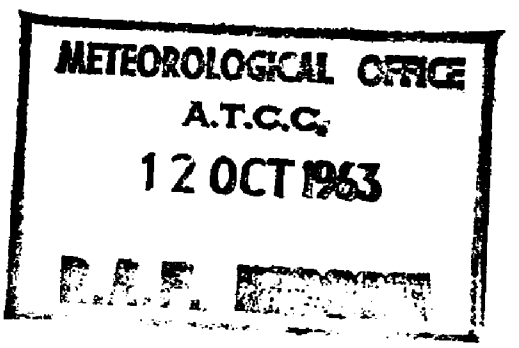
M.O. 745

Meteorological Office

REPORT FOR THE YEAR
ENDING
31 DECEMBER 1962



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ANNUAL REPORT
ON THE
METEOROLOGICAL OFFICE

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

FOR THE YEAR
1 JANUARY TO 31 DECEMBER 1962

LONDON
HER MAJESTY'S STATIONERY OFFICE
1963

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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
Mr. S. Earl
Professor J. Proudman, F.R.S.
Chairman, Meteorological Research Committee (*ex officio*)

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

The Committee met twice in 1962.

METEOROLOGICAL RESEARCH COMMITTEE

Terms of reference:

The Meteorological Research Committee will advise the Secretary of State for Air on the general lines along which meteorological and geophysical research should be developed within the Meteorological Office and encouraged externally. It shall review progress and report annually.

It is empowered to appoint sub-committees, one of which shall be responsible for advising on the usage of monies allocated annually from Air Votes for research projects conducted outside the Meteorological Office. The Committee will be responsible for co-ordinating the work of its sub-committees.

Chairman: Professor P. A. Sheppard

Members: Dr. A. C. Best, C.B.E. (Director of Services, Meteorological Office)
Professor H. Bondi, F.R.S.
Instructor Captain J. A. Burnett, R.N. (Admiralty)
Professor T. V. Davies
Dr. G. E. R. Deacon, C.B.E., F.R.S.
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Squadron Leader G. P. Lewis (Air Ministry)
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Dr. H. L. Penman, O.B.E., F.R.S.
Dr. R. C. Sutcliffe, C.B., O.B.E., F.R.S. (Director of Research, Meteorological Office)
Sir Graham Sutton, C.B.E., F.R.S. (Director-General, Meteorological Office)
Mr. A. E. Woodward-Nutt (Ministry of Aviation)

Secretary: Mr. D. C. E. Jones

The Committee met three times in 1962 and its sub-committees eleven times.

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Terms of reference:

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

(*b*) to submit to the Meteorological Committee any proposals in connexion 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, K.B.E., F.R.S. (Royal Society)
Mr. J. B. Dempster (Scottish Development Department)
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Mr. W. O. Kinghorn (Department of Agriculture and Fisheries for Scotland)
Mr. J. Paton, F.R.S.E. (Royal Society of Edinburgh)
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. (Department of Agriculture and Fisheries for Scotland)

Secretary: Mr. R. Cranna

The Committee met on 1 November 1962.

PRINCIPAL OFFICERS OF THE METEOROLOGICAL OFFICE

(on 31 December 1962)

DIRECTOR-GENERAL

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

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., F.R.S.
Assistant Director (Special Investigations)	J. K. Bannon, B.A.
Assistant Director (Synoptic Research)	C. J. Boyden, B.A.
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.

DIRECTOR OF SERVICES

A. C. Best, C.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)	V. R. Coles, M.Sc.
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, I.S.O., 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.).

SECRETARY, METEOROLOGICAL OFFICE

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

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APPENDICES

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 Public Building and 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 £5,800,000. Of the amount chargeable to Air Votes, about £4,200,000 represents expenditure associated with staff and £1,400,000 expenditure on stores, communications and miscellaneous services. Over £1,200,000 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

In presenting this Report on the activities of the Meteorological Office during the year 1962 I am happy to record that the new offices at Bracknell are now fully occupied and working smoothly. It is also pleasant to be able to state that recruitment continues to go well in all grades so that for the first time in many years the Office is now almost at full strength.

The many activities of the Office, both in its capacity as a national service and also as a major research unit, are described in detail in the pages that follow. It is difficult to choose for special mention particular items from such a wide field but I would like to call special attention to the steady progress of purely mathematical methods of predicting pressure and temperature patterns for short-range forecasts. This work has now reached the stage when its introduction into routine weather forecasting can be regarded as inevitable. This step cannot be taken immediately because the present Meteorological Office high-speed digital computer, which has given excellent service in research, is too small and too slow for regular use as an aid to forecasting. Steps are being taken to acquire a larger, faster computer that, it is hoped, will be adequate to cover Meteorological Office requirements, both in operations and research, for some years to come. Attention should also be drawn to the active work on radar meteorology now in progress at Malvern.

It is with great pleasure that I record the election in March 1962, of Mr. J. S. Sawyer, Deputy Director in charge of Dynamical Research, to the Fellowship of the Royal Society. This honour was conferred on Mr. Sawyer in recognition of his distinguished contributions to dynamical meteorology, especially in the field of numerical forecasting.

I attended the XIVth Session of the Executive Committee of the World Meteorological Organization at Geneva from 29 May to 20 June 1962, in my capacity as a member.

O. G. SUTTON

Note on the inclusion of the centigrade scale of temperature in communications to the public by the Meteorological Office

The Meteorological Office has used only the centigrade (or Celsius) scale of temperature for all observations, international exchanges of weather information and internal activities since 1 January 1961. This decision was made in the interests of international co-operation following a resolution of the World Meteorological Organization and also because of the convenience of the centigrade scale in scientific work.

This decision on the use of the centigrade scale led to consideration of the desirability of introducing it in weather reports and forecasts for the general public. Before this was done the Office sought the views of the leading technical and scientific bodies of this country, as well as those of the principal makers

of thermometers, on a proposal that for a period of several years both the Fahrenheit and centigrade scales should be used in weather reports for the public. No objections were raised to this proposal in the replies.

With the authority of the Secretary of State for Air, centigrade values were included in all public communications emanating from the Office on 15 January 1962. From that date until 15 October 1962, Fahrenheit values were given first, followed by the equivalent centigrade values. From 15 October 1962 the order has been reversed. No decision has yet been taken regarding the omission of the Fahrenheit scale from statements put out by the Meteorological Office for general use.

THE DIRECTORATE OF SERVICES

1. Special Topic—Marine Meteorology

The Meteorological Office was originally an exclusively maritime institution; and indeed it owes its foundation to a naval officer, Matthew Fontaine Maury who, about 1850, was employed in the Hydrographic Department of the United States Navy on the compilation of charts and sailing directions describing the winds and currents of the oceans. He soon realized how greatly he was handicapped in this task by having available only observations from American ships, and conceived the idea of an international organization for the purpose. It was chiefly due to his energy and enthusiasm that an international conference was held in Brussels in 1853, with the objects of 'establishing a uniform system of meteorological observations at sea and of concurring in a general plan of observations of the winds and currents of the ocean with a view to the improvement of navigation and to the acquirement of a more correct knowledge of the laws that govern those elements'. This was the first international meteorological conference and, probably the first international scientific conference organized between Governments.

Early in 1855, as a direct result of the Brussels Conference, a small office with a staff of four people under the direction of Admiral Robert FitzRoy, F.R.S., was set up as a department of the Board of Trade (this being the Department responsible for the safety of merchant shipping at the time) for the purpose of collecting meteorological observations from British ships at sea. Parliament authorized expenditure for the provision of tested instruments and log-books to be supplied on loan to those ship-masters who were willing to do this work. By May 1855, FitzRoy was already able to report that 50 merchant ships and 30 warships had been recruited.

In 1861, largely as a result of the loss of the steam passenger ship *Royal Charter* off Anglesey in a gale, FitzRoy instituted the first storm warning service for shipping, based upon observations received by telegraph from British and European sources. This visual storm warning system, consisting of a cone point up to indicate gales from some northerly direction and point down for gales from a southerly direction, is still in use in the United Kingdom and it forms the basis of the present international visual storm warning system. It was the forerunner of our weather forecasting service. The first detailed forecast was published in the newspapers in August 1861.

The Meteorological Office today is divided into nineteen Branches, and it has long since ceased to be a predominantly maritime body; but the Marine Branch still bears the number M.O.1 as a reminder that it is the oldest Branch. Likewise, the Central Forecasting Office, which issues gale warnings, and was the second Branch to be formed is still called M.O.2.

Until 1912, ships' meteorological observations were simply recorded in log-books, to be used long afterwards for climatological studies. But the introduction of wireless telegraphy made it possible to transmit observations immediately and so to use them for forecasting. This great advance in forecasting technique was particularly valuable in Great Britain since it meant that depressions approaching from the Atlantic—the usual direction—could be observed before they reached our shores.

At present, under a scheme which is co-ordinated by the Commission for Maritime Meteorology of the World Meteorological Organization, a voluntary observing ship scheme, similar to that conceived by Maury, continues to supply

the world's meteorologists with the picture of the weather at sea. There are about 3900 ships of all nations taking part in this scheme, of which nearly 700 are under the British flag while about 350 belong to other countries of the British Commonwealth. The backbone of this international fleet consists of the 'selected' ships which are supplied with tested instruments on loan by their parent meteorological services. They make observations of wind, pressure, air temperature, humidity, surface sea temperature, weather, visibility, direction, period and height of waves, and amount, type and height of cloud, at 0000, 0600, 1200 and 1800 GMT. Observations are first of all recorded in the meteorological log-book in an international 'five-figure' numerical code, the position of the ship and time of the observation being included. They are then transmitted by radio to the most convenient radio station ashore, addressed to the meteorological service of the country in which that radio station is situated. For this purpose the world is divided up into various areas in which the ships send their messages to specified radio stations.

In the United Kingdom the work begun by FitzRoy is continued by the Marine Branch of the Meteorological Office. Its head is the Marine Superintendent, who is a Master Mariner and is the Director-General's adviser on all maritime matters. The function of the Marine Branch is to organize the making and reporting of meteorological observations by the voluntary observing ships, to control, administer and organize work of the British ocean weather ships, to deal with marine inquiries, to check and classify all ship's meteorological logbooks and to analyse observations of surface sea currents and sea ice.

The Marine Superintendent represents the Office on the World Meteorological Organization's Commission for Maritime Meteorology and on the Advisory Committee for the operation of European Ocean Weather Ships (of which he is the present Chairman).

Careful organization and a considerable effort are needed to recruit and instruct the voluntary observing officers and radio officers aboard some 700 merchant ships, to supply and maintain the necessary instruments and written instructions, and to sustain interest in this work. Personal contact with the ships is maintained by the Port Meteorological Officers at London, Glasgow, Liverpool, Cardiff and Southampton and by Merchant Navy Agents at Hull, Newcastle and Leith. Between them they try to visit each voluntary observing ship at least once in every three months. Under modern conditions of 'shore leave', ships' officers change very often and it is only by such frequent visits that continuity can be maintained. Generally, the ships' officers seem to enjoy meteorological work and there is never much difficulty in recruiting ships for the purpose. In fact there is often a waiting list. The instruments provided are a barometer, an open-scale barograph, wet- and dry-bulb thermometers, and a special bucket and thermometer for measuring sea-surface temperature; there is also some ancillary equipment such as 'screens' to contain the thermometers. The barograph is a fairly recent addition, otherwise the instruments are the same in principle as those issued in FitzRoy's day, so that old and new observations are directly comparable. The high cost of the equipment, and of replacements which are, naturally, more frequently necessary at sea than on land, are among the principal factors limiting the size of the observing fleet.

