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M.O. 710

Meteorological Office

REPORT FOR THE YEAR
ENDING
DECEMBER 31, 1960

LONDON
HER MAJESTY'S STATIONERY OFFICE
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M.O. 710

ANNUAL REPORT
ON THE
METEOROLOGICAL OFFICE

Presented by the Director-General
to the
Secretary of State for Air

FOR THE YEAR
JANUARY 1 TO DECEMBER 31, 1960

LONDON
HER MAJESTY'S STATIONERY OFFICE
1961

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METEOROLOGICAL COMMITTEE

Terms of reference: —

(a) to keep under review the progress and efficiency of the Meteorological Service and the broad lines of its current and future policy;

(b) to keep under review the general scale of effort and expenditure devoted to the meteorological services;

(c) to ensure the maintenance of adequate contacts between the Meteorological Service and those who use its services.

Chairman: The Lord Hurcomb, G.C.B., K.B.E.

Members: Sir Austin Anderson
Sir David Brunt, F.R.S. (later Professor J. Proudman, F.R.S.)
Mr. S. Earl
Chairman, Meteorological Research Committee (ex-officio)

Secretary: Mr. W. J. B. Crotch (Secretary, Meteorological Office)

The Committee met four times in 1960.

METEOROLOGICAL RESEARCH COMMITTEE

This Committee, established by authority of the Secretary of State for Air, advises on research in the Office. A new Sub-Committee has been set up to advise on the allocation of funds made available by the Air Ministry for extra-mural research. The direct allocation of funds for this purpose by the Air Ministry to the Royal Society for disbursement by its Gassiot Committee is superseded by the new arrangement.

Chairman: Professor P. A. Sheppard

Members: Dr. G. E Bell, O.B.E. (Ministry of Aviation)
Professor H. Bondi, F.R.S.
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Mr. J. Paton, F.R.S.E.
Dr. H. L. Penman
Sir Graham Sutton, C.B.E., F.R.S. (Director-General, Meteorological Office)
Dr. H. M. Wilson, M.B.E. (Ministry of Aviation)

Secretary: Dr. F. J. Scrase, O.B.E.

The Committee met twice in 1960.

ADVISORY COMMITTEE ON METEOROLOGY FOR SCOTLAND

Terms of reference: —

(a) to review the development of meterological science and its application to Scotland;

(b) to submit to the Meteorological Committee any proposals in connection therewith.

Chairman: Sir Graham Sutton, C.B.E., F.R.S. (Director-General, Meteorological Office)

Members: Sir Edward Appleton, G.B.E., K.C.B., F.R.S. (University of Edinburgh)
Sir David Brunt, F.R.S. (Royal Society)
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Professor P. A. Sheppard (Royal Meteorological Society)
Professor D. W. N. Stibbs (University of St. Andrews)
Professor P. A. Sweet (University of Glasgow)
Dr. J. B. Tait, F.R.S.E. (Fisheries Division, Scottish Home Department)

Secretary: Mr. R. Cranna

The Committee met on October 18, 1960.

PRINCIPAL OFFICERS OF THE METEOROLOGICAL OFFICE

(on December 31, 1960)

DIRECTOR-GENERAL

Sir Graham Sutton, C.B.E., D.Sc., LL.D., F.R.S., J.P.

DIRECTOR OF SERVICES

A. C. Best, O.B.E., D.Sc.

Deputy Director (Central Services)	B. C. V. Oddie, B.Sc.
Deputy Director (Outstation Services)	P. J. Meade, O.B.E., B.Sc., A.R.C.S.
Assistant Director (Central Forecasting)	C. J. Boyden, B.A.
Assistant Director (Climatological Services)	R. H. Clements, M.A.
Assistant Director (Observations and Communications)	L. H. Starr, M.B.E., M.Sc.
Assistant Director (Aviation Services)	T. W. V. Jones, B.Sc.
Assistant Director (General Services)	J. Harding, B.A., M.Sc.
Assistant Director (Techniques and Training)	H. L. Wright, M.A.
Assistant Director (Defence and International)	C. W. G. Daking, B.Sc.
Assistant Director (Support Services)	G. A. Bull, B.Sc.
Marine Superintendent	C. E. N. Frankcom, O.B.E., R.D., Commander, R.N.R. (retd.).

DIRECTOR OF RESEARCH

R. C. Sutcliffe, C.B., O.B.E., B.Sc., Ph.D., F.R.S.

Deputy Director (Physical Research)	G. D. Robinson, B.Sc., Ph.D.
Deputy Director (Dynamical Research)	J. S. Sawyer, M.A.
Assistant Director (Special Investigations)	J. K. Bannon, B.A.
Assistant Director (Dynamical Research)	E. Knighting, B.Sc.
Assistant Director (Synoptic Research)	V. R. Coles, M.Sc.
Assistant Director (Climatological Research)	A. G. Forsdyke, B.Sc., Ph.D., A.R.C.S.
Assistant Director (Observatories and Micrometeorology) ..	L. Jacobs, M.A., M.Sc.
Assistant Director (Atmospheric Physics)	R. F. Jones, B.A.
Assistant Director (Instrument Development)	A. L. Maidens, B.Sc.
Assistant Director (High Atmosphere)	R. Frith, O.B.E., M.A., Ph.D.

SECRETARY, METEOROLOGICAL OFFICE

W. J. B. Crotch, M.A., A.K.C.

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FUNCTIONS OF THE METEOROLOGICAL OFFICE

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

The general functions of the Meteorological Office are:

(i) Provision of meteorological services to the Army, Royal Air Force, Civil Aviation, 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 Director-General is the Permanent Representative of the United Kingdom with the World Meteorological Organization.

Except for the common services provided by other Government Departments as part of their normal function (e.g. accommodation by the Ministry of Works; stationery by Her Majesty's Stationery Office) the cost of the Meteorological Office is borne by Air Votes.

The gross annual expenditure by the Exchequer, including that on the common services, is of the order of £5,500,000. Of the amount chargeable to Air Votes, about £3,700,000 represents expenditure associated with staff and £1,600,000 expenditure on stores, communications and miscellaneous services. Over £1,000,000 is recovered from other Government Departments and outside bodies in respect of special services rendered, sales of meteorological equipment, etc.

FOREWORD BY THE DIRECTOR-GENERAL

This year sees some changes in the Annual Report. Hitherto it has covered the period 1st April to 31st March, the governmental financial year. The present Report and all future Reports will cover a calendar year. It has also been decided that the text will not describe all the activities of the Meteorological Office, many of which show only small changes from one year to another, but will attempt instead to give a broad picture of what has happened with more detailed accounts of certain aspects.

In 1957, considerable changes were made in the structure of the directorate of the Office as a result of the report of Lord Brabazon's Committee. In 1961 the Headquarters sections of the Office will come together in the new building at Bracknell, after many years of dispersion between London, Dunstable and Harrow. This has allowed certain changes, which were necessary because of developments in meteorology, both as a science and a profession, to be made.

The Brabazon Committee recognized that the Meteorological Office had a dual function to perform, to provide meteorological services for the nation and to act as the primary institution of the country for the advancement of the science of the atmosphere. This principle, which was recognized in the 1957 reorganisation by the creation of two directorates, of services and research respectively, has been maintained in the new structure. The changes that have been made consist in the main of grouping of certain activities which in the past were somewhat artificially separated because of the dispersion of the headquarters units, together with the creation of two new assistant directorates required by the growth of the science.*

In previous Reports I have called attention to the gratifying increase in demands for services not specifically related to aviation. This has now reached a point at which it has become necessary to place much of the work under a separate assistant director with the title of General Services.

The major interests of this unit lie in agricultural meteorology and in the application of the knowledge and skill of meteorologists to problems which arise in industry, transport, public utilities, sport, tourism, etc. In particular, this assistant director will control the weather information centres of which three are now open to the public in London, Glasgow and Manchester.

The administration of both civil and military aviation meteorological services has been combined into one assistant directorate with provision for the international work connected with civil aviation, which is considerable, to be undertaken by the assistant director in charge of defence and international matters. All climatological inquiries, including those relating to the oceans and foreign parts, will be handled by the climatological services unit. Finally, the growth of the demands for rapid and efficient data handling and processing, and the inevitable increase in specialization that has come with the widespread use of machine methods, have necessitated the formation of

* An organisation-diagram is given at Appendix I.

an assistant directorate of Support Services to deal with these and other cognate matters such as the Library, archives and all editorial and cartographic work for official publications. The new buildings at Bracknell have been specially designed to cope with this side of our work.

On the research side, the outstanding event is the setting-up of an assistant directorate to investigate problems of the high atmosphere, using novel devices such as rockets and satellites as these become available. This aspect need not be considered further here as it is dealt with at some length in the pages that follow. Another change, which also follows current trends in meteorology, is the transfer of investigations into long-range forecasting from synoptic to climatological research. This reflects the belief that progress in this notoriously intractable problem will come, if at all, from studies of the major circulations of the atmosphere over the globe. Finally, a new deputy-directorship, that of dynamical research, has been created. The occupant of this post is Mr. J. S. Sawyer, who has relinquished his personal post of Chief Forecasting Research Officer.

The Meteorological Office has responsibilities for two branches of geophysics, geomagnetism and seismology, besides meteorology. Because of the pressure of work in meteorology, interest within the Office in these disciplines has waned somewhat in recent years, although observations have been maintained at Kew, Eskdalemuir and Lerwick Observatories. I am glad to record that steps have now been taken to rectify this position by the appointment, in association with the Royal Society, of two Gassiot Research Fellows who are expected to take up their appointments in 1961.

In September, 1960, Dr. J. M. Stagg retired from the post of Director of Services and was succeeded by Dr. A. C. Best. I wish here to record my appreciation of the many years of devoted service which Dr. Stagg gave to the Office.

I attended the session of the Executive Committee of the World Meteorological Organization in Geneva in June, 1960, and afterwards the General Assembly of the International Union of Geodesy and Geophysics at Helsinki.

O. G. SUTTON

THE DIRECTORATE OF SERVICES

1. General Description

By definition the function of this directorate is to satisfy, as far as possible, the demands of the community for meteorological services. Largely, but not wholly, these demands are for either forecasts of weather or for climatological information. For this reason some assistant directorates are concerned directly and almost exclusively with services in one or other of these two categories. Others are concerned primarily with the provision of data and facilities without which the forecaster and climatologist could not do their jobs.

For administrative purposes it is convenient to group the assistant directorates and Marine Branch under one or other of two deputy directors, but two assistant directorates do not fall naturally into this pattern and report direct to the Director. The general pattern of the organisation of work in the Services directorate is as shown in Appendix I.

The numbering of the branches and assistant directorates shown in Appendix I owes more to tradition than to logic. In the following paragraphs of this section an outline of the work of each element is given, dealing with the forecasting branches first, climatological branches second and other branches last. Section 3 contains a greatly amplified account of one category of work in the Services directorate. The subject chosen this year is " the Forecasting Services ". Important events or innovations during the year are described in greater detail in Section 2. The volume of work in some categories may be measured by the statistics given in Section 5.

Central Forecasting (*M.O.2*). The Central Forecasting Office (CFO) has a dual function. First, it is a master analysis centre with an output designed to help other meteorological offices in the United Kingdom and Northern Ireland to meet their forecasting commitments. The material for this purpose is broadcast by teleprinter and facsimile machine and consists mainly of actual and forecast analyses of surface and upper air charts supplemented by appreciation of developments in the pressure pattern in the atmosphere. In addition to acting as a master analysis centre, the CFO is responsible for the preparation of forecasts and " warnings " which have a nation-wide application. These forecasts fall into three main categories, general forecasts for land and sea areas for dissemination by the Press and by broadcasting, forecasts for some public utilities such as the Central Electricity Generating Board and certain special forecasts for periods up to three or four days ahead. Parallel services in the first two categories are provided by local meteorological offices which prepare more detailed forecasts applicable to smaller areas.

The Central Forecasting Office is also responsible for the preparation of the Meteorological Office daily publications, mainly the *Daily Weather Report* with its *Overseas Supplement* and *Monthly Summary* and the *Daily Aerological Record*.

Aviation Services (*M.O.6*). For many years the meteorological services for the Royal Air Force and for civil aviation had been supervised by separate branches of the Meteorological Office. Late in 1960 this work was all placed under one assistant director (see Section 2).

The pattern of the outstation meteorological service for the Royal Air Force largely conforms with the R.A.F. organisation. Main offices, functioning throughout the 24 hours, are often located at the Headquarters of a R.A.F. Group and control and advise subsidiary offices at R.A.F. stations in the Group. At these subsidiary offices a forecaster is available at times which depend on the needs of the Royal Air Force. At observing offices there is no forecaster and the duties comprise the making and issue of weather observations. At R.A.F. Command Headquarters the meteorological unit usually consists of a senior officer of the Meteorological Office who acts as an adviser to the Air-Officer-Commanding-in-Chief and as a liaison officer between him and the Director-General of the Meteorological Office. The same general pattern applies both in the United Kingdom and overseas in Western Germany, the Mediterranean, Middle East and Far East areas.

During 1960 a major re-organisation of the meteorological service in Bomber Command was undertaken (see Section 2). Minor changes included the institution of a limited forecast service on Gan in the Maldive Islands and the handing over to the Ceylon Meteorological Department of the subsidiary office at Katunayake.

Meteorological services in the United Kingdom for civil aviation are organised on a similar pattern to those for the R.A.F., with main offices at air traffic control offices and on major civil aerodromes, subsidiary offices at civil aerodromes of intermediate importance and observing offices at some minor civil aerodromes. To meet the need for observations at aerodromes where there is no meteorological office, training is given to Air Traffic Control Officers and to Flight Information Service Officers in the making and reporting of weather observations. The functions of the main offices include not only the provision of forecasts to pilots before a flight, but also the provision of forecasts, warnings and observations to aircraft in flight.

Overseas meteorological services for civil aviation are provided at a number of joint user (i.e. R.A.F. and civil) aerodromes in the Near and Middle East Commands.

General Services (*M.O.7*). This is a new assistant direcorate (though with an old number) which was brought into existence in the re-organisation (see Section 2) towards the end of the year. Prior to this its functions were shared between several other parts of the Office. For convenience the accounts of these activities are gathered together here to be consistent with the diagrammatic organisation shown in Appendix I.

Basic climatological investigation into meteorological matters which are of concern to agriculturalists and special investigations into the relation between meteorological and agricultural parameters are carried out at Headquarters . Staff are also engaged on the application of meteorology to the problems of agriculture at stations at Bristol, Cambridge, Leeds and Edinburgh. Contact with research and advisory workers in agriculture is maintained through the National Agricultural Advisory Service, research stations, experimental farms, universities and farm institutes.

The ballistics work of the assistant directorate involves maintaining meteorological offices at a few War Office establishments where the information supplied is of a specialist nature.

Services for the general public are supplied through many different channels, the press, broadcasting (sound and vision), the automatic telephone weather service, offices on airfields, weather information centres and several assistant directorates. It is the function of M.O.7 to co-ordinate all these activities and to supervise some of them.

The three weather information centres in London, Glasgow and Manchester (the centre in Manchester was opened in 1960) were opened with the primary intention of meeting non-aviation enquiries from the public. The London Centre has existed for many years though it was only in 1959 that it moved to its present location. It is this centre which provides the staff for the routine weather broadcasts on the B.B.C. sound and television channels (though, in this matter, they are acting largely as the mouthpiece of the Central Forecasting Office).

Climatological Services (*M.O.3*). The function of this assistant directorate is to collect, examine, analyse and preserve meteorological data from surface and upper air observations and to supply answers to queries to which these data are relevant. The area of collection is world-wide though obviously the work carried out is far more detailed in respect of observations made at stations in the United Kingdom, and at places abroad where the observing stations are maintained by the Meteorological Office, than in respect of observations made under the supervision of other meteorological services. The data collected and preserved cover all the usual meteorological elements. The enquiries answered are mainly, but by no means exclusively, concerned with climate in the United Kingdom and Northern Ireland. These enquiries cover an extraordinarily wide field, ranging from problems of water supply to the sale of ice cream, from the building of power stations to the location of convalescent homes. Data for the United Kingdom are published mainly in the *Monthly Weather Report* and the *Annual Summary* and in the yearly publication *British Rainfall*. M.O.3 is responsible also for the preparation of occasional publications dealing with climatological statistics.

Until the latter part of 1960 some parts of the present work of M.O.3 were carried out elsewhere in the Office.

The rainfall and hydrology section, in addition to supplying information and advice on rainfall and evaporation and more general hydrological problems in which these elements are important, also supervises and inspects co-operating rainfall stations maintained in Great Britain and Northern Ireland by local government and other authorities. Liaison is maintained with many organisations and establishments which are active in the field of hydrology or in civil engineering where hydrology is involved. Averages of rainfall over a standard period are computed for many places in the United Kingdom and statistical techniques are adopted for estimating corresponding averages for places where records are incomplete. An examination is in hand to determine the best method of punching rainfall data on tapes in order that analysis may be carried out on the electronic computer rather than a punched-card machine.

Another section of M.O.3 is responsible for the supply of meteorological advice and information relating to all aspects of climate other than rainfall and agricultural matters. In addition to dealing with the data received from official stations, this section also supervises and arranges for the inspection of co-operating climatological stations in Great Britain and Northern Ireland. In this section, too, the relative merits of card-punching machines and the electronic computer for the preparation of climatological statistics are being examined.

To a large extent the office at Edinburgh deals in climatological services in so far as Scotland is concerned. During 1960, as described in Section 2, an office was opened in Belfast to carry out a similar function for Northern Ireland. In these matters these two offices act on behalf of, and are supported by, the assistant directorate.

Marine Branch (*M.O.1*). For all forecasters in the United Kingdom, whether they are serving the general public in London or trans-Atlantic aviation, weather observations from the Atlantic are very important. For other nations other oceanic areas are important and international co-operation has resulted in arrangements whereby each maritime nation arranges for weather reports to be made by a number of its own ships. It is the function of the Marine Branch to organise the making and reporting of meteorological observations by ships of the British merchant navy and by British ocean weather ships and to see that, as far as practicable, meteorological requirements of the Merchant Navy are met.

All meteorological observations from British merchant navy ships are made on a voluntary basis. As may be seen in Section 5 the backbone of the voluntary observing fleet consists of the " Selected Ships " which make, encode, and transmit by radio to specified stations, meteorological observations at four specified times each day. These reports are made in whatever ocean the ship may be. " Supplementary " ships report according to a similar procedure, but make reports in a less complete form. Other, generally smaller, ships co-operate in providing reports from areas which are generally nearer to the United Kingdom.

Ocean weather ships operated by European countries report from five specified stations in the North Atlantic Ocean. Of the four Meteorological Office ships maintained for this purpose, two are always " on station ". These ocean weather ships are the main source of information about temperature and wind in the upper atmosphere over the Atlantic. Without these reports it would be impossible to construct upper air charts for that area.

The Marine Branch also analyses ship reports of sea ice and ocean currents and makes the results available to the mariner. Enquiries concerning weather (other than forecasts) at sea are also dealt with.

Observations and Communications (*M.O.5*). The making of meteorological observations at a large number of places is the first essential for any meteorological service. For forecasting purposes an equally essential facility is a method of transmitting these observations rapidly and accurately to the places where they are required. With this latter facility must be combined arrangements for the international exchange of observations. These duties are combined in the one assistant directorate.

Most meteorological offices in the United Kingdom also have the duty of making surface observations, but there are also nearly as many ancillary reporting stations, manned by members of the Coast Guard and Trinity House organisations and other authorities. To obtain information about the upper air, a network of combined radio-sonde and radar wind stations is also maintained both in the United Kingdom and overseas. Meteorological reconnaissance flights are also made over sea areas around the British Isles by Hastings aircraft of No. 202 Squadron of the Royal Air Force, based at Aldergrove. Thunderstorms can be located by means of a network of radio direction finding stations. Four linked stations in the United Kingdom can locate thunderstorms up to a distance of about 1,500 miles, and a similar network has been developed employing stations in Gibraltar, Malta and Cyprus.

