chapters were prepared for publication.

(e) **Special Work.**—

(i) Lists of vapour-pressure data for about 4,500 stations over the world were completed in connexion with the preparation of world maps of vapour pressure; a full bibliography was also prepared.

(ii) A detailed analysis was completed of the diurnal and seasonal variation of associated dry-bulb and wet-bulb temperatures at Aden, Accra and Habbaniya.

(iii) A full investigation was begun for certain tropical stations of the humidity conditions at the times of maximum and minimum temperature and also of the temperatures associated with maximum and minimum relative humidity.

(iv) Work was begun on the preparation of world maps of average daily maximum temperature and average daily minimum temperature.

(v) Work continued on the revision of the mean surface wind charts for the world.

(vi) Data from the monthly CLIMAT broadcasts were tabulated and monthly charts plotted showing the mean pressure, mean temperature and total rainfall for the month, with their departures from normal.

(f) **Inquiries.**—Over 600 inquiries were received during the year, most of which came from industry. There was again a large demand for temperature and humidity data ; 3,300 tables of these elements, prepared in the Branch, were issued.

(3) Marine Meteorology*

(a) **Organization and collection of observations.**—*Voluntary observing ships.*—The Marine Branch has Port Meteorological Officers in London, Liverpool, Southampton, Cardiff and Glasgow, and Agents in the Forth, Tyne and Humber areas. (The Agency at the Forth was vacant in March 1954, but a new appointment was expected to be made shortly.) It is their duty to visit the masters and officers of merchant ships, to interest them in keeping meteorological records, to recruit them as voluntary meteorological observers, to instruct them as necessary in making the observations, and thereafter to re-visit the ships at regular intervals. They also issue meteorological instruments to certain classes of ships and inspect them as opportunity offers. During the year some 3,920 visits were made to ships by these officers.

The Voluntary Observing Fleet consists of the following classes of observing ships :—

(i) “ Selected ” ships which make meteorological observations four times daily (0000, 0600, 1200 and 1800 G.M.T.) on a world-wide basis, in accordance with arrangements made by the World Meteorological Organization and the International Convention for Safety of Life at Sea. Meteorological instruments, log-books and instructions for doing the work are supplied to these ships. The observations are transmitted by wireless in the international meteorological code to specified meteorological services in whatever ocean the vessel is situated. Approximately 500 British ships co-operate in this manner out of a world total of about 1,800 ships. Included in this figure are 11 British whaling vessels which were especially recruited for making meteorological observations in the Antarctic Ocean.

(ii) Supplementary ships which make and transmit their coded results by radio (using an abbreviated code) on a world-wide basis, in a similar manner to “ selected ” ships, four times daily. These ships are supplied

* See also §2(1)(c), p.6.

only with a mercury barometer, thermometers and screen, such instruments being sufficient for this limited reporting. The number of supplementary ships is approximately 54.

(iii) About 86 coasting vessels (MARID ships) which make observations of sea temperatures in home waters once daily, and transmit the coded results by radio-telephone to G.P.O. coast stations and thence to the Central Forecasting Office, Dunstable.

(iv) Thirteen light-vessels, which make observations of wind, waves, visibility and air and sea temperatures twice daily. The coded results of 11 of these vessels are similarly transmitted to Dunstable.

(v) Nineteen trawlers fishing in far northern waters make non-instrumental observations and send their coded messages by radio-telegraphy or telephony, as convenient, to British, Norwegian or Icelandic radio stations. Owing to physical difficulties, no record of these observations is required to be kept aboard the trawlers.

The meteorological observations made aboard all the above vessels, with the exception of trawlers, are recorded in special log-books and are forwarded to the Marine Branch for climatological analysis. There is evidence that the observations are, in general, made carefully and accurately by the voluntary observers aboard the ships and that the radio weather messages are regularly transmitted to the various authorities concerned. The log-books and messages from the ships are also, in most cases, prepared with great care, many of them containing interesting detailed observations of unusual meteorological and astronomical phenomena, as well as of oceanographical and ornithological subjects. On the average, some 115 log-books were received each month in addition to log-books and forms kept aboard Canadian and Norwegian ships. Among their other activities, certain "selected" and supplementary ships make observations of whales on behalf of the National Institute of Oceanography, and special radar observations are also made aboard "selected" ships equipped to do so.

In the latter part of 1953 the yacht *Petula* left Dakar towing a small locally built raft on a drift voyage to Barbados. The *Petula* was equipped as a "selected" ship for making and transmitting weather observations *en route*. The expedition reached Barbados in February 1954.

Dr. B. M. Cwilong's non-magnetic yacht *Princess Waimai*, engaged on a scientific voyage in the Atlantic and Pacific Oceans, was also recruited as a "selected" ship in October.

Ocean weather ships.—During the year each of the 4 British ocean weather ships completed 6 years' service. Station J (Juliatt), in position 52° 30' N., 20° 00' W., was manned on 352 days of the year, either by a British or a Netherlands weather ship; the station was vacated on 13 days due to landing sick members of the ships' companies to hospital at Londonderry. Station I (India), in position 59° 00' N., 19° 00' W. until 1200 G.M.T. on August 29, 1953, and subsequently in position 61° 00' N., 15° 20' W., was manned on 305 days by a British weather ship; although technically "on station" the ship was moved from 59° 00' N., 19° 00' W. to position 60° 47' N., 14° 01' W. for special purposes on a total of 31 days. Other absences amounting to 29 days were

occasioned by landing patients to hospital at Londonderry or Stornoway (10 days), search duties (7 days), late sailing of relief ship due to repairs (6 days) and return to Londonderry for repairs to radar (6 days).

As mentioned on p. 6 the weather ships carried out a full programme of meteorological work, including surface and upper air observations, which were transmitted to the Central Forecasting Office, Dunstable, by W/T. Search and rescue exercises were carried out, whenever practicable, in co-operation with aircraft of R.A.F. Coastal Command with the aim of keeping the ships' companies practised in search and rescue drill and organization. During these exercises mail, newspapers and urgently needed stores were dropped by the aircraft.

The weather ships' navigational aids are used regularly by both civil and R.A.F. aircraft flying over the North Atlantic; 8,422 aircraft made use of the facilities provided by the ships during the year. Radio contact was made frequently with ocean weather ships of other nations. Special arrangements were made for the ships to provide navigational aids to the British Overseas Airways Corporation aircraft carrying Her Majesty the Queen to Bermuda, to the aircraft conveying the Prime Minister to Bermuda and back, and to certain Canberra aircraft on transatlantic flights.

Special routine observations of the sea-water temperature gradient were made aboard O.W.S. *Weather Recorder* with a bathythermograph lent by the Admiralty. Observations were made twice daily when steaming and when on station down to a depth of 450 ft.

Observations utilizing a wave recorder, lent by the National Institute of Oceanography, were made regularly and satisfactorily aboard O.W.S. *Weather Explorer*.

Oceanographical work was carried out for the Ministry of Agriculture and Fisheries and the Fisheries Division of the Scottish Home Department. This included towing plankton recorders, taking samples of sea-surface water and jettisoning drift bottles. Since January 1, 1954, on behalf of the National Oceanographical Institute, plastic envelopes were jettisoned daily "on station" in connexion with an investigation into oil pollution.

Some special cinematograph observations of waves in rough weather alongside O.W.S. *Weather Explorer* were made from an R.A.F. aircraft for a special investigation being undertaken by the Imperial College of Science and Technology.

Magnetic variation swings were carried out "on station" by weather ships for the Hydrographic Department of the Admiralty.

O.W.S. *Weather Explorer* attended the Review of the Fleet by Her Majesty the Queen at Spithead on June 15, 1953. The master and officers of the ship acted as hosts to a number of guests from the Meteorological Office who witnessed the Review and the illuminations.

O.W.S. *Weather Recorder*, when on duty at station I, was appointed by the Oceanic Control to direct the search for a missing United States Air Force B.36 aircraft, followed by a lengthy search for survivors and wreckage. O.W.S. *Weather Observer* took over from O.W.S. *Weather Recorder* when she arrived on station.

Log-books and upper air data were received regularly from all four British weather ships and from the Netherlands weather ship when she operated at station J. Microfilmed copies were made and distributed to the other nations signatory to the North Atlantic Ocean Stations Agreement.

No major damage was sustained throughout the year by any of the four ocean weather ships, but O.W.S. *Weather Explorer* had her 16-ft. dinghy smashed beyond repair when the ship was hit by a heavy sea. Each British weather ship had a period in harbour for overhaul and repairs during the year.

(b) Analysis of observations.—Routine work during the year included :—

(i) Observations from log-books received from voluntary observing ships of Great Britain, British ocean weather ships and from Naval log-books were punched on to Hollerith cards. The total number of observations punched was 299,848.

(ii) Tabulations of all observations in the southern hemisphere made by British observing ships, totalling 53,900 observations, were supplied to the Massachusetts Institute of Technology for a special project, and since July replicas of these tabulations were also sent by request to the Union of South Africa. The large number of Hollerith cards which are available in the Marine Branch made possible the special climatological studies and investigations on a world-wide basis which were undertaken during the year.

(iii) Two consignments of approximately 5,000 Hollerith cards each were punched for the Ministry of Food to their requirements at the request of the Treasury.

(iv) Approximately 292,000 German cards were counted and sorted to refer to squares and months.

(v) Tabulation of swell and wind conditions in the southern North Sea was made by decades and months from the year 1920 to provide data requested by the Royal Netherlands Navy.

(c) Currents and ice.—The computation of data for the preparation of surface current charts of the North Pacific Ocean, eastward of longitude 160° W., was continued.

(d) Admiralty Pilots and charts.—The sections relating to surface currents were entirely re-written for new editions of six Admiralty Pilots required during the year, and generalized current charts were prepared for these where necessary. Sections relating to ice in three of these Pilots were also re-written. The meteorological sections of the six Pilots were revised by the World Climatology Branch and co-ordinated with the Marine Branch. Meteorological charts were prepared for these publications in the Marine Branch.

During the year a new request was received from the Admiralty to supply information relating to currents to be placed on the series of Admiralty Navigational Charts. Information for six of these charts was forwarded.

(e) Special work.—Meteorological and ocean-current statistics for ocean stations I and J in the North Atlantic Ocean covering the period April–December 1950 and the years 1951 and 1952 were prepared and distributed. The preparation of similar statistics for 1953 was started.