When a ship is recruited the permission of the owners and the master is first of all obtained and then the individual officers are approached. Meteorology forms part of the syllabus for the technical qualification of masters and mates, so that voluntary observers aboard ship are not beginners when they take up

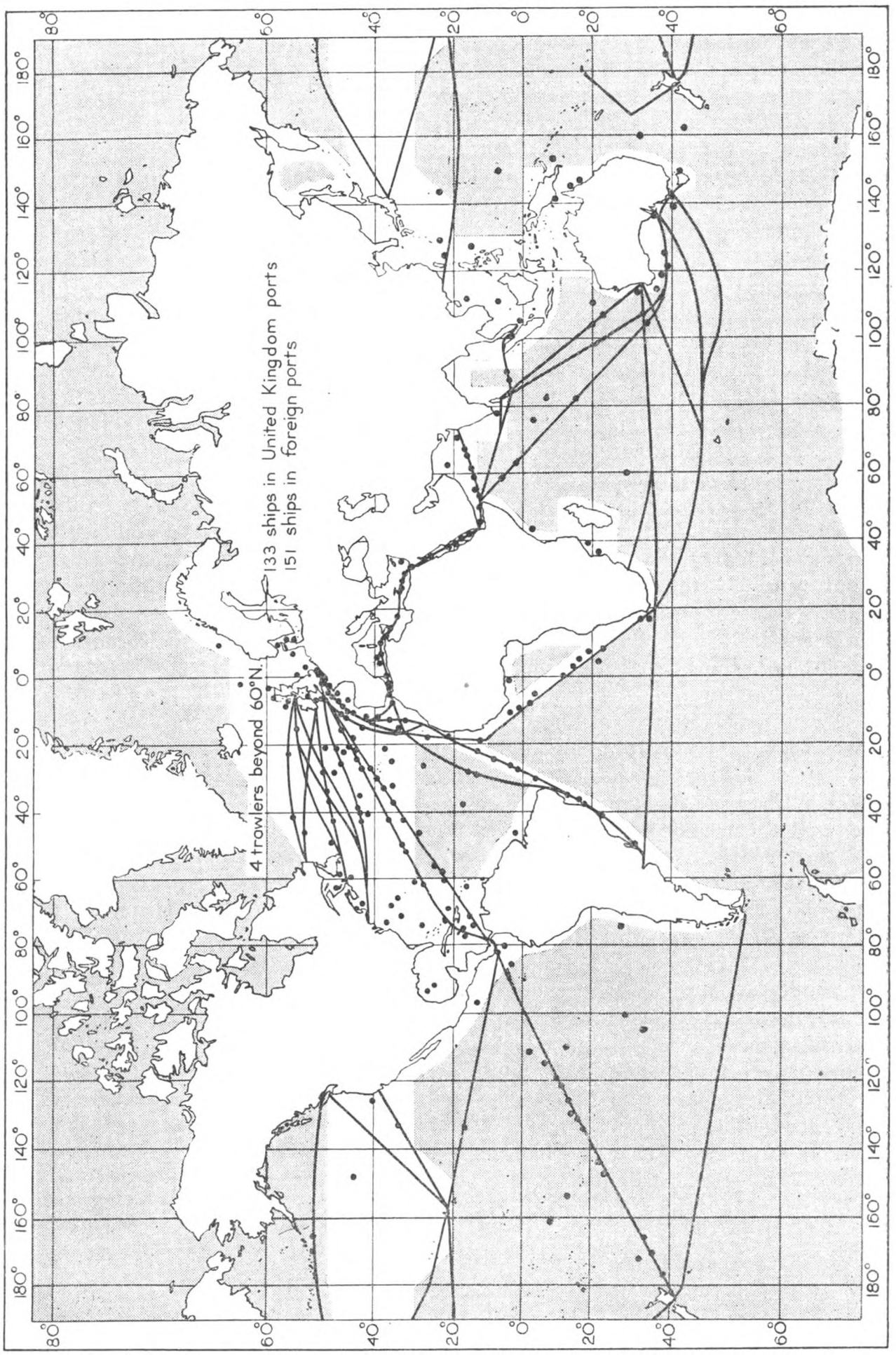


FIGURE 1—The positions of U.K. Selected and Supplementary Ships on 10 May 1962 (a day picked at random). The shaded areas are those in which shipping is sparse, and in which Auxiliary Ships make reports.

this work. It is only in detail of observing, care of instruments and coding the messages that they need instruction.

The recruitment of ships is designed to ensure that the network of observations in each ocean is as rational as possible and a special effort is always made to recruit ships known to be trading in unfrequented waters. Under the guidance of the World Meteorological Organization all ship-owning nations make a similar endeavour to recruit voluntary observing ships to fill in the gaps. A map showing the distribution of British Selected Ships on a day picked at random is at page 3.

On an average, a meteorological log-book takes about six months to fill up and it is then sent in to the Meteorological Office. In addition to the purely meteorological observations, and details about transmission of the radio weather messages, it contains ocean current observations, reports of sea ice encountered, reports of atmospheric and oceanographic phenomena such as aurorae, haloes, coronae and abnormal refraction, phosphorescence (bioluminescence) in the sea, discoloured water, tide rips, etc. Reports of whales and unusual fish sighted, and ornithological observations are also frequently recorded. As soon as a log-book is received in the Office its observations are carefully scrutinized by meteorological assistants and by a nautical officer. The latter invariably writes a personal letter of thanks to the master of the ship, in which he comments on the quality of the observations and makes any necessary suggestions for improvement. This close scrutiny shows that, in general, the observations are made conscientiously and accurately and that the resulting radio weather messages are regularly and promptly dispatched to their destination. Some of the log-books are beautifully maintained and contain excellent sketches of unusual phenomena.

Every observation is extracted and used for some scientific purpose. The meteorological observations are used for climatological purposes and for answering a wide variety of inquiries. The work entailed was very greatly lightened in 1921 by the introduction of a 'punched card' system—the first in the world to be used for meteorological purposes. One 'synoptic observation' (or more properly, all the data recorded by one ship on one particular date and time) is punched on to each card, and the cards are then sorted mechanically and stored according to geographical location and month: one box of cards normally contains all the observations made in a particular month of the year and in a particular 'Marsden Square', i.e. an area ten degrees of latitude by ten degrees of longitude. By the use of mechanical sorting and tabulating machines it is a simple matter to extract from the cards the mean value of any selected meteorological element, or the frequency of a selected phenomenon for any required geographical area and for any month of the year, and the time and labour required to prepare climatological atlases are thus very greatly lessened. A great many inquiries concerning conditions at sea can likewise be answered very quickly from the punched cards. The total number now held approaches ten million: but the distribution is very uneven and there are many parts of the ocean where the data are still inadequate and indeed are likely to be so for many years to come.

In November 1960, as a result of a reorganization in the Office, marine climatological work, which had been handled by the Marine Branch since 1855, was taken over by the Climatological Services Branch. The reason for this change is that climatology had developed into a more exact mathematical study than previously and marine climatology is so closely related to climatology of

the land areas and of the upper atmosphere that it was thought preferable to have all climatological studies in the one branch. But the Marine Branch still deals with numerous 'day-to-day' marine inquiries. For many years the punched card installation also was in the Marine Branch, but punched cards are so widely used throughout the Office nowadays that a unified installation has been established for the whole Office. However the Marine Branch still collects and checks the observations, and prepares them in a form suitable for punching: and it still retains its responsibility for the preparation of charts of ocean currents and of the distribution of ice, both matters of great importance to mariners.

The ocean current observations are not strictly a meteorological matter but fit in conveniently with the meteorological work of the observer because they are so intimately related with wind, waves, and sea temperatures. The Marine Branch calculates these currents by comparing the observed change in the ship's position with the change by dead reckoning, and has already used them to prepare atlases showing the directions and speeds of the mean surface currents in all oceans and for each quarter of the year. The atlases also give an indication of the variability of the currents. Hitherto, the extraction of the data from log-books has all been done in manuscript and the calculations, which are beyond the scope of the punched card installation, have been carried out by hand methods. However, the Meteorological Office now has an electronic computer which can easily perform the calculations, and the observations are now being punched in a form suited to the computer. In this way, it is hoped to produce more accurate and comprehensive ocean current atlases than have hitherto been possible.

Knowledge about the distribution and movement of sea ice is valuable, not only for the safety and economics of shipping but also for meteorological and oceanographical research. The loss of the *Titanic* off the Grand Banks of Newfoundland in 1912 and of the Danish passenger ship *Hans Hjortoft* off Cape Farewell (Greenland) in 1960 are spectacular reminders of the iceberg danger; while movements of shipping through the Gulf and River of St. Lawrence, into Hudson Bay or into the Baltic are all affected by ice conditions. Various authorities broadcast ice information by radio or facsimile, notably U.S.A., (Grand Banks and Davis Strait), Canada (St. Lawrence and Hudson Bay), Baltic countries (Baltic Sea), and U.S.S.R. (White Sea area). All this information is received in the Meteorological Office and redistributed to shipping interests as necessary, and the Marine Branch produces, at the end of each month, a chart giving the distribution of sea ice, sea temperature and vertical variation of sea temperature in sea areas in and around the North Atlantic Ocean. The front of the chart gives the distribution of pack ice and icebergs and on the reverse monthly averages and variability of sea temperature are plotted, based upon observations made at ocean stations A, I, J, B, and C (see map, page 7). For the Baltic area, in addition to the ice coverage, information is given as to periods of sustained frost. Copies of these maps are sent to various authorities both in this country and abroad, and to shipping interests.

The narrative observations of miscellaneous phenomena are extracted from the log-books and are sent to the appropriate national authority. The aurora observations are sent to the Aurora Survey at Edinburgh University, oceanographical observations, including whale sightings to the National Institute of Oceanography, and astronomical observations to the Royal Astronomical Society. No British authority has yet been found to take an interest in the

observations of bioluminescence and these are at present sent to Germany. Ornithological observations are referred to the Naval Bird Watching Society.

In order to help to maintain the interest of the voluntary observers, a quarterly magazine entitled *The Marine Observer* is produced in the Marine Branch and issued free to all the voluntary observing ships. It contains articles of scientific and marine interest, mostly of a meteorological and oceanographical nature, and a feature is the 'Marine Observers' Log' which consists of a selection of the more interesting narrative observations received from the ships. Every six months, a 'fleet list' giving the names of the voluntary observing ships and their officers is published; this is unique and is very popular with the observing fleet.

The activities of the British voluntary observing fleet are rather closely related to those of the various countries in the British Commonwealth. Most of the Commonwealth ships use British meteorological log-books and some of them use British instruments, and there is very considerable consultation and liaison between the meteorological services concerned (particularly between the Port Meteorological Officers).

In order to make sure that ships' Officers have a reasonably good meteorological background, the Marine Branch prepares textbooks on meteorology, covering the Ministry of Transport syllabus, and maintains contact with the Principal Examiner of Masters and Mates and with the navigation schools at the various ports throughout the country. The sections of 'Admiralty Pilots', concerning ocean currents and ice are prepared in the Branch in consultation with the Hydrographer of the Navy.