The communication system of the Meteorological Office utilises wireless telegraphy, radio-teleprinter, land-line teleprinter, facsimile transmission both by radio and by land-line, and cable. W/T and R.T.P. transmissions are both employed in the international exchange of collections of reports but, by agreement within the World Meteorological Organisation, the former is gradually being replaced by the latter. Land-line teleprinters are also employed for the international exchange of information and, within the United Kingdom, are the main means of collecting and redistributing information. The distribution of information (including foreign information received at headquarters) takes place over five teleprinter channels, one of which is used for international exchange purposes. Facsimile transmission by radio broadcast of analysed and forecast weather charts takes place as a contribution to international collaboration. Land-line facsimile transmission of plotted charts is under development within the United Kingdom (see Section 2). Cable is used for the reception of some data from North America.

Support Services (*M.O.18*). Ancillary services are required by many different parts of the Office. It was decided to take the opportunity of the reorganisation which was made possible by the imminent move of the Headquarters to Bracknell to gather these services together under one Assistant Director who has charge of M.O.18. This occurred late in 1960. The services so collected together comprise the Library and Archives, the sub-editing of Meteorological Office publications, data processing facilities and data storage, and the cartographic drawing office.

The Library is the national library of meteorology and other branches of geophysics. It provides not only all the usual services of a technical library for members of the staff but also an information service to external research workers, other Government departments, industry and the general public.

Publications prepared for the press by M.O.18 include the monthly periodical *Meteorological Magazine*, the *Observatories' Year Book*, the main research publications of the Meteorological Office—*Geophysical Memoirs* and *Scientific Papers*—and various occasional publications.

Until 1959 the data processing facilities were limited to the punched card installation. Data are stored on punched cards of which the Office now has a store of over thirty million. The installation is capable of rapidly extracting and tabulating information from this store, but cannot perform calculations. Early in 1959, however, an electronic computer was purchased which, although

intended primarily for experimental forecasting by numerical processes, has also been available for other researches and investigations. Both the computer and the punched card installation have been widely used by climatological and research branches of the Office. New applications of automatic data processing are being studied, as well as more advanced and compact methods of storing data (on punched tape or magnetic tape).

The nature of the duties of the cartographic drawing office are apparent from the title and are largely associated with charts and diagrams for Meteorological Office publications which are sub-edited in M.O.18, and with new forms.

Techniques and Training (*M.O.8*). This assistant directorate has the dual responsibility for supervising the work of the Meteorological Office Training School and the complementary function of co-ordinating and encouraging at offices investigational work aimed at solving problems associated with local forecasting.

The Training School provides formal professional courses at different levels catering both for new recruits in all classes and for experienced meteorologists. Several courses in specialist subjects are also provided. Attendance at these courses is not restricted to members of the Meteorological Office staff and sponsored overseas students from many different countries receive training there. A detailed table of the number of students trained in 1960 is given in Section 5 (Table 15, p. 49). In addition to the formal training received in the lecture-rooms of the school, staff are encouraged to study for higher external qualifications. As far as possible they are given financial aid and allowed a certain amount of time off for studying. Arrangements for these concessions are co-ordinated by M.O.8.

From time to time manuals dealing with some aspect of operational techniques are prepared.

There are many problems in local forecasting which can best be tackled by the man on the spot, provided that he can fit the work in with his other duties. Some of these problems occur in similar form at a number of stations. Others are amenable to attacks by statistical techniques which require the computational facilities available only at Headquarters. Most of them have the common characteristic that co-ordination of the work at many stations and advice on the computational facilities available improves progress. M.O.8 provides that co-ordination and advice. For that purpose two groups, dealing respectively with statistical and synoptic problems, have been set up.

Defence and International (*M.O.17*). The international character of meteorology inevitably leads to a number of international conferences each year. Most, but not all, of these are held under the auspices of one or other of three organisations. The World Meteorological Organisation (WMO) deals with matters of pure meteorology. This Organisation is composed of six regional associations (one for each Continent) and also sponsors a number of technical commissions each of which deals with a particular branch of meteorology. The International Civil Aviation Organisation (ICAO) deals with all international questions affecting civil aviation and also has geographical component parts and specialist panels. Many of the ICAO meetings are concerned either directly or indirectly with the meteorological aspects of civil aviation. Thirdly, various aspects of meteorological support for the armed

forces of the North Atlantic Treaty Organisation are discussed at meetings of committees and working groups organised for that purpose. There are also meteorological committees associated with the other international military organisations in which the United Kingdom is concerned.

Delegates from the Meteorological Office to these various meetings are drawn from all parts of the Office but the administration and co-ordination is carried out by M.O.17. An account of the principle meetings attended will be found in the " International Co-operation " section (p. 55).

Considerations of the national meteorological wartime policy are closely connected with agreements reached in NATO Meteorological Committee (and other similar) meetings and properly fall within the province of M.O.17.

From time to time other government departments require advice on administrative, financial and technical aspects of meteorological questions which arise in the international field. These matters are also dealt with.

2. Major Events and Changes in the Services Directorate

The major event during 1960 which affected the Services Directorate as a whole was the re-organisation which took place late in the year in anticipation of the move of the headquarters of the Meteorological Office to the new accommodation in Bracknell.

The following notes describe significant changes in the work of the individual components of the Services Directorate.

Central Forecasting (*M.O.2*). Substantial changes were made in the *Daily Weather Report, Daily Aerological Record* and the *Monthly Summary* of the Daily Weather Report. The primary aim was to replace manuscript tabulated observations by typescript so as to provide the information in a form which is more legible and easier to use. At the same time Her Majesty's Stationery Office wished to replace obsolete printing processes.

The *Daily Weather Report* preserves its size and general plan, though with a change in colour, but the observations are tabulated essentially in the standard synoptic code form. The *Daily Aerological Record* has changed substantially in layout. The somewhat random collection of maps previously included has been replaced by maps extended to much of the northern hemisphere, with analyses up to the mid-point of the troposphere.

Two useful meetings of a general nature were arranged. The first was with B.B.C. announcers and other staff for the purpose of describing the work of the Office and exchanging views on forecasts. The second was with shipping representatives at which there was a free exchange of views on the meteorological services provided for seamen.

Aviation Services (*M.O.6*). On November 21, 1960, the aviation work of the two former assistant directorates which dealt with the requirements of the Royal Air Force and of civil aviation (other than ICAO matters) respectively was merged into one assistant directorate with the title given above. The following notes refer to changes in work in the whole field during the year.

In July, 1960, a major re-organisation of the meteorological services for Bomber Command took place. A main meteorological office is now located

at Headquarters Bomber Command with direct communication channels for speech, teleprinter and facsimile to meteorological offices at its Groups and operational stations. The purpose of this re-organisation is to meet the increasingly exacting requirements arising from the use of aircraft which fly higher, further and faster. Some initial difficulties, exaggerated by staff shortages, have been encountered and it is as yet too early to say whether some modifications to the re-organised service will be required.

Following a revision of the organisation of Air Traffic Control for R.A.F. aircraft over the United Kingdom and adjacent areas, meteorological work for Air Traffic Control was transferred from the meteorological office at Gloucester to that at Uxbridge. Gloucester has undertaken additional commitments for aviation and also for public services.

The administrative chain of command of meteorological offices in the central and eastern Mediterranean area was modified to bring it into line with that for Middle East Air Forces (M.E.A.F.) (later retitled Near East Air Forces (N.E.A.F.)). All meteorological units in the area are now administratively controlled by the Chief Meteorological Officer, M.E.A.F. (later retitled N.E.A.F.), but technical control remains with senior meteorological officers of the several main meteorological offices. The increasing frequency of air movements through Gan has required a larger meteorological establishment on this remote island in the Indian Ocean. Conditions on Gan have been rather arduous and the staff have worked hard to provide the required service. On April 30th, 1960, the meteorological office on Christmas Island was closed. Meteorological observations continue to be made by R.A.F. Air Traffic Control personnel. The office at Bahrain was upgraded to the status of a main meteorological office in November, 1960.

During the year approval was obtained for the establishment of a senior meteorological officer as adviser to the Air Officer Commanding No. 38 Group Transport Command.

In April, 1960, a senior experimental officer post was established at No. 1 B.R. Corps in Germany, the holder of the post being required to act as meteorological adviser to the Corps Commander. Experience has indicated that this appointment meets a dual need. One part of the work consists of assisting and advising various Army units regarding the meteorological work which they are now performing for themselves. Another part concerns more typical staff work and advice regarding the meteorological organisation required by No. 1 B.R. Corps.

In the field of civil aviation a system to provide a more efficient means of exchanging weather reports every half-hour and aerodrome forecasts every three hours between 85 of the more important aerodromes in Europe was introduced internationally on April 1, 1960. This system, known as the Meteorological Operational Telecommunication Network Europe (MOTNE), consists of a teleprinter ring network supplemented in some of the outlying areas by radio-teletype, and covers almost all states in Europe and the Mediterranean area. In the United Kingdom there are two distinct MOTNE circuits, both under the control of the Ministry of Aviation. One, the Broadcast Circuit, provides eleven meteorological offices with data relating to the areas outside the United Kingdom. The other, known as the Conference Circuit, is confined to the United Kingdom, Ireland, the Channel Islands and

the Isle of Man and is used for the mutual exchange of weather reports and aerodrome forecasts between twenty civil aerodromes in the area. Messages relating to some of these aerodromes are injected into the main European network.

Specialist forecasting services were provided to a number of clubs at the request of the British Gliding Association during two National Gliding Weeks held during early June and late July at St. Mawgan (Cornwall), Sutton Bank (Yorkshire), Dunstable (Bedfordshire) and Edge Hill (Warwickshire). Services were also provided for the Inter-Services Gliding Championships at Odiham (Hampshire).

Blackbushe aerodrome was closed and forecast facilities withdrawn at the end of May, but this reduction of effort was offset by the need to meet a large increase in British European Airways and other services through Edinburgh (Turnhouse) which was taken over by the Ministry of Aviation from the Air Ministry at the beginning of July.

Towards the end of the year the main forecasting office at London Airport, which had remained in the old accommodation on the north side when the new office was opened in the Queen's Building, also moved to the Queen's Building. This has made possible a number of improvements in the services to both Air Traffic Control and airline operators.

General Services (*M.O.7*). This assistant directorate did not come into being until November 21, but the following notes indicate the major events during 1960 in the field of work now covered by it.

The work of the London Weather Centre, opened in 1959, has increased at a phenomenal rate, while the Centre in Manchester, opened on June 10, 1960, has proved a great attraction in that city. Somewhat surprisingly it has been found that masters of ships using the Manchester Ship Canal en route to the Atlantic have made a habit of visiting the office to consult latest charts before sailing.

Close co-operation with the B.B.C. has been maintained and the personally presented "Your Holiday Weather" broadcast was this year given by our staff directly from the London Weather Centre in Kingsway. Members of the staff were invited to address assembled B.B.C. announcers at one of their regular conferences at Broadcasting House.

The Office was asked conjointly by the B.B.C. and the Forestry Commission to assist in warning the public of forest fires. The wetness of the summer season precluded a reasonable appraisal of the value of the new service, but the Forestry Commission expressed appreciation of efforts made by the Office.

The automatic telephone weather service has been introduced in four new areas during this year, bringing the total to fifteen. Forecasts were issued for Bristol (from June 1) and for southern Hampshire (from November); the latter is available only to subscribers in the Portsmouth area, but Southampton and Bournemouth will be added later. Forecasts already issued for the Essex coast are now available also to subscribers in Colchester, and for the Sussex coast in Brighton and Hove.

During the year the Central Electricity Generating Board installed, at its own expense, tie-lines to the main meteorological offices serving them. Late

in the year C.E.G.B. asked, as a new daily service, for detailed forecasts up to 27 hours from time of issue.

There has been a growth in the demand for information from local gas authorities and now, in addition to routine forecasts supplied to key operation centres in each Gas Board area, forecasts are supplied to individual gas works in many areas.

Particularly close co-operation has been maintained with the Automobile Association which very willingly agreed to members of its staff sending us simple weather reports from their town offices, thus filling a long standing gap in our observational network. In certain areas such as London, Manchester and Glasgow detailed reports from road patrols and from fixed points such as garages and police stations are passed quickly and freely by the Automobile Association to appropriate meteorological offices.

The tempo of investigational work in agricultural meteorology has continued at a high level, and has included work on many subjects—potato blight, apple scab, downy mildew of hops, tomato leaf mould and the aerial trajectories of Black Rust spores; yields of meadow hay; milk yields; shelter, shelter screens and the microclimate of sheltered areas, frost liability, soil temperatures, soil climates under mulches, minimum temperature under cloches and possibilities of frost protection by spraying water over glass frames, minimum temperatures over various surfaces, and irrigation.

Climatological Services (*M.O.3*). The re-organisation in November extended the work of this assistant directorate to cover world and upper air climatology.

Progress has been made in the use and exploration of electronic data processing methods in climatological work. Most routine upper air statistics are now being computed on METEOR* with consequent staff saving. Programmes have been written, proved and used for such work as multiple regression analyses, calculation of new long-period humidity statistics, photo-reconnaissance opportunities, analysis of intense rain over short intervals and small areas at Cardington in connection with design data for urban drainage, estimates of averages over short periods, such as weeks or ten days, from monthly averages. Perhaps the most striking example of time saving by use of these methods is in the production of the data required for drawing base charts, using generalised programmes. This takes a very few hours on METEOR compared with a year by hand methods.

On the exploration side, experimental programmes for quality checking rainfall data from two drainage areas and which will enable various statistics and area rainfall calculations to be made, have been tested and show great promise. There are hopes that the time is not far distant when routine work in this sphere for the whole country will be performed electronically and that the growing volume of work can be performed with much the same number of staff. Similarly, on the upper air side, a programme is being developed which may enable the upper air routine data to be obtained by electronic processing of the frequencies actually observed in upper air ascents and success in this field would free relevant stations of much tedious computation work. On the surface climatological side, such experiments have yet to be undertaken.

* METEOR is the name given to the high-speed electronic digital computer owned by the Office.

A climatological office was opened in June in Tyrone House, Ormeau Avenue, Belfast, to act for Northern Ireland in the same way as the Meteorological Office, Edinburgh, acts for Scotland; office facilities being provided by the Government of Northern Ireland. This new office holds past climatological records for Northern Ireland, is responsible for current accumulation of data and extension of the co-operating network, and for the answering of climatological enquiries in Northern Ireland.

In contrast with the autumn of 1959, when estimations of the probability of sufficient rainfall for re-charge of reservoirs during the last three months were required, in the autumn of 1960 numerous requests were received for estimations of areal rainfall in connection with serious flooding in many parts of the country. For example, special maps of daily rainfall, and tabulated data of hourly, daily and monthly rainfall for the Devon River Board area were requested by consulting engineers acting on behalf of the Devonshire County Council.

During the year a firm of consulting engineers approached us for services in two major projects—an estimation of maximum probable precipitation over the basin of the Blue Nile down to Roseires in the Sudan and of the Kaduna down to the Shiroro gorge in Nigeria, in connection with the design of spillways for dams. Two officers of this Office will do most of this work in 1961, but some preparatory work was begun in the year under review.

For some years we have been carrying out rainfall experiments at Cardington in Bedfordshire, much of it giving the time variation of rainfall intensity in heavy showers for use in storm water drainage questions. These experiments need to be repeated in more hilly terrain of the type near the limit for possible urban development, in order to find whether differences are likely to occur from a flat area such as Cardington. Plans for this work were well advanced during the year and it is hoped that observations will commence over an area near Winchcombe in Gloucestershire, in the spring of 1961.

The Hydraulics Research Station of the Department of Scientific and Industrial Research sought and obtained our collaboration in a study of rainfall/run-off relationships in the area of the river Ray in Buckinghamshire. This experiment will continue for some years. Our collaboration with other bodies, as in the previous report, continued.

Marine Branch (M.O.1). In September the second of the four converted corvettes which made up the original ocean weather ship fleet in 1947 was replaced by a converted frigate. The corvette " Weather Observer " had given excellent service but the replacement vessel " Weather Adviser " and her sister ship already in service " Weather Reporter " are larger and so can offer better accommodation.

A new atlas *Quarterly surface current charts of the eastern North Pacific Ocean* was published and completion of computations for a revised edition of the South Pacific Ocean current atlas is now in sight.

The computation of wave-height frequencies for five degree squares of latitude and longitude for each month for all ocean areas was completed during the year. The tabulation of radiation records from British Ocean Weather Ships obtained throughout the year was put on to punched cards. Summaries were prepared of ocean weather ships' observations made during 1959.

Observations and Communications (*M.O.5*). A major change in the method of making measurements of upper air temperatures has taken place with the introduction of automatic radio-sonde recording equipment. The characteristic transmissions of the radio-sonde are measured by the equipment and the results recorded graphically. During the year the equipment was installed at eight stations in the United Kingdom and at two overseas stations. The system has also been proved suitable for use on ocean weather ships.

The programme of upper air observations at Gibraltar, Malta and Tobruk was increased to meet the needs of aviation by the inclusion of wind finding ascents at 0600 and 1800 G.M.T. daily (in addition to the radio-sonde and wind finding observations at 0000 and 1200 G.M.T. daily).

Special radio installations located at Gibraltar, Malta and Nicosia have been operated, in conjunction with the established United Kingdom network and in several combinations, to discover the best method of giving improved coverage for thunderstorm location over the Mediterranean, North Africa and the Near East.

The daily observational routine of the four stations of the United Kingdom network was extended to 24 hours in April.

In accord with WMO agreements, three of the four European subcontinental broadcasts of meteorological data have been converted from morse to radio-teleprinter operation. The conversion of the Dunstable sub-continental broadcast is planned for early 1961 and the data to be included have been rescheduled to include additional observations requested by other nations via WMO. The necessary re-equipment of our overseas stations with radio-teleprinter receivers encountered supply difficulties and various "ad hoc" arrangements have had to be made.

The planned development of the National Facsimile Landline Network continued through the year, and this system was also installed for certain special projects. In all some forty-six additional facsimile recorders were installed, bringing the total to seventy-four. Earlier trials had revealed the need for engineering changes and for a special plotting technique. These proved practicable and as a result it became possible to transmit plotted charts at the highest available transmission speed. A new transmission programme, in which plotted weather charts predominate, was introduced. It is not yet possible to transmit plotted data by radio with equal reliability and the radio-facsimile broadcast from Dunstable has remained largely unchanged. Dunstable took part in international trials designed to test the adequacy of radio-facsimile transmission of weather charts plotted compositely by the participating nations, but this trial had only limited success and has hitherto led to no practical developments.

A large volume of detailed work has been carried out in conjunction with Air Ministry branches, the Post Office, and the Ministry of Works in connection with the transfer to Bracknell of telecommunications now terminating in Dunstable. This will involve only telegraphic circuits and parallel plans for the reception of radio traffic, initially in Dunstable and later (probably by the end of 1962) at Bampton and Dunstable, and the onward transmission of data to Bracknell have been brought to an advanced stage.

Telecommunication staff at Dunstable have for many years been under the functional control of the Meteorological Office. On June 1, administrative control passed from Signals Command to the Meteorological Office. This

change rendered possible an integration of technician duties, including routine and emergency servicing of meteorological radar, radio-sonde, facsimile and other electronic instruments used at outstations.

Support Services (*M.O.18*). The much-needed re-arrangement and re-cataloguing of the Library stock prior to the move to Bracknell was almost completed.

A considerable saving of time and work has been effected by the introduction in March of a Flexowriter automatic typewriter. This machine produces a punched tape on making a typescript. The tape may subsequently be used to retype automatically and it is therefore suitable for library work where retyping is commonly required for subject and author indexes, bibliographies, etc.

The bibliography for October, 1960, recorded the accession during that month of 841 items, the highest to date.

Observatories' Year Books covering the period of the International Geophysical Year, 1957/8 were published. A notable publication was also the *Handbook of Aviation Meteorology*. The last numbers of *Meteorological Reports* and *Professional Notes* and the first numbers of the new series *Scientific Papers* which replaces them were published.

The Data Processing Officer visited meteorological data processing and computing organisations of the U.S. Weather Bureau and the Air Weather Service.

Techniques and Training (*M.O.8*). With the aim of improving the technique of deducing the surface wind from a forecast of the geostrophic wind, the electronic computer METEOR was used to determine the relations between surface and geostrophic winds from series of observations and measurements for London, Manchester and Prestwick airports. The results are under examination.