Work proceeded on investigations into the incidence and characteristics of temperature inversions at ocean weather stations in relation to the synoptic situation. A series of special observations was made aboard the ocean weather ships to determine errors of exposure of air thermometers, hygrometers and rain-gauges aboard ships. As a result of other investigations, modifications were made to the radar sets to improve accuracy. Trials were made with some success with a Dan buoy, associated with electrical resistance thermometers and attached to the ship, to determine whether this equipment can be used by ocean weather ships for the measurement of air temperature gradient near sea level in moderate or strong winds. Further sets of simultaneous wind measurements by radar were made by pairs of ocean weather ships when they relieved on station, as often as possible, as a check on errors of radio wind observations.

The editorial work on the new edition of the Greenland and Barents Sea Meteorological Atlas was completed.

Work proceeded on investigation into wave data and on the climatic fluctuation in the tropics.

Close co-operation, such as on the measurement of waves, was maintained between the Marine Branch and the National Institute of Oceanography, and much use was made of the records held by the Marine Branch in the problem of heat exchange between ocean and atmosphere.

(f) Inquiries.—Much information, including statistical tables and charts of marine data, was prepared for the Naval Weather Service, other Government Departments, scientific institutions and commercial firms. Examples of such information included the occurrence of thunderstorms at sea (for the World Meteorological Organization); wave statistics supplied to the United States Air Force and the Royal Netherlands Navy, Saunders Roe Ltd (flying boat constructors) and Lloyds Register of Shipping; and weather conditions at the time of collision between the two ships s.s. *Haiti Victory* and s.s. *Duke of York* (for the United States Coastguard Section).

Information was supplied to the Ministry of Transport and Civil Aviation for several formal investigations into serious shipping casualties. In three of these cases, the S.T. *Guava* inquiry in November 1953 and the S.T. *Sheldon* and S.T. *Beldock* inquiries in March 1954, the personal attendance of an officer was necessary. Further information was supplied prior to the appeal against the finding of the Court of Inquiry into the loss of the M.V. *Princess Victoria* which was heard in September 1953, and information was supplied for the formal investigation to be held into the losses of the steam trawlers *Michael Griffiths*, *Yew Valley* and *Island Magee*.

During the year over 90 inquiries necessitating certified statements of weather conditions were answered in addition to numerous telephone requests.

(4) Agricultural Meteorology

The Agricultural Branch is responsible for the application of meteorological knowledge to forestry, horticulture and agriculture; it is also responsible for collaboration in current research in these subjects.

(a) **Liaison with other organizations.**—Both by correspondence and personal visits, the normal liaison was maintained with officers of the Ministry of Agriculture and Fisheries, University faculties and County Institutes. There was a definite advance in co-operation with the Forestry Commission, the Royal Forestry Society and the Agricultural Land Service regarding demonstrations of shelterbelts and the planning of future planting. Help was also extended to the Nature Conservancy in relation to problems in their Nature Reserves.

The issue of weekly weather summaries to National Agriculture Advisory Service officials was continued, and a large programme of inspection of crop weather climatological stations was carried out. A number of observers from such stations attended a course at the Training School, and received instruction both on observational routine and on research problems.

A special 2-day course on agricultural meteorology was arranged in May at Bristol. This was very successful, and over 50 research workers attended. Half the course was repeated in January at Leeds. Individual lectures from this course were given at various places throughout the year, and formed the basis of a Meteorological Office discussion held in January. A paper on the effects of shelter was read to the British Association in September, and evidence was given to the Committee on hedgerow and farm timber on this topic. Contributions were made to many farming programmes broadcast by the B.B.C., and a talk was given on the Third Programme.

There was less opportunity than usual to give help at Agricultural Shows, but plans were made to co-operate in the demonstrations at the "Royal" at Windsor in July 1954.

(b) **Special work.**—The Head of the Agricultural Branch visited Cyprus in January at the request of the Colonial Office to examine and report on problems of agricultural meteorology in the Colony.

Special reports on the progress of work on the subject were submitted to the Provincial Directors of the National Agricultural Advisory Service, the Agricultural Improvement Council and the Meteorological Research Committee.

Collaboration with the Plant Pathology Laboratory was particularly successful. In a year when the potato blight disease reached serious proportions, forecasts of the onset, prepared with the help of meteorological observations, were extremely accurate. With a view to improving still further the efficiency of this service a detailed examination of past records was started, together with several field experiments.

Assistance was given in other current experimental work, notably that in connexion with protective cropping at the Experimental Horticulture stations of the Ministry of Agriculture. The wetness of the summer prevented any striking results being obtained from a series of irrigation experiments, but, despite the rain, increases in yield were obtained. The Meteorological Office was represented on a working party which was examining the question of water supplies for agricultural purposes.

Several discussions took place with the Central Forecasting Office on the subject of special forecasts for farming, and steps were taken to increase publicity of the existing services.

(c) **Inquiries.**—Many inquiries for climatological data in connexion with agriculture were dealt with; the subjects investigated included weather at harvest time, climate and the distribution and behaviour of reptiles, potential transpiration and irrigation planning, frost liabilities and methods of protection, rainfall in the east coast flood areas, the leaching of salts in the soil, air pollution, spells of dry weather, wind distribution in the British Isles, weather and the production of tree seeds, accumulated temperatures and food storage, and the effect of wind-born sea-salt spray on crops.

(5) Upper Air Climatology

The Upper Air Climatology Branch is concerned both with routine work and research. The routine work is chiefly the custody, scrutiny, summarizing and preparing for publication of the upper air observations from radio-sonde and radar wind stations manned by staff of the Office both at home and overseas. The research effort during the year was directed to the preparation of a memoir on the distribution of upper air temperature over the world and of its standard deviation, to a more detailed study of upper winds in all parts of the world with a view to the revision of *Geophysical Memoirs* No. 85 "Upper winds over the world", and to the study of special problems.

(a) **Collection and publication of observations.**—Monthly returns of daily observations made by radio-sonde and radar were received from 23 stations (including two ocean weather stations). Observations from three aircraft flights were also received as in the previous year, but wind observations by radar ceased from Singapore. The Office controls eight radio-sonde stations in the British Isles, seven in the Mediterranean and Middle East, two on ocean weather ships in the Atlantic, and one in the Falkland Islands. Returns from stations in the British Zone of Germany ceased with the returns for December 1952, except for radar winds at Iserlohn.

Returns of daily observations were received from Valentia, Nairobi, Hongkong, Lagos (Ikeja) and Khartoum through the courtesy of the Directors of the Meteorological Services concerned; those for Khartoum began in March 1953. Through the courtesy of the Director of the Meteorological Service of the Netherlands returns were also received from ocean weather station J during the period when it was manned by the Netherlands. Monthly returns of ozone observations at British stations continued to be received.

Arrangements were made for selected stations overseas, in regions where pilot-balloon observations can usually be made to considerable heights and where radar winds are not available, to send returns of these observations from January 1, 1954.

The forms and Hollerith cards for recording radio-sonde data remained essentially unchanged during the year, but a modification was made in the method of entry of discontinuities of wind. The punching of Hollerith cards continued at Fazakerley, though towards the end of the year consideration was given to the transfer of the work to Harrow.

As part of the arrangements made in May 1953 for a "pool" of Hollerith operators to be established at Harrow, administered by the Marine Branch, two machine operators were detailed for upper air work. The Hollerith tabulator and sorter were in regular operation throughout the year, and routine

summarizing of monthly data for all stations for 1952 and for the first few months of 1953, apart from some data for ocean weather stations, was completed. Only minor modifications of the methods devised for routine observations were found necessary.

The publication of summaries of radio-sonde observations and radar wind measurements in "Upper air data for stations maintained by the Meteorological Office" continued. Part 4 (Malta) was sent to the printer in June 1953, and Part 5 (Aden) in November 1953.

Consideration was given to proposals for the publication of monthly summaries of upper air data in conformity with Resolution 41 of the fourth meeting of the Executive Committee of the World Meteorological Organization.

The tabulation and plotting of CLIMAT TEMP broadcasts were continued, and the broadcast data were supplemented by additional information where possible. By the end of the year charts had been drawn up to March 1953.

(b) Special work.—*Upper air temperature and standard deviations.*—The provisional text of the proposed memoir was drafted and minor amendments were made to the charts, but work was considerably delayed through staff shortage. A preliminary study was made of the distribution of extreme temperatures, and cross-sections were drawn of the temperature distribution along selected meridians.

Tropopause.—Charts were compiled of the average pressure and temperature of the tropopause over the world. Special studies were made for regions in the tropics and subtropics where two tropopauses are observed, with a view to testing the validity of new definitions of the tropopause.

Upper winds over the world.—Data for the revision of *Geophysical Memoirs* No. 85 were received from several overseas services, and some progress was made with the compilation of the data.

Upper winds in the tropics and subtropics.—The summarizing of high-altitude winds in the tropics and subtropics was continued. Special studies were made of vector mean winds at stations in the Mediterranean and Middle East, and of the structure of the belts of strong westerly winds which are present in the upper troposphere in latitudes 20° to 35° N. in winter and spring. A member of the Branch attended the Joint Meeting of the Royal and American Meteorological Societies at Toronto in September 1953, and presented a paper summarizing recent knowledge of winds in the upper troposphere.

Stratospheric-tropospheric relations.—Further statistics were computed of the relationship between stratospheric temperatures and tropospheric parameters. The closeness of the relationship decreases with height in the stratosphere over Great Britain, but much more quickly in winter and spring than at other seasons.

(c) Inquiries.—Inquiries were received for many types of upper air data: temperature, wind, heights of isobaric surfaces, tropopause, humidity, air density, and many involved extensive computation. In general, demands were for data for levels above 30,000 ft. In response to a request from the Australian Meteorological Service duplicates of Hollerith cards giving wind data for about three years' observations in the Falkland Islands were supplied.

§ 4. RESEARCH AND DEVELOPMENT

(1) Co-ordination of Research

(a) **Meteorological Research Committee.**—The programme of meteorological research conforms with the recommendations of this Committee (see p. 2) which was established for the purpose in 1941. Two meetings of the Committee were held during the year to review progress and discuss requirements.

Since 1948 the more detailed work of the Committee has been done largely through three Sub-Committees, each dealing with problems in a particular field and each including members of the main Committee, together with outside specialists, representatives of interested organizations and of the Meteorological Office. The Chairmen of these Sub-Committees at the end of the year were :—

| | |
|---|---|
| Instruments development | Prof. P. A. Sheppard |
| Synoptic and dynamical research | Sir Charles Normand |
| Physical research | Dr. T. W. Wormell (in succession to Dr. O. G. Sutton) |

Eleven meetings of the Sub-Committees were held to consider the results of research, to review progress and to make recommendations to the main Committee. Sixty papers and reports were dealt with. Approved papers were made available to other institutions and individual workers. A number of the papers were communicated to a scientific society or journal, or will receive official publication.