In 1947, on a recommendation of the International Civil Aviation Organization, 13 ocean stations were established in the North Atlantic to provide meteorological, navigational and rescue services for transatlantic flying. The ships keeping these stations make the same kind of surface observations as merchant ships but in addition measure the wind speed and direction, temperature, pressure and relative humidity, in the upper air. This information is essential for the planning of transatlantic flights, and equally so for the automatic preparation of forecasts by electronic computer: and it is of very great value in general forecasting. The number of ocean weather ships was reduced from 13 to 10 in 1949, and to 9 in 1954 for reasons of economy. They are far too few to provide an adequate coverage of data for so vast an area as the North Atlantic, and have in no way lessened the importance of observations from merchant shipping.

The North Atlantic Ocean station scheme is a remarkable example of international co-operation. Every country which operates scheduled airlines across the Atlantic contributes, either by providing ships or by paying cash. The four western stations B, C, D, and E, are operated by vessels of the United States; the five eastern stations are a European responsibility, station M being normally operated by Norway (2 vessels) while stations A, I, J, and K, are operated jointly by France, (2 vessels), Netherlands (2 vessels) and United Kingdom (4 vessels). The positions of the stations and some of the main transatlantic aircraft routes are shown on the map at page 7.

The four British weather ships are based at Greenock; each voyage lasts 30–34 days (24 days 'on station'), and is followed by about 15 days in harbour. 'Flower' class corvettes (having a length of 205 feet) did this duty for about 13 years and were then replaced by 'Castle' frigates (length 252 feet). The 'Flower' class ships did a very good job and were exceptionally good sea boats, but being

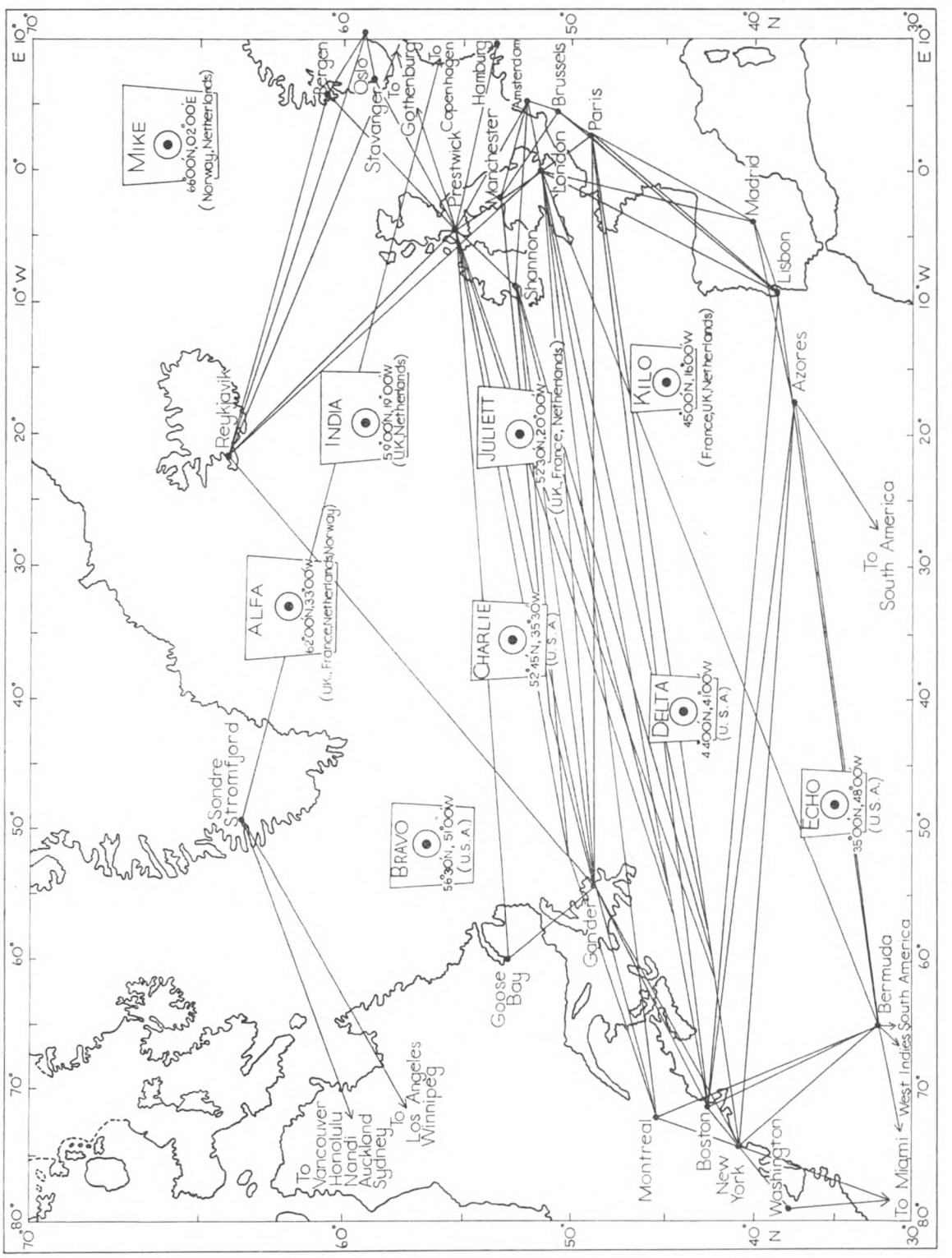


FIGURE 2—Ocean weather stations and transatlantic air routes

so small they were rather cramped for accommodation. The 'Castle' class vessels are also proving to be 'seakindly' and reasonably economical to operate, and since they are larger than their predecessors, have much better accommodation. Each British weather ship carries a crew of 56, including 7 meteorologists.

A weather ship, when on station, provides surface observations, similar to those provided by a merchant ship, every hour throughout the day and night. Every six hours a balloon carrying a radar target is launched, and the ship's radar follows this to a height of about 60,000 feet and thus determines the upper winds. For alternate ascents the balloon also carries a radiosonde—an instrument which measures pressure, temperature and humidity during the ascent and automatically sends its observations to the parent ship by radio. All this information is broadcast by the ship on a fixed schedule, so that all countries in Europe and on the American continent can receive the messages directly. It requires great agility and judgement to launch a large balloon with all its equipment in an Atlantic storm, and the meteorologists on board take pride in maintaining the programme of observations in all weathers.

The meteorological equipment aboard the ship includes, in addition to that carried by the merchant ships, two anemometers, one each side of the main mast, distant-reading instruments for recording surface sea temperature, air temperature and humidity and instruments for recording total solar radiation and net flux of radiation. Twice a day, sea temperature observations to a depth of 450 feet are taken, with a bathythermograph.

Besides their meteorological work, the weather ships have many other activities. One of their primary duties is to provide navigational aid and meteorological information for aircraft in flight, and to perform limited air traffic control duties. For this purpose they have to maintain constant watch on various radio frequencies (radio-telegraphy and radio-telephony), both with aircraft in flight and with the Air Traffic Control Centre at Prestwick. The weather ship on duty at station 'J' for example (a busy station) supplies navigational aids and meteorological information to 50 aircraft daily. Another duty they have is to relay radio weather messages from merchant ships which are out of radio contact with the shore. The weather ships form part of the air–sea rescue organization of the North Atlantic and if a casualty to a ship or aircraft occurs, this takes priority over everything else. As in the case of the U.S. aircraft 'Flying Tiger' which ditched in the Atlantic last September with the loss of 33 lives, the weather ship may be the only radio link between aircraft and merchant ships and will probably be required to control the search and rescue activities at the site of the incident. The ships are provided with special rescue equipment and their crews are expertly trained in air–sea rescue: they are kept in constant practice, which includes a considerable amount of boat work, both at sea and in harbour.

In accordance with the North Atlantic Ocean Agreement, the weather ships take part in various other scientific activities. Once a week oceanographic soundings to a depth of up to 1000 fathoms are made, to obtain observations of temperature and salinity. When on passage to and from station, a plankton recorder is towed which yields information about the distribution of plankton, the staple diet of many fish. Other activities have included observations of gradients of air and sea temperature near the surface, experimental rainfall observations (still one of the unsolved problems of observing at sea), comparisons between subjective estimates and instrumental observations of the wind, measurements of magnetic variation and routine ornithological observations on behalf

of the French authorities. Life in a weather ship is rarely dull; there is always plenty to do!

All the activities of the British ocean weather ships are controlled by the Marine Branch and the day-to-day administration and operation of the ships is dealt with by the Shore Captain and his staff at the Ocean Weather Ship Base in Greenock. There is a meteorologist on his staff, who ministers to the requirements of the meteorologists serving in the ships, sees that their instruments and equipment are properly maintained, and deals with any problems and queries that arise. The operation of the ships is quite a complex job, and it involves much consultation, not only with the Government departments in this country, but also at an international level. A committee of the operating and contributing countries makes an annual scrutiny of the costs of the ocean weather ships, and also exercises a general supervision over the operation of the ships and their methods of observation.

It seems unlikely that the work begun by FitzRoy will ever come to an end; as long as the earth has an atmosphere, meteorologists will need to know what is happening to the weather at sea.

2. General Description of the Services Directorate

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 either for 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. The general pattern of the organization of work in the Services Directorate is as shown in Appendix I.

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. An amplified account of one category of work in the Services Directorate is given in Section 1, the subject this year being 'Marine Meteorology'. Important events and innovations during the year are described in Section 3 and Section 4 contains notes on the weather of 1962. Finally the statistics in Section 5 provide some measure of the volume of work.

Central Forecasting (*M.O.*2). The Central Forecasting Office (C.F.O.) has a dual function. Firstly it is, by international agreement, a Master Analysis Centre, with an output designed to help other forecasting offices both domestic and foreign. The material for this purpose is broadcast over the meteorological communications system (described later in this report) and consists mainly of actual and forecast charts, both surface and upper air, supplemented by written commentaries. Secondly the C.F.O. 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, namely the *Daily Weather Report* with its *Overseas Supplement* and *Monthly Summary* and the *Daily Aerological Record.*

Aviation Services (*M.O.*6). The pattern of the outstation meteorological service for the Royal Air Force largely conforms with the RAF organization. Main offices, functioning throughout the 24 hours, are often located at Group Headquarters and control and advise subsidiary offices at stations in the Group. At these subsidiary offices a forecaster is available at times which depend on Service needs. At observing offices there is no forecaster and the duties comprise the making and dissemination of weather observations. At 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.

Meteorological services in the United Kingdom for civil aviation are organized on a similar pattern to those for the RAF with a principal forecasting office at London (Heathrow) Airport, main offices at air traffic control centres, subsidiary offices at civil aerodromes of intermediate importance and observing offices at some minor civil aerodromes. At civil aerodromes where there is no meteorological office, meteorological services are usually provided by telephone or teleprinter from a suitable meteorological office in the vicinity. To meet the need for observations from these aerodromes, training is given to air traffic control staff in the making and reporting of weather observations. The functions of the main meteorological offices include not only the provision of forecasts to captains of aircraft 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. RAF and civil) aerodromes in the Near and Middle East Commands.