A report on observations of fog over the Fens was prepared for the Meteorological Research Committee. Some 50 private observers provided useful observations, a study of which has indicated that when fog is observed on the borders it is usually foggy in the interior, that clearance spreads downwind, and that fog forms initially, and is more dense, over the peaty soil in the south than over the silt in the north.

A trial was arranged for the production of photographs at 15 minute intervals of the Plan Position Indicator at a network of R.A.F. radar stations during the passage of a depression across the country. The positions of weather echoes were compared with those of rain areas inferred from hourly synoptic charts. The radar pictures gave a wealth of detail which is still under study.

Production of charts describing the local weather characteristics of individual aerodromes has started. These are designed to assist the forecaster dealing with landing conditions at these aerodromes.

Work on the production of simplified topographical maps was held up by a shortage of cartographic staff; by the end of the year nine of the 21 areas of the United Kingdom had been covered. A three-dimensional folding model of a depression M.O.657 (A.P. 3359) was issued to the Royal Air Force and certain meteorological offices. The text of a new book entitled " A course in

elementary meteorology ", designed to replace the late W. H. Pick's popular book, was approved for publication, as also was " A pictorial guide to the maintenance of meteorological instruments ".

At the Training School the initial forecasting course was extended by three weeks to allow for the inclusion of new material and more time for practical work. The opportunity was taken to re-organise the programme of courses by synchronising the initial courses for Scientific Officers and Assistant Experimental Officers, thus dividing the school year into two separate sessions. A new course, lasting one week, was introduced for coastguards and lightkeepers whose observations supplement the synoptic network of local meteorological offices.

A. C. BEST
Director of Services

3. SPECIAL TOPIC—THE FORECASTING SERVICES

The atmosphere may be likened to a laboratory in which physical processes are taking place all the time. The task of the weather forecaster is to apply the laws and principles of physics to predict the changes that are taking place in the different elements in the atmosphere that combine to produce the weather—temperature, pressure, wind, humidity, clouds, precipitation and so on. An important consideration, which serves to contrast the work of the meteorologist with that of the scientist in many other branches of physics, is that the atmospheric laboratory is not subject to control. The basic concern of the forecaster is therefore to form an accurate picture of conditions in the atmosphere at a particular moment of time. Thereby he gains an insight into the processes at work. Such a picture, consisting of charts plotted and analysed for different levels from the surface into the stratosphere, reveals the pattern of pressure systems with their associated weather, permits boundaries to be drawn separating air masses of different characteristics and provides a synthesis of the dynamical and thermal state of the atmosphere over a wide area. A detailed study of this picture leads to the production of a weather forecast or, in other words, an assessment of the probable changes in the structure of the atmosphere in both place and time. However, one such picture is not enough because of the complexity of the various changes that can occur in the atmosphere and the forecaster must therefore form a fresh picture at regular intervals, usually every three or six hours, but as frequently as every hour if forecasts of a very detailed nature are required. Each new and up-to-date picture of the weather serves a dual purpose—as a check on forecasts already issued and currently in use, and as a basis for the issue of fresh forecasts.

The construction of weather charts, surface and upper air, to give what is called a synoptic picture of the atmosphere depends on having available observations of the different weather elements from a large number of places distributed over an area which in size may amount to about half a continent or to the major portion of a hemisphere, depending on the scope of the responsibilities borne by the forecasting office. It is an indispensable condition that each forecasting office should be able to receive the observations it requires with the least possible delay. That is one reason why the organisa-

tion of meteorological services throughout the world demands a high degree of international co-operation, with communications playing a vital part.

The observations consist of measurements or descriptions of the more important meteorological elements and are made at stations established in all continents, on islands, on ships at sea and on aircraft. In Europe alone such stations are numbered in thousands. The observational data are transmitted to central offices, usually one in each country, for assembly into collective messages which are broadcast to stations within the national network and to other central offices for further dissemination to individual stations. The whole procedure, which operates almost continuously because of the frequency and regularity of the observing routine, involves a vast and intricate system of land-line, cable, radio and facsimile communications. Speed is the keynote and for the most part forecasting offices, whether at the centre or on the periphery of their national communications network, receive data from far and wide within a few minutes of the observations being made.

When the observations have been plotted on to the appropriate surface or upper air charts and the analysis completed, the techniques of forecasting are applied. In their general approach these amount to the construction of forecast charts which display the state of the atmosphere as the forecaster thinks it will be at some fixed time ahead, usually 24 to 30 hours but perhaps as much as 96 hours for special purposes. The production of detailed forecasts then begins and here the requirement varies from one forecasting office to another. At an aviation centre an airline pilot may be given a forecast of wind, temperature, cloud and weather conditions for various heights up to 50,000 feet for a flight over a route that may be as much as 3,000 miles long. At another office a public utility may merely want a guide to local temperature variations over the next 24 to 48 hours. Although the detailed requirements may differ, apparently more comprehensive and complex at one office than at another, it would not be true to say that any type of forecast is comparatively less demanding than another kind upon a forecaster's physical understanding, judgment and experience.

Current techniques and the observational and communications organisation on which they are based are applicable to short and medium range forecasting. The period of validity of a forecast depends very much on the amount of detail to be attempted. In the temperate latitudes in which the United Kingdom is situated, fairly detailed forecasts up to 24 hours ahead can be made with reasonable confidence and these can be supplemented with further outlooks for 48, 72 or 96 hours ahead. However, both the detail and the confidence inevitably decrease as the period of the further outlook increases. Long-range forecasts, dealing with the weather prospects for weeks or months ahead cannot yet be produced with adequate reliability for routine applications. It is unlikely that such forecasts, if ever they do become practicable, will require the elaborate and widespread organisation that has been developed for short- and medium-range forecasts.

The organisation of the forecasting services has developed naturally along mainly functional lines. There is a Central Forecasting Office (CFO) and offices of appropriate responsibilities are linked to the R.A.F. chain of command, including R.A.F. operational stations, and are also situated on airfields controlled by the Ministry of Aviation and in certain towns in order to meet the growing demands for public services forecasting. Many of the

forecasting offices which are concerned primarily with aviation also provide service to the public where the need exists and the work can be done conveniently.

The whole organisation of the forecasting services is divided for administration in accordance with the nature of the work—central, aviation or public services—but is integrated technically, the Central Forecasting Office representing the focal point. The necessity for such an arrangement stresses the importance of team work in weather forecasting. The organisation, which is described in greater detail below, has evolved gradually over the years. It is possible that in time some of the more routine and laborious tasks will be done automatically but it seems unlikely that the human element will ever be entirely eliminated. The nature of atmospheric processes is such that judgment, based on knowledge and accumulated experience, is likely to be demanded of forecasters for many years to come.

The Central Forecasting Office. The Central Forecasting Office is the principal analysis and advisory centre of the nation's meteorological service and, in addition, it is one of the master analysis centres in the international network developed by the World Meteorological Organisation. Compared with techniques in use a quarter of a century ago, modern forecasting depends on a greatly increased density of observations and on the ability to analyse the state of the atmosphere up to great heights as well as over a large area. The volume of basic data becoming available every few hours has left little alternative but to centralise the work nationally and to zone it for international purposes. Thus in the scheme which operates under the auspices of the World Meteorological Organisation, the Central Forecasting Office is responsible for producing and disseminating surface and upper air analyses and forecasts for the Eastern Atlantic and Europe. Exchanges of analyses with similar centres in other zones, for example Washington and Moscow, greatly assist the task of global weather analysis.

In its national rôle, the Central Forecasting Office provides overall guidance to the outstation forecasting offices. This is accomplished by routine transmissions, several times each day, of actual and forecast surface and upper air charts accompanied by plain language statements, called Synoptic Reviews, containing an appreciation of the current situation with a discussion of the various possible lines of future development. In carrying out this work the Central Forecasting Office provides outstations with the technical framework within which their more detailed work is conducted and thereby ensures a high degree of technical uniformity in every type of forecast. At the same time the independence of the outstation in relation to its own particular tasks remains real and vital.

It is inherent in the responsibility of the Central Forecasting Office for the issue of master analyses and overall advice that the forecasters there should be as free as possible from the interruptions occasioned by routine forecasts of a restricted scope or by casual enquiries. However, forecasts issued to the public through the press, radio and television are nationwide in their application and are published or broadcast throughout the country. Close co-ordination is therefore essential and these forecasts are prepared at the Central Forecasting Office and, apart from their public distribution, are sent by teleprinter to outstation forecasting offices. Shipping forecasts,

provided for a particular section of the community, are also prepared at the Central Forecasting Office. These forecasts relate to two areas. Forecasts and gale warnings are broadcast by the B.B.C. and by G.P.O. shore radio stations for coastal sea areas roughly 300 miles from our coasts. In addition, forecasts and storm warnings are broadcast from Portishead radio for a further area extending to mid-Atlantic. The forecasts are broadcast twice daily in a North Atlantic Weather Bulletin which also includes a detailed weather analysis and a selection of reports.

In connection with forecasts for the general public, the London Weather Centre (see p. 28) stands in special relationship to the Central Forecasting Office. This centre is in many respects a mouthpiece of the Central Forecasting Office and, under the latter's technical control, takes part in personal radio and television weather broadcasts and in forecasting for the concentrated population of London and south-east England.

At present nearly all of the forecasts issued by the Meteorological Office are " short-range ", that is, they cover a period varying from a few hours to 24 hours. " Medium-range " forecasts have been the subject of experiment over many years and take the form of forecast charts for 2 and 3 days ahead accompanied by a verbal explanation. Until recently these forecasts received little circulation outside the Central Forecasting Office, where they are prepared, but now they are broadcast to outstations which are connected to the facsimile network, and supplement the routine further outlooks. The technique for medium-range forecasting is in some degree an extension of the methods used for short-range forecasting but some new factors assume importance and these, together with the much larger area that has to be studied, puts the work into a separate category for which a special section has been formed.

The forecast charts for several days ahead give the general meteorological interpretation of expected changes. These charts provide the basis for specialised medium-range forecasts issued by the Central Forecasting Office examples of which are given below: —

(a) Weekend mean and minimum-temperature forecasts during the winter months as an aid to economy in factory heating.

(b) Warnings of spells of frosty weather, in connection with construction work, the heating of buildings, the freezing of water tanks in trains, etc.

(c) Forecasts of at least 3 days of dry weather during the summer months, a service primarily for farmers.

(d) Forecasts for 3 or 4 days ahead of weather likely to result in increased demands for a variety of products such as ice-cream in summer and anti-freeze fluids in winter.

(e) Weekend forecasts for use in estimating the risk of forest and heath fires.

(f) The outlook (given every Sunday) in the television programme for farmers.

(g) Forecasts of the occurrence of specified weather types so that the Ministry of Housing and Local Government can obtain series of comparable photographs of the effects of smoke control.

The Central Forecasting Office also contains a unit which is responsible for the preparation of the *Daily Weather Report*, with which there is a *Monthly Summary*, the *Daily Aerological Record*, and the *Overseas Supplement* which includes both surface and upper air data from stations overseas which are controlled by the Meteorological Office. These publications are prepared to fulfil an internationally agreed requirement and are also sold to the public, to schools and to scientific bodies.

Forecasting Services for Aviation. The Assistant Directorate for Aviation Services (M.O.6) is responsible for providing forecasting services to the Royal Air Force and to civil aviation. It controls a large number of outstations which, for the most part, fall into one of the following categories: —

(a) Main meteorological office.

(b) Subsidiary meteorological office.

(c) Observing office.

All these offices are connected either directly or indirectly to the Central Forecasting Office by teleprinter, and in recent months many have also been connected by facsimile. The offices are thus enabled to receive all the basic data they require and also the results of the analyses carried out by the Central Forecasting Office and the forecast charts constructed there.

Main meteorological offices have wide responsibilities and are located at many R.A.F. Command and Group Headquarters, at or in the vicinity of all Air Traffic Control Centres and at major airports. A main office, besides its work for the headquarters or airfield where it may be situated, also gives technical advice and guidance to subsidiary offices and observing offices under its control. Certain main offices, such as those at London Airport and Prestwick and some attached to the Royal Air Force, have areas of responsibility more extensive than those normally covered by the Central Forecasting Office and, in consequence, maintain their own independent sequences of analysed and forecast charts.

Subsidiary offices are to be found at most of the operational stations of the Royal Air Force and at civil airports of intermediate importance. These offices, in addition to their local responsibilities, may also supply forecasts to observing offices and to authorities—stations, airports or other establishments—without meteorological offices of their own. Observing offices are located at minor civil aerodromes and at certain Royal Air Force Stations.

Forecasting procedures for military and civil aviation have naturally a great deal in common. The task of the forecaster is essentially the same whether the aircraft to be flown is military or civil, but some differences arise in the precise nature of the information supplied because, as one would expect, military and civil flying are both highly specialised. The airline operator, for example, is greatly concerned with the need for economy and with maintaining regularity of service and adherence to traffic schedules.

For the most part forecasting procedures are associated with pre-flight planning and with information to be supplied while an aircraft is in flight. For civil aviation the procedures are laid down in regulations and recommendations drawn up by the International Civil Aviation Organisation (ICAO) in agreement with member states. The arrangements covering the supply of meteorological information for military flying are on similar lines.

Pre-flight forecasts are primarily intended to show the captain and the navigator of an aircraft the conditions likely to be encountered on a proposed flight and during descent and landing at destination. With the aid of such a forecast, decisions are made about the route, the operating height and, especially for civil aircraft, the amount of fuel required and hence the load that can be carried. For long routes, such as those over the North Atlantic, a wide choice of flight path is available and the pre-flight forecasts must show the distribution of weather, wind and temperatures over a very large area surrounding the direct or great circle track. When a route has been selected, the aircrew are provided with a detailed forecast, consisting of surface and upper air charts accompanied by written details of meteorological elements, and also receive an oral briefing to which much importance is attached. The forecast documents also contain landing forecasts for destination and possible diversion airfields and these are in fact prepared at the terminal airfields concerned. This represents an important principle since a forecaster has a better understanding of the weather at his own airfield than at another station, perhaps a thousand or more miles away.

In-flight service is normally provided by main meteorological offices at Air Traffic Control Centres (ATCC), each of which is responsible for a large area and has the task of advising and controlling aircraft flying within the area. Weather information is supplied to aircraft by means of routine W/T or R/T broadcasts of observations and landing forecasts, by means of broadcast warnings as necessary, and, of course, the captain of an aircraft in flight may request any special information that he may need at the time.

Long range aircraft of the latest types, whether military or civil, operate at very high altitudes and present difficult problems in the accurate forecasting of winds and temperatures. The existence of jet streams demands special care because of the large velocity gradients in their vicinity. As a rule the operating heights are "above the weather" and free from hazards such as icing and thundrstorms, but these factors as well as others have to be taken into account when the aircraft descends on approaching its destination.

A forecasting problem of an unusual nature and apt to be of great difficulty arises on the military side with the operation of fighter aircraft. These are not only extremely fast but also have a very short endurance, especially if operating at low levels. The problem of diversion in the event of weather deterioration at a destination airfield is therefore of extreme importance and frequently demands instant decision by the Air Traffic Control Officer on receipt of meteorological advice. At fighter airfields, therefore, observations are made every hour, and are supplemented by additional reports at 15-minute intervals to show whether or not any significant changes in the weather have occurred. By this means controllers have available almost up-to-the-minute reports for all likely destination and diversion airfields and also receive advice from forecasters as to whether improvements or deteriorations are likely to occur. A similar procedure for the rapid exchange of reports and, in addition, landing forecasts also exists for civil aviation, but in this case the frequency is half-hourly instead of 15 minutes.

Forecasting Services for Public Requirements. The Assistant Directorate, M.O.7, is responsible for public service work and also deals with the requirements of agriculture and the Army. In recent years the Meteorological Office has given an increasing amount of attention to the provision of forecasts and

other meteorological information to public utilities, industry and commerce, and to government departments associated with such activities. In addition, there has been an extension of the well established services made available to the public through the press, radio, television and the telephone.

Nearly all existing forecasting offices were opened primarily to serve the needs of aviation and are therefore situated on aerodromes or at such places as Air Traffic Control Centres. However, there are now very few of these offices which are not exposed to the impact of public service work over a wide range of subject matter. Until December 1959 the London Weather Centre was the only forecasting office working more or less exclusively for public services, but in that month a new weather centre was opened in Glasgow and another one was established in Manchester in the following June. These three weather centres reflect in part the rapid growth in the forecasting work which is connected with the life of the community generally.

Many of the services available to the public are provided without charge except for the cost of a telephone call when a special enquiry is made or when the automatic telephone weather service is used. Forecasts for the press are issued four times daily for the whole of the United Kingdom, divided as necessary into some 10, 20 or 30 areas. Distribution takes place through the London Weather Centre and copies of the forecasts are also transmitted by teleprinter to most of the forecasting offices throughout the United Kingdom. Special arrangements are made for provincial newspapers.

Radio broadcasts of weather forecasts have been a feature of B.B.C. programmes for many years. The overall responsibility for these forecasts is borne by the Central Forecasting Office but, in order to take full account of local or regional peculiarities of weather, contributions to each nation-wide message are received from outlying main meteorological offices which are in direct communication with the B.B.C. regional transmitting stations.

A fairly recent innovation on sound radio has been the direct broadcasting of a morning weather talk by a forecaster on the staff of the London Weather Centre. This feature, which received a great welcome, is known as "Your Holiday Weather" and is broadcast on the Light Programme at 8.55 a.m. during the summer months.

The B.B.C. European Services also contain weather forecasts which are prepared by the Central Forecasting Office and from time to time sections of the routine shipping forecasts are translated by the B.B.C. for use in foreign language broadcasts.

The main feature of the use of television for giving forecasts to the public is the nightly appearance before the cameras of a forecaster of the London Weather Centre who, in the space of about 3 minutes, discusses the day's weather and indicates on specially prepared charts the probable weather for the morrow. Later each evening caption charts with forecasts for both land and sea areas are prepared at the London Weather Centre for display by the B.B.C. after television news programmes. The independent television companies make their own arrangements for the broadcast of weather forecasts but these are all based on material supplied by the Meteorological Office, mainly by the London Weather Centre.

The automatic telephone weather service is now available in eight major cities and consists of brief local area forecasts which are recorded by G.P.O. staff every 6 hours, or more frequently if the conditions justify, and cover

a period of 12-24 hours. Forecasts for coastal strips in south-east England are also available through the London Exchange. For the Teletourist Service organized jointly by the British Travel and Holiday Association, the B.B.C. and the G.P.O., the Meteorological Office provides twice daily short forecasts for the London area which are translated into French and German and added to the recordings of " the day's events " available on ASK 9311 and 9411.

The public has direct access to the Meteorological Office not only through the weather centres in London, Glasgow and Manchester, but also through some 40 aviation forecasting offices which are listed in the *Post Office Guide*. This facility is greatly used especially during holiday periods and at times of inclement weather such as fog, heavy rain or snow. The users include farmers, industrialists, transport operators, employers, editors in search of a topical story, as well as housewives, sportsmen and others. The weather centres, of course, are able to provide a personal rather than a telephone link with the public and it is evident that many people appreciate the opportunity of a face-to-face discussion with a forecaster.

The preceding paragraphs in this section have been concerned with forecasts which the Meteorological Office, as the State Weather Service, is required to provide and disseminate as freely and widely as possible. Many authorities, however, require in addition specialised advice adopted to their particular needs and at the same time require the Office to keep a weather watch over the operations or activities in progress. Facilities of such a nature are subject to a charge which is based mainly on the time occupied by staff in providing them. The Office's customers for specialised work include the public utilities —railways, electricity, gas and so on—local authorities, the Port of London Authority, the Forestry Commission, Hydro-electricity Boards, industrial and commercial concerns, building contractors, engineers, film companies, food manufacturers, the Automobile Association and a host of others. For such concerns meteorological requirements arise principally through the need for efficient and economical operation whether day-to-day or long term. The work to the meteorologist is of absorbing interest involving as it does a close participation in the planning and direction of the work of the individual customer. Quite often the application of weather information has led to developments or modifications of long established operating procedures and, incidentally, given rise to new meteorological problems. The rapid increase in demands for specialised weather forecasts is a sure indication that the work of the Meteorological Office has much to contribute to the economic and social well-being of the community.