The greater part of the investigations with which the Committee is concerned is undertaken within the Meteorological Office. The number of staff available for this purpose remained almost unchanged, despite the many other commitments of the Office. Valuable collaboration was again received from research establishments of the Ministry of Supply and the Clarendon Laboratory, Oxford, in the perfecting of specialized equipment. Arrangements were made for financial support to be given to the Imperial College of Science and Technology for the investigation of the disturbance of air flow by hills and mountains, and to Cambridge University for the laboratory investigation of a problem of turbulence related to convection in the atmosphere.

The Committee set up in 1949 by the Meteorological Research Committee and the Aeronautical Research Council to promote the investigation of gusts in relation to aeronautics, met twice during the year.

(b) **Collaboration with the Royal Society.**—As for several years, the Gassiot Committee of the Royal Society, assisted by a grant from Air Ministry funds, continued to sponsor long-term research into the properties of the high atmosphere and studies of atmospheric radiation. The broad divisions of the programme are

- (i) the measurement of atmospheric ozone and other gases, and their relation to meteorological conditions
- (ii) laboratory and theoretical studies directed towards obtaining basic data necessary for the interpretation of atmospheric phenomena
- (iii) chemical investigation of samples of stratospheric air obtained by rocket ascents in the United States
- (iv) observation of air glow and auroral phenomena.

Work on different aspects of these problems was in progress at several universities. The measurement from an aircraft of the infra-red absorption of solar radiation by gases in the stratosphere, which was initiated at Cambridge University, was continued by the Royal Aircraft Establishment, South Farnborough.

Measurements of atmospheric ozone at a network of stations in western Europe and adjacent areas, organized from Oxford to increase knowledge of the circulation in the stratosphere were continued. Chemical measurements of ozone, commenced in 1952 on aircraft ascents to 12 or 15 Km. by the Meteorological Research Flight, provided valuable information on the height variation of ozone concentration.

A conference on high atmospheric research by means of rockets was held in Oxford in August 1953 under the auspices of the Gassiot Committee. A delegation from the United States Rocket Research Panel described the methods developed and results obtained since 1946. Consideration was given to the practicability of similar research by the British Commonwealth.

(c) Other activities.—The Meteorological Office is represented on the British National Committees for Geodesy and Geophysics and for Scientific Radio, the Gassiot Committee of the Royal Society, the Gust Research Committee of the Aeronautical Research Council and the Meteorological Research Committee, the Air Navigation Committee of the Aeronautical Research Council, the Atmospheric Pollution Research Committee, the Road Research Laboratory Joint Committee on Soils and on several other scientific committees of Government Departments and other bodies. During 1953 members of the Meteorological Research Committee and the Meteorological Office had opportunity to discuss, in Canada and the United States, some of the meteorological research in progress in those countries.

A number of university students of physics or mathematics were attached, during the summer vacation, to research centres of the Meteorological Office to gain acquaintance with the problems under investigation.

(d) Research programme.—The chief items to receive attention, and on which work is continuing, are summarized below. Several include a number of separate investigations.

(i) Development of aircraft thermometers and hygrometers, if possible with automatic recording suitable for high-speed jet aircraft.

(ii) Further development of radio and radar techniques for the measurement of wind, temperature and humidity to heights of 60,000 ft. and above.

(iii) Dynamical, statistical and synoptic investigations in relation to the improvement of the technique of forecasting for a day or two and for longer periods.

(iv) Numerical solution of the dynamical equations in specified situations and the application of computing machinery to forecasting problems.

(v) Formation, persistence and dispersal of radiation fog and visibility in relation to aircraft operational problems.

(vi) Physical processes of cloud and precipitation together with the meteorological factors affecting ice accretion on aircraft.

(vii) Temperature and humidity structure of the upper troposphere and lower stratosphere in various situations and further examination of the circumstances affecting the formation of condensation trails.

(viii) Various problems associated with the operation of high-level high-speed aircraft.

(2) Instrument Development

The Instrument Development Division is situated at Harrow. There is one Branch devoted to general instruments and a second to radio-sonde and aircraft instruments. The Branch concerned with the provisioning, accounting, testing and calibrating of instruments is also controlled by the Assistant Director (Instrument Development); its work is described on p. 43. The Division gave technical advice and assistance in connexion with many special investigations, including expeditions by sea and to Greenland and Everest, undertaken by other Government Departments, the universities, and commercial and industrial concerns.

(a) **General instruments.**—Considerable progress was made in the design of an instrument, using a searchlight with a modulated beam, for measuring the height of the cloud base by day. Further modifications were also made to the pulsed-light method in order to make it satisfactory for use with low cloud.

Work continued on instruments for measuring rainfall at sea, and also for measuring extreme rates of rainfall, especially for investigations in connexion with drainage.

A self-contained transportable meteorological office, for field use, was designed, and construction of the first experimental model was almost completed.

Instruments in routine use on which important modifications were made include the Kew barometer, the marine barograph, anemometer towers, the humidity slide-rule and the hand-aspirated Assmann psychrometer.

(b) **Aircraft instruments.**—An electrical thermometer was designed for the accurate measurement of air temperature from high-speed aircraft. By restricting its measuring element to part of the surface of a small-angle cone, a constancy of the speed-correction coefficient from Mach number 0·3 to 0·9 inclusive was obtained.

A fully automatic frost-point hygrometer was constructed in which the thimble for the frost deposition has negligible thermal inertia. This was achieved by using a platinum film baked on a ceramic glaze on a platinum disc. The development of the frost-point hygrometer using polarized light was also continued.

(c) **Radio-sonde and radio instruments.**—The installation of the radar-sonde theodolite ground equipment at Crawley reached the stage of flight trials with an airborne transponder. The design of the sonde and meteorological units for measurement of pressure, temperature and humidity was completed.

A series of trials of the light-weight sonde was made under operational conditions at sea, with satisfactory results.

An investigation of radiation and lag errors of the Mk II radio-sonde was completed. The results will enable corrections to be applied to temperature

observations. They account for observed day and night temperature differences up to 15 Km.

Improvements were made to the radar equipment used for upper wind observations at land stations and on the ocean weather ships, which are expected to increase the accuracy of the observations.

(3) Forecasting Research

The Forecasting Research Division is accommodated at the Napier Shaw Laboratory, Central Forecasting Office, Dunstable. Its main activities may be sub-divided as follows :—

(a) Research on short-period forecasting (up to 24 hours ahead).—

(i) A method was developed using electronic calculation to enable an approximation to the synoptic situation 24 hours ahead to be computed from the current observations. Only a few such calculations were completed by March 1954, but the results are encouraging.

(ii) The study of winds at levels from 30,000 to 50,000 ft. was continued with a view to improving the methods of forecasting winds at these levels. A study of the apparent diurnal changes of pressure and wind at these high levels was begun in order to eliminate some spurious variations from charts of high-level winds.

(iii) The analysis of some 40 flights by the Meteorological Research Flight through fronts and jet streams was completed. These flights emphasized the great variations in atmospheric conditions near fronts. Theoretical and synoptic studies of fronts were continued.

(iv) Statistical synoptic investigations were continued regarding the distribution of rainfall from depressions and fronts and regarding the occurrence of low stratus cloud.

(b) Research on medium-range forecasting (up to 4 days ahead).—Statistical studies of the distribution of cold pools and the behaviour of long waves in the westerlies were continued to provide an aid to the preparation of experimental forecasts for 4 days ahead now carried out in the Forecast Division.

(c) Development of medium-range forecasting.—The experimental forecasting of the general character of the weather for an extended period of about 4 days ahead was maintained by the Forecast Division. This work was taken over from the Forecasting Research Division in December 1952 with the aim of developing the techniques and applying them to operational requirements. However, operational forecasts for extended periods are not yet issued except to a small number of specialist users.

(d) Research on long-range forecasting (beyond a period of a few days ahead).—Fundamental research into the possibility of long-range forecasting was commenced. The problem is a difficult one and much observational material must be collected and analysed ; progress is therefore likely to be slow. The first problem was to determine the duration and extent of the weather anomalies which are most likely to be amenable to forecasting. This was begun. An empirical study was also made of wet and dry spells in the autumn

in order to determine whether spells of dry weather in south-east England are associated with abnormal conditions elsewhere in the hemisphere. Such studies may help to locate the physical causes of long-period weather anomalies.

(4) Research in Physical Meteorology

Some of the main activities are mentioned below.

(a) Cloud and precipitation.—

(i) The cloud-exploration flights carried out by the Meteorological Research Flight to obtain measurements of the drop-size distribution, liquid-water content, temperature, vertical motion and the nature of particles within clouds continued. An interim report on cumulus exploration was written and discussed, and a comprehensive report was in course of preparation. During several of the flights concurrent radar observations of the cloud under exploration were made by the Meteorological Office radar station at East Hill. Particular attention was paid to investigating the possibility that widespread precipitation may originate in isolated cells within a continuous cloud sheet.

(ii) A study of cirrus observations made during high-level flights by the Meteorological Research Flight provided valuable statistics regarding the occurrence, height and temperature of cirrus cloud. Some relations with the general synoptic situation were suggested, and additional observations of cirrus, which will be used to study these relations further, were collected by a unit of the Royal Air Force.

(iii) A series of flights through fronts by the Meteorological Research Flight showed that no simple model is adequate to describe the complexity of the atmosphere in the vicinity of fronts. Although a sloping zone of horizontal temperature usually exists, it is related in no simple way to the distribution of cloud and precipitation.

(iv) The prediction of the length and persistence of condensation trails, mainly from piston-engined aircraft, was considered in a series of three reports, one of which treated the matter as a problem of diffusion. Since the acquisition of a Canberra by the Meteorological Research Flight the problem of condensation trails from jet aircraft is being actively pursued.

(v) An investigation into the accuracy of short-period forecasts of precipitation, based on the movement of associated weather echoes, was started at East Hill. The information derived will help in the assessment of the operational value of radar for short-period forecasting.

(b) **Ice accretion on aircraft.**—Measurements of the rate of icing made in the cloud-exploration flights carried out by the Meteorological Research Flight, together with reports received from the Royal Air Force and civil aircraft, are being analysed. A refrigerated rotating-disc icing meter was built and wind-tunnel tests of it started.

(c) **Turbulence in cumulonimbus cloud.**—A comprehensive report on turbulence within cumulonimbus cloud was prepared from data obtained during further flights by a Meteor aircraft (of the Royal Aircraft Establishment) which was controlled by the East Hill radar station. This phase of the work in the United Kingdom was completed.

(d) Turbulence in clear air.—The motion of smoke puffs fired by aircraft of the Meteorological Research Flight at levels up to 40,000 ft. was observed in the camera obscura at East Hill, and provided statistical information on wind fluctuations over time intervals of up to 100 sec.