General Services (*M.O.*7). This assistant directorate has a triple function. Firstly, it co-ordinates and in some cases supervises the supply of services for the general public through many different channels, for example the Press, broadcasting (sound and vision), the automatic telephone weather service, offices on airfields and weather information centres. Weather Information Centres, established to meet non-aviation inquiries from the public, are now available in London, Manchester, Glasgow and Southampton. The London centre continues to provide the staff for the routine weather presentation on the BBC sound and television channels, though, in this matter, they are acting largely as the mouthpiece of the Central Forecasting Office.

Secondly, 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.

Thirdly the assistant directorate is responsible for liaison with the War Office on meteorological services for the Army. Ballistics work involves maintaining meteorological offices at a few establishments (War Office and Ministry of Aviation) where the information supplied is of a specialist nature.

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 inquiries answered are mainly, but by no means exclusively, concerned with climate in the United Kingdom. These inquiries 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.

Much of the data collected comes from voluntary co-operating stations maintained by private individuals, local authorities, river boards, private firms, schools, public utilities, etc., this being particularly so in the case of rainfall observations (see Table IV). The Meteorological Office sets the required standards for sites, instrumentation and observational procedure and arranges for periodical inspections of the stations.

This assistant directorate also engages in investigational work, including field experiments, mainly of a character relevant to the provision of climatological services.

To a large extent the office at Edinburgh deals with climatological services in so far as Scotland is concerned and an office in Belfast carries 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). The main functions of the Marine Branch are to organize the supply of meteorological reports by the British Merchant Navy and ocean weather ships, and to arrange for meteorological services to the Merchant Navy.

Meteorological observing by the British Merchant Navy is entirely voluntary and unpaid: nevertheless nearly 700 ships participate. An analysis of the voluntary observing fleet is given in Section 5.

The United Kingdom co-operates with France, Holland and Norway in maintaining a constant watch at five ocean weather stations in the North Atlantic. For this purpose the Meteorological Office operates four ocean weather ships, of which two are always 'on station'. These ships make hourly observations of surface weather, but their most important function is the measurement of winds and temperature in the upper atmosphere. In addition to their

meteorological duties the ships also provide the following services:—

(i) air–sea rescue service
(ii) navigational aid to transatlantic aircraft
(iii) other scientific observations (usually at the request of other Government scientific branches)

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

Observations and Communications (*M.O.*5). Most meteorological offices in the United Kingdom have the duty of making surface observations, but there are also nearly as many ancillary reporting stations, manned by members of the Coast Guard, Trinity House and Northern Lighthouse Board organizations and other authorities. To obtain information about the upper air, a network of combined radiosonde and radar-wind stations is 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 1500 miles, and a similar network has been developed employing stations in Gibraltar, Malta and Cyprus.

Meteorological data are collected and distributed within Great Britain principally by a land-line teleprinter system, but 'facsimile' transmission over land-lines is also used, mainly to broadcast completed charts, diagrams and tables from the Central Forecasting Office. For overseas exchanges, land-line teleprinters, radio-teleprinter and radio-facsimile are the principal means employed. Wireless telegraphy is little used nowadays except to communicate with ships. There is a cable link with Canada.

Support Services (*M.O.*18). M.O.18 provides under one Assistant Director the technical ancillary services required by the Office. The services are those of the Library; Archives; sub-editing of Meteorological Office publications; computing, processing and storage of data by electronic and punched-card methods; and the cartographic drawing office.

The Library is the national library of meteorology and those other branches of geophysics within the scope of the Office. It provides an information service and the usual other services of a technical library to the Office staff, other Government departments, external research workers, industry and the general public.

The archives contain and make available for use original records of observations and returns made by observers, including autographic records.

Publications prepared for the press by the editing section include the monthly periodical *Meteorological Magazine*, the main research series of the Office—*Geophysical Memoirs* and *Scientific Papers*, the *Observatories' Year Books*, and occasional publications such as 'A Course in Elementary Meteorology'.

Until 1959 the only data-processing machine facilities in the Office were those provided by a punched-card installation, backed by a store of some 30 million cards. This installation can quite rapidly extract and tabulate data from the store but is restricted to very simple calculations. M.O.18 now includes both the punched-card installation and the electronic computer which acquired,

early in 1959 primarily for research into numerical methods of weather forecasting, is being increasingly used on other onerous computing tasks. Both the computer and punched-card installation are widely used by all the research and climatological services branches of the Office. The computer operates with punched paper-tape and two card-to-tape converters provide a link between the punched-card store and the computer. Plans are well advanced to supplement or replace these facilities during the next two years by the latest type of electronic data-processing system using magnetic tape, punched paper tape and Hollerith cards.

The cartographic drawing pool prepares diagrams for Meteorological Office publications and many others required in the Office such as the base maps for weather plotting charts.

Techniques and Training (*M.O.*8). 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 attack 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. One section of M.O.8 provides that co-ordination and advice and to this end two groups have been set up, one dealing with statistical and the other with synoptic problems.

The second function of the assistant directorate is the supervision of training within the Meteorological Office. The Training School provides formal professional courses, both for new recruits in all classes and for experienced meteorologists. Instruction in a number of specialist subjects is also given. In addition to the Meteorological Office staff, sponsored students from many overseas countries receive training at the School. Details of the numbers of students attending different courses are given in Table XVI of Section 5 (p. 39). Staff are encouraged to supplement their formal training by studying for higher external qualifications. Financial aid and a certain amount of time off for study may be allowed and these concessions are co-ordinated by M.O.8.

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 organizations. The World Meteorological Organization (WMO) deals with matters of pure meteorology. This organization 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 Organization (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 Organization (NATO) are discussed at meetings of committees and working groups organized for that purpose. There are also meteorological committees associated with the other international military organizations 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 principal meetings attended will be found in the 'International Co-operation' section (p. 55).

Considerations of national meteorological war-time 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.

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

The Assistant Director (Defence and International) also assists the Director-General as Permanent Representative of the United Kingdom with the World Meteorological Organization and in his personal capacity as a member of the Executive Committee of that Organization.

3. Major Events and Changes in the Services Directorate

Central Forecasting (*M.O.*2). There was no major change in the work of the Central Forecasting Office during the year.

Aviation Services (*M.O.*6). There was no major change during the year in the pattern of outstation meteorological services for aviation, although the move of a number of Flying Schools of Flying Training Command necessitated an alteration in the function of some meteorological offices and the reopening of four others, two of which were required for short periods only.

Meteorological services were provided for RAF aircraft on long flights from the United Kingdom to destinations overseas, including flights using in-flight refuelling techniques. Where possible the service was provided from British Meteorological Offices. Facilities for the rapid interchange of information between U.K. and some overseas offices were improved by the introduction of additional channels which are used exclusively for meteorological information.

There was co-operation with Dominion and foreign meteorological services in the provision of meteorological information for Royal Flights abroad, International Exercises and long distance Troop Transport Flights.

All meteorological forecasting offices serving the RAF in the United Kingdom were provided with facilities for the reception of National Facsimile Broadcasts from Bracknell.

The Principal Forecast Office at London (Heathrow) Airport has provided meteorological information for a number of new airline services including long-range direct flight forecasts to the west coast of the United States and to West Africa. Arrangements were agreed with the Blackpool Corporation to maintain a meteorological observing office at Squires Gate Airport when this was taken over by the Corporation from the Ministry of Aviation in April.

Certain new procedures for civil aviation were agreed with the Ministry of Aviation. Notable amongst these was the introduction, in October at London (Heathrow) Airport, of a new form of aircrew documentation for all European/Mediterranean flights.

General Services (*M.O.*7). The weather Information Centres in London, Manchester, Glasgow and Southampton dealt with 415,310 non-aviation inquiries, an increase of 28 per cent on 1961. London Weather Centre handled

253,833 inquiries, an increase of 11 per cent on 1961. In the 5-day foggy period early in December in London over 10,000 telephone inquiries were answered with a peak of over 2500 on one day. The new centre at Southampton had 37,764 inquiries in its first year of operation. The increasing demand for this type of service has not been confined to Weather Centres; aviation meteorological offices handled nearly 400,000 inquiries during the year, double the number of five years ago. There were outstanding increases throughout the country in inquiries associated with the building trade, industry and commerce, marine matters, the Press, public utilities and road transport.

Development in Glasgow of meteorological services for the public has been seriously hampered by the lack of suitable premises for the Glasgow Weather Centre. After a long search the Ministry of Public Building and Works has now been able to allocate new premises for the Weather Centre at the corner of Douglas Street and Waterloo Street. The accommodation includes a shop and display window and will also house the Port Meteorological Officer. The new premises should be ready for occupation in mid-1963. New premises in High Holborn have been offered for the London Weather Centre with a target date for the move towards the end of 1963.

BBC Television introduced an improved layout and new display maps for weather presentation late in the year. The Office co-operated with the Local Broadcasting Committee of the BBC by supplying special forecasts for trial local broadcasts throughout the country. However, this scheme has been in abeyance since the publication of the White Paper on broadcasting. Liaison visits took place between forecasting and communications staff at Bracknell Headquarters and BBC announcers and newsroom staff at Broadcasting House.

Another independent television company, Wales (West and North) began operations during the year and now gets routine forecasts from the Office; this brings to 14 the number of such companies in the United Kingdom receiving weather information. Southern Television appointed a weather man late in the year and arrangements were made for him to be supplied with the necessary information from Southampton and London Weather Centres. Forecasts are now supplied daily to Malta Television by the Main Meteorological Office which is situated on the RAF airfield at Luqa, Malta.

M.O.7 staff appeared in a considerable number of broadcasts on both sound and vision during the year.

The grand total of calls on the automatic telephone weather service (ATWS) topped the six million mark of which just over half were for London area forecasts. This represents an overall increase of 10 per cent on 1961, but there were falls in some areas and particularly in Birmingham—19 per cent. Kent coast forecasts became available from Canterbury and local exchanges.

Extended forecasts were introduced on an experimental basis for the Gas industry and were still being supplied at the end of the year. After a number of meetings with representatives of the sport, plans were completed for an improved forecast service for pigeon racing in 1963.

The inclusion of the centigrade scale of temperature in public announcements is described elsewhere in this report. Most of the correspondence with the public on this matter was handled within M.O.7.

Sixty-eight party visits to Bracknell Headquarters were organized during the year.

M.O.7 staff co-operated in a special investigation of the damaging February

gales in and around Sheffield, making a study of damage to property in Sheffield and distribution of tree damage in the north-east.

The meteorological services for the Army continued on much the same scale as in the previous year. The training of the Army meteorological sections was extended to include instruction in the use of radiosondes.

Investigational work connected with agricultural meteorology has concerned milk yields, shelter problems, plant and animal diseases, building ventilation and grass growth. Advice and assistance were given on both the New Town plan for Cumbernauld and projected Motorways. Beaumont and Smith periods were made available to farmers as a chargeable service. The Office was represented at many meetings and symposia related to agriculture both in this country and overseas.