4. Notes on the Weather of 1960

After the wettest winter in England and Wales since that of 1915-16, the spring and early summer of 1960 were comparatively warm and dry. The second half of the year, however, will long be remembered for its exceptional rainfall, particularly in southern England during the five months July to November. These months provided a striking contrast to the corresponding months in 1959. The summer of 1959 was memorable for long spells of fine weather in England and Wales with the general rainfall during the period May to September the lowest since comparable records began in 1727; but, in 1960 the period extending from late summer into autumn was the wettest on record in England and Wales, and the general rainfall for the year as a

whole has only twice been exceeded—in 1872 and in 1852. In Scotland on the other hand amounts of rainfall in 1960 were by no means remarkable, indeed, rainfall during July, September and October was below the average, and the totals for the months July to November and also for the calendar year were slightly less than the average for these periods. The distribution of rainfall over the country, as a percentage of the average, is shown in figure 1.

The diagrams on pp. 34 to 42 show for each month of 1960 (full lines) the average temperature in °F, the average rainfall in inches and the average amount of sunshine in hours per day for England and Wales, for Scotland and for Northern Ireland. On each diagram the long period monthly averages (1916-50 for rainfall and 1921-50 for temperature and sunshine) are shown as dotted lines and, for comparison, the corresponding values for 1959 are indicated by dashed lines. Temperature was below average in 1960 in the months February, July to September and December, whereas in 1959 it had been above average in every month except January. Rainfall was above average over England Wales in every month of 1960 except March and June inclusive, while in 1959 it had been below average in February and in every month from May to October. 1960 sunshine was below the average in England and Wales in May and in July to October inclusive; in 1959 it was above the average from May to October inclusive.

January and February, 1960, were wet generally with mild periods but there were also falls of snow. Level snow lay about 12 in. deep over large areas of southern England about the middle of January but by the 22nd the flow of Atlantic air was restored and temperature was in the upper fifties (fahrenheit) over the whole of the British Isles. February was a sunny month, especially in the north-west of the country and was notable for extremes of temperature. The mild south-westerly winds prevailing during the latter part of January soon moderated and were replaced by cold northerly winds during the second week of February. Snow fell over a wide area from 10th to 20th and level snow lay 1-2 ft. deep in parts of Scotland and 4-8 in. deep in parts of Wales and central England for much of this period. On the 17th/18th air temperature fell to 20°F at a number of places in England and Wales and below 0°F in Scotland; −8°F was recorded at Granton-on-Spey. The last two days of February, however, were exceptionally mild; on the 29th temperature was higher at Stonyhurst than in any previous February since records began there in 1848.

After four months with more than average rainfall in England and Wales, March began a series of four dry comparatively warm months. The weather of March was dominated by an anticyclone in the vicinity of Scandinavia giving a preponderance of easterly winds over the British Isles. These were replaced by south-westerly winds during the last week of March but by the middle of April the Azores anticyclone had extended towards this country and a high pressure belt extended across the country to Scandinavia. This persisted until the first week of May when south-westerly winds again spread across the country. Anticyclone conditions were restored towards the end of the month and lasted into early June after which a fortnight of changeable

westerly conditions was again followed by anticyclonic conditions. During these four months temperature was above average in Scotland and Northern Ireland though in these territories April was wet. March was generally dull, especially in the east, owing to the predominantly easterly winds. The first half of April was changeable but the latter part of the month, and also the month of May were mainly warm and dry, though with some unsettled spells, chiefly in the south and west. Day temperatures in May were particularly high in Scotland where there has been only one other May, that of 1919, as warm as this since the beginning of the century; in eastern Scotland the mean maximum temperature was more than 5°F above average. June was warm and sunny generally but with heavy instability rains at times. A severe outbreak of thunderstorms began in south-west England on the night of the 22nd and the storms became widespread the following day. Among the many noteworthy falls of rain recorded was one of 4 in. in 5 hours at Oxford.

In England and Wales July began a sequence of three cool months and of at least six months with rainfall above the average. During July and August thunderstorms were again widespread and frequently severe. At some places, particularly in south-east England, the days were unusually cool. For example, at Hastings the highest temperature recorded in July was 67°F which was the lowest July maximum temperature there since records began in 1874, while in August the temperature rose to only 70°F, the lowest August maximum there for 15 years. Apart from a brief anticyclonic spell during the second week, weather during September was mainly cyclonic, cool and wet especially over central and southern England. During the last four days of the month exceptionally heavy rain fell over a wide area around Exeter resulting in a disastrous series of floods. Some places had five inches of rain during these four days.

October and November were comparatively mild but December was rather cold. Brief anticyclonic spells occurred during the second week of October, towards the end of the first week of November and for much of the second and third weeks of December, otherwise the weather continued to be mainly cyclonic in character with frontal systems crossing the country every two or three days. October was exceptionally wet, especially in southern and eastern England where there were extensive floods. Eastern Devon and western Somerset and the North Riding coast received more than three times the average rainfall. There was an unprecedented intense fall of rain for October in the Horncastle area on the 7th, more than 7 in. being recorded in about 5 hours. Flooding was again widespread in England and Wales in November but fortunately southern Devon and western Somerset had slightly less than average rainfall and was one of the drier areas. December began with further unsettled weather and there was serious flooding in South Wales after more than 7 inches of rain had fallen on the Brecon Beacons in the first three days. From the next fortnight weather was much more settled with light winds and a good deal of fog. This was followed by a period of northerly winds, with wintry precipitation in eastern districts, but after Christmas an unsettled westerly type was resumed.

The outstanding feature of the weather of 1960 was undoubtedly the excessive rainfall over England and Wales from July onwards. This made

dismal weather for holiday makers, except in north-western Scotland, and made harvesting conditions exceptionally difficult. Probably the worst effect was the widespread flooding which was at its most disastrous in October but which was renewed in various districts of England and Wales up to the end of the year.

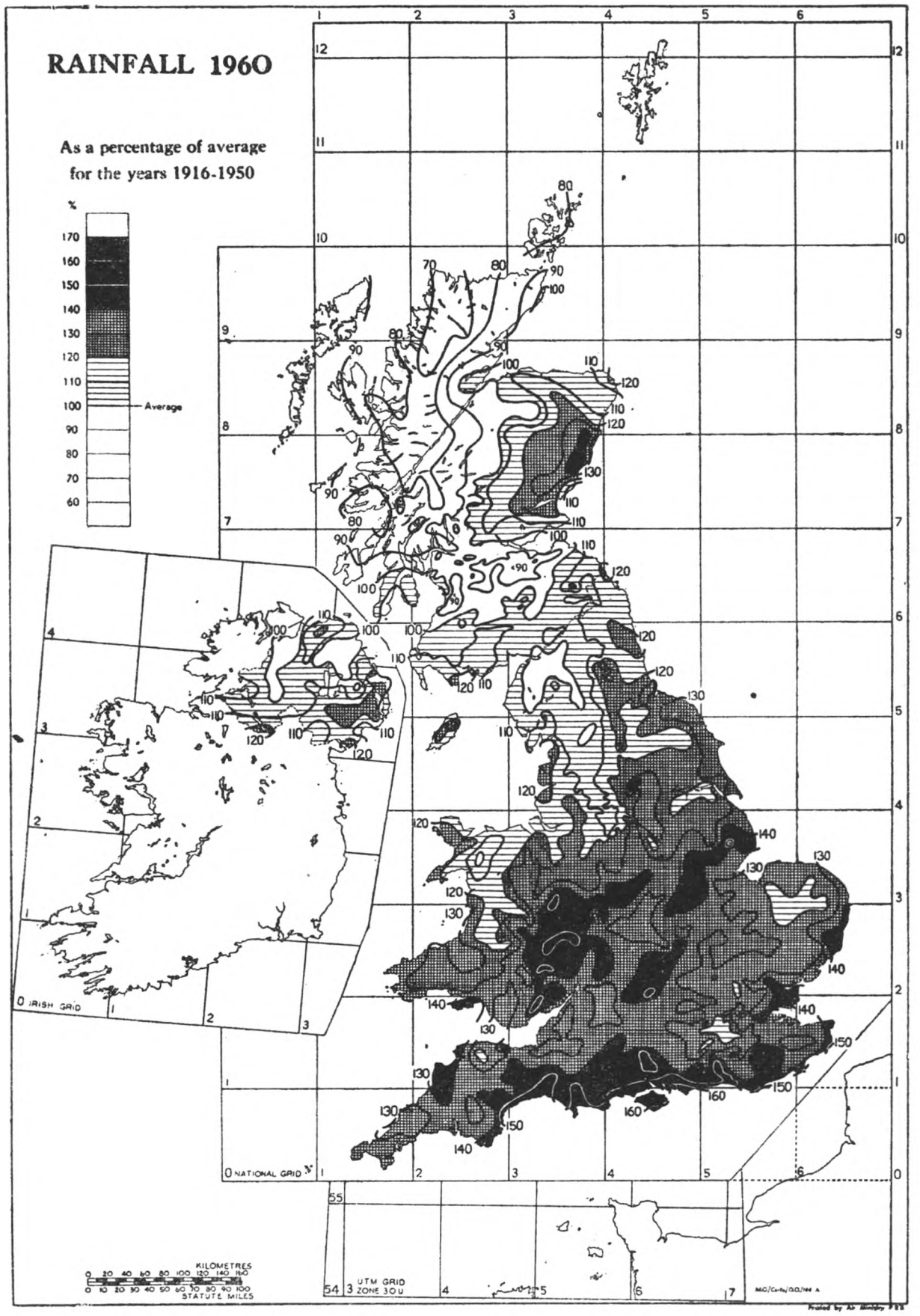


Fig. 1—Rainfall 1960

Highest maximum and lowest minimum air temperatures (°F.).

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1960	59	65	63	68	78	87	77	78	78	69	66	59
	12	8	22	17	20	30	30	30	29	25	19	14
1959	55	66	66	71	82	84	96	88	86	83	65	59
	7	14	19	20	21	30	32	27	23	23	14	22

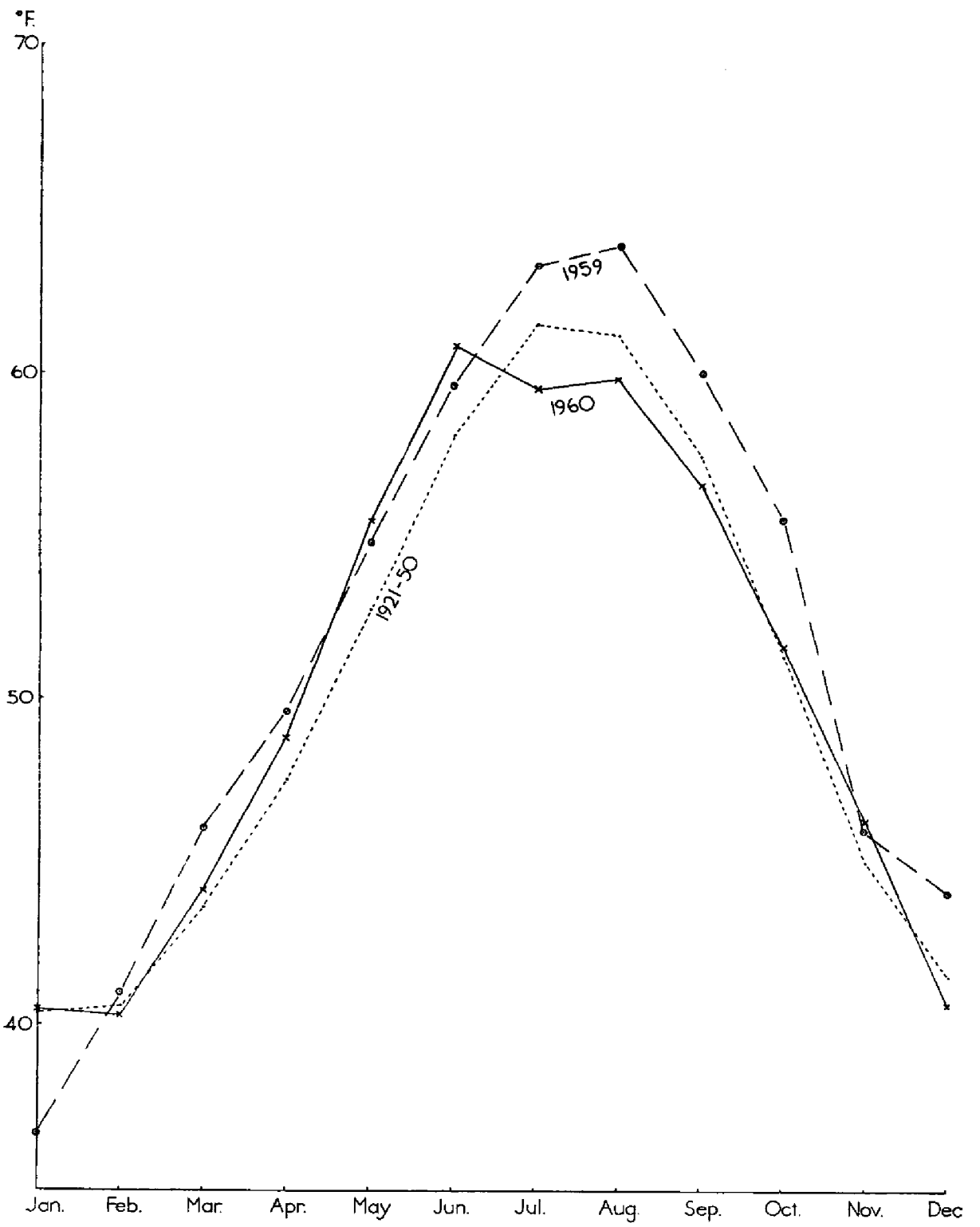
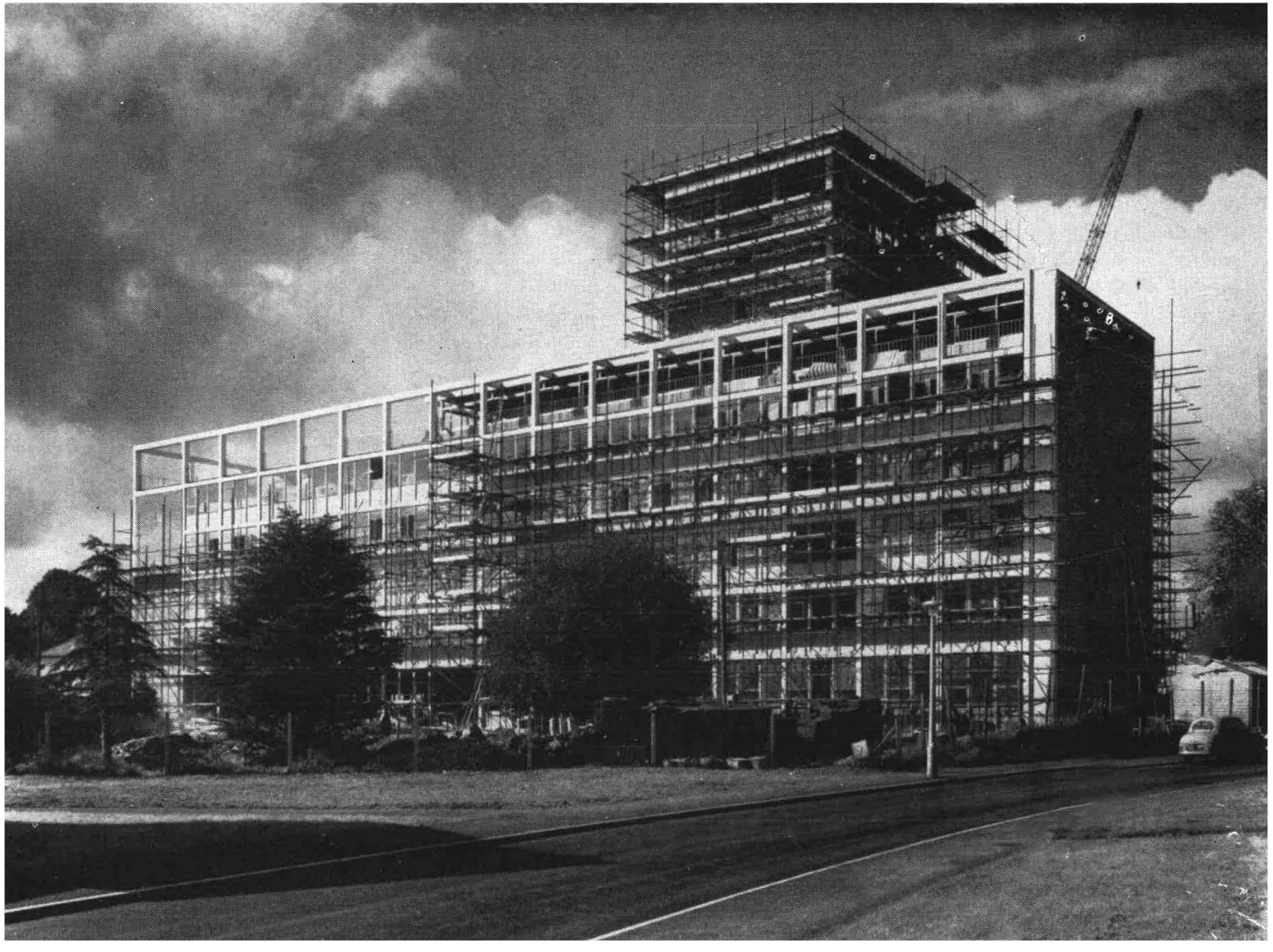


Fig. 2—England and Wales. Monthly general values of temperature in °F.

PLATE I



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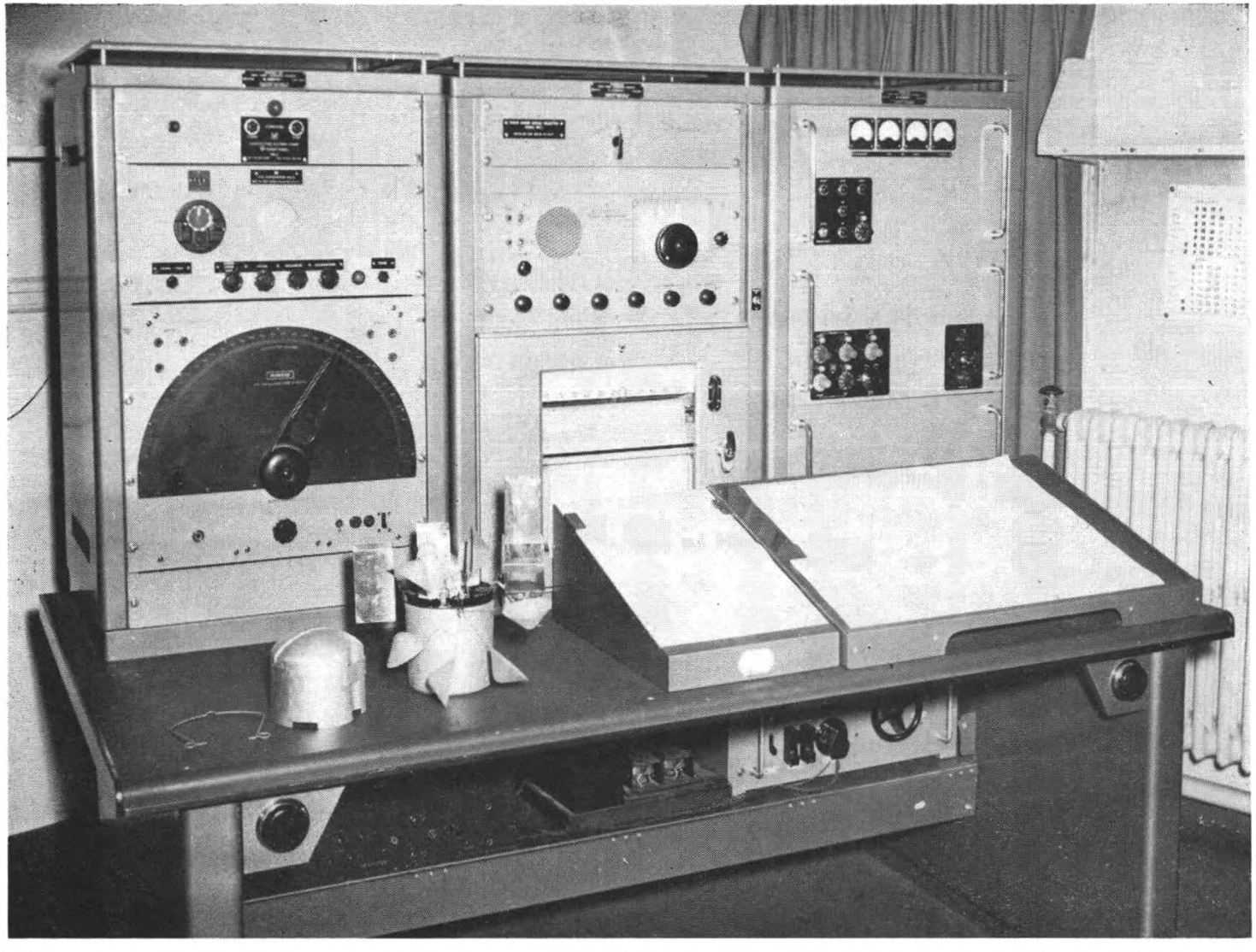
The new Headquarters building at Bracknell. (See p. 7.)