In order to study the fluctuations of upper winds during longer time intervals, trials were started with strips of metal foil followed by radar. This method has the advantage that trials do not have to be restricted to cloudless skies.

(e) Turbulent transfer near the surface of the earth.—

(i) The Meteorological Office unit at the School of Agriculture, Cambridge, completed an analysis of some fifty field experiments over short grass in an open exposure at Cardington. The data obtained included simultaneous observations of the vertical profiles of humidity, temperature and wind, measurements of the aerodynamic drag at the earth's surface and water losses from soil samples. The analysis suggested that the eddy coefficients of water vapour, heat and momentum were approximately equal under all conditions of stability, and showed that natural evaporation from a closely cropped grass surface could be obtained from the equations of turbulent transfer.

(ii) Apparatus was constructed to investigate sub-surface temperatures below various natural cropped surfaces.

(iii) Other aspects of turbulent transfer near the ground were under investigation at Kew Observatory (see p. 36).

(f) Upper troposphere and lower stratosphere.—

(i) Frequent flights were again made by the Meteorological Research Flight to measure humidity, temperature, and on occasions ozone, at a series of levels up to the lower stratosphere. The replacement of a Mosquito aircraft by a Canberra aircraft toward the end of 1953 enabled the explorations to be extended from a height of 12 Km. to 15 Km.

(ii) At the request of Professor G. M. B. Dobson, chemical measurements of ozone were made on 17 ascents to about 12 Km. and once to 15 Km. It is found that about 8 per cent. of the total ozone is below 12 Km. in this country, that the concentration only increases slowly (and often irregularly) with height, and that contrary to expectation no marked increase is found on crossing the tropopause.

(iii) The first of a series of measurements of long-wave radiation at night in an aircraft up to an altitude of 12 Km. was made at the request of the Clarendon Laboratory, Oxford.

(g) Radiation fog.—Observations to assist in the study of factors which determine whether or not fog will develop on apparently favourable occasions were continued. On radiation nights measurements of temperature, humidity and wind speed were made at intervals of height up to 2,000 or 3,000 ft. Visibility, temperature within the ground and dewfall were recorded, and measurements were also made of the density of fog at various levels above the ground. An analysis of these observations was begun.

(5) Work of the Observatories and Geophysical Research

(a) **Kew Observatory.**—*Meteorological observations and records.*—Autographic records of atmospheric pressure, dry- and wet-bulb temperature, wind, rainfall, sunshine and evaporation, together with standard measurements of certain of these elements and of grass minimum and earth temperature, cloud, visibility, and weather, were maintained according to normal procedure. A night-sky recorder was operated regularly. Records of atmospheric pollution were obtained from an Owens automatic filter and from a Department of Scientific and Industrial Research smoke filter.

Tabulations were prepared for the *Observatories' Year Book* and other official publications. To meet the needs of many inquirers it was found convenient to distribute a weekly statement of observations.

Measurement of solar radiation.—Continuous records of solar intensity at normal incidence, total and diffuse radiation on a horizontal surface and illumination of a horizontal surface were maintained. The properties of the solarimeters were examined, and the effect on the records of imperfect exposure were reconsidered. Some minor changes in the methods of tabulation were made as a result of this work, and small corrections were applied retrospectively to mean values which had been computed from the first five years' tabulations. Analysis of these tabulations, which is expected to yield useful information on the transmission of solar radiation in a polluted atmosphere, proceeded slowly. Further small modifications were made to the bimetallic actinograph, and preparation of a specification for its manufacture started. One of these instruments was on loan to a glaciological expedition operating on the Baffin Island ice-cap, and gave very satisfactory service. A paper on the modified bimetallic actinograph was prepared for publication.

Atmospheric electricity.—Continuous photographic records of the electrical potential gradient were obtained. Measurements of the potential gradient and the air-earth current were made on suitable days.

Seismology.—The Galitzin seismographs (two horizontal components and one vertical component) and the short-period vertical component instruments gave satisfactory records. The *Monthly seismological bulletin*, which is widely distributed to other institutions, included particulars of 423 earthquakes recorded at Kew, the epicentres of 99 being determined. Copies of seismograms were supplied at the request of several observatories in other countries.

The staff of the *International Seismological Summary* continued to be accommodated in the Observatory.

Other investigations.—Investigation of the short-period variations of wind and temperature near the ground continued, apparatus capable of recording fluctuations of period less than 1/50 sec. being successfully brought into use. Analysis of records obtained with this equipment is tedious, but the results confirmed previous work at lower resolving power. The position in March 1954 was that the vertical convective heat flux computed from the simultaneous wind and temperature records was consistently found to be about half that computed from the energy balance at the ground. The investigation is continuing. It is hoped that further insight will result from a series of field experiments to be undertaken in an open situation at Cardington during 1954. The power spectra of the fluctuations of horizontal and vertical wind were

computed for one of the high resolution records, confirming and extending previous results. The possibility of speeding this work by machine computation was investigated. Apparatus was set up for the determination of the components of the heat balance at a surface of short grass over a period of about a year. Recording commenced in May 1953. In connexion with this, the calibration of heat flux meters for use in the ground was investigated.

Miscellaneous.—A new central heating system and new electric supply wiring were installed. The workshop was re-equipped with machine tools. Workshop assistance was provided to other parts of the Meteorological Office.

A large number of inquiries from individuals and institutions was dealt with. Visitors included several from other countries.

(b) Meteorological Office, Edinburgh.—Research on aspects of geomagnetic disturbance continued. Papers on geomagnetic and ionospheric relationships and on a universal time component in magnetic disturbance were published in the *Journal of atmospheric and terrestrial physics*. Papers were also prepared on the relations of magnetic disturbance to variations in the value of the geomagnetic field in different latitudes, and on the recovery phase of the magnetic field after a period of disturbance.

In conformity with the arrangements of the International Association of Terrestrial Magnetism and Electricity, the three-hourly indices of magnetic activity, K , for Eskdalemuir and Lerwick, together with modified K figures used in evaluating a planetary index of magnetic disturbance, were forwarded regularly to De Bilt. The K indices are published in the *Journal of atmospheric and terrestrial physics*. Information on magnetic "sudden commencements" and "sudden impulses", and on the magnetic effects of solar flares was also supplied to De Bilt for publication in analyses of these phenomena throughout the world.

Assistance was given in Edinburgh and at Eskdalemuir Observatory to an officer of the Irish Meteorological Service concerned with the extension of the magnetic work at Valentia Observatory.

(c) Eskdalemuir Observatory.—*Meteorological observations and records.*—The normal instrumental and other observations were made for synoptic and climatological purposes. Autographic registration of atmospheric pressure, dry- and wet-bulb temperature, wind, rainfall and sunshine was maintained. A night-sky (pole-star) recorder continued in operation. Hourly values of the meteorological elements were tabulated.

Records of atmospheric pollution, by smoke filter, were obtained for the Director of Fuel Research, Department of Scientific and Industrial Research.

Solar radiation.—Total radiation received on a horizontal surface was recorded throughout the year, and diffuse radiation from June 1953 (after repair of the instrument).

Atmospheric electricity.—Continuous photographic records of electrical potential gradient were maintained and standardized by absolute measurements made at one metre above the ground at regular intervals of time. The electrometers used were calibrated.

Terrestrial magnetism.—Absolute observations of the magnetic elements were made thrice weekly or more frequently. Magnetic declination was measured with a Kew-pattern unifilar magnetometer. Horizontal force was determined with a Schuster-Smith coil magnetometer until August 1953, and after modification of the potentiometer and re-calibration of the standard cells again in March 1954: in the interim the quartz-fibre magnetometers Q.H.M. 119 and 120 were used. The Schulze inductor used for measurement of magnetic dip was sent for overhaul in March 1954. The balance magnetometer B.M.Z. 35 was in use from August 1953 and B.M.Z. 53, lent by the Department of Geodesy and Geophysics, Cambridge University, was brought into use in March 1954.

Declination, horizontal force and vertical force were recorded continuously by two sets of la Cour magnetographs, ordinary-run and quick-run. The orientation of the magnet of the standard horizontal force variometer was checked in July 1953. All magnetic storms were recorded satisfactorily.

The records were tabulated in preparation for inclusion in the *Observatories' Year Book*. Daily magnetic character figures and also three-hourly indices, *K*, of disturbance were assigned. As for several years, hourly values of declination were contributed weekly to the *Colliery guardian* and the *Iron and coal trades review*. Copies of the photographic magnetic records were supplied on request to the National Coal Board, to De Bilt and other institutions. Notification of magnetic disturbance exceeding certain limits was sent to the Radio Research Station at Slough, the Marconi Company at Chelmsford and the Cavendish Laboratory at Cambridge.

(d) *Lerwick Observatory.*—*Meteorological observations.*—Full hourly synoptic observations were made and transmitted by teleprinter to the Central Forecasting Office, Dunstable. Autographic records were maintained and climatological tabulations prepared.

Records of atmospheric pollution were obtained for the Director of Fuel Research, Department of Industrial and Scientific Research.

The upper air programme was unchanged, with radio-sonde ascents daily at 0200 and 1400 G.M.T., and radar wind measurements at 0200, 0800, 1400 and 2000 G.M.T. No radio-sonde ascent was missed, and the average level to which temperature was measured was 77 mb. (about 60,000 ft.). Unserviceability of ground radar equipment caused a 11 per cent. reduction in the number of wind soundings.

Solar radiation.—Records of total and diffuse radiation were obtained throughout the year, and hourly values were tabulated.

Ozone.—Measurements of the total amount of atmospheric ozone, using a Dobson spectrophotometer, were made twice daily from March to October, and once daily from November to February, but limited to occasional direct sun observations at noon for a few weeks around the winter solstice.

Terrestrial magnetism.—Absolute measurements of the magnetic elements were made thrice weekly, using a Kew-pattern unifilar instrument for declination, a Smith coil magnetometer (and also a Q.H.M. instrument) for horizontal force, and a balance magnetometer B.M.Z. for vertical force.

Continuous photographic registration of declination and of horizontal and vertical force was maintained by two sets of la Cour magnetographs, standard and quick-run. Supplementary records were obtained from less sensitive variometers. Hourly and other values were measured from the records. Daily magnetic character figures and three-hourly range-indices, *K*, were assigned.

Aurora.—Regular watch for auroral display was kept in the winter period September to April, but cloud seriously reduces the opportunities for visual observation of aurora at Lerwick.

Atmospheric electricity.—Autographic records of electrical potential gradient were obtained with the Benndorf electrograph. The records were standardized by measurement of the electrical potential at one metre above the ground in the open.