Climatological Services (*M.O.*3). A change in organization within this assistant directorate has made one section responsible for collection and scrutiny of all data, another for answering all inquiries, including those relating to hydrology, whilst a third is responsible for publications and statistical work. The scientists in the branch continue to advise these sections as necessary, as well as being reponsible for investigations and the development of improved methods of carrying out routine work. As regards this latter the large quantity of rainfall data received from stations in England and Wales has been checked for accuracy throughout the year by means of the electronic computer METEOR. This new venture is regarded as so successful that the next stage of the operation —the production of rainfall statistics by computer—has been pursued during the year. Special efforts have been made to reduce the leeway in the publication of *British Rainfall* and it is hoped that future use of the computer will further accelerate this work. Exploratory work has also been carried out on the possibilities of feeding surface climatological data directly from the teleprinter network, i.e. from the stations where the data are prepared into the computer for subsequent scrutiny and processing.

The number of inquiries dealt with by the assistant directorate (including Meteorological Offices Edinburgh and Belfast) was again higher than in previous years. In this connexion a preliminary report on weather hazards likely to affect the projected Lancashire–Yorkshire Motorway was prepared. In the autumn a valuable addition was made to the field equipment for obtaining essential data for this work—a visibility recorder giving a continuous record of visibility at one of the sites.

On the investigation side M.O.3 made a contribution to the detailed examination of the Sheffield Gale which occurred on 16 February 1961. Some work was also done on the prediction of state of sea, a necessary preliminary to any future development of work on ship routeing. In rainfall work, it became possible to open half the network of synchronized open scale rain recorders at Winchcombe in Gloucestershire. This is a repetition, in moderately hilly terrain, of the Cardington rainfall experiment, mounted chiefly to aid better definition of intense falls of rain, for the purposes of urban storm water drainage design. Also on the hydrological side and through Meteorological Office representation on the Hydrological Research Committee of the DSIR, the assistant directorate has been involved in hydrological planning work amongst which is the proposal to carry out research on the effect of land use on the water balance, in selected catchments. The branch also maintained close contact with the Land Drainage Division, Ministry of Agriculture, Fisheries and Food and also River Board

Engineers (England and Wales) with the object of developing and giving suitable meteorological information to the Engineers in connexion with river flood prediction.

Marine Branch (*M.O.*1). The British ocean weather ships completed 15 years' service in the North Atlantic during the year. The 'Castle' class vessels have proved generally successful vessels for the purpose. *Weather Adviser* assumed the duties of control vessel in the search and rescue operation for survivors of the American Super Constellation aircraft, forced by engine trouble to ditch in the Atlantic on 23 September.

The new ocean weather ship base at Greenock, made necessary because of the inclusion of the site of the old base in the construction work on the new dry-dock at Greenock, was completed and occupied in July.

Oceanographical and biological work was continued for the Admiralty, Ministry of Agriculture, Fisheries and Food and the Department of Agriculture and Fisheries for Scotland.

Since February the twice daily bathythermograph observations of the British and Dutch weather ships have been broadcast to Dunstable the following morning. This information is used for the preparation of graphs showing the monthly average sea temperature at fixed depths. Since September bathythermograph soundings by the weather ships on passage to and from station at six-hourly intervals have been taken for the Ministry of Agriculture, Fisheries and Food.

During the year, and throughout the period of the International Indian Ocean Expedition (1962–64) Selected and Supplementary ships, when in the Indian Ocean, were requested to make a point of recording in the meteorological log-book all rainfall, giving the time rain begins and ends. The data will be used for an investigation into the cause of monsoon winds and rains.

A number of Selected and Supplementary ships which are fitted with the very accurate Pitometer log have made special ocean current observations on our behalf to improve the accuracy of our determinations of surface currents. The ocean weather ships have also made a useful contribution to this work. Observations of many interesting auroral and other special phenomena have been received from the voluntary observing fleet during the year.

By arrangement with the Hydrographer of the Navy and the Director of the Naval Weather Service, H.M. Survey ships are now keeping the same type of meteorological log-book as that used by British Selected ships and are regularly sending weather observations by radio. These vessels do not form part of the voluntary observing fleet but their observations are of great value as many of them are made in areas of the world where observations are few.

The Marine Branch, in collaboration with the Climatological Branch, has made a study during the year of 'weather routeing'—a procedure by which the master of a ship is advised, both before and during a voyage, of the best course to follow in order to take advantage of the most favourable conditions of weather and sea. Weather routeing has been tried experimentally in the U.S.A. and Holland, and is claimed to result in fuel savings and less damage to cargo. Trials have so far been only on paper, using imaginary ships, and have been inconclusive, but the work is continuing. The Netherlands Meteorological Service has assisted with advice and by supplying us with copies of the synoptic wave maps, prepared for their own studies of the problem.

The number of marine inquiries handled during 1962 was substantially

greater than in the previous year. The largest group came from solicitors and insurance agents concerned with claims for loss or damage. A number of reports were prepared for investigations by the Ministry of Transport into the loss of ships. There were very many inquiries about sea waves, arising from such diverse operations as the construction of harbour works, the demonstration of hovercraft, oil-drilling under the North Sea, the laying of submarine pipes and the building of the Channel Tunnel. Data on sea temperatures were supplied to the RAF for a study of the survival of ditched aircrew.

Observations and Communications (*M.O.*5). Of the 199 stations making synoptic weather observations within the United Kingdom at 31 December 1962, 97 were auxiliary stations maintained, but not manned, by the Office. Nine such stations were added during the year. Four of these are co-sited with television transmitters on high ground in North-East England, South Scotland and Northern Ireland. At Dalwhinnie, in the Central Highlands of Scotland, where auxiliary observations have been made continuously for 31 years, it has been impossible to obtain further voluntary observers and the station has been closed.

Automatic recorders of radiosonde observations earlier introduced at home and overseas land stations have this year been installed on our weather ships. For land-based radiosonde stations the local generation of hydrogen by electrolysis is being studied. There are indications that this may effect economy in comparison with methods used hitherto. The United Kingdom network of four thunderstorm location stations, using low-frequency radio detection, has remained unchanged but further trials in conjunction with three similar stations at Gibraltar, Malta and Nicosia have been made. Results obtained have been analysed and a scheme to obtain the maximum usefulness from the combined networks is now under discussion.

During the year it was agreed that the domestic land-line facsimile transmission of weather charts and analyses from Bracknell should be extended to offices on civil airfields in the United Kingdom. Six new installations were made and equipment to complete the task is on order. Radio facsimile reception was arranged at two stations at home and one overseas. Continuous radio-teleprinter contact between the Bracknell and Aden offices was made available by the RAF from late April. Similar links between offices in Aden, Gan and Singapore were also provided.

Much interest has centred on reception of a new facsimile radio transmission from New York. The United States Weather Bureau make available on this their numerical weather predictions and a diagrammatic presentation of cloud photographs made from TIROS satellites. This transmission is received satisfactorily at Dunstable on most occasions and relayed to Bracknell.

Support Services (*M.O.*18). Steps were taken during the year towards the purchase of a powerful new electronic computer system for use in research, numerical weather forecasting, data-processing, and a trial of automatic editing of the synoptic weather transmissions. A working party, covering all aspects of the use of the new system, drew up a specification which was issued by Air Ministry Contracts Division to a number of computer manufacturers with an invitation to tender. A number of tenders for computers and ancillary equipment was received and studied by the same working group, and recommendations made to the Air Ministry.

The use of the existing electronic computer METEOR markedly increased during the year. It was used on an average for 68·5 hours a week during the last quarter compared with 41·2 in the first.

The Archives hall in the building at Eastern Road, Bracknell with over two miles of shelving was completed in April and the existing separate Archives at Harrow, Dunstable, and Victory House were brought together in it under M.O.18's control soon after. Following negotiations conducted by M.O.18 with the Public Record Office the Lord Chancellor appointed the Meteorological Office Archives at Bracknell, Edinburgh, and Belfast as 'places of deposit' under Section 4 of the Public Records Act 1958. The Archives at Edinburgh and Belfast hold records for Scotland and Northern Ireland respectively. All other records are held at Bracknell. Detailed regulations on the selection of documents for permanent retention and the methods of storing and indexing them were drawn up in accordance with the Public Records Act and approved by the Public Record Office.

The large increase during recent years in the work of the Library consequent on the increased intake of scientific publications has necessitated an increase in the Library staff establishment by fifty per cent. A second translator, to make translations from Russian, was among the additions to the staff. A third Flexowriter tape-operated typewriter was acquired to accelerate cataloguing and preparation of bibliographies.

The major publication prepared for printing by the Editing Section was the new (fourth) edition of the Meteorological Glossary which is now in the last stages of proof correction.

The provision and supervision of projection equipment for the lecture theatre was placed under M.O.18. Cine-projectors and loudspeakers were fitted in the theatre and a comprehensive epidiascope and projection screen ordered.

Head of M.O.18 represented the Office on a British Standards Institution Committee set up to review the British Standard on the terminology, notation, and formulae of atmospheric humidity. The Committee met twice during the last two months of the year.

Techniques and Training (*M.O.*8). Investigations into several synoptic problems mentioned in last year's report were completed by the publication in the *Meteorological Magazine* of articles on the following topics: the formation of fog over higher ground; delay in clearance of cloud and rain behind certain cold fronts; fog and low cloud over the Fens. The results of investigations on stratus over East Anglia and on smoke palls over London were also published in the same periodical.

The preparation of charts showing the detailed spatial distribution of rainfall in selected synoptic situations, and charts of snow depth on selected dates, has been maintained.

Studies of the relationship between surface and upper winds (geostrophic and 900 mb) have continued. Values have been derived for the ocean weather station 'Juliett', London (Heathrow) Airport and West Raynham, and are being found for the ocean weather station 'India'.

It was decided that diagrams for predicting the visibility at London Airport by an objective technique should be produced for eight hours of the day during the six winter months. Work started on the extraction of the large amount of data needed. One of the parameters required was the geostrophic wind and the computer METEOR was used to make an objective analysis of pressures at about

20 stations and compare the resulting geostrophic wind with measurements from synoptic charts.

Data were supplied to outstations to assist them with 28 new forecasting problems and 13 problems which had been formulated earlier.

The training of Scientific Assistants, which had been suspended in November 1961, was resumed in August, and by the end of the year over 100 assistants had attended training courses. A shortened course of five weeks duration is being given to assistants who have had several months' experience at outstations. Details of attendances at training courses may be found in Table XVI.

A colour film entitled 'The Changing Sky—Convection Cloud' has been prepared by the School, and is now in use as a training aid.

During the year 132 members of the staff were enrolled under the external training scheme which gives financial aid and time off for study and examinations. On 31 December, 301 students were in receipt of these concessions.

Discussion meetings were held at the Royal Society of Arts in January, March, October and December, the topics being turbulence and diffusion, meteorological satellites, dry and wet spells, and agricultural meteorology.

A. C. BEST
Director of Services

4. NOTES ON THE WEATHER OF 1962

Perhaps the most noteworthy feature of the weather of 1962 was its persistent coolness, only one month (October) after February having a mean temperature above average. An unusually cold March heralded a cold Spring—the coldest in Manchester this century. The promise of summer in a dry, sunny but rather cool June was not fulfilled, July being dull and cool and August cool and wet. It is of interest to note that one has to go back to the Second World War to find a dry August in England falling in an even year. September was like August and only October brought a welcome respite. However, a very cold and snowy spell in November was followed by persistent fog in some places in early December; the worst fog in London since 1952. By Christmas the weather was very cold and soon attended by widespread and, in some parts, heavy snowfall.