PLATE II

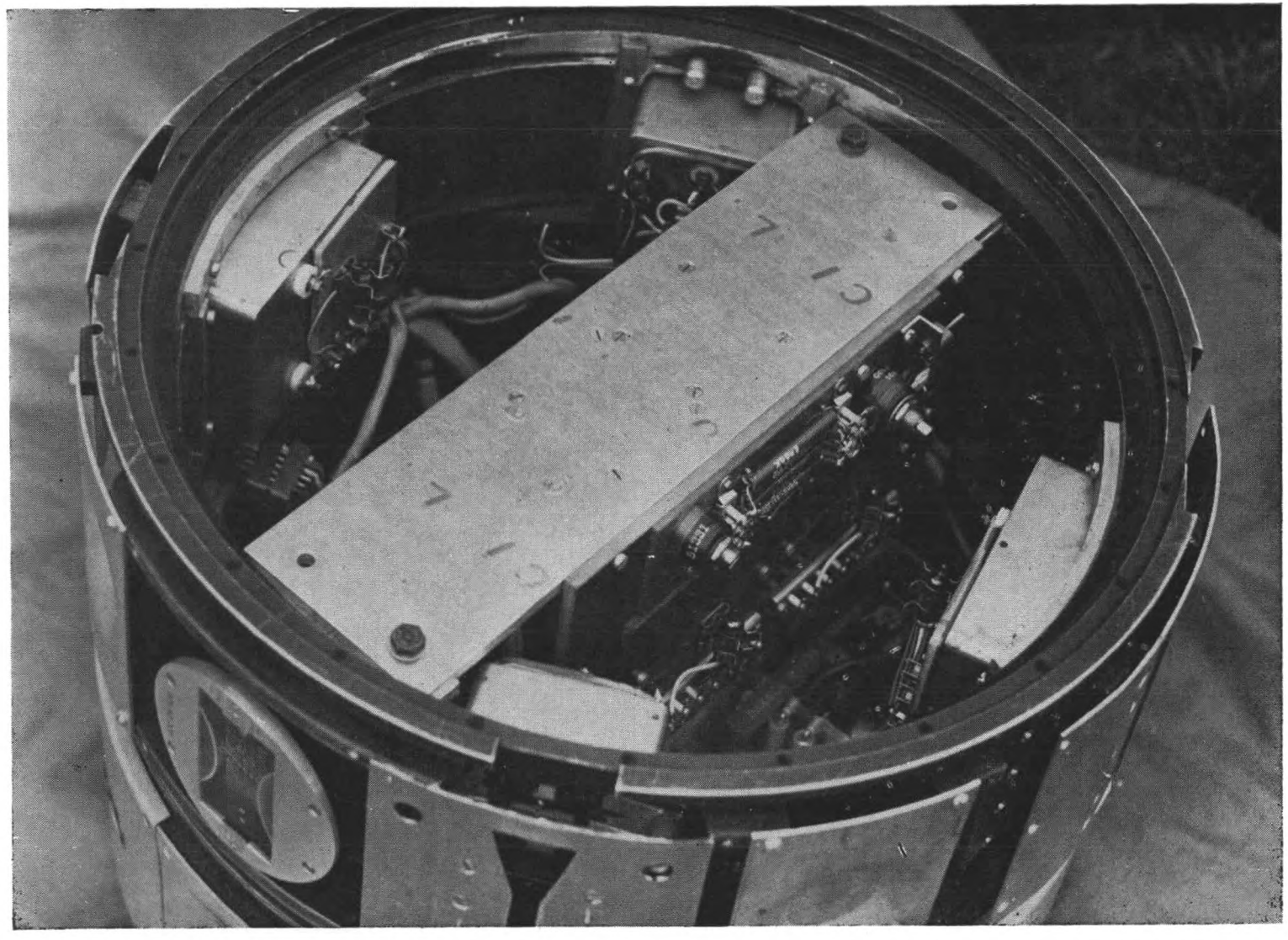
Reproduced by kind permission of the Sport and General Press Agency Ltd.

An assistant plotting the location of rain areas displayed on the storm-warning radar at the London Weather Centre. (See p. 20.)



CINTEL equipment for the automatic recording of radio-sonde signals. (See p. 20.)

PLATE IV



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Instruments, being developed for use in a satellite, for measuring the vertical distribution of atmospheric ozone, mounted in the instrument bay of a rocket. (See p. 53.)

Highest maximum and lowest minimum air temperatures (°F.).

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1960	62	61	66	65	77	85	74	78	72	65	59	55
	−2	−8	14	21	22	33	30	30	23	21	16	10
1959	52	61	63	69	79	83	82	83	80	77	62	57
	0	0	16	21	20	30	33	32	28	25	12	19

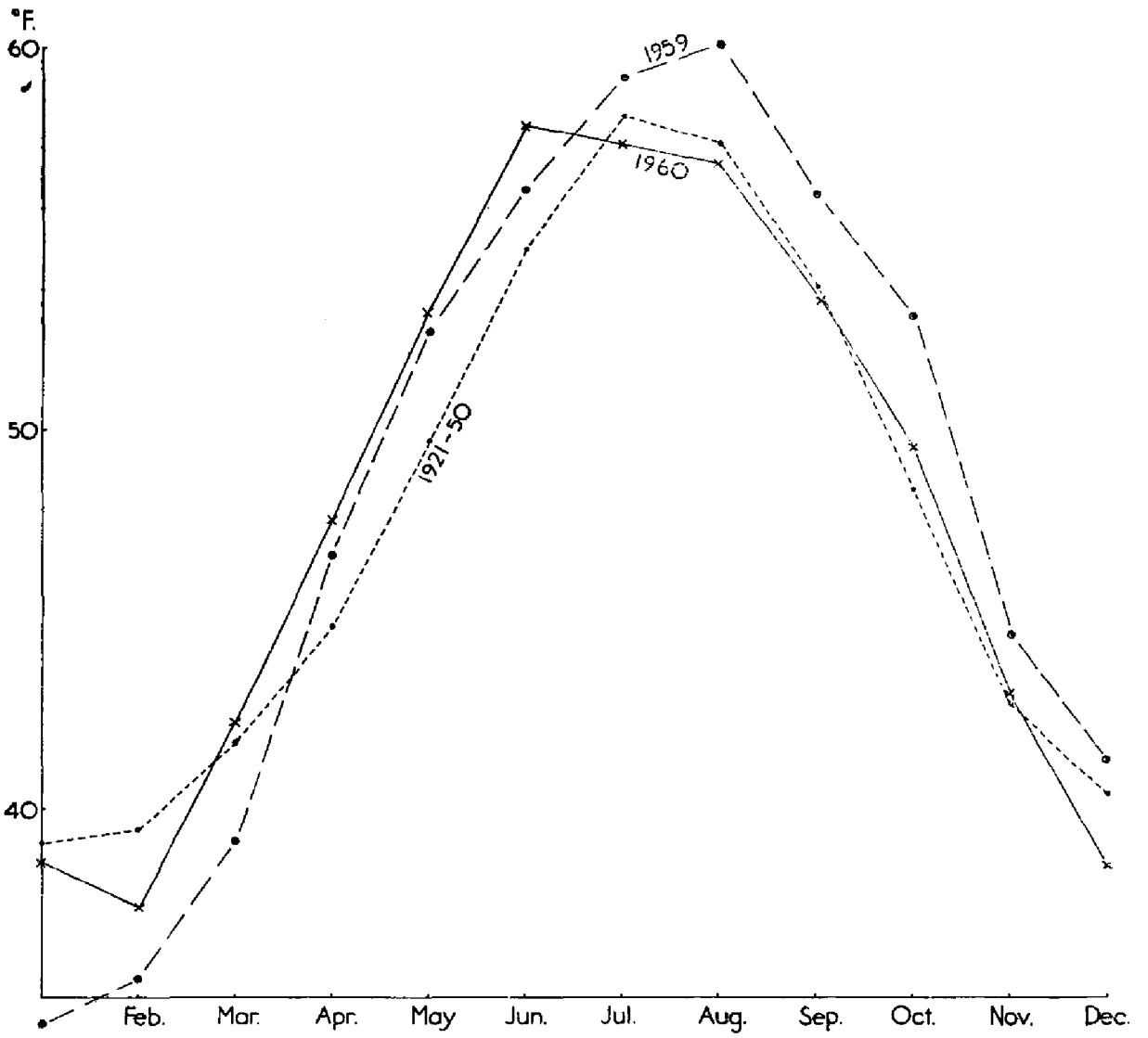


Fig. 3—Scotland. Monthly general values of temperature in °F.

Highest maximum and lowest minimum air temperatures (°F.).

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1960	56	57	59	65	71	77	72	73	69	64	58	56
	21	9	28	28	31	39	40	37	34	31	23	19
1959	51	56	61	62	76	80	79	76	80	72	58	54
	13	18	27	28	27	37	39	37	36	33	25	25

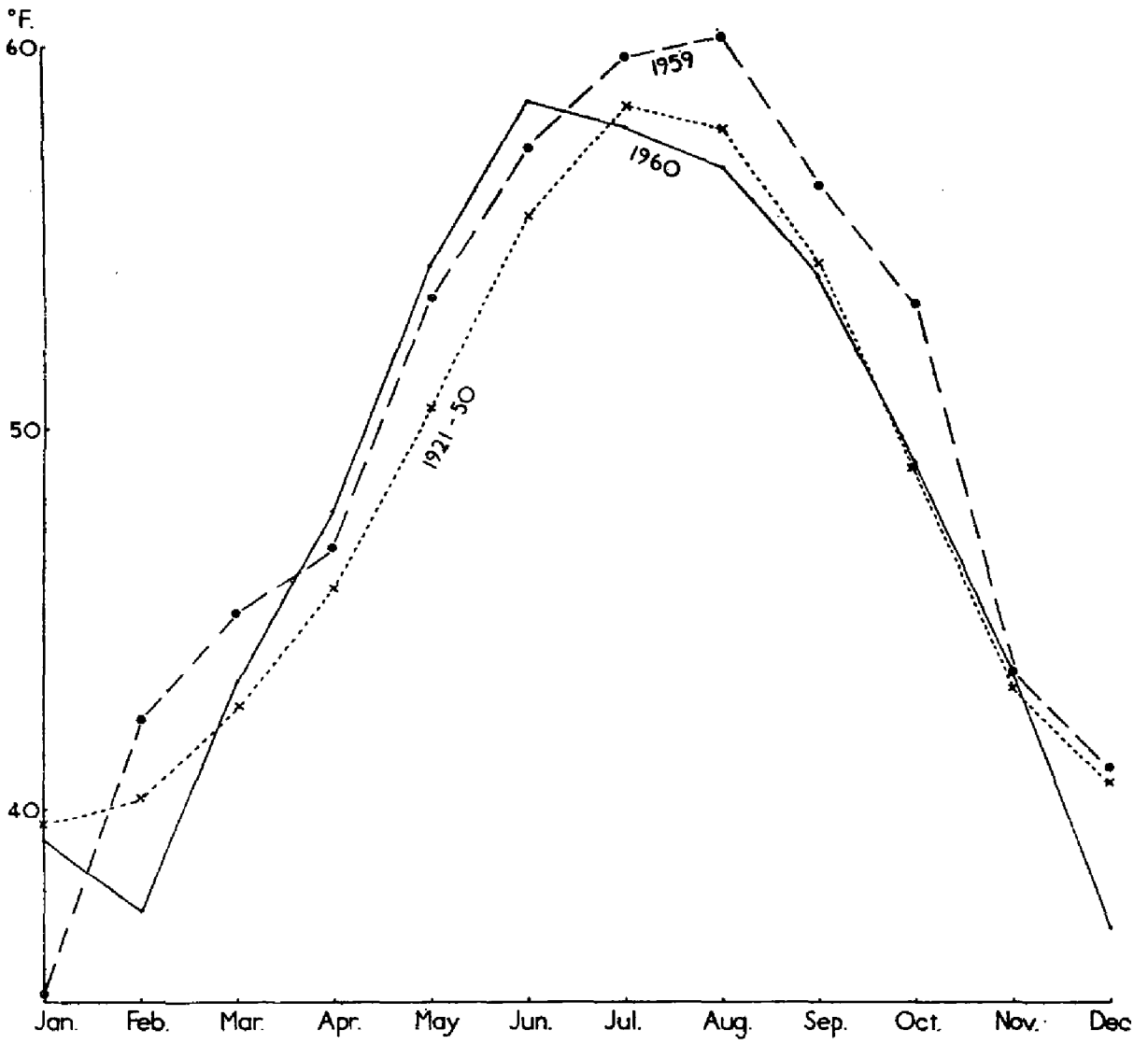


Fig. 4—Northern Ireland. Monthly general values of temperature in °F.

Percentage of 1921-50 average sunshine.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1960	78	118	59	106	97	128	85	95	94	68	114	122
1959	171	91	83	98	121	115	132	122	146	139	98	75

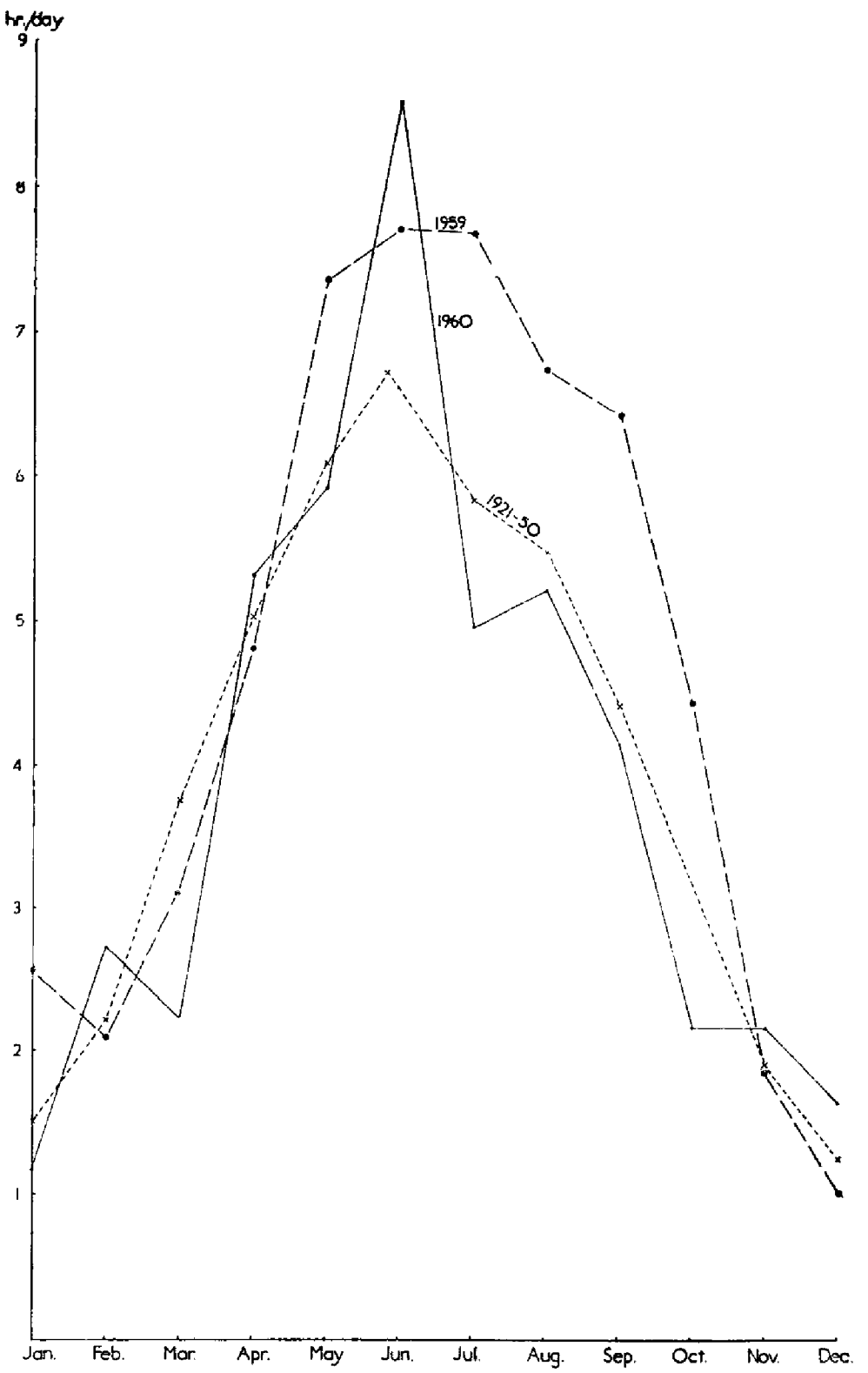


Fig. 5—England and Wales. Monthly general values of sunshine in hours per day.

Percentage of 1921-50 average sunshine.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1960	116	149	81	95	108	116	100	105	119	63	110	141
1959	175	102	92	96	114	109	97	102	132	128	90	67

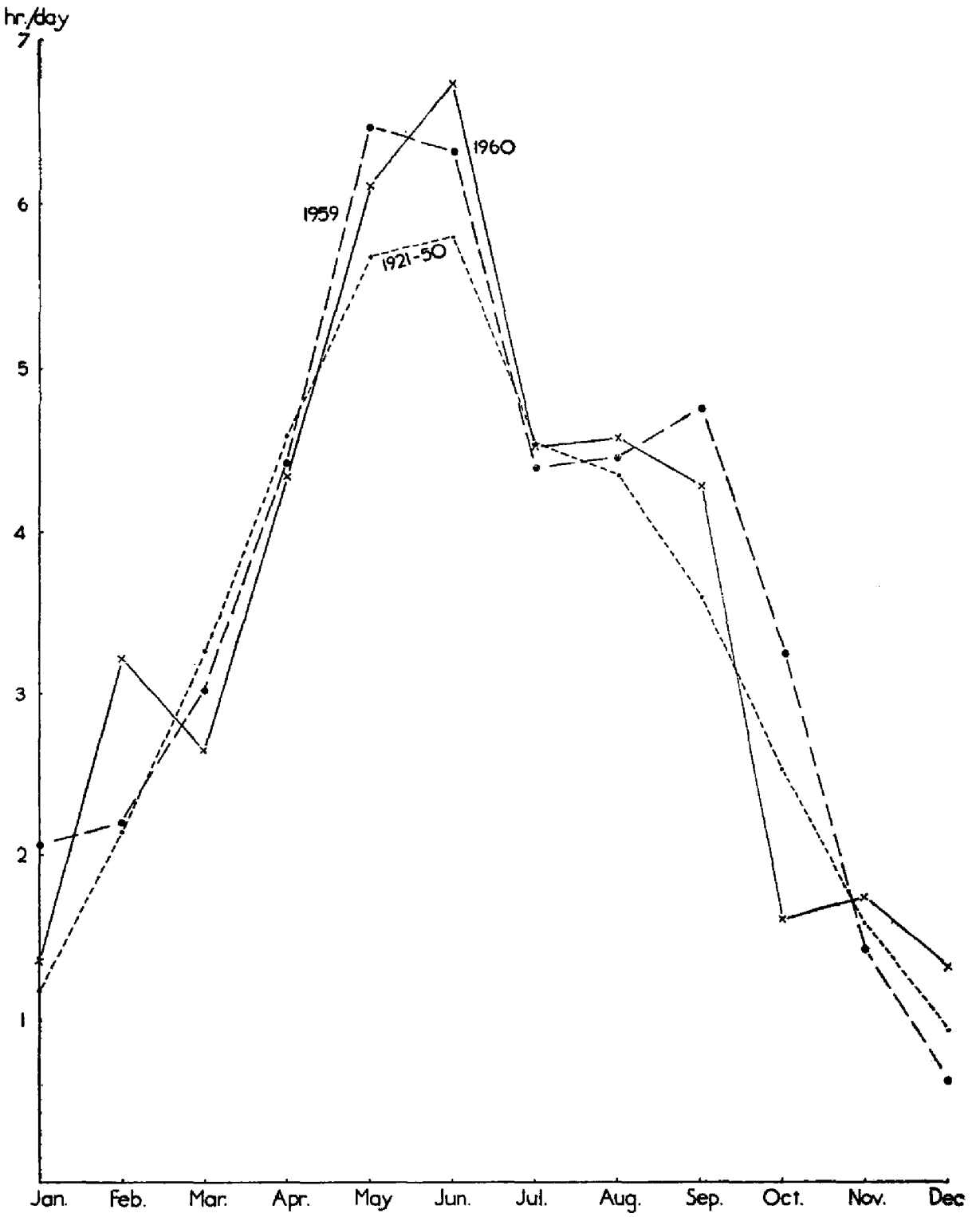


Fig. 6—Scotland. Monthly general values of sunshine in hours per day.