Miscellaneous.—Apparatus for recording the field strength of V.H.F. radio signals was kept in operation for the British Broadcasting Corporation.

(6) Special Investigations

The continued discussion of the suitability of Gatwick as an alternative airport to London resulted in many requests for meteorological information, both about Gatwick and about comparisons between Gatwick and various other airfields in south-east England.

A steady flow of requests for information about wind and temperature in connexion with the operation of civil aircraft continued.

§ 5. ORGANIZATION

(1) Structure

(a) **Headquarters**.—The administrative headquarters of the Meteorological Office is situated in Victory House, Kingsway, London, W.C.2. Here are accommodated the Director, Principal Deputy Director, Deputy Director (Services), Deputy Director (Research) and some of the Assistant Directors and Heads of Branches, with their staffs. The Headquarters structure is shown in Appendix I, and a list of the Directorate and Heads of Branches in Appendix II.

(b) **Branch Meteorological Office, Edinburgh**.—No important change in organization was made during the year (see p. 37).

(2) Staff

(a) **Director of the Meteorological Office**.—On August 31, 1953 Sir Nelson Johnson, K.C.B., relinquished the office of Director which he had held since 1938. He was succeeded on September 1, 1953, by Dr. O. G. Sutton, F.R.S.

(b) **Retirements**.—Further changes in the Directorate resulted from the retirement of Dr. A. H. R. Goldie, C.B.E., on May 4, 1953 and Mr. E. G. Bilham on May 31, 1953. Dr. Goldie was succeeded as Deputy Director (Research) by Dr. R. C. Sutcliffe, O.B.E., and Mr. Bilham's post as Deputy Director (Forecasting) was filled by Mr. S. P. Peters. The year saw the retirement of Mr. M. T. Spence, O.B.E., Assistant Director for Personnel, and Mr. C. S. Durst, O.B.E., Assistant Director for Special Investigations, but both these officers remained with the Office in a temporary capacity.

(c) **Complements.**—During the year there was some reduction in the requirement for staff, due partly to the closing of some Flying Training Command stations. The office was still seriously below strength in March 1954 in Scientific Officers, and recruiting visits were made to a number of universities in order to attract candidates to the 1954 Open Competition of the Civil Service Commission. The rate of resignation of Assistants continued to be high, and with some decrease in the number of new applicants accepted the general deficiency of trained staff showed no improvement on that of the previous year.

Two meteorologists in the Experimental Class were promoted to Senior Scientific Officer, but no outside candidates satisfied the Civil Service Commissioners. The deficiency in the Scientific Officer class on March 31, 1954, was 22. Fifteen appointments were made to the grade of Assistant Experimental Officer, 11 of the successful candidates being Assistants already in the Meteorological Office. Establishment was granted to 41 Assistants, nearly all of whom already held temporary appointments in that grade.

The continued change in the composition of the Assistant Grade is illustrated by the following table :—

| | 1952-53 | 1953-54 |
|--|---------|---------|
| Number of airmen meteorologists not accepting appointments as civilian assistants on completion of National Service.. .. . | 61 | 32 |
| Resignations and other losses of assistants .. | 191 | 185 |
| Total losses | 252 | 217 |
| Number of assistants recruited throughout the year | 289 | 183 |
| Number of assistants still under training on March 31, 1953 | 83 | 81 |

(d) **Strength of staff.**—The strength of staff at March 31, 1954, is shown in the table below.

For the purpose of comparison the strength for a year ago is also given.

| | March 31, 1953 | March 31, 1954 |
|--|-------------------|-------------------|
| Scientific Officers | 162 | 155 |
| Experimental Officers | 658 | 656 |
| Nautical Officers | 8 | 8 |
| Assistants (Scientific) | 1477* | 1,456** |
| Ocean Weather Ship Staff (Nautical Grades) | 37 | 37 |
| Signals Grades | 206 | 208 |
| Radar Maintenance Grades | 52 | 53 |
| Clerical and Typing Staff | 102 | 99 |
| Miscellaneous (non-industrial) | 38 | 38 |
| Miscellaneous (Industrial) | 191 | 199 |
| Locally entered employees (overseas) .. | 186 | 188 |
| Total | 3,117 | 3,097 |

* Includes 222 airmen meteorologists. ** Includes 216 airmen meteorologists.

(e) **Uniformed personnel.**—The strength of the Meteorological Section Royal Air Force Volunteer Reserve on March 31, 1954 was 106 officers and 45 airmen and airwomen showing a gain of 2 officers and a loss of 2 other ranks. Of these 92 officers and 42 other ranks were qualified to perform duties appropriate to their ranks.

Reservists again gave valuable assistance during their training in filling posts vacant owing to leave or other absence of Meteorological Office staff. 29 officers and 6 airmen participated in major air exercises, and 26 officers completed between them 387 days of training additional to statutory requirement. For the first time reservist officers were posted overseas for training. During a Royal Air Force Exercise the Chief Meteorological Officer and one other officer were attached to the Coastal Command Squadron which operated from Montijo, Portugal. Four officers were attached to Squadrons of the Royal Air Force in Germany.

Courses of instruction in higher forecasting at the Meteorological Office Training School were given to 18 officers as part of their training. An initial forecasting course was also arranged for 6 officers who had little or no previous forecasting experience.

Officers continued to undertake week-end roster duties to provide a meteorological service for the Royal Auxiliary Squadrons at Biggin Hill, North Weald and Thornaby.

National Service airmen.—The number of airmen serving in the trade of Meteorologist on engagements under the National Service Acts, was 216 on March 31, 1954. They were held against a block establishment of airmen assistants.

Class "H" Reservists.—There was a steady flow of released National Service airmen into the Reserve, and during their annual training they filled assistant posts in many meteorological offices. Of these reservists 43 were allocated for training during the major air exercises of the year. Numbers on strength are as follows :—

| Year of release | Meteorological Office staff | Former Meteorological Office staff | Total |
|-----------------|-----------------------------|------------------------------------|-------|
| 1950 | 34 | 40 | 74 |
| 1951 | 53 | 56 | 109 |
| 1952 | 73 | 73 | 146 |
| 1953 | 68 | 38 | 106 |
| 1954 | 21 | 3 | 24 |
| | — | — | — |
| Total | 249 | 210 | 459 |
| | — | — | — |

Air Meteorological Observers.—No change in organization was made during the year but consideration was given to ways of increasing the number of suitable recruits, which was disturbingly low.

(f) **Training of staff.**—The Chief Instructor, Training School, is responsible for the training of staff in meteorological duties. He is also responsible for arrangements by which staff are encouraged to undertake external study in subjects related to their work.

The only change made during the year was the addition of a refresher course at the Training School for Senior Scientific Officers. It provided theoretical and practical instruction in some aspects of modern synoptic meteorology and reviewed the current work of the research branches of the Office. Seven Senior Scientific Officers attended for four weeks.

Course for Scientific Officers.—This lasts for four months. During the year training was given to two officers.

Initial course for Forecasters.—This course is designed for newly appointed Assistant Experimental Officers. It lasts for 12 to 15 weeks according to previous synoptic experience, and provides instruction in the basic principles of meteorology and training in forecasting. Four courses were held for 40 trainees.

Advanced course for Forecasters.—This is a four weeks' course for Assistant Experimental Officers nearing promotion, and is concerned mainly with the application of upper air analysis to forecasting. Four courses were held, 23 officers attending.

Refresher course for experienced Forecasters.—Forty-five Senior Experimental Officers and 13 Experimental Officers attended the seven courses, which provided instruction in recent advances in synoptic meteorology for officers who had not attended a course since the war.

Initial course for Assistants (Scientific).—This course, lasting eight weeks, includes revision of basic physics, some elementary meteorological theory, and instruction and practice in those duties which an assistant carries out at a synoptic station. Seventeen courses were held, attended by 189 assistants.

Course for Voluntary Observers.—Two courses each lasting four days are held annually, giving general instruction on the making of weather observations. This year's courses were attended by 38 observers who contribute to the climatological statistics of the British Climatology Branch.

Training of Dominion, Colonial and foreign personnel.—Training in forecasting or in assistant work was provided for 11 officers recruited by the Colonial Office, and for 13 of overseas governments.

Course for Royal Air Force Volunteer Reserve Officers.—This is on the lines of the Advanced course for Forecasters, but lasts only the two weeks laid down as the period of annual training for reservists. Four courses were held for 24 trainees, some of whom were new to meteorology.

Course for Nautical Officers.—This course was arranged for two Instructors from Nautical Schools. It lasted for one week and gave refresher instruction in the meteorology required for the Master Mariner's Certificate.

External training.—The concessions granted to members of the staff following approved courses of study, include payment of fees and time off with pay to attend classes and examinations. During the year 4 members of the staff were successful in B.Sc. (Special), 6 in Intermediate B.Sc., 25 in General Certificate of Education (Advanced) in one, two, or three subjects, and 1 obtained a Higher National Certificate.

(g) **Technical discussions.**—Meetings for the discussion of recently published meteorological papers or of research work in progress in the Office were held once a month from October 1953 to March 1954. These meetings are attended by members of the staff, and, on invitation, by staff of other Government Departments or University research workers interested in the subject under discussion.

The subjects discussed and the openers were :—

| | | |
|-------------------|--|----------------------|
| October 19, 1953 | The relation of the amount of ozone in the atmosphere to meteorological conditions | Mr. D. H. McIntosh |
| November 16, 1953 | Evaporation from a lake | Mr. E. Knighting |
| December 21, 1953 | Frontal analysis in the higher troposphere and lower stratosphere | Mr. C. L. Hawson |
| January 18, 1954 | Some applications of meteorology to agriculture | Mr. L. P. Smith |
| February 15, 1954 | Dynamical forecasting by numerical methods | Mr. F. H. Bushby |
| March 15, 1954 | Investigations of cumuliform cloud by the Meteorological Research Flight | Mr. R. J. Murgatroyd |

(3) Supply of Instruments

(a) **Provision and production of equipment.**—During the year 1,336 orders and contracts were placed. The total expenditure was £309,560, and £73,210 was received by sale of equipment and for testing and inspecting instruments. Production and delivery of new equipment was, on the whole, better than last year, especially for spare parts for radar wind equipment, but manufacture of radio-sondes lagged on account of various technical difficulties which arose. Among the more important contracts dealt with were the extension of the contract for the use of an electronic computer for forecasting research, and a contract for two complete radar-sonde ground equipments.

(b) **Issue of equipment.**—Meteorological offices at home and overseas were maintained by regular supplies of instruments and stores. Advice was given to many inquirers at home and in the Dominions and Colonies about the best source of supply and of suitability of equipment.