Other noteworthy features were the windiness of January and February, especially the gales in February, one of which caused particularly severe damage in Sheffield; the gale of early March which breached the sea walls in parts of South-West England, causing disastrous flooding; the over-all dryness of February to June in much of the West of England, and the flood-producing rains of August in North-West England and South-West Scotland.

The Weather, Month by Month. January—The very cold weather and heavy snowstorms which brought in the New Year over much of southern and central Britain soon gave way to milder conditions which persisted for much of the month. The predominantly westerly cyclonic type gave some severe gales.

February—A rather dry month over southern England and the Midlands, though rainfall was more than average over Scotland. During the first three weeks pressure remained relatively high to the south-west of the country while depressions from the Atlantic moved east over, or to the north of, Scotland. A week of stormy weather, most severe in the north, began on the 11th; at Lowther Hill gusts of 106 knots and 103 knots were recorded on the 11th and 16th respectively. The month ended with a week of cold easterly winds, the main centre of high pressure being first over Scandinavia, then near Iceland and later near Greenland. Snow showers, scattered at first, became frequent and pro-

longed and easterly gales on the 26th and 27th piled snow seven feet deep in drifts in parts of Lincolnshire.

March—March was unusually cold, weather being predominantly anticyclonic in character. The high pressure centre was over Greenland for the first two weeks then in the region of Iceland until the 25th, maintaining a generally cold north to north-east airstream over the country. During the first week, snow lay up to 4 inches deep in many parts of central and northern England and in the extreme south-west; in Scotland it lay 2 feet deep in the Cairngorms. The last week was milder and cyclonic with depressions from the Atlantic crossing the country.

April—The month was rather cold generally, dull in the south-east of England but exceptionally sunny in north-west Scotland; Stornoway had its sunniest April since records began in 1880. After a cyclonic, rather stormy beginning from the 12th to 16th the country came under the influence of an anticyclone moving from Iceland to southern Scandinavia. Thereafter weak troughs crossing the country in a generally cyclonic régime maintained very changeable weather until the 22nd when anticyclonic conditions were restored.

May—May was a generally cool month and, like April, rather dull in the south-east but sunny in the north-west of the British Isles. There were two unsettled cyclonic periods, the 3rd–11th, and the 16th–22nd, otherwise weather was mainly dry and anticyclonic in character with pressure high to the north and west of the country. A feature of the month was the persistent lowness of the daily maximum temperature, especially in the south-east. Air frost occurred locally.

June—A dry and sunny month especially in southern and eastern England; it began and ended with anticyclonic weather, but from the 9th to 25th relatively weak frontal systems, followed by pronounced ridges of high pressure moved across the country. Afternoon temperatures reached 27°C (81°F) at a few places on the 8th and 9th, but they were below average nearly everywhere during the second half of the month. The 18th–24th was rather a stormy period with gales in the north.

July—Mean temperature during July was below the average for the fifth successive month. The first and last weeks were mainly anticyclonic in character, but a succession of slow-moving depressions brought thundery rain to many districts during the second and third weeks, leading to local flooding in central and southern England. Rainfall over the country as a whole, however, was below the average.

August—A cool, wet and mainly cyclonic month with a succession of troughs of low pressure moving across the country from the Atlantic, the series being broken only by short anticyclonic spells on the 12th–13th, and the last two days of the month. Periods of heavy rain caused flooding in the Lake District and parts of Scotland on both the 11th and 23rd. Day temperatures were below average throughout the month except around the 19th, and temperature over grass fell locally to 0°C (32°F) on ten nights.

September—Another cool, wet and mainly cyclonic month apart from a week of anticyclonic weather on the 18th–24th, and two short spells around the 1st and 13th. Afternoon temperatures were mostly below average and as much as 5°C (9°F) below over most of England during the week of anticyclonic weather. Air frost was fairly extensive in southern England on the 22nd.

October—The outstanding feature of the month was the generally dry anticyclonic weather which lasted with little interruption from the 3rd until the

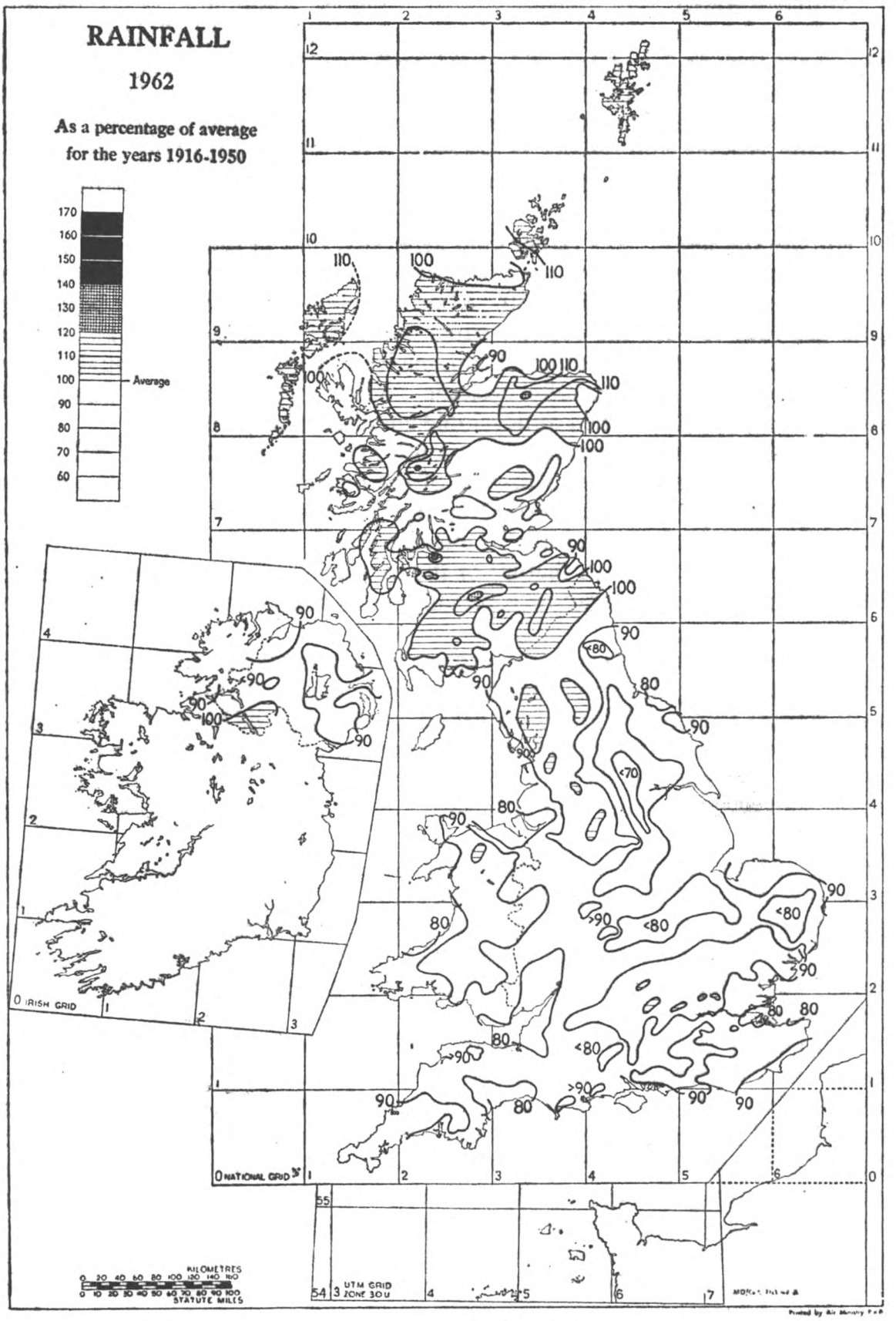


FIGURE 3—Rainfall 1962

England and Wales: highest maximum, lowest minimum, average mean maximum and average mean minimum temperature (°C) in 1962

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Highest max.	14.4	15.0	15.6	22.8	21.1	26.7	27.2	25.0	27.8	22.8	16.1	15.0
Lowest min.	−21.1	−7.2	−15.0	−7.8	−5.6	−5.6	−1.1	−1.7	−1.7	−5.6	−11.7	−15.6
Average mean max.	7.4	7.3	6.5	11.3	13.9	18.2	18.4	18.3	16.6	14.2	8.3	5.2
Average mean min.	2.8	2.9	0.0	4.7	7.3	9.6	11.3	11.7	10.0	8.2	4.1	0.7

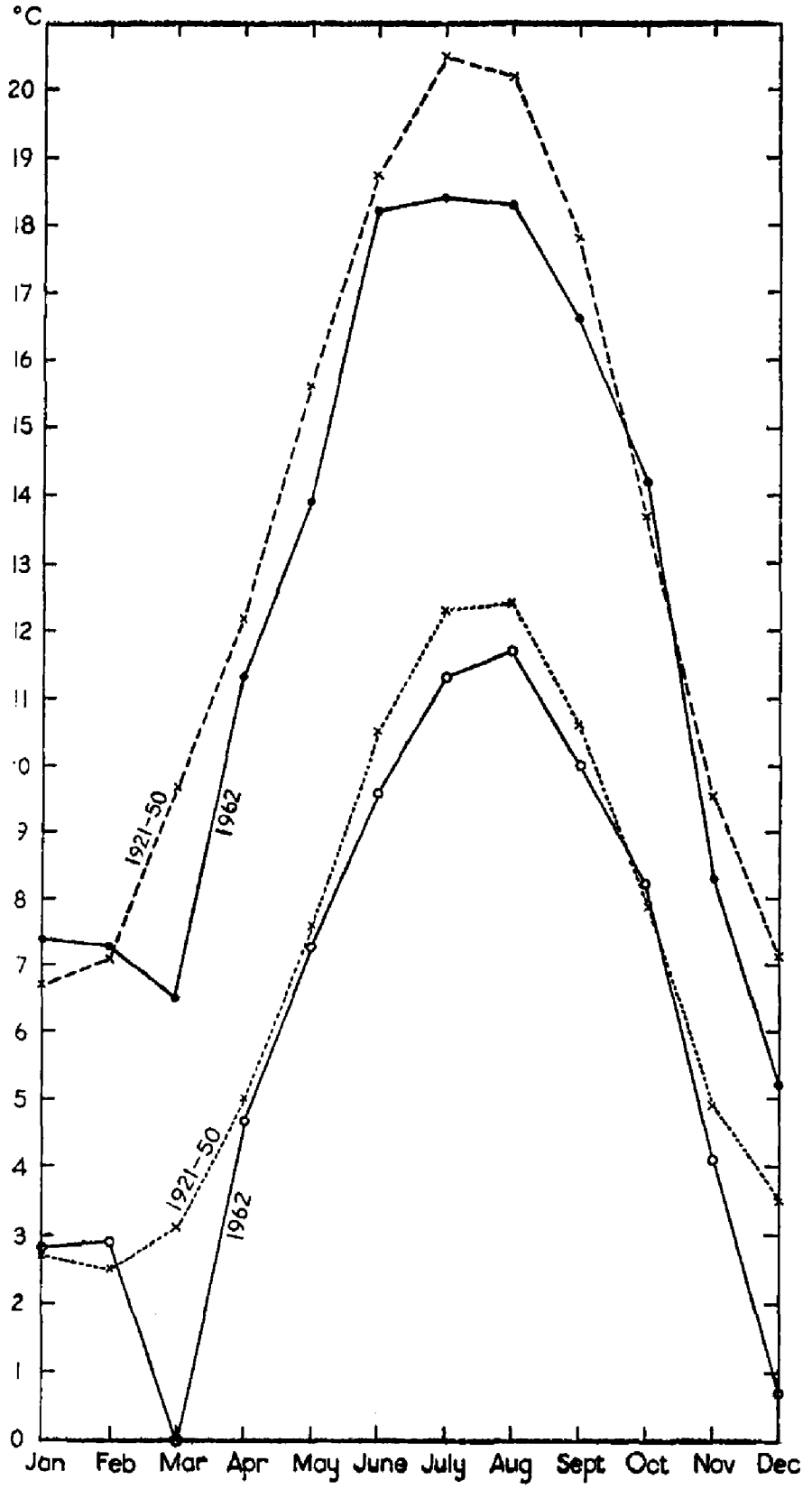


FIGURE 4—England and Wales: monthly general values of mean maximum and mean minimum temperature in °C