Percentage of 1921-50 average sunshine.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1960	94	155	64	111	106	135	102	115	108	70	104	148
1959	180	95	109	104	120	123	98	112	130	115	115	100

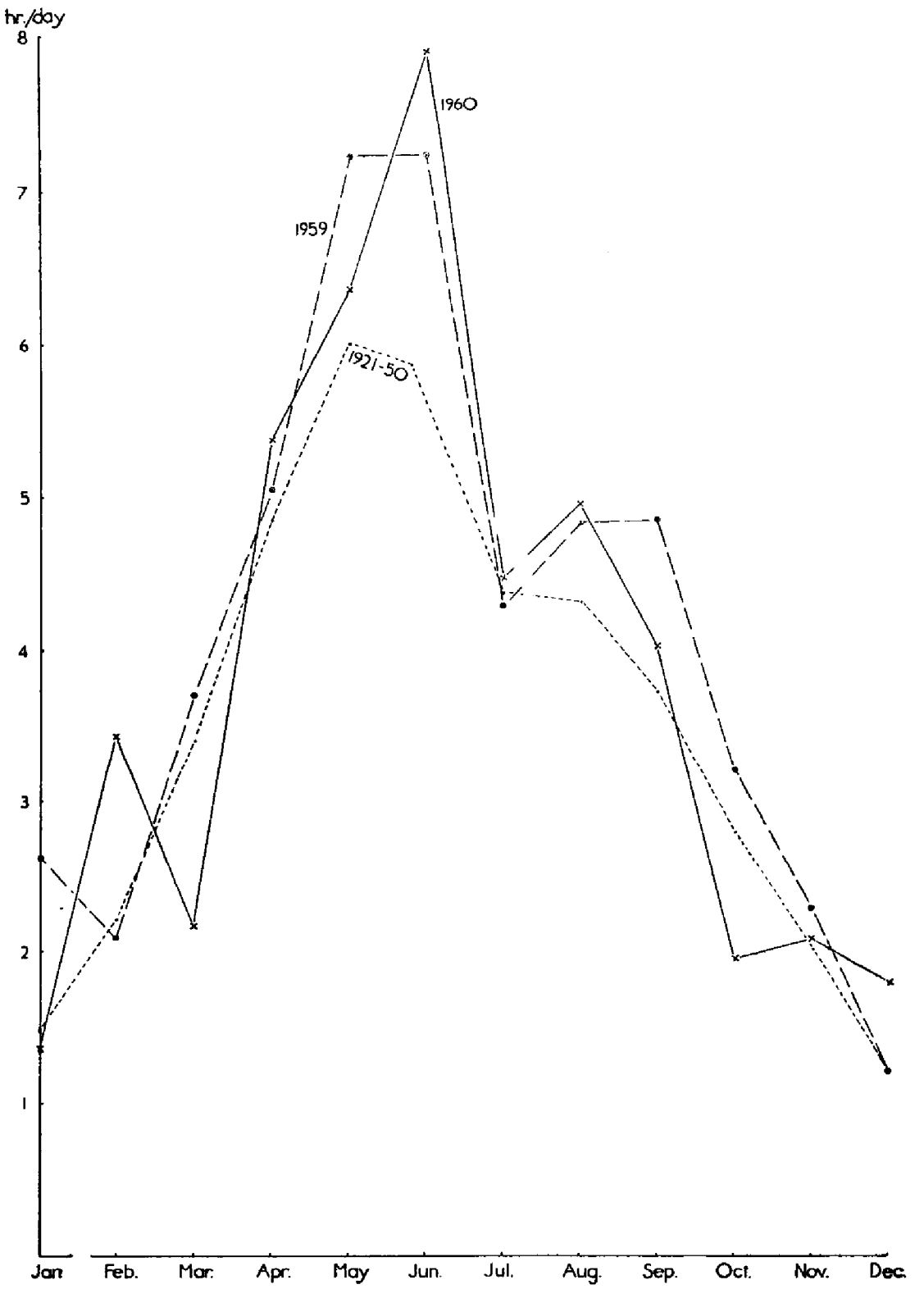


Fig. 7—Northern Ireland. Monthly general values of sunshine in hours per day.

Percentage of 1916-50 average rainfall.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1960	143	119	89	74	71	90	141	140	147	202	152	131
1959	111	14	114	130	44	81	83	44	11	92	123	181

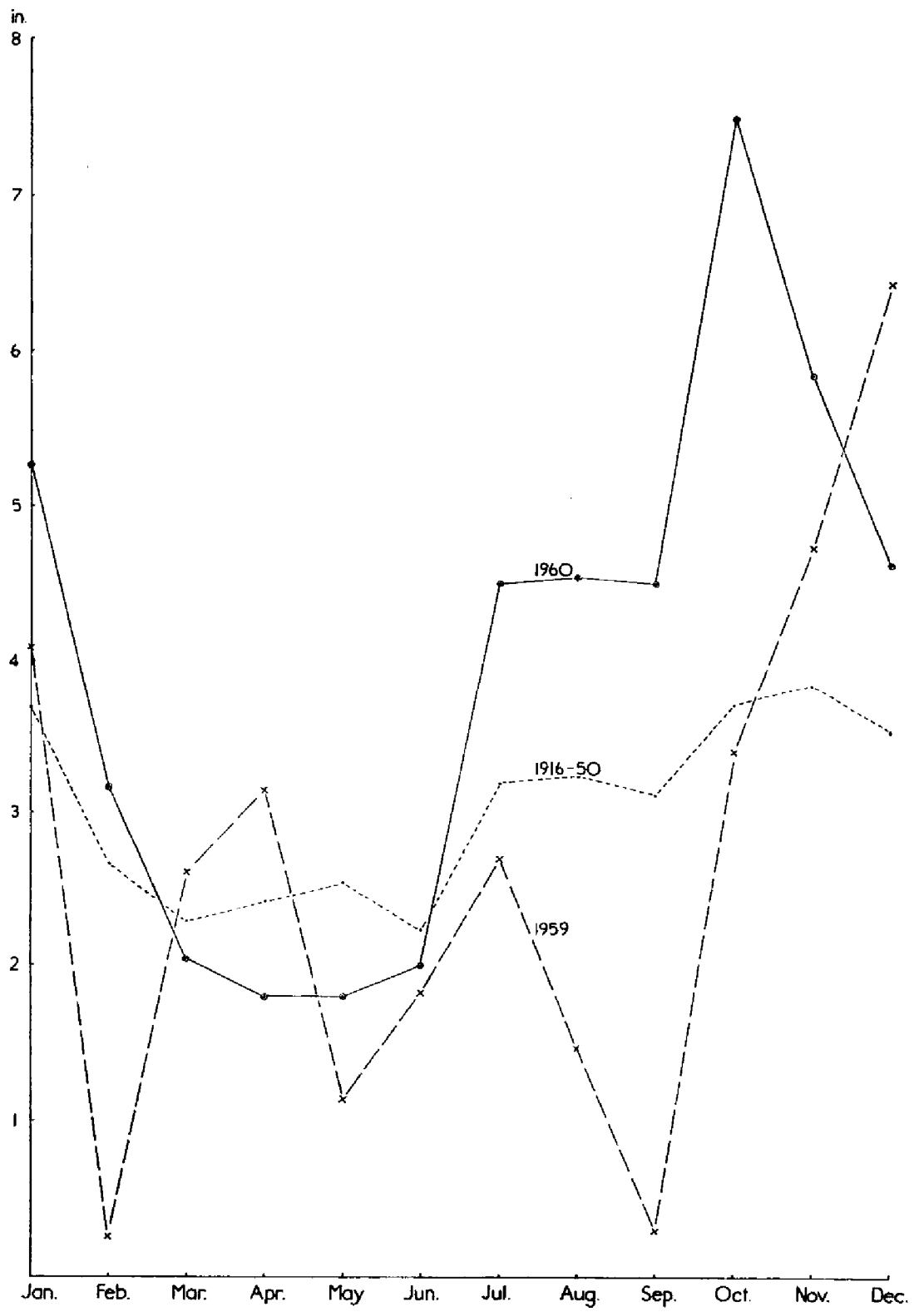


Fig. 8—England and Wales. Monthly general values of rainfall in inches.

Percentage of 1916-50 average rainfall.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1960	89	124	63	122	71	95	95	126	72	85	114	104
1959	71	44	91	125	53	112	122	51	37	106	139	141

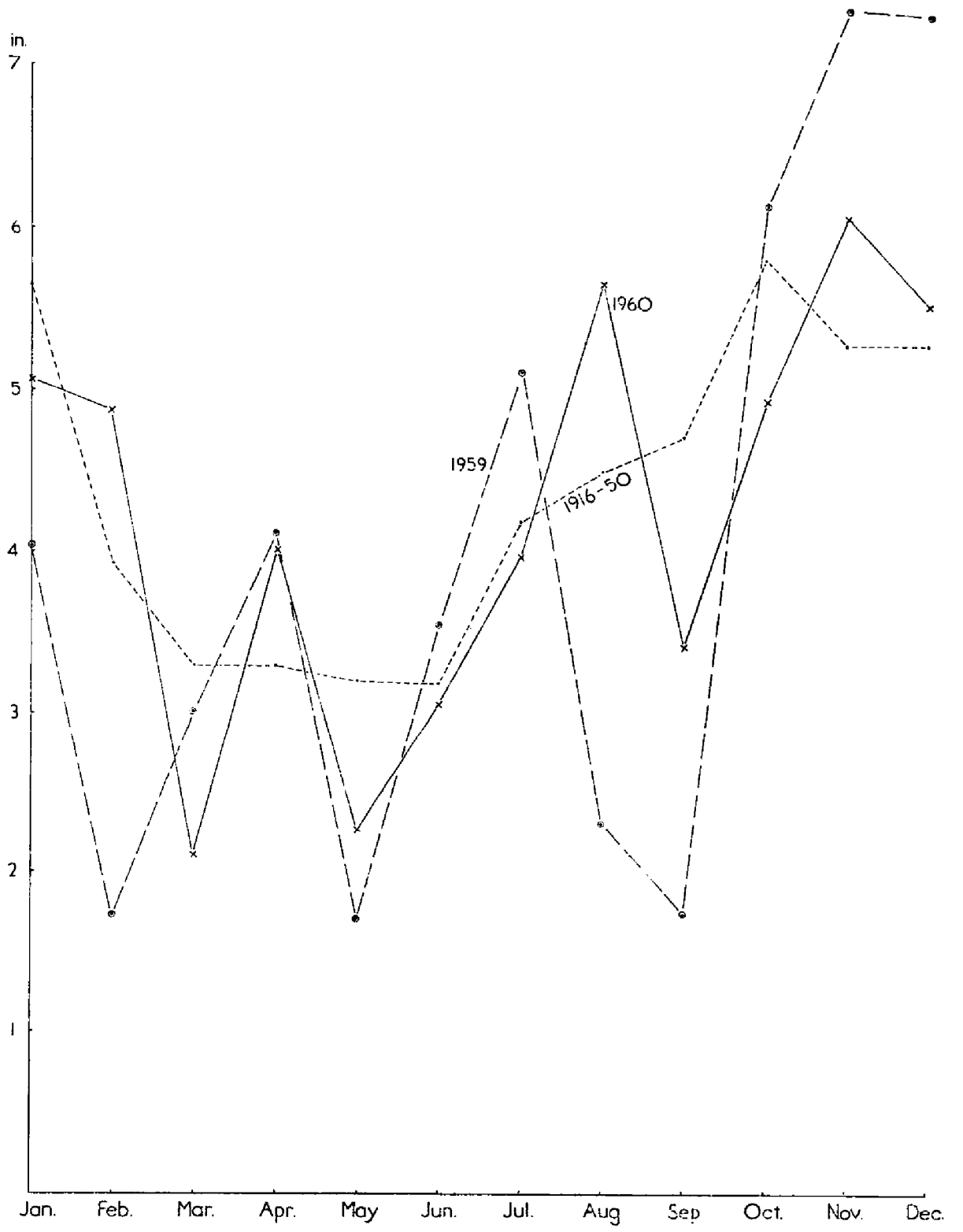


Fig. 9—Scotland. Monthly general values of rainfall in inches.

Percentage of 1916-50 average rainfall.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1960	96	128	91	119	87	105	164	135	88	102	102	88
1959	64	41	123	122	50	87	102	35	47	122	110	87

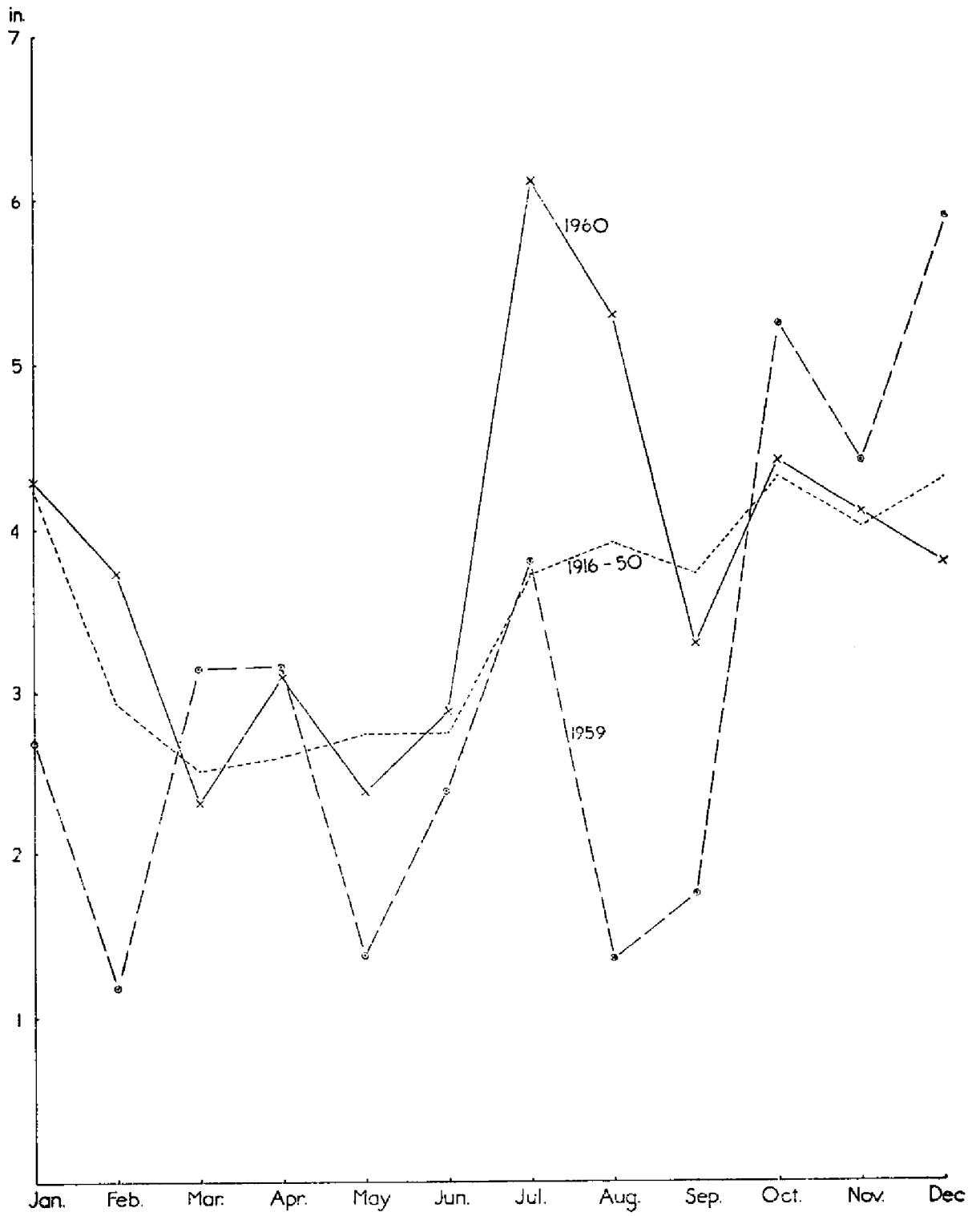


Fig. 10—Northern Ireland. Monthly general values of rainfall in inches.

5. Statistics

The quantitative analyses in this section are intended to provide an indication of the distribution of work within the Directorate of Services and of the extent of the services provided.

Table 1

NUMBERS OF OFFICES OF VARIOUS TYPES STAFFED BY METEOROLOGICAL OFFICE STAFF AND OPERATING ON DECEMBER 31, 1960.

	Within U.K.	Overseas
Principal forecast offices associated with R.A.F.	1	—
Main meteorological offices associated with R.A.F.	12	7
Subsidiary meteorogical offices associated with R.A.F.	50	15
Observing offices associated with R.A.F.	6	1
Principal forecast offices associated with civil aviation	1	—
Main meteorological offices associated with civil aviation	2	—
Subsidiary meteorological offices associated with civil aviation	15	1
Observing offices associated with civil aviation	6	—
Upper air observing offices	8	8
Public service offices	3	—
C.R.D.F. offices	4	3
Port meteorological offices	5	—
Offices associated with National Agricultural Advisory Service	3	—
Other offices	14	4

Notes

A principal forecast office meets the needs of aviation flying over very long distances and operates throughout the 24 hours.

A main meteorological office operates throughout the 24 hours for the benefit of aviation and normally supervises the work of subsidiary offices.

A subsidiary meteorological office is open for that part of the day necessary to meet aviation requirements.

At an observing office no forecaster is available. An upper air observing office may be located with an office of another type if this is convenient.

Public service offices are located in big cities.

C.R.D.F. offices form the network for thunderstorm location.

Port meteorological offices are maintained at the bigger ports.

TABLE 2

OCEAN WEATHER SHIPS

Four ocean weather ships are used to ensure that two ocean weather stations are occupied continuously. There are five stations manned by European ships and, by international agreement, the British ships do not always operate the same stations.

Number of voyages	31
Number of days on station	727
Number of days on passage	197

TABLE 3

MERCHANT NAVY SHIPS

Many ships of the merchant navies of the world make and transmit to the appropriate shore stations meteorological reports. British ships do this on a voluntary basis. " Selected " ships make full reports at four specified times per day; " supplementary " ships report according to a similar procedure but in less complete form. On December 31, 1960, the numbers of British ships reporting were:

Selected ships	485
Supplementary ships	51
Coasting ships	90
Lightships	14
Trawlers	29

TABLE 4

CLASSIFICATION OF STATIONS WHICH RENDER CLIMATOLOGICAL RETURNS

A large amount of meteorological data is obtained, for climatological purposes, from meteorological observing stations which are not part of the Meteorological Office organization. The following table shows how the sources of climatological information in the United Kingdom (including Meteorological Office stations) were distributed on December 31, 1960.