Demands for stores numbered 11,559, including some from Commonwealth, Colonial and foreign Governments and from observers co-operating with the Meteorological Office. The extent to which meteorology enters into the various activities of the country is briefly illustrated by the following loans of equipment which were made during the year :—

Ministry of Food—for problems connected with food storage.

Holls Cross Farm, Essex and School of Agriculture, Loughborough—equipment for research into heat and humidity problems arising in pig-keeping and field crops respectively.

King's College Hospital—to determine the effect of humidity in relation to explosions in operating theatres arising from static electricity near inflammable anaesthetics.

Sports Turf Research Institute—for research into turf diseases.

University of Wales—for a micro-climatological survey.

Universities of Edinburgh, Nottingham and the British Public Schools Exploring Society for expeditions to Norway, Iceland and British Columbia respectively.

Everest Expedition.

(c) **Testing and calibration.**—*General instruments and aircraft instruments.*—The total number of instruments tested, excluding balloons, was 71,800. The number of balloons of all sizes received and subjected to a 5 per cent. check was 222 066. Fees received for the testing and inspection of instruments for manufacturers and others amounted to £705.

Instruction on the maintenance of instruments was given to climatological observers.

Radio-sondes.—The total number of radio-sondes received for test from the makers was 9,395. In addition 13,931 were calibrated from stock and 5,970, recovered after flights, were overhauled and re-calibrated for future use.

The new calibration plant designed and installed by two members of the staff was brought into use, and proved to be a considerable advance on previous methods. Temperatures down to -120°F . were achieved regularly, and experimental work, such as the investigation of the factors necessary to correct the pressure observations for the effect of temperature was facilitated.

Training in radio-sonde calibration methods and in maintenance of equipment generally was given to representatives from Burma, Southern Rhodesia, Thailand, Mauritius, Ceylon and west Africa.

(d) **Maintenance of radar wind equipment.**—Regular inspections of the equipment were maintained, though not so frequently as desirable owing to shortage of skilled staff and transport.

The radar wind equipment at Gibraltar was replaced by a reconditioned set. Equipments required for issue to Hongkong, Nigeria and South Africa were serviced. Technical advice was given to the Ministry of Supply contractor who is overhauling a number of radar wind equipments. A number of small modifications were made to the radar wind equipment. These included a modification to the scale treblers, and the production of small amplification units.

Courses of instruction in maintenance were given to newly recruited radar staff.

(4) Library and Publications

The Meteorological Office Library is at Harrow.

(a) **Library.**—*Exchange of publications.*—Publications were exchanged with other national meteorological services and with certain independent institutions

concerned with meteorology, seismology and terrestrial magnetism ; 329 exchange agreements were in operation in March 1954. A check of these exchanges was completed.

Publications were issued gratis by special sanction to 41 institutions.

Accessions.—The total number of papers and publications taken into the Library during the year, exclusive of *Daily Weather Reports*, was 10,754. This number included 308 papers copied photographically from periodicals not received in the Library. The wide range of meteorological literature and the continuing increase in the number of papers of meteorological interest were again noticeable ; 5,250 papers of direct meteorological interest were catalogued during the period. Additions to the Library's collection of visual aids included 306 lantern slides, 138 photographs, 2 films and 2 filmstrips.

Financial arrangements for purchase of non-periodical publications.—The Meteorological Office Headquarters Technical Libraries Grant was continued at its initially agreed value, and is to remain unchanged for the year 1954–55.

Binding of publications.—Progress in this work continued to be unsatisfactory, and could only be made whenever current inquiry work allowed ; 194 publications were prepared for binding.

Co-operation with other libraries.—The *Monthly bibliography of meteorological literature* was supplied to 70 libraries and institutions.

Full co-operation was maintained with the Science Museum Library, the National Central Library and the libraries of the Royal Geographical Society and the Royal Meteorological Society. Papers appearing in the *Quarterly journal of the Royal Meteorological Society* were classified, and numerous inquiries forwarded by the Society were dealt with. Inter-library lending and borrowing continued on a large scale. The number of publications borrowed from other libraries is given below :—

| | No. of publications |
|--|------------------------|
| Science Museum | 358 |
| Ministry of Supply | 85 |
| Other Government Departments | 185 |
| National Central Library | 89 |
| Universities and Colleges | 49 |
| Scientific Societies and Research Institutes | 184 |

The Library continued to function as a corporate member of the Association of Special Libraries and Information Bureaux, and dealt with several inquiries received from them. A Library representative attended their Annual Conference and assisted with the preparation of the meteorological section of the ASLIB publication "British scientific and technical books. A select bibliography". Permission was granted to ASLIB to include a copy of the newly-designed library loan form in their proposed "Manual of special library practice".

A party of members of the Reference and Special Library Section of the Library Association was shown the detailed working of the Library.

Five of the staff are members of the Circle of State Librarians which provides an unofficial forum for discussion of general problems of Government libraries. One member of the staff passed the ~~Registration~~ ^{Entrance} Examination of the Library Association.

Loans.—The number of publications issued on loan continued at the high rate of 11,000 a year. The number of publications consulted in the Library, which amounts to several times the number issued on loan, resulted in some congestion. Further table space for inquirers was provided by re-distributing the Library staff within the catalogue rooms.

The automatic issue of publications considered of special interest to research staff and specialist branches was continued.

The demand for visual aids for lectures and exhibitions continued at approximately the same level ; 865 lantern slides, 89 films, 17 film strips and 289 photographs were issued on loan to the staff and general public.

Bibliographies.—The *Monthly bibliography of meteorological literature* was issued regularly, with short abstracts included when considered necessary. In spite of the increased number of items in successive years, the time lapse between receipt of the publication and the issue of the bibliography has been reduced to two months.

Selected bibliographies were provided on request and included bibliographies on : mountain air-flow effects ; the SW. monsoon over India, variation of wind with height in the lower layers ; electricity of precipitation ; aircraft icing ; wind power for generation of electricity. Assistance was given to the American Meteorological Society in the preparation of bibliographies on " sferics " and arctic meteorology for publication in the Society's " Meteorological abstracts and bibliography ".

Inquiries.—Inquiries were, as usual, received from other Government Departments, the World Meteorological Organization, universities and research institutions, and from members of the general public at home and overseas in addition to staff inquiries.

A few of these inquiries serve to indicate their variety : information on the effect of atomic explosions on weather ; the albedo of grass for diffuse radiation ; weather on a proposed motor-cycle journey across Europe and Asia and thence to Australia ; information on utilization of solar energy ; classification of the climates of Africa ; relation between sun-spots and the levels of Lake Victoria ; sources of the hydrogen in the atmosphere ; snow cover in Scandinavia ; magnetic observations in the Canadian Arctic ; relative air pollution in relation to airfield selection ; water content of stratus clouds ; nomograms for effective temperature ; variation of shade temperature with height above sea level ; climatological data for all rice-growing areas ; frequencies of temperature inversions over Europe.

Miscellaneous.—Meteorological publications surplus to the needs of the Library of the Royal Greenwich Observatory were collected, sorted and offered to Meteorological Office technical and observatory libraries.

Considerable numbers of publications surplus to the requirements of this

Library were similarly disposed of, and a number of other surplus publications were supplied to the World Meteorological Organization.

A large scale re-organization of the library stock was planned, and, as a preliminary, early numbers of periodicals not specifically meteorological in character were sent to Archives.

Much help with papers in foreign languages was again given to staff. Translations of longer papers were made for the library by the Air Ministry Translation Branch, and by the Central Office of Information. Translations of the titles of articles in two Russian periodicals were supplied to the Department of Scientific and Industrial Research for publication in that Department's monthly publication *Translated contents lists of Russian periodicals*.

The Library collection of lantern slides was revised to allow for the inclusion of new material. Some 450 older slides were withdrawn.

The introduction of the new library loan form reduced the loans work to within the capabilities of one full-time assistant with some part-time help. Delays in issues were negligible.

The draft "Manual of meteorological librarianship", prepared for consideration of the World Meteorological Organization Commission for Bibliography and Publications, was revised in conjunction with Dr. C. E. P. Brooks.

Assistance was given in conjunction with the Training School with the preparation of a film strip on meteorology proposed by the Army Kinema Corporation.

The Head of the Library Branch was appointed Chairman of a working group of the World Meteorological Organization Commission for Bibliography and Publications established to compile the World Meteorological Organization meteorological lexicon and polyglot vocabulary, a member of the World Meteorological Organization Working Group on International Meteorological Tables, and a member of the Aeronautical Glossary Committee of the British Standards Institution.

(b) Publications.—*Geophysical Memoirs, Professional Notes, Meteorological Reports.*—A list of papers published under these general titles is given in Appendix V. One *Geophysical Memoirs*, four *Professional Notes* and two *Meteorological Reports* were also sent for printing.

Meteorological Magazine.—The *Meteorological Magazine* was published regularly throughout the year. The articles published covered a wide field including a description of the gale of January 31, 1953, associated with the east coast floods, the forecasting from meteorological observations of the probability of an outbreak of potato blight, the structure of jet streams, the synoptic situations favourable for the development of new anticyclones, the global circulation of the atmosphere at high levels, a review of methods of long-range forecasting, the effect of atmospheric inhomogeneities on the interpretation of upper air temperature observations, electronic computation of the development of the pressure field, and the prediction of the rate of cooling of the air near the ground at night.

Marine publications.—Publication of the *Marine Observer* was continued with the four quarterly numbers for April, July and October 1953, and January 1954. The articles published dealt amongst other matters with radar echoes

from precipitation, the effect of weather on the propagation of sound, bird navigation, measurement of condensation nuclei, and the correlation between meteorology and shipping casualties.

Replacement No. 1 to the "Marine observer's guide" and a completely revised edition of the atlas "Monthly meteorological charts of the Greenland and Barents Seas" were sent for printing.

Summaries of meteorological conditions and currents at the ocean weather stations I and J for 1950, 1951 and 1952 were issued.

A revised reprint of "International meteorological code. Decode for use of shipping" was sent for printing.

Extensive revisions were made to "Meteorology for mariners".

Observatories' Year Book.—The volume for 1938 was sent for printing and preparation of the volume for 1939 begun.

Other publications.—The "Handbook of statistical methods in meteorology" by C.E.P. Brooks and N. Carruthers, the "Averages of temperature for Great Britain and Northern Ireland 1921–50" and the "Averages of bright sunshine for Great Britain and Northern Ireland 1921–50" were published.

The "Handbook of meteorological instruments, Part 1" was in the press at the end of the year.

§ 6. INTERNATIONAL CO-OPERATION

(1) World Meteorological Organization

During the period under review, members of the Meteorological Office attended the following meetings.