Scotland: highest maximum, lowest minimum, average mean maximum and average mean minimum temperature (°C) in 1962

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Highest max.	13.6	15.0	12.8	21.1	21.1	26.1	25.6	21.2	24.4	21.7	15.6	12.8
Lowest min.	−16.1	−9.2	−17.2	−7.8	−6.1	−3.2	−1.0	−1.1	−1.7	−6.1	−15.0	−16.1
Average mean max.	6.3	7.0	5.4	10.1	12.5	16.0	15.8	15.6	13.8	12.6	7.5	5.8
Average mean min.	1.9	2.1	0.1	3.4	6.4	9.3	10.4	10.2	8.9	7.8	3.1	1.7

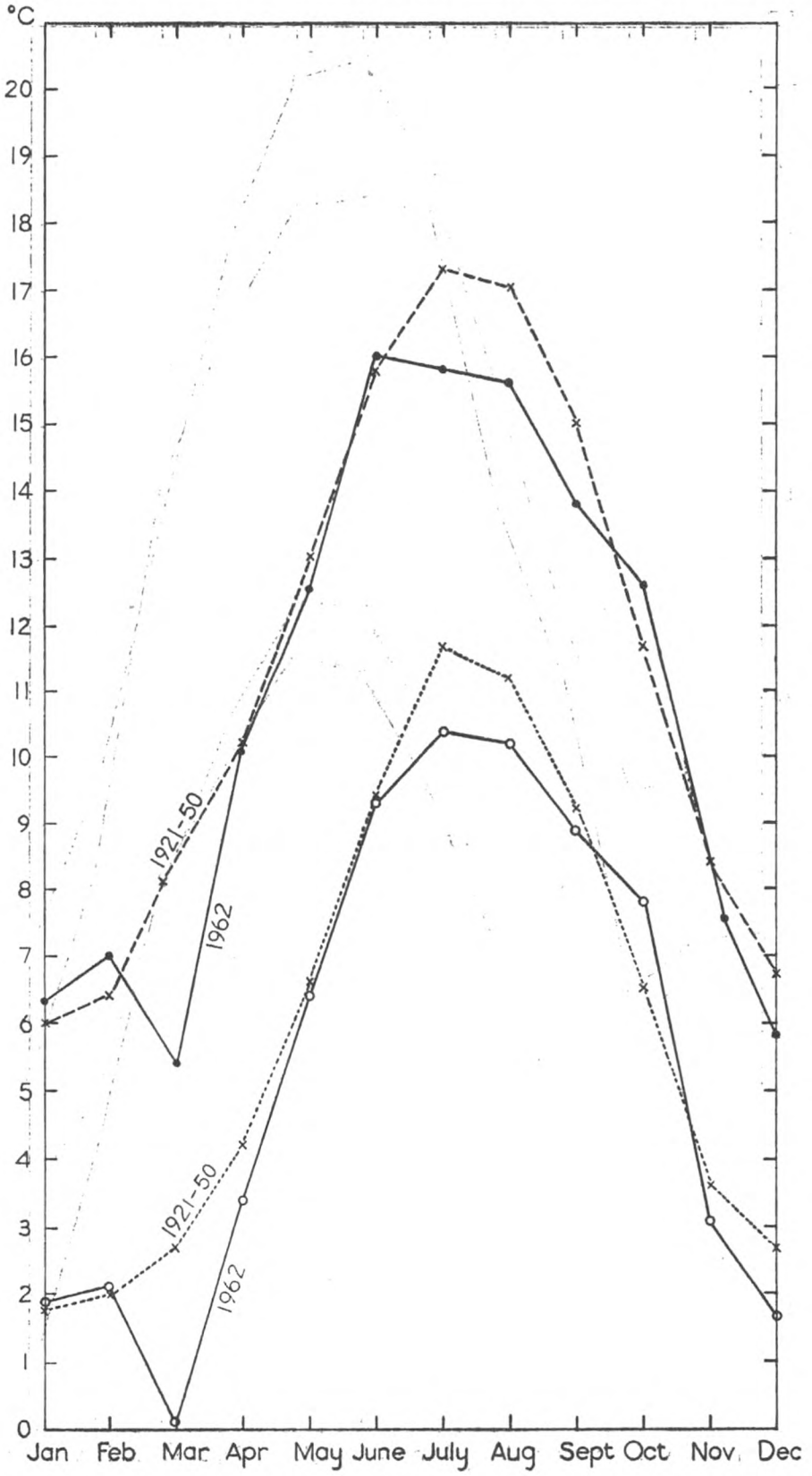


FIGURE 5—Scotland: monthly general values of mean maximum and mean minimum temperature in °C

Northern Ireland: highest maximum, lowest minimum, average mean maximum and average mean minimum temperature (°C) in 1962

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Highest max.	12.8	12.2	12.8	20.0	20.0	24.4	22.8	22.3	20.6	18.4	13.3	13.3
Lowest min.	−11.1	−5.6	−11.7	−3.9	−1.7	−2.2	3.3	0.0	0.6	−1.1	−6.6	−9.4
Average mean max.	7.1	8.0	6.9	12.2	14.1	16.8	17.4	17.1	14.8	13.6	8.7	6.8
Average mean min.	0.8	2.2	−1.0	2.7	5.5	8.2	9.9	9.7	8.4	7.0	3.2	1.3

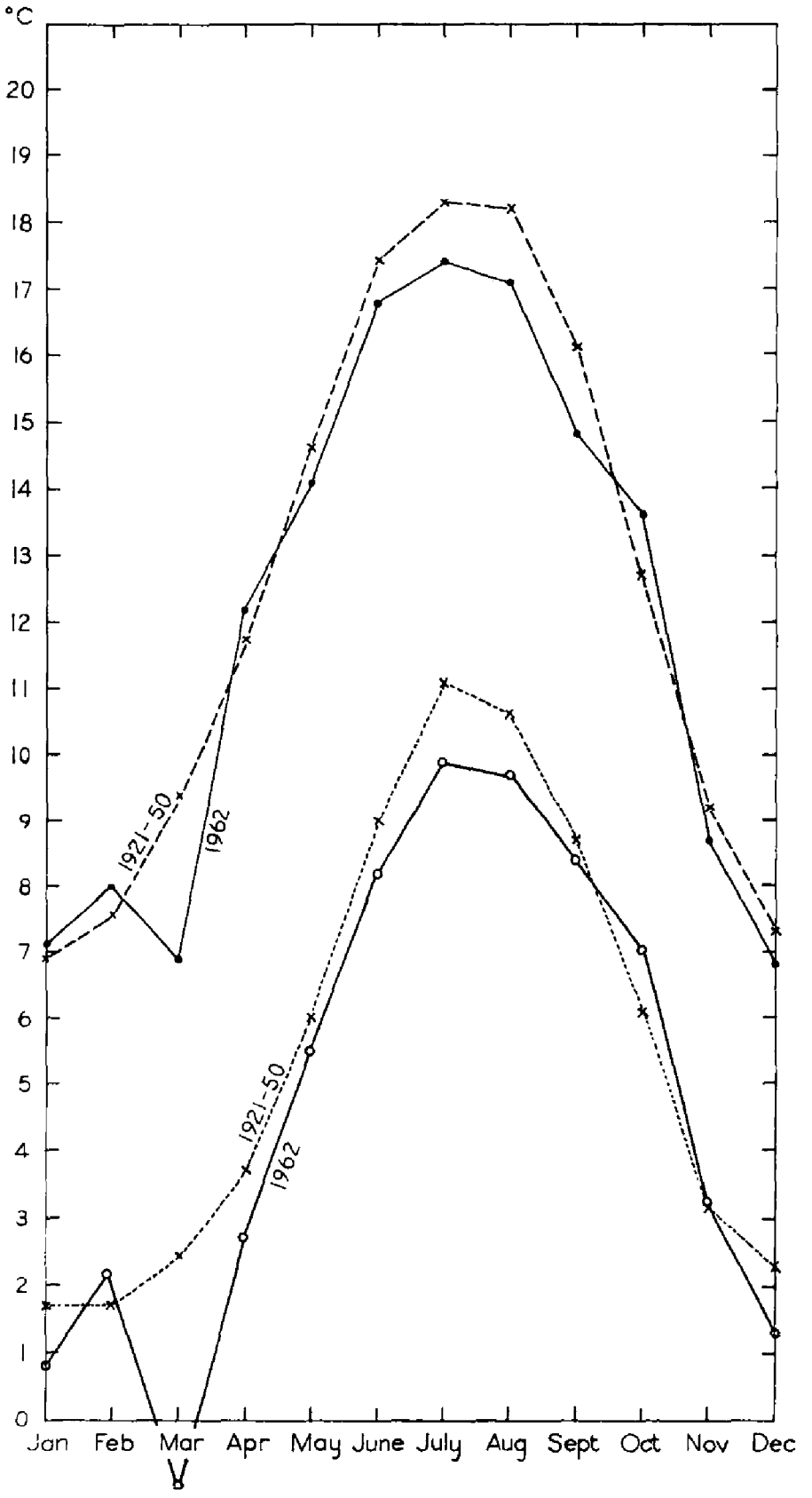


FIGURE 6—Northern Ireland: monthly general values of mean maximum and mean minimum temperature in °C

England and Wales: percentage of 1921–50 average sunshine in 1962

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
135	110	105	104	89	119	74	92	88	109	77	157