	Stations					Autographic Records		
	Observatories	Synoptic	Agro-meteorological	Climatological	*Rainfall	Sunshine	Rainfall	Wind
Scotland, North	1	8	0	22	300	17	8	8
Scotland, East	0	7	8	58	525	43	20	7
Scotland, West	1	6	3	40	519	25	19	6
England, North-east	0	9	4	24	392	29	15	4
England, East	0	11	12	18	480	26	19	8
England, Midlands	0	13	21	47	1,179	60	39	4
England, South-east (including London)	1	16	17	63	880	65	78	18
England, South-west	0	7	8	27	497	31	12	3
England, North-west	0	4	4	24	489	24	34	9
Wales, North	0	1	3	18	216	8	2	1
Wales, South	0	4	8	15	310	22	10	4
Isle of Man	0	2	0	1	16	3	1	1
Scilly and Channel Isles	0	2	0	4	24	6	1	2
Northern Ireland	0	4	1	17	121	8	4	3
Total ..	3	94	89	378	5,948†	367	262	78

* Includes stations in earlier columns.

† Figures for rainfall stations and autographic rainfall records refer to data for the year 1959 received during 1960. All other figures show the position on 31st December, 1960.

TABLE 5

HEIGHTS REACHED IN UPPER AIR ASCENTS

The following table shows the number of upper air ascents giving observations of (a) temperature, pressure and humidity and (b) wind which have reached specified heights.

Observations of Temperature, Pressure and Humidity

	Number of observations	Percentage reaching 100mb approx. height 53,000 ft.	50mb approx. height 67,000 ft.	30mb approx. height 78,000 ft.
Eight stations in U.K. ..	5,855	91.2	58.2	30.0
Eight stations overseas ..	5,072	93.4	61.2	28.0
Four ocean weather vessels ..	1,001	88.4	42.3	9.2

Observations of Wind

	Number of observations	Percentage reaching 100mb approx. height 53,000ft.	50mb approx. height 67,000ft.	25mb approx. height 82,500ft.	10mb approx. height 100,000ft.
Eight stations in U.K. ..	10,590	81.8	39.5	11.5	0.2
Eight stations overseas ..	6,200	84.5	42.8	10.9	0.4
Four ocean weather vessels ..	1,991	78.6	27.9	2.0	0.4

TABLE 6

THUNDERSTORM LOCATION

Number of thunderstorm positions reported by C.R.D.F. network ..	73,000

TABLE 7

METEOROLOGICAL COMMUNICATION TRAFFIC

Almost all the national and international exchange of meteorological data which are used in the construction of synoptic charts and the production of forecasts is effected by either coded messages or facsimile charts. The coded messages are composed of groups of five figures and there may be three to thirty such groups in one message. The messages are exchanged by radio and teleprinter. The following figures give an analysis of the traffic through the Meteorological Office Communication Centre for one typical day (24 hours) near December 31, 1960 (the actual date was January 13, 1961) and, for comparison, some corresponding figures for December 31, 1959.

Communication Traffic for one Day

Coded Messages	Number of Groups in one day			
	In	Out	Total	One day Total in 1959
Land line teleprinter ..	303,038	354,847	657,885	641,426
Radio	100,420	169,140	269,560	238,766

Facsimile charts	Number of charts in one day			
	In	Out	Total	One day Total in 1959
Land line	—	59	59	27
Radio	30	25	55	54

TABLE 8

FORECASTS FOR AVIATION

The Central Forecast Office is almost solely concerned with analysis of the weather situation, the issue of guidance in outline to other offices and the issue of forecasts to the B.B.C. and the national press. Thus the volume of work shows little variation from year to year. Forecasts for aviation constitute the primary function of many of the offices. The following figures indicate the numbers of forecasts issued for aviation and the number of meteorological " briefings " which took place during 1960. They do not include warnings and routine general forecasts. The services to military and civil aviation in the United Kingdom are given separately since these services were provided almost completely by separate networks of stations. This does not apply at overseas stations.

Number of meteorological briefings for	
Military aviation in United Kingdom	170,100
Civil aviation in United Kingdom	174,862
Aviation at overseas stations	71,186
Number of aviation forecasts issued for	
Military aviation in United Kingdom	376,999
Civil aviation in United Kingdom	261,406
Aviation at overseas stations	197,661

TABLE 9

NON-AVIATION ENQUIRIES

There are three forecast offices devoted to meeting the needs of the general public for forecasts for specific purposes. But many of the forecast offices established to meet aviation requirements also answer telephonic requests for forecasts, from the general public, public corporations, local press, commercial firms, etc. The *Post Office Guide* lists the telephone numbers of 38 such offices which are available for this service. During 1960 the incidence of these enquiries varied from month to month, with maxima in summer (12.4 per cent in June) and winter (10.5 per cent in December). The following figures show the total number of such enquiries answered by offices outside London in 1960 and the percentage coming from the principle classes of customer.

Total number of enquiries		357,465
Percentage of enquiries connected with		
Agriculture, etc.	17.2	
Holidays	17.1	
Public utilities	17.1	
Road transport	9.7	
Local Press	8.8	
Marine	7.6	

In addition to these a further 177,855 enquiries were answered by the London Weather Centre.

TABLE 10

AUTOMATIC TELEPHONE WEATHER SERVICE

By the end of 1960 forecasts for fifteen areas were available on the automatic telephone weather service. Most, but not all, of these forecasts refer to the neighbourhoods of some of the larger cities. The number of calls made during 1960 on this service are indicated by the following figures (supplied by courtesy of the Post-Master General).

Forecast Area	Number of calls	Remarks
London	2,467,337	
Essex coast	119,478	Available on a London number
Kent coast	94,120	Available on a London number
Sussex coast	148,527	Available on a London number
Colchester	46,121	Same as Essex Coast. Started in June
Brighton and Hove	17,100	Same as Sussex Coast. Started in October
Birmingham	423,721	
Liverpool	338,020	
Manchester	307,374	
Cardiff	172,750	
Belfast	177,978	
Glasgow	341,215	
Edinburgh	177,271	
Bristol	65,037	Started in June
Portsmouth	14,497	Started in November
Total	4,910,546	

TABLE 11

CLIMATOLOGICAL ENQUIRIES

Most of the enquiries dealt with by the offices outside headquarters refer to current weather or to forecasts. M.O.3 receives a number of enquiries relating to past weather or to climatology. The following figures give the total number of such enquiries and the percentage of this number arising from the main reasons for the enquiries.

Total number of climatological enquiries	7,524
Percentages related to	
Agriculture, horticulture, forestry	8.8
Building and building design	7.7
Commerce (sales, marketing, advertising)	7.1
Drainage	6.4
Educational and literary	8.3
Industrial or manufacturing activities	8.7
Legal (damage, accidents, insurance)	18.6
Research	6.8
Water supply, including hydro-electricity schemes.	5.1

TABLE 12

AGRICULTURAL ENQUIRIES

In addition to the agricultural enquiries answered by the offices outside London (Table 9) and by M.O.3 (Table 11) such enquiries are also dealt with by that part of M.O.7 which is concerned with the application of meteorology to agriculture. During 1960 these enquiries totalled 695.

TABLE 13

LIBRARY AND EDITING

The following figures indicate the distribution of work in the Library during 1960.

Library Statistics

Number of publications received during 1960	9,585
Number of individual books, pamphlets, articles, microfilms, etc., classified and catalogued	approx. 7,000
Transparencies acquired	660
Publications lent	8,179
New exchange of publications arrangements	8
Total number of exchange agreements	386

Publications	Editing No.	Remarks
Geophysical Memoirs	3	Nos. 102, 103, 104
Meteorological Reports	2	Nos. 21, 22
Professional Notes	1	No. 124
Scientific Papers	4	Nos. 1, 2, 3, 4
Meteorological Magazine	14	Nov. 1959—Dec. 1960 (incl.)
Observatories' Year Book	7	1946, 1948, 1949, 1950, 1951, 1957, 1958.

TABLE 14

DATA PROCESSING

Punched Cards

Number of cards punched by the Meteorological Office installation	743,000
Number of cards punched outside for the Meteorological Office	399,000
Number of cards converted to tape	485,000

TABLE 15

TRAINING

The following figures show the number of courses, in the Meteorological Office Training School, which ended during the period January 1 to December 31, 1960.

	Number of Courses	Length of Course Weeks	Number of Students
Scientific Officers	1	23	4
Forecasters (Initial)	2	16	26
Forecasters (Advanced)	5	6	23
Senior Forecasters	2	3	18
Assistants	16	9	227
Climatology	3	4* and 8	11
Radio-sonde (Initial)	4	8	48
Radio-sonde (Advanced)	4	4	15
Voluntary observers	2	1	43
Auxiliary observers (Coastguards)	1	1	20

* Elementary course

Part-course attendance:—

Tropical meteorology	—	2	2
Mediterranean meteorology	—	2	1
Elementary instrument maintenance	—	1	5
Advanced instrument maintenance	—	2	6
		Total	449

Students from the following meteorological services attended courses:—

Country	Number of students
Belgium	4
British East Africa	4
Channel Islands	1
Egypt	2
Falkland Islands	5
Ghana	1
India	1
Iran	3
Iraq	3
Japan	1
Lebanon	1
Mauritius	2
Nigeria	6
Norway	1
Saudi Arabia	1
Switzerland	2
West Indies	2
Total	40

THE DIRECTORATE OF RESEARCH

1. General

The task of research in the Office, which absorbs a large proportion of its scientific effort, is to advance the study of the physics and dynamics of the atmosphere. It is a study of remarkable diversity, concerned at one extreme with the mechanism whereby millions of cloud droplets of a few microns diameter may combine together to form raindrops and, at the other extreme, with explaining how the climate of the world has varied through geological and historical time. These many puzzling problems are of great intrinsic interest and practical importance. If, to take the same two illustrations, we fully understood the natural raindrop mechanism, the possibilities of artificial control could be much more certainly assessed; if we fully understood climatic changes we might estimate whether changes of importance to humanity could come in the next 100 years, of like importance to the changes in the past—and take economic advantage of the knowledge.

Naturally it is impossible in the Office to make worthwhile advances in all directions simultaneously and the sensible course for a national research centre is to maintain a reconnaissance on a broad front and be prepared to follow up the promising local advance. Instead, therefore, of attempting each year to catalogue the aims and achievements under a dozen different headings, it should be of more interest to pick out one or more subjects of topical interest in which progress has been striking or in which the problems are especially challenging. A few years ago the news of the day was the promising application to weather forecasting of calculations based on the theoretical equations of atmospheric fluid dynamics. The promise led to investment by the Office in an advanced electronic computer, a Ferranti Mercury known as METEOR, to the deployment of a team of half-a-dozen able mathematicians, and to a programme of research which is now yielding important results for the future of weather forecasting. But the fuller story of this project, for which further mathematical physicists still need to be recruited, may be left to a later year when it is hoped the results will be more definite.

As an illustration of activity on this occasion choice is made of something as far removed, it would appear, from the dynamics of weather as a meteorologist could go without losing touch with the earth altogether: the study of the high atmosphere with rockets and satellites. This, for the Meteorological Office, is so far a story of planning and preparing more than of achievement, but has been the occasion for much interesting and challenging work. The special topic which follows is an account of this work, written by Dr. R. Frith, the Assistant Director in charge of high atmosphere research, and there the matter is put, as it were, into context. With so many earthly problems needing attention why should meteorologists follow the fashionable drive towards space? Partly, no doubt, the appeal lies in the novelty and in the unknown, and science will atrophy if this kind of growth is wholly pruned away, but there is more to the question than this. All the energy which drives the winds

and produces the weather comes to us from the sun through the high atmosphere and on its way suffers important changes, especially due to absorption by ozone. At the present time meteorologists have no acceptable explanation of why the English summer of 1959 was lovely, that of 1960 atrocious and that of 1961 utterly unpredictable at the time these notes were being written. The elucidation of this problem must come in time and possibly by a fuller knowledge and better understanding of the behaviour of the outer atmosphere. Remarkably large and sudden changes in temperatures and winds in the ozone layers have been observed and need to be explained. Direct relations with weather near the ground are not by any means obvious but on theoretical grounds we know that the dynamics of the lower atmosphere is, in some respects at least, highly sensitive to upper boundary conditions. Thus the study of the high atmosphere may very well be proved essential for later developments in dynamical weather forecasting which, as has been mentioned, a special team is engaged upon. The atmosphere is a continuous medium and all its problems are interrelated. It may be that the studies of the high atmosphere described below will prove to be strictly utilitarian and be none the less interesting on that account.

R. C. SUTCLIFFE
Director of Research

2. SPECIAL TOPIC—RESEARCH ON THE HIGH ATMOSPHERE

One of the consequences of the intensive investigation of the ionosphere by radio methods has been the discovery that ionised trails left by meteors frequently persist sufficiently long for winds to be measured. These ionised trails occur at about the same levels as visible meteor trails, somewhere between 75 and 110 km. Some 50-100 measurements can be made every hour, day and night, in all weathers, and there now exists a considerable body of infor-tion of this sort, mostly obtained, in this country, by a team at Manchester University. There emerges a picture of strong winds, remarkably turbulent, showing both diurnal and semi-diurnal variations[1]. This picture is being studied by the High Atmosphere assistant directorate of the Meteorological Office where we are trying to understand the causes of these winds and to link them, if we can, to what occurs at lower levels.

Unfortunately measurements are much harder to get at the lower levels. The practical limit of balloons is about 35 km. while meteorites large enough to provide ionised trails to much below 80 km are rare and there is left an important gap where other techniques must be used. One way is to use rockets. As we shall see later, there are other ways; but rockets have obvious advantages and, although it is not easy to use even relatively small rockets in this country, we hope to be making more or less routine soundings to a height of at least 60 km before the end of 1962. Up to this height, or perhaps a little below, it is possible to use techniques similar to those now used with balloons: a sonde, measuring temperature only, is attached to a very large metallised parachute, and the whole ejected from the rocket at apogee. It is now established[2] that parachutes can be made which will open even in the very thin air at 60 km (density about 1/5,000 of surface density); and that, in spite of the low density and the high rate of fall (perhaps 50 m/sec to begin with),

the parachute will drift with the winds. Then, by radar tracking, winds can be found. It seems likely too (though this is less well established) that temperatures can be measured with fair accuracy in these circumstances using either a fine resistance wire, or a " micro-bead " thermistor. A parachute and a simple sonde should not weigh more than 5 kg (10 lb), so a rocket capable of carrying 5 kg (10 lb) should enable winds and temperatures (and therefore also densities and pressures) to be measured up to, perhaps, 60 km.

In the even thinner air at higher levels parachutes will not open; and lag and radiation errors of conventional thermometers become enormous. A number of other techniques are possible. The simplest, for wind measurement only, consists of ejecting from the rocket a quantity of " window ", which is tracked by radar as it falls. Somewhat more elaborate is the ejection of a sphere, which is also tracked by radar—its horizontal movement giving wind and its vertical movement, in the absence of appreciable vertical air current, density.

The " grenade " method operates on quite different principles. In this experiment grenades are ejected from the rocket, at intervals, and exploded. If the time of arrival of the sound wave, at each of a network of microphones on the ground, is recorded very accurately then it is possible to deduce both the mean temperature and the mean wind over the layers between successive explosions. This is an attractive technique, but an elaborate and extensive microphone network (covering distances of about 30 km) is necessary; and a great deal of work is needed to get temperatures and winds from the raw data.

Density can also, of course, be measured using, for example, ionisation gauges.

All these techniques, and others, and techniques for the measurement of other properties of the high atmosphere (especially the ozone and the water vapour concentration) are being considered for use in, necessarily, somewhat larger rockets. These " research " rockets, designed to carry 20 kg (40 lb) to 100 km will, it is hoped, be brought into use during 1963.

In the meantime work continues on two other ways of investigating the high atmosphere. In one the back-scattered light from a powerful searchlight beam is measured; this has the advantage that the apparatus can be installed almost anywhere. In the other, observations are made from an artificial earth satellite; this has the merit that observations are made, at frequent intervals, over the whole globe. The searchlight experiment is essentially very simple. Light scattered by pure air is directly proportional to the density of the air. Therefore if we can measure the light scattered at various levels from a searchlight beam, we can deduce the densities at these levels. For a number of reasons it has so far proved impracticable to make absolute measurements of the intensity of the scattered light; but relative measurements can be made and, since we know the density at, say, 30 km from radio-sonde ascents, we can compute the densities at higher levels—*provided that the air at 30 km and above is " clean "*, i.e., does not contain too much " dust ". Measurements of this sort cannot often be made in this country—clear, cloudless, moonless nights are required—but about a dozen runs have so far been obtained, using a base line 40 km long, across Cardigan Bay. On every occasion there was apparently far too much light scattered from levels above about 60 km (the greatest height for which measurements can be obtained is about 80 km—limited mainly by the length of the base line). This may arise from the presence

of large amounts of dust at these levels; but it is hard to understand how this could come about. Alternative explanations are being considered and experiments to test them devised.

In the satellite field we are of course studying results obtained from American satellites—especially the TIROS cloud photographs and the Explorer VII radiation measurements (the latter being received direct from the satellite by the Radio Research Station at Slough); but we are also ourselves building instruments for use on a satellite. These instruments are scheduled to go in the second British satellite, to be put into orbit by an American Scout rocket, possibly in the first half of 1963, and are designed to measure the vertical distribution of ozone in the earth's atmosphere. The measurements will be made in this way. Sensors on the satellite measure direct radiation from the sun. The sensors are made to respond only to radiation in an ozone absorption band (part of the Hartley-Huggins band—about 2500-3500 Å—is used). For most of each orbit the satellite is either in complete darkness, or is in full sun; in either case no useful information is obtained. But for about a minute at "sunrise", and a minute at "sunset", the satellite sees the sun through the earth's atmosphere (Figure 11); and from measurements made during these periods the distribution of ozone in the vertical can be computed.

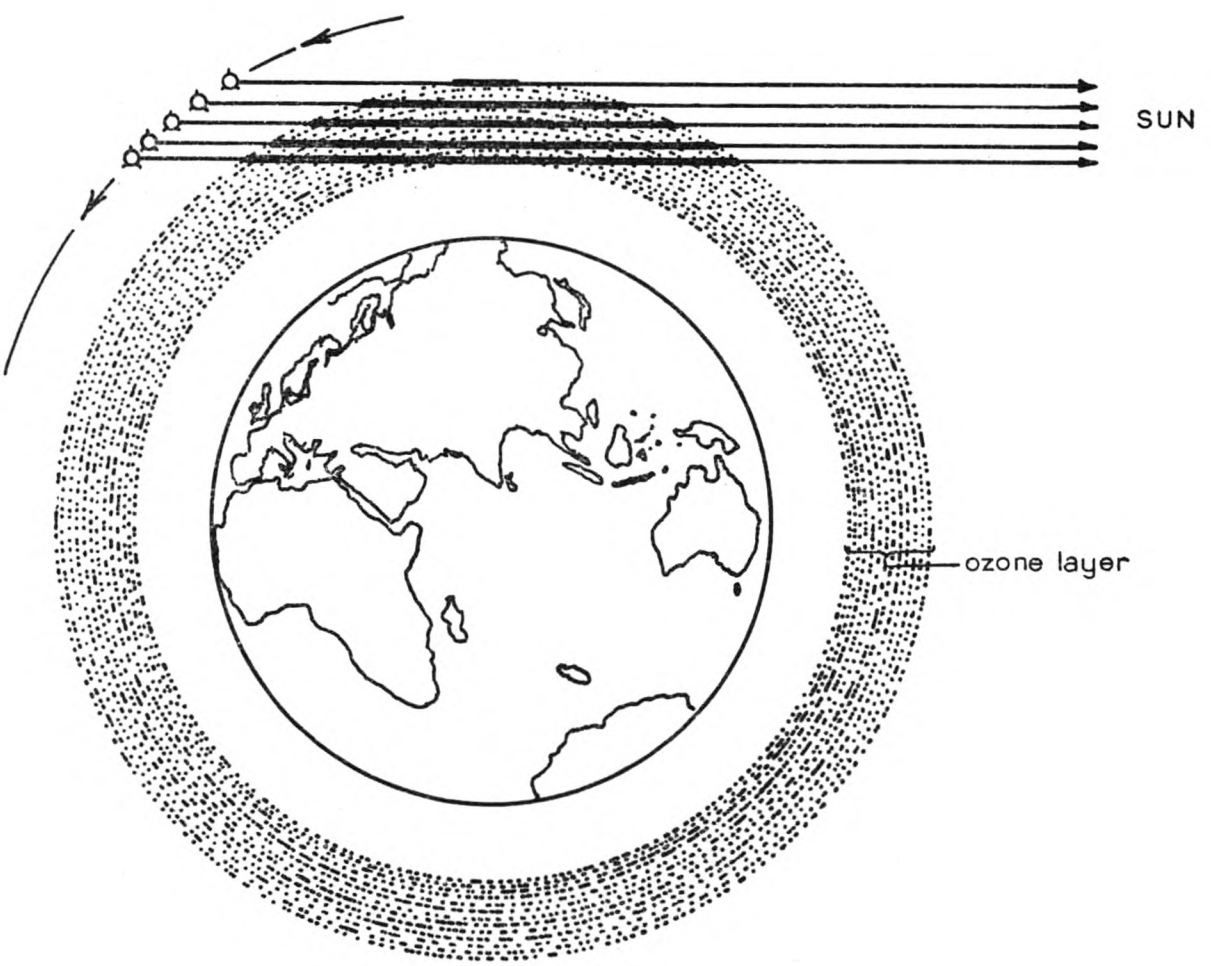


Fig. 11—Showing how the path in the ozone layer, and therefore the absorption in the ozone band, increases as the satellite passes into the earth's shadow ("sunset").