(a) **Commission for Synoptic Meteorology.**—The first session of this Commission, held in Washington, United States, from April 2 to 29, 1953, was attended by Mr. S. P. Peters, Mr. C. V. Ockenden and Mr. W. H. Bigg. Three technical committees were formed, Mr. C. V. Ockenden being elected chairman of that for telecommunications. The Commission adopted 8 resolutions and submitted 69 recommendations to the Executive Committee.

(b) **Commission for Aerology.**—The Commission for Aerology held its first session in Toronto, Canada, from August 10 to September 5, 1953. Dr. R. C. Sutcliffe and Miss E. E. Austin attended and Dr. R. C. Sutcliffe was elected vice-president of the Commission. The Commission divided into 4 working committees, adopted 12 resolutions and made 36 recommendations. During a series of discussions Dr. R. C. Sutcliffe presented a report on numerical and dynamical forecasting, and read a review paper by Dr. J. M. Stagg on methods of long-range forecasting.

(c) **Commission for Instruments and Methods of Observation.**—The first session of this Commission was held in Toronto, Canada, from August 10 to September 4, 1953. Dr. D. N. Harrison and Dr. R. Frith represented the Meteorological Office. As a result of the meeting five working groups were established, Dr. R. Frith being chairman of that on measurement of visibility for synoptic reports and Dr. D. N. Harrison a member of that on radio-sonde comparisons.

(d) **Executive Committee.**—The fourth session of the Executive Committee, held in Geneva from October 6 to 26, 1953, was attended by Dr. O. G. Sutton, who succeeded Sir Nelson K. Johnson as Permanent Representative of the United Kingdom in September 1953. The reports of the Technical Commissions were received, and, in all, 45 resolutions on technical subjects were adopted. Perhaps the most important of these was that authorizing the introduction on January 1, 1955 of new meteorological codes and forms of message. Administrative and financial matters concerning the World Meteorological Organization were discussed, and preliminary arrangements were made for the Second Congress to be held in early 1955.

(e) **Commission for Agricultural Meteorology.**—The Commission for Agricultural Meteorology held its first session in Paris from November 3 to 20, 1953. Mr. L. P. Smith represented the Meteorological Office. The meeting divided into two committees, Mr. L. P. Smith acting as secretary to that dealing with the research items of the agenda. Ten resolutions were adopted, five of which referred to the formation of working groups on instructions in agricultural meteorology, observational requirements, weather and animal husbandry, weather and plant pathology, and locust control.

(f) **Commission for Bibliography and Publications.**—This Commission, on which the United Kingdom was represented by Mr. G. A. Bull, held its first session in Paris from November 24 to December 12, 1953. The meeting discussed the classification of meteorological literature, the exchange of meteorological publications, and the publication by the World Meteorological Organization of a lexicon and a polyglot vocabulary, a guide to meteorological library practice and a world meteorological bibliography. Mr. G. A. Bull was elected vice-president of the Commission.

(2) International Civil Aviation Organization

The Meteorological Office was represented on the United Kingdom Committee on International Language for Aviation.

Advice was given on the meteorological aspects of the United Kingdom brief for the Fifth Meeting of the Commonwealth Division, held at Montreal in March 1954.

Representatives of the Meteorological Office attended the following meetings :—

Second Africa-Indian Ocean Regional Air Navigation meeting, Tenerife, November-December 1953

Third North Atlantic Ocean Station Conference, Brighton, July 1953

Fourth North Atlantic Ocean Station Conference, Paris, February 1954.

(3) Commonwealth Meetings

The Meteorological Office was consulted on meteorological aspects of the meetings of the South Pacific Air Transport Council and the South African Air Transport Council, and on matters of meteorological interest arising out of the Second Colonial Civil Aviation Conference in September 1952.

(4) North Atlantic Treaty Organization

The tenth meeting of the Standing Group Meteorological Committee under the chairmanship of Sir Nelson Johnson was held in London during July 1-4, 1953.

Representatives of the Meteorological Office also attended the following meetings :—

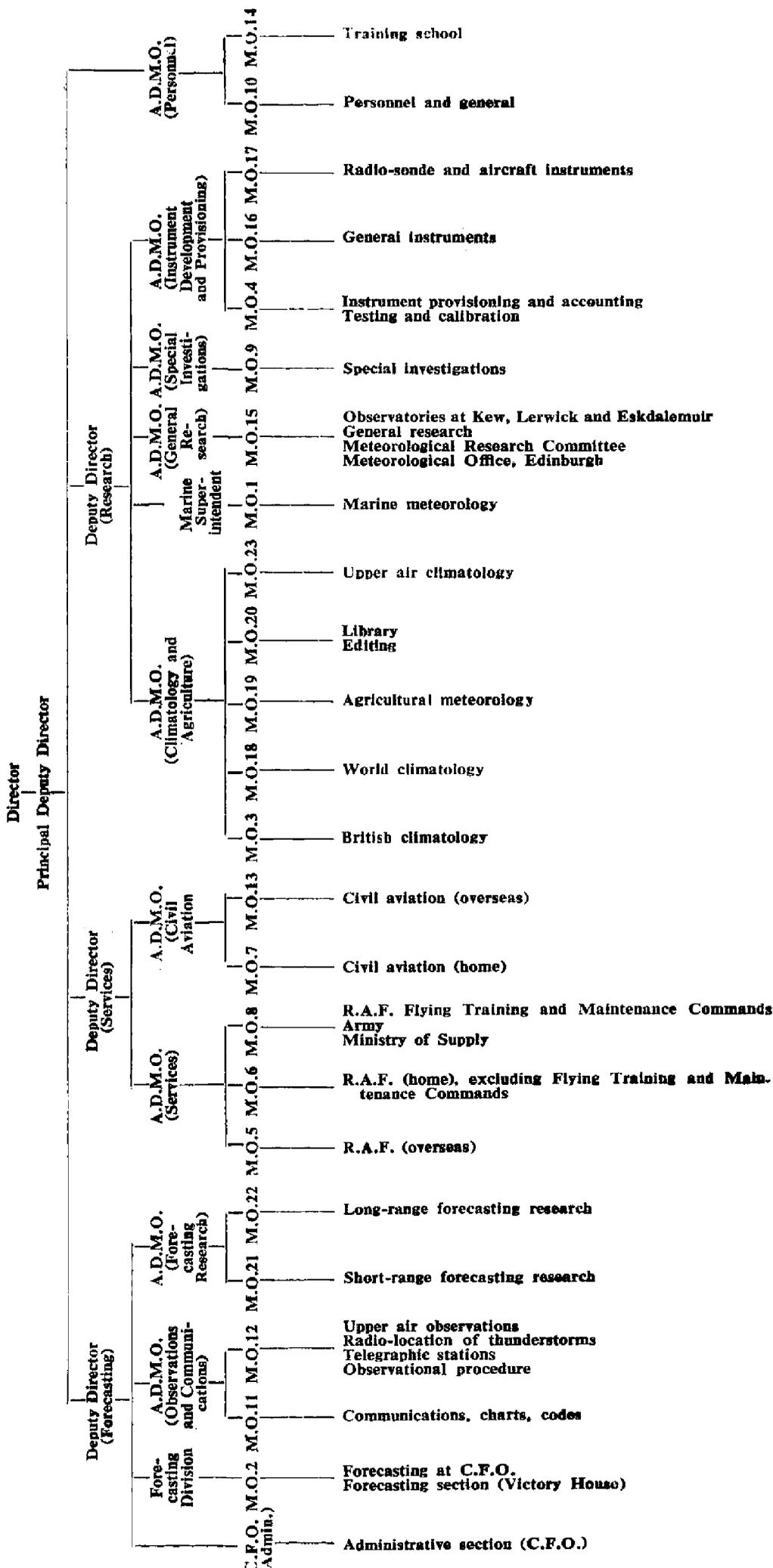
SHAPE Meteorological Committee, second meeting, Supreme Headquarters Allied Powers Europe, June 23-25, 1953

Allied Forces Mediterranean Command Meteorological Committee, first meeting, Malta, November 12-13, 1953

Allied Air Forces Central Europe Meteorological Committee, second meeting, Fontainebleau, November 18-20, 1953

Allied Air Forces Central Europe Meteorological Committee, third meeting, Brussels, March 17-19, 1954.

APPENDIX I
ORGANIZATION OF THE METEOROLOGICAL OFFICE



APPENDIX II

DIRECTORATE OF THE METEOROLOGICAL OFFICE AND HEADS OF BRANCHES

DIRECTOR

O.G. Sutton, C.B.E., D.Sc., F.R.S., J.P.

PRINCIPAL DEPUTY DIRECTOR

J. M. Stagg, C.B., O.B.E., M.A., D.Sc.

| | |
|---|---|
| DEPUTY DIRECTOR (RESEARCH) | R. C. Sutcliffe, O.B.E., B.Sc., Ph.D. |
| <i>Assistant Director (General Research)</i> | H. W. L. Absalom, B.Sc., A.R.C.S., D.I.C. |
| General Research and Observatories Branch (M.O.15) | R. Frost, B.A. |
| <i>Assistant Director (Special Investigations)</i> | A. C. Best, O.B.E., M.Sc. |
| Special Investigations Branch (M.O.9) | L. Dods, B.Sc. |
| <i>Assistant Director (Instrument Development and Provisioning)</i> | F. J. Scrase, O.B.E., M.A., Sc.D., F.Inst. P. |
| General Instruments Branch (M.O.16) | R. Frith, O.B.E., M.A., Ph.D. |
| Radio-sonde and Aircraft Instruments Branch (M.O.17) | D. N. Harrison, D.Phil. |
| Instrument Provisioning Branch (M.O.4) | P. N. Skelton, M.B.E. |
| <i>Assistant Director (Climatology and Agriculture)</i> | R. G. Veryard, B.Sc. |
| British Climatology Branch (M.O.3) | J. Glasspoole, M.Sc., Ph.D. |
| World Climatology Branch (M.O.18) | J. Pepper, M.A., B.Sc., Ph.D. |
| Agricultural Meteorology Branch (M.O.19) | L. P. Smith, B.A. |
| Library and Editing (M.O.20) .. | G. A. Bull, B.Sc. |
| Upper Air Climatology Branch (M.O.23) | Miss E. E. Austin, M.A. |
| <i>Marine Superintendent (M.O.1)</i> .. | Cmdr C. E. N. Frankcom, O.B.E., R.D., R.N.R. (Retd) |
| DEPUTY DIRECTOR (FORECASTING) | S. P. Peters, B.Sc. |
| <i>Forecasting Division (M.O.2)</i> | C. K. M. Douglas, O.B.E., B.A. |
| <i>Assistant Director (Observations and Communications)</i> | J. S. Farquharson, M.A., D.Sc. |
| Communications ; Charts and Codes Branch (M.O.11) | C. V. Ockenden, B.Sc. |
| Upper Air Observations (M.O.12) ... | W. A. L. Marshall, M.B.E. |
| <i>Assistant Director (Forecasting Research)</i> | A. L. Maidens, B.Sc. |
| Short-Range Forecasting Research Branch (M.O.21) | J. S. Sawyer, M.A. |
| Long-Range Forecasting Research Branch (M.O.22) | G. A. Corby, B.Sc. |
| DEPUTY DIRECTOR (SERVICES) | J. M. Craddock, M.A. |
| <i>Assistant Director (Services)</i> | J. Durward, C.M.G., M.A. |
| R.A.F. (Overseas) Branch (M.O.5) | R. P. Batty, O.B.E., B.A. |
| R.A.F. (Home) Branch (M.O.6) .. | C. W. G. Daking, B.Sc. |
| Flying Training, Army and Ministry of Supply Branch (M.O.8) | M. J. Thomas, O.B.E., B.Sc. |
| <i>Assistant Director (Civil Aviation)</i> ... | B. C. V. Oddie, B.Sc. |
| Civil Aviation (Home) Branch (M.O.7) | W. H. Bigg, O.B.E., B.Sc. |
| Civil Aviation (Overseas) Branch (M.O.13) | N. H. Smith, B.Sc. |
| <i>Assistant Director (Personnel)</i> | J. C. Cumming, O.B.E., M.A. |
| Personnel and General Branch (M.O.10) | — |
| Training Branch (M.O.14) | C. J. Boyden, B.A. |
| | K. H. Smith, B.Sc. |