Perhaps the main meteorological interest is in the region between 15 and 40 km, where the lifetime of ozone molecules is rather long (days, or weeks, or even longer), and where ozone can therefore be used as a tracer. The satellite should provide an almost world-wide picture of the ozone distribution, day by day, for a year; we should learn much about the general circulation, and about vertical movements, in this little-known region. At higher levels the time constants of some of the processes are known to become very short; but little is known about the time constants of others. Since we shall be making measurements in two very different circumstances, namely, when the levels being examined have been in sunshine for only a few minutes, after several hours of darkness; and, again, when the same levels have been in continuous sunshine for several hours, something may be learned about the several chemical and photo-chemical processes involved.

This technique, if it is successful, could be refined in a number of ways to measure ozone more accurately; it could also be used for other gases—for example molecular oxygen and water vapour. But tremendous advances in techniques, in knowledge and in understanding are constantly being made; it is impossible to foresee, at this stage, whether our next satellite experiment will be such a refinement, or something quite different.

R. FRITH
Assistant Director (High Atmosphere)

REFERENCES:

[1] GREENHOW, J. S. and NEUFELD, E. L.; *Proc. phys. Soc., London,* **75,** 1960, p. 228.

[2] WEBB, W. L. and JENKINS, K. R.; *J. geophys. Res., Washington,* **64,** 1959, p. 1855.

INTERNATIONAL CO-OPERATION

1. World Meteorological Organization

The twelfth session of the Executive Committee took place in the new permanent building of the WMO from June 27 to July 15, 1960. The session was attended by the Director-General who is a member of the Committee and the Permanent Representative of the United Kingdom with the World Meteorological Organization. The Director-General was accompanied by Mr. C. W. G. Daking, Assistant Director (Defence and International).

The third session of the Commission for Maritime Meteorology was held in Utrecht, Netherlands, from August 16 to September 3, 1960. The United Kingdom delegation consisted of Commander C. E. N. Frankcom (Marine Superintendent), Instructor-Captain J. A. Burnett, R.N. (Director of Naval Weather Service, Admiralty), and Mr. F. E. Lumb (M.O.1).

The third session of Regional Association VI (Europe) was held in Madrid, Spain, beginning on September 26, 1960, and lasting about three weeks. Studies of the observational network, telecommunications and code problems were made. The regional aspects of maritime and aeronautical meteorological questions and the exchange of information between Europe and North America were also examined. The United Kingdom delegation was led by Dr. A. C. Best, Director of Services: the other members of the delegation were Instructor Captain J. A. Burnett, R.N., Mr. L. H. Starr, Assistant Director (Observations and Communications), and Mr. J. Harding, Assistant Director (General Services).

The United Kingdom acted as host for the third session of the Commission for Climatology, which was held in Church House, Westminster, London, S.W.1, from December 1 to 16, 1960. The session was opened by the Rt. Hon. The Viscount Hailsham, Q.C., Minister for Science. The President for the session was a former Deputy Director of the Meteorological Office, Mr. R. G. Veryard. The United Kingdom delegation was led by Dr. A. G. Forsdyke, Assistant Director (Climatological Research) who was assisted by seven other members of the Office. The agenda covered a very wide field and the regions of the world under review ranged from the arid zone and humid tropics to the Antarctic continent.

2. North Atlantic Treaty Organization

The seventeenth meeting of the Meteorological Committee of the Standing Group was held in Washington D.C. from May 23 to 25. The United Kingdom was represented by its member, Dr. J. M. Stagg, Director of Services, assisted by Mr. L. H. Starr, Assistant Director (Observations and Communications). Policy questions concerning meteorological service to NATO and arrangements for meteorological support to NATO military formations were discussed.

Meetings of the two working groups of the Standing Group Meteorological Committee concerned with weather plans and with communications took place twice during the year—in Washington D.C. from March 8 to 17, and in Oslo

from October 18 to 27. The United Kingdom was represented on both occasions by Mr. L. H. Starr, and Mr R. A. Buchanan (M.O.17).

The SHAPE Meteorological Committee held its ninth meeting from May 3 to 5, near Paris. Mr. L. H. Starr and Mr. R. A. Buchanan attended.

The External Ballistics Group of the NATO Armaments Committee met in Paris from November 8 to 11. Mr. N. C. Helliwell (M.O.7) attended as a member of the United Kingdom delegation.

3. Central Treaty Organization

Mr. R. Murray, Chief Meteorological Officer, Middle East Air Force, represented the United Kingdom at a meeting of the Regional Meteorological Policy Committee in Ankara in January.

A meeting of the Working Party of the Central Treaty Organization Sub-Committee on Civil Aviation was held in London from October 21 to 22, 1960. It was followed by a meeting held in London from December 1 to 6, 1960, of meteorologists of member countries. Implementation by CENTO member countries of international recommendations in respect of meteorological services for civil aviation was discussed. Mr. A. A. Worthington (M.O.17) attended both meetings as the United Kingdom delegate.

4. South East Asia Treaty Organization

The Meteorological Committee of the Organization met in Bangkok in March. Mr. R. Frost, Chief Meteorological Officer, Far East Air Force, attended on behalf of the United Kingdom.

5. International Civil Aviation Organization

The third Africa-Indian Ocean Regional Air Navigation meeting was held in Rome from January 26 to February 19, 1960, to discuss procedures for services for civil aviation in that Region. Mr. A. A. Worthington attended the meeting as the meteorological member of the United Kingdom.

The fifth North Atlantic Ocean Stations Conference was held at The Hague from March 17 to 29, 1960, to discuss joint financing problems. The meeting was attended by Dr. A. C. Best as chief delegate for the United Kingdom and Commander C. E. N. Frankcom, Marine Superintendent.

The third meeting of the Meteorological Operational Telecommunication Network (Europe) Development/Implementation Panel was held in Paris from October 25 to November 11, 1960. Advice and assistance was given by the Meteorological Office on meteorological matters.

6. Commonwealth Meetings

The fourteenth meeting of the South Pacific Air Transport Council was held, under the auspices of Commonwealth Air Transport Councils, in Melbourne from November 15 to 18, 1960. Delegations from Australia, New Zealand, Canada, Fiji and the United Kingdom attended. Mr. A. A. Worthington attended as the meteorological member of the United Kingdom delegation. Particular attention was paid at this meeting to the provision of facilities to meet the needs of jet aircraft operation in the South Pacific region.

STAFF

The names of the principal officers of the Meteorological Office are listed on p. 4.

At the end of the year 1960 the total number of posts for all grades was 3,480, of which 134 were filled by airmen meteorologists on national service. The total civilian strength on December 31 was 3,166 made up as follows:—

Scientific Officer Class	
Chief Scientific Officer	3
Deputy Chief Scientific Officer	4
Senior Principal Scientific Officer	22
Principal Scientific Officer	75
Senior Scientific Officer	37
Scientific Officer	7
Administrative Class	
Assistant Secretary	1
Experimental Officer Class	
Chief Experimental Officer	17
Senior Experimental Officer	195
Experimental Officer	350
Assistant Experimental Officer	163
Scientific Assistant Class	1,344
Marine Staff	
Nautical Officer Class	8
Ocean Weather Ships and Base	
Officers	44
Crew	122
Technical and Signals grades	276
Executive and Clerical grades	112
Typing and miscellaneous non-industrial grades ...	123
Industrial employees	84
Locally entered staff and employees overseas ...	179
Total	3,166

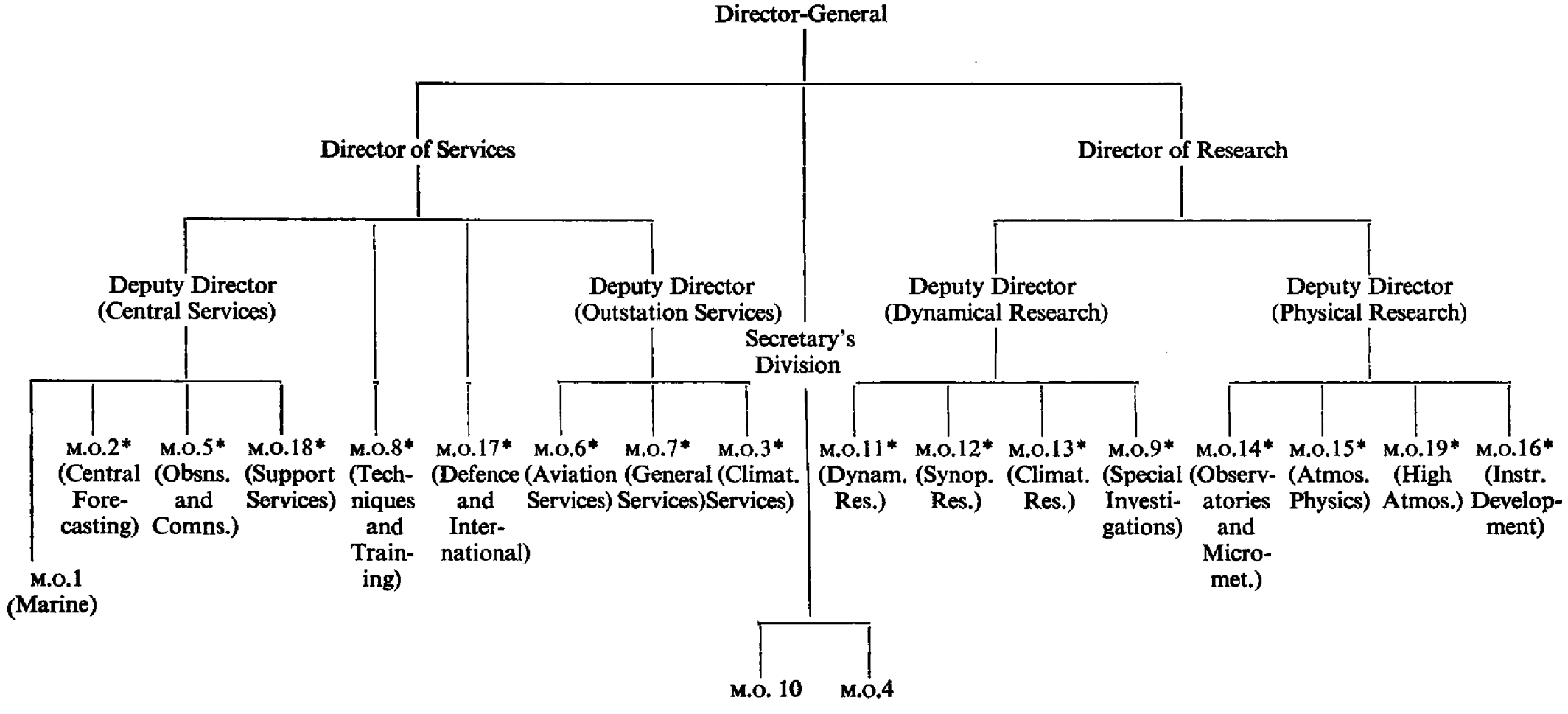
In common with other Departments employing scientific staff, the Meteorological Office continued to find it difficult to obtain sufficient new entrants with university degrees, or indeed with first year university qualifications, to fill all the available posts. By contrast, the flow of school-leaving boys and girls into the grade of Scientific Assistant improved markedly, but the turnover remained too high.

In the course of the year members of the Executive and Clerical classes who did not wish to be transferred with Headquarters from London to Bracknell were gradually replaced by those who had volunteered to do so.

Of the many undergraduates who applied to work in the Office as vacation students 14 were selected. Two regular members of staff under age 26 were chosen to take sandwich courses, under which they alternate between six months on duty and six months in regular full-time study at a technical college. During 1960 310 staff enjoyed study concessions of other kinds.

APPENDIX I

METEOROLOGICAL OFFICE HEADQUARTERS ORGANIZATION



*Assistant Directorates

APPENDIX II

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 Her Majesty's 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 December 21, 1960).

Daily Weather Report, containing weather maps for the northern hemisphere, British Isles, etc., and data (to December 31, 1960).

Daily Weather Report, Overseas Supplement, containing surface and upper air data (to August 31, 1960).

Meteorological Magazine (to December, 1960).

Monthly Weather Report, with a summary for the year (to May, 1960).

Seismological Bulletin. A diary of seismological disturbances recorded on the Galitzin aperiodic seismographs at Kew Observatory, Richmond (to October, 1960).

Marine Observer (quarterly) (to October, 1960).

British Rainfall, 1957. A report on the distribution of rain in space and time over Great Britain and Northern Ireland as recorded by about 5,000 observers.

The Observatories' Year Book, comprising the meteorological and geophysical results obtained from autographic records and eye observations at the Lerwick, Eskdalemuir, and Kew Observatories 1946, 1948, 1949, 1950, 1957 and 1958.

SERIAL

Geophysical Memoirs: Vol. XIII:

102. Average water vapour content of the air. By J. K. Bannon, B.A., and L. P. Steele.
103. Upper winds over the world, Parts I and II. By H. Heastie, M.Sc., and P. M. Stephenson, M.Sc.
104. The exchange of energy between the atmosphere and the oceans of the Southern Hemisphere. By D. W. Privett, M.Sc.

Meteorological Reports: Vol. III:

21. Synoptic evolution of 500 millibar flow patterns. A medium range forecasting aid. By C. V. Smith, M.A., B.Sc.
22. Aviation meteorology of the West Indies.

Professional Notes: Vol. VIII:

124. The preparation of statistical wind forecasts and an assessment of their accuracy in comparison with forecasts made by synoptic techniques. By C. S. Durst, B.A., and D. H. Johnson, M.Sc.

Scientific Papers:

1. Airborne measurements of the latitudinal variation of frost-point, temperature and wind. By N. C. Helliwell, B.Sc.
2. Conservation of vorticity at 100 millibars. By J. R. Probert-Jones, B.A.
3. The rainfall of Malta. By B. F. Bulmer, M.A., B.Sc., and K. Stormonth, B.Sc.
4. Pressure variation over Malaya and the resonance theory. By R. Frost, B.A.

OCCASIONAL

Averages of earth temperatures for the British Isles.

Handbook of aviation meteorology.

Handbook of weather messages. 3rd Edition, 1959.
Part I. Transmission schedules and station index numbers.
Part III. Coding, decoding and plotting.

Instructions for the preparation of weather maps with tables of specifications and symbols. 3rd Edition, 1959.

Quarterly surface current charts of the eastern North Pacific Ocean, eastward of Longitude 160°*W.*

Upper Air Data for stations maintained by the Meteorological Office—Summaries of radio-sonde observations of temperatures and humidity and of radar-wind measurements at standard pressure levels.

1951–1955. Part 4, Khartoum.

1951–1955 Part 5, Benina.

APPENDIX III

BOOKS OR PAPERS BY MEMBERS OF THE STAFF

The following books or papers by members of the staff were published during the year ended December 31, 1960:

SIR GRAHAM SUTTON, D.SC., F.R.S. A discussion on the results of the Royal Society's Expedition to Halley Bay, Antarctica, during the International Geophysical Year. *Proc. roy. Soc., London*, **256A**, 1960, p. 145.

SIR GRAHAM SUTTON, D.SC., F.R.S. Gassiot Fellowships in geophysics. *Met. Mag., London*, **89**, 1960, p. 129.

SIR GRAHAM SUTTON, D.SC., F.R.S. Headquarters re-organisation. *Met. Mag., London*, **89**, 1960, p.309.

SIR GRAHAM SUTTON, D.SC., F.R.S. High atmosphere research in the Meteorological Office. *Met. Mag., London*, **89**, 1960, p.97.

SIR GRAHAM SUTTON, D.SC., F.R.S. Looking ahead in weather forecasting. *Geogr. Mag., London*, **33**, 1960, p. 287.

SIR GRAHAM SUTTON, D.SC., F.R.S. *Ed., The World Around Us* (Royal Institution Christmas Lectures, 1958). London (English Univ. Press), 1960, 8vo., Pp. vi+122.

SIR GRAHAM SUTTON, D.SC., F.R.S. The Royal Society's Expedition to Halley Bay during the International Geophysical Year. *Nature, London*, **186**, 1960, p. 191.

SIR GRAHAM SUTTON, D.SC., F.R.S. Theories of the circulation of the earth's atmosphere (Halley Lecture). *Observatory, London*, **80**, 1960, p. 169.

SIR GRAHAM SUTTON, D.SC., F.R.S. Understanding weather. Harmondsworth (Penguin Books Ltd.), 1960, 8vo. Pp. 215.

J. M. STAGG, M.A., D.SC. The earth's magnetism. *Sutton, Sir G., Ed., The World Around Us, London*, 1960, p. 17.

J. M. STAGG, M.A., D.SC. Has meteorology become too professionalized? *Quart. J. R. met. Soc., London*, **86**, 1960, p. 295.

R. C. SUTCLIFFE, B.SC., Ph.D., F.R.S. Basic problems of weather forecasting with special reference to the Mediterranean. *Met. Abh. Inst. Met. Geoph. Freie Univ., Berlin*, **9**, H.1, 1960, p. 119.

R. C. SUTCLIFFE, B.SC., Ph.D., F.R.S. Co-operation in international meteorology. WMO and IAMAP. *World Met. Org. Bull., Geneva*, **9**, 1960, p. 158.

R. C. SUTCLIFFE, B.SC., Ph.D., F.R.S. Depressions, fronts and air mass modification in the Mediterranean. *Met. Abh. Inst. Met. Geoph., Freie Univ., Berlin*, **9**, H.1, 1960, p. 135.

R. C. SUTCLIFFE, B.SC., Ph.D., F.R.S. International Union of Geodesy and Geophysics, Twelfth General Assembly, Helsinki, 1960. International Association of Meteorology and Atmospheric Physics. *World Met. Org. Bull.*, **9**, 1960, p. 201.

R. C. SUTCLIFFE, B.SC., Ph.D., F.R.S. The Mediterranean in relation to the general circulation. *Met. Abh. Inst. Met. Geoph. Freie Univ., Berlin*, **9**, H. 1, 1960, p. 125.

R. C. SUTCLIFFE, B.SC., Ph.D., F.R.S. Weather forecasting as a problem in fluid dynamics. *Yearb. phys. Soc., London*, 1960, p. 9.

A. C. BEST, D.SC. and E. C. FIELDER. Short-period variations in visibility. *Met. Mag., London*, **89**, 1960, p. 42.

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