APPENDIX III

CLASSIFICATION OF BRITISH STATIONS WHICH REPORT TO THE BRITISH CLIMATOLOGY BRANCH

| | Stations | | | | | Autographic records | | |
|--|---------------|-----------|--------------|----------------|---------------|---------------------|------------|-----------|
| | Observatories | Synoptic | Crop weather | Climatological | Rainfall | Sunshine | Rainfall | Wind |
| Scotland, North | 1 | 7 | 0 | 13 | 144 | 15 | 9 | 2 |
| Scotland, East | 0 | 5 | 3 | 43 | 348 | 36 | 17 | 4 |
| Scotland, West | 1 | 4 | 2 | 30 | 401 | 24 | 13 | 6 |
| England, North-east | 0 | 9 | 4 | 22 | 326 | 27 | 15 | 5 |
| England, East | 0 | 10 | 12 | 24 | 488 | 29 | 26 | 7 |
| England, Midlands | 0 | 12 | 18 | 41 | 1,057 | 53 | 41 | 3 |
| England, South-east (including London) | 1 | 17 | 10 | 65 | 772 | 62 | 61 | 15 |
| England, South-west | 0 | 7 | 7 | 29 | 481 | 34 | 13 | 4 |
| England, North-west | 0 | 4 | 3 | 24 | 451 | 23 | 32 | 6 |
| Wales, North | 0 | 3 | 2 | 10 | 190 | 9 | 6 | 2 |
| Wales, South | 0 | 3 | 5 | 15 | 269 | 20 | 9 | 4 |
| Isle of Man | 0 | 2 | 0 | 1 | 9 | 4 | 1 | 1 |
| Scilly and Channel Isles | 0 | 3 | 0 | 1 | 17 | 3 | 1 | 1 |
| Northern Ireland | 0 | 4 | 0 | 10 | 89 | 4 | 3 | 1 |
| Total | 3 | 90 | 66 | 328 | 5,042* | 343 | 247 | 61 |

* Includes stations in earlier columns.

APPENDIX IV

PROVISION IN AIR ESTIMATES FOR METEOROLOGICAL SERVICES

The approximate cash provision in Air Estimates, 1954-55, for meteorological services is as follows :—

| Item | Service | Provision | Vote |
|------|---|-----------|------|
| | | £ | |
| 1 | <i>Staff</i> | | |
| 1a | Salaries, wages, etc. of staff at headquarters of the Meteorological Office | 247,000 | 3 |
| 1b | Salaries, wages, etc. of civilians at meteorological observatories and outstation offices and in ocean weather ships | 1,643,500 | 4 |
| 1c | Pay, etc. of airmen employed as air meteorological observers and meteorologists and of air force personnel of the meteorological research flight .. | 61,000 | 1 |
| 1d | National insurance contributions | 3,200 | 1 |
| 1e | Pay, etc. of meteorological personnel of the Royal Air Force Reserve | 4,000 | 2 |
| 1f | Superannuation allowances and gratuities | 32,000 | 10 |
| 1g | Conveyance of personnel ; travelling allowances and expenses | 74,000 | 5 |
| 2 | <i>Equipment and Supplies</i> | | |
| 2a | Meteorological equipment | 268,000 | 7 |
| 2b | Radio, radar and electrical equipment for meteorological services | 134,000 | 7 |
| 2c | Conveyance of equipment for meteorological services | 16,000 | 5 |
| 2d | Mechanical transport vehicles for meteorological services | 2,000 | 7 |
| 2e | Solid fuel, electricity, gas, water and sanitary services for meteorological observatories and outstation offices | 3,800 | 6 |
| 2f | Liquid fuel, lubricants, etc. for aircraft of the meteorological research flight and for vehicles required for meteorological services | 25,000 | 6 |
| 2g | Liquid fuel for ocean weather ships | 52,000 | 6 |
| 2h | Other equipment and services for aircraft of the meteorological research flight | 5,000 | 7 |
| 2i | Other equipment and services for ocean weather ships | 152,000 | 7 |
| 2j | General stores for meteorological services | 1,500 | 7 |
| 2k | Food and ration allowances for air force personnel ; food for crews of ocean weather ships | 36,600 | 6 |
| 2l | Clothing, clothing allowance and laundry services for airmen ; clothing for crews of ocean weather ships | 10,900 | 7 |
| 3 | <i>Works services for meteorological observatories and outstation offices</i> | | |
| 3a | Capital expenditure | 65,000 | 8 |
| 3b | Maintenance expenditure | 25,000 | 8 |
| 4 | <i>Telecommunication services for meteorological purposes</i> | 285,000 | 9 |
| 5 | <i>Flights by civil aircraft for meteorological purposes</i> | 5,000 | 9 |
| 6 | <i>Contribution to the World Meteorological Organization</i> | 7,000 | 9 |
| 7 | <i>Fees for special services relating to meteorological research</i> | 3,000 | 9 |

| Item | Service | Provision | Vote |
|------|---|------------|------|
| | | £ | |
| 8 | <i>Grant to the Royal Society in aid of meteorological research</i> | 5,000 | 9 |
| 9 | <i>Other miscellaneous effective services</i> | 7,500 | 9 |
| | GROSS TOTAL | £3,174,000 | |
| 10 | <i>Deduct-Appropriations in aid</i> | | |
| | | £ | |
| 10a | Repayment in respect of meteorological staff employed on special services, etc. | | |
| | £ | | |
| | Salary, wages, etc. .. | 304,000 | 4 |
| | Movement expenses .. | 14,000 | 5 |
| | Contributions towards non-effective benefits .. | 5,400 | 10 |
| | ————— | 323,400 | |
| 10b | Receipts relating to meteorological equipment | 58,000 | 7 |
| 10c | Payments by airmen for issues of clothing and footwear | 1,600 | 7 |
| 10d | Receipts for miscellaneous meteorological services | 16,000 | 9 |
| | | ————— | |
| | | 399,000 | |
| | NET TOTAL | £2,775,000 | |

APPENDIX V

PUBLICATIONS

The publications prepared by the Meteorological Office are generally issued by Her 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 H.M. Stationery Office is sent free to any applicant.

The following official publications were issued during the period of this report :—

Periodical

- Daily Aerological Record*, containing information respecting meteorological conditions in the upper air over the British Isles (to March 31, 1954).
- Daily Weather Report*, containing weather maps for the northern hemisphere, British Isles, etc. and data (to March 31, 1954).
- Daily Weather Report Overseas Supplement*, containing surface and upper air data (to September 26, 1953).
- Meteorological Magazine* (to March 1954).
- Monthly Weather Report*, with summary for the year (to December 1953).
- Seismological Bulletin*. A diary of seismological disturbances recorded on the Galitzin aperiodic seismographs at Kew Observatory, Richmond (to February 1954).
- Marine Observer* (quarterly) (to January 1954).
- British Rainfall 1951*. A report on the distribution of rain in space and time over Great Britain and Northern Ireland as recorded by about 5,000 observers.
- Annual Report and results of meteorological observations, 1950 and 1951*. Southport Auxiliary Observatory. By George A. Lidster.
- Notes on the meteorological observations made in British Colonies and Protectorates, etc. in 1948 and summarized in the annual reports of Colonial Governments*.

Occasional

- Handbook of statistical methods in meteorology. By C. E. P. Brooks, D.Sc. and N. Carruthers, B.Sc.
- Averages of bright sunshine for Great Britain and Northern Ireland 1921–1950.
- Averages of temperature for Great Britain and Northern Ireland 1921–1950.
- Upper Air Data for stations maintained by the Meteorological Office*. Summaries of radio-sonde observations of temperature and humidity and of radar wind measurements at standard pressure levels, 1946–50. Part 3, Habbaniya. Part 4, Malta.
- Geophysical Memoirs* :—
- Vol. XI :—
90. Seasonal change of surface temperature of the North Atlantic Ocean. By T. H. Kirk, B.Sc.
 91. Vertical profiles of mean wind in the surface layers of the atmosphere. By E. L. Deacon, B.Sc.
 92. Day-to-day variations in the tropopause. By J. S. Sawyer, M.A.
- Professional Notes* :—
- Vol. VII :—
107. Upper air circulation in low latitudes in relation to certain climatological discontinuities. By R. Frost, B.A.
 108. Comparison of the wind recorded by anemograph with the geostrophic wind. By W. A. L. Marshall.
- Meteorological Reports* :—
- Vol. II :—
13. 1000–500-mb. thickness, North America to Europe, 1946–51. Monthly means and extremes.

The following books or papers by members of the staff were published during the year.

- O. G. SUTTON, D.Sc., F.R.S. :—
 Method of forecasting the weather. *Listener, London*, 51, 1954, p. 522.
 Weather forecasts on television. *Met. Mag., London*, 83, 1954, p. 65.
- J. M. STAGG, D.Sc. :—
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- R. C. SUTCLIFFE, Ph.D. :—
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