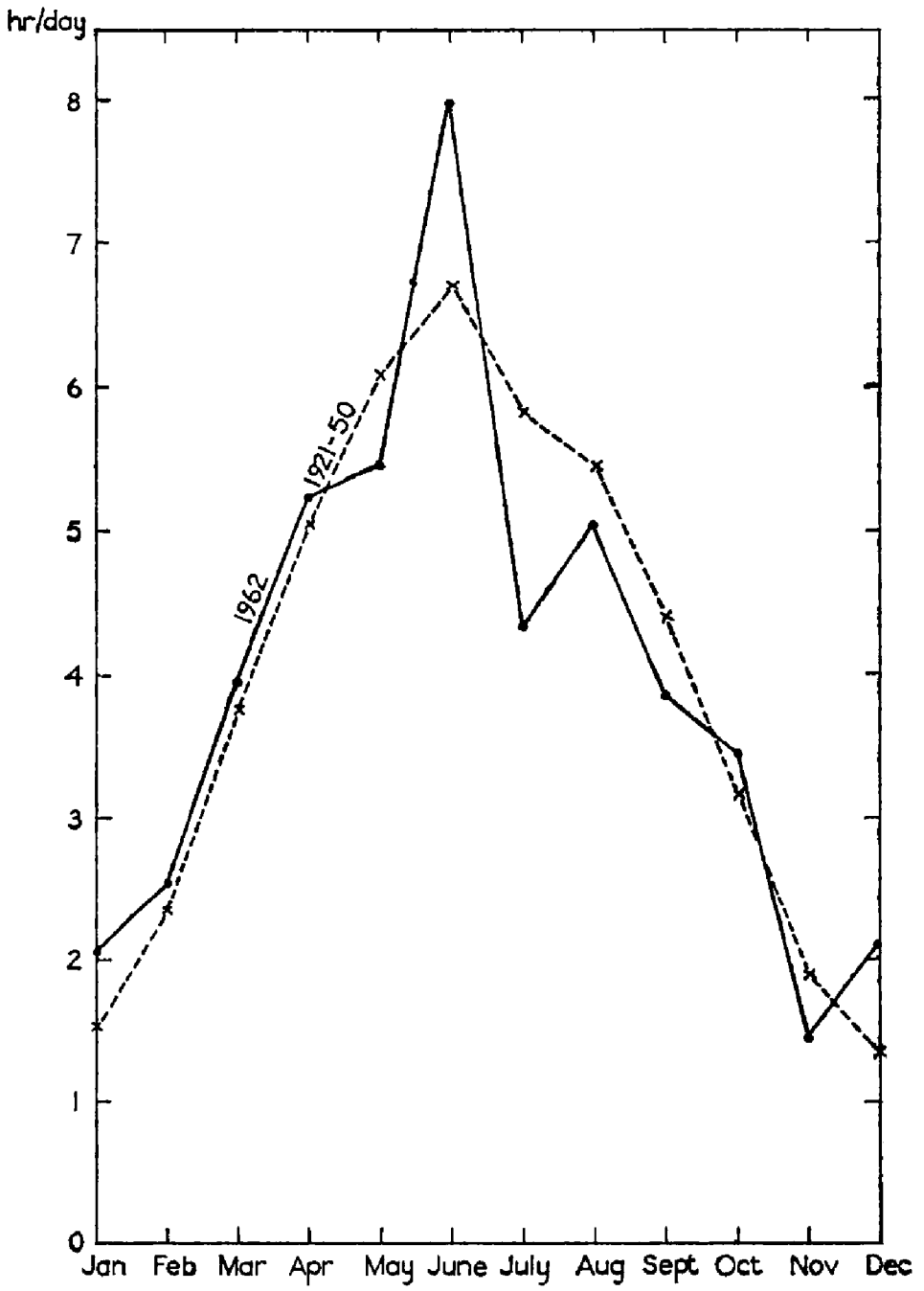


FIGURE 7—England and Wales: monthly general values of sunshine in hours per day

Scotland: percentage of 1921–50 average sunshine in 1962

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
123	112	107	141	97	99	98	109	69	98	81	119

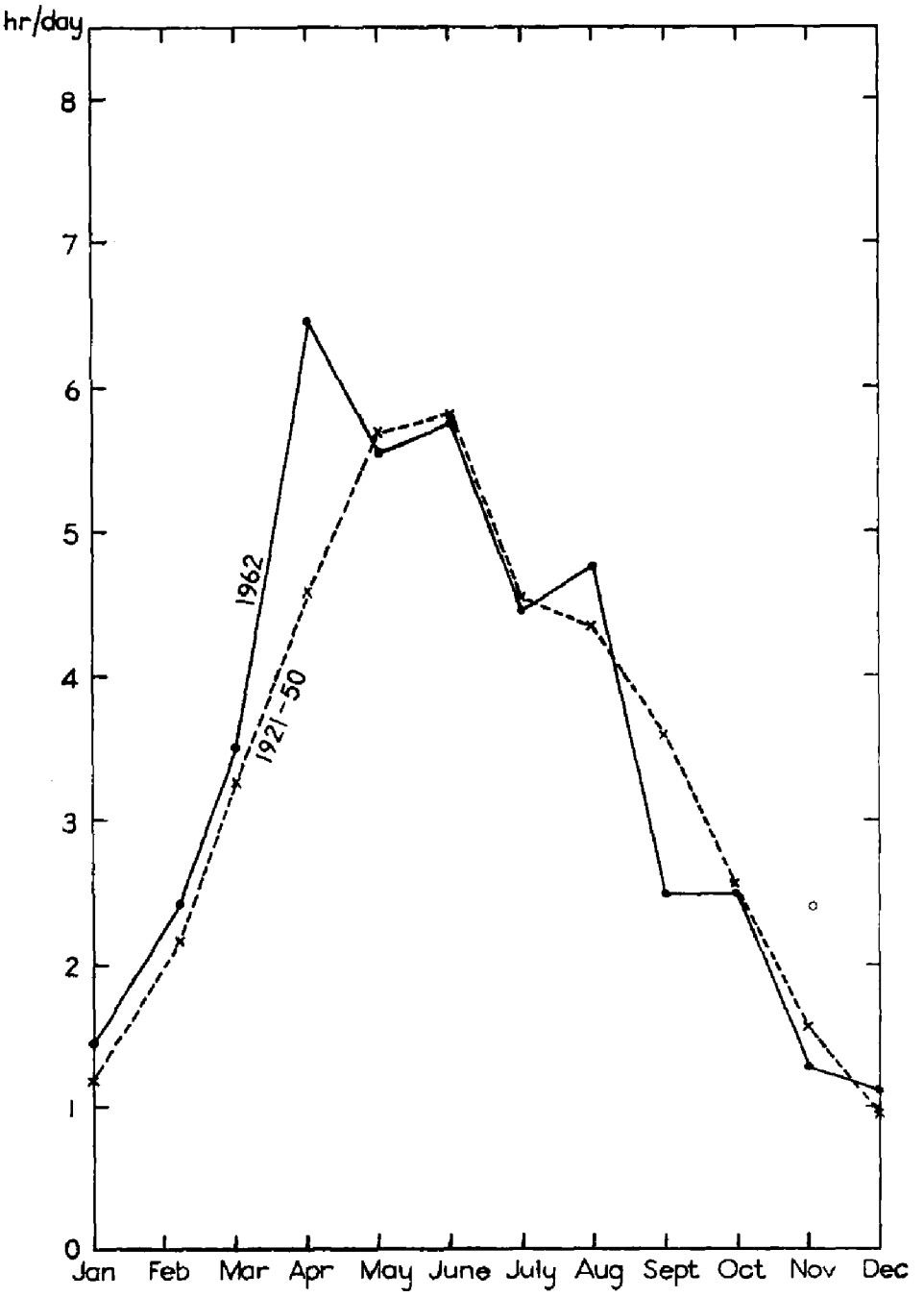


FIGURE 8—Scotland: monthly general values of sunshine in hours per day

Northern Ireland: percentage of 1921–50 average sunshine in 1962

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
114	100	111	143	111	103	85	115	65	110	51	97

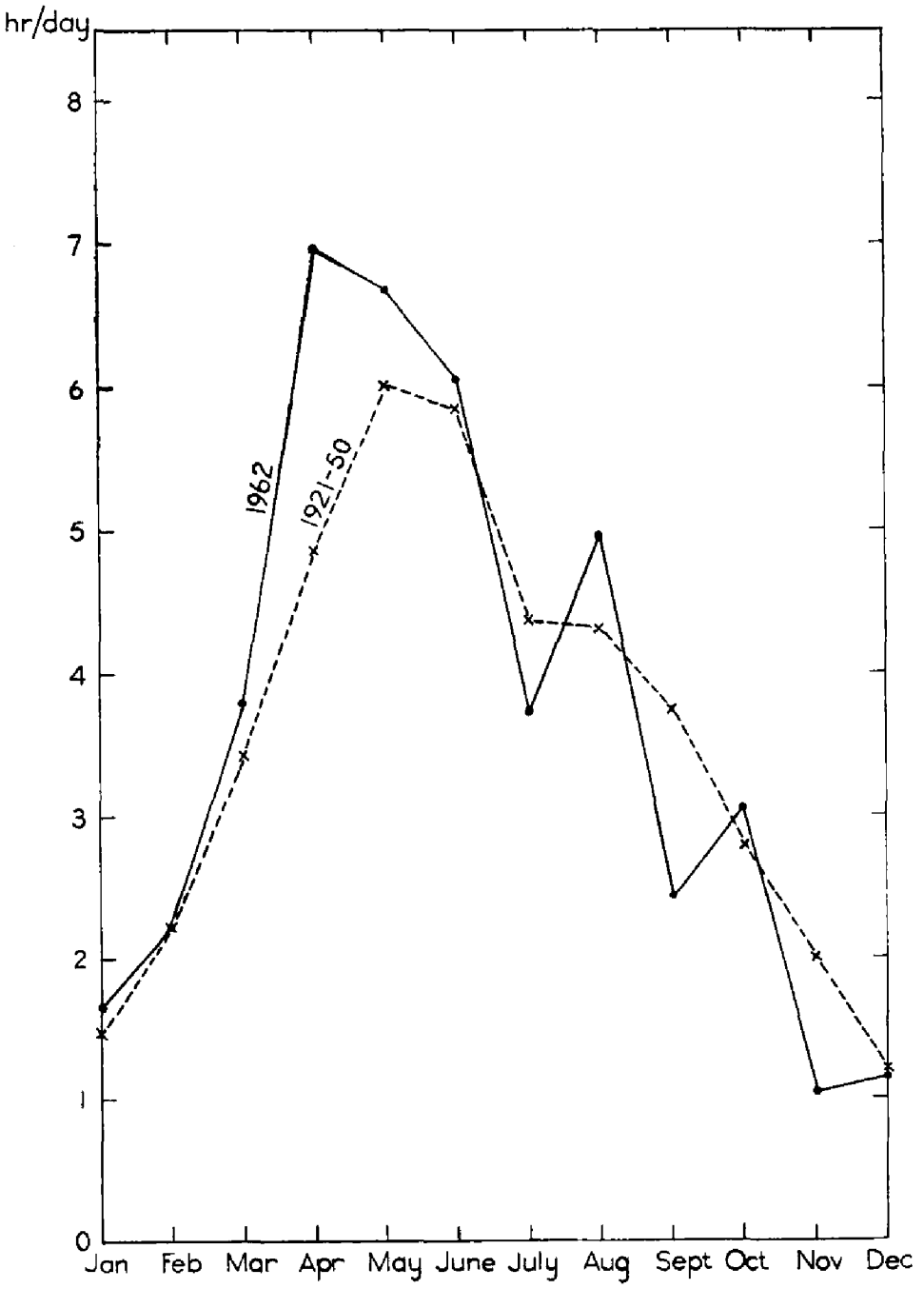


FIGURE 9—Northern Ireland: monthly general values of sunshine in hours per day

England and Wales: percentage of 1916–50 average rainfall in 1962

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
114	53	78	114	104	31	78	135	135	40	74	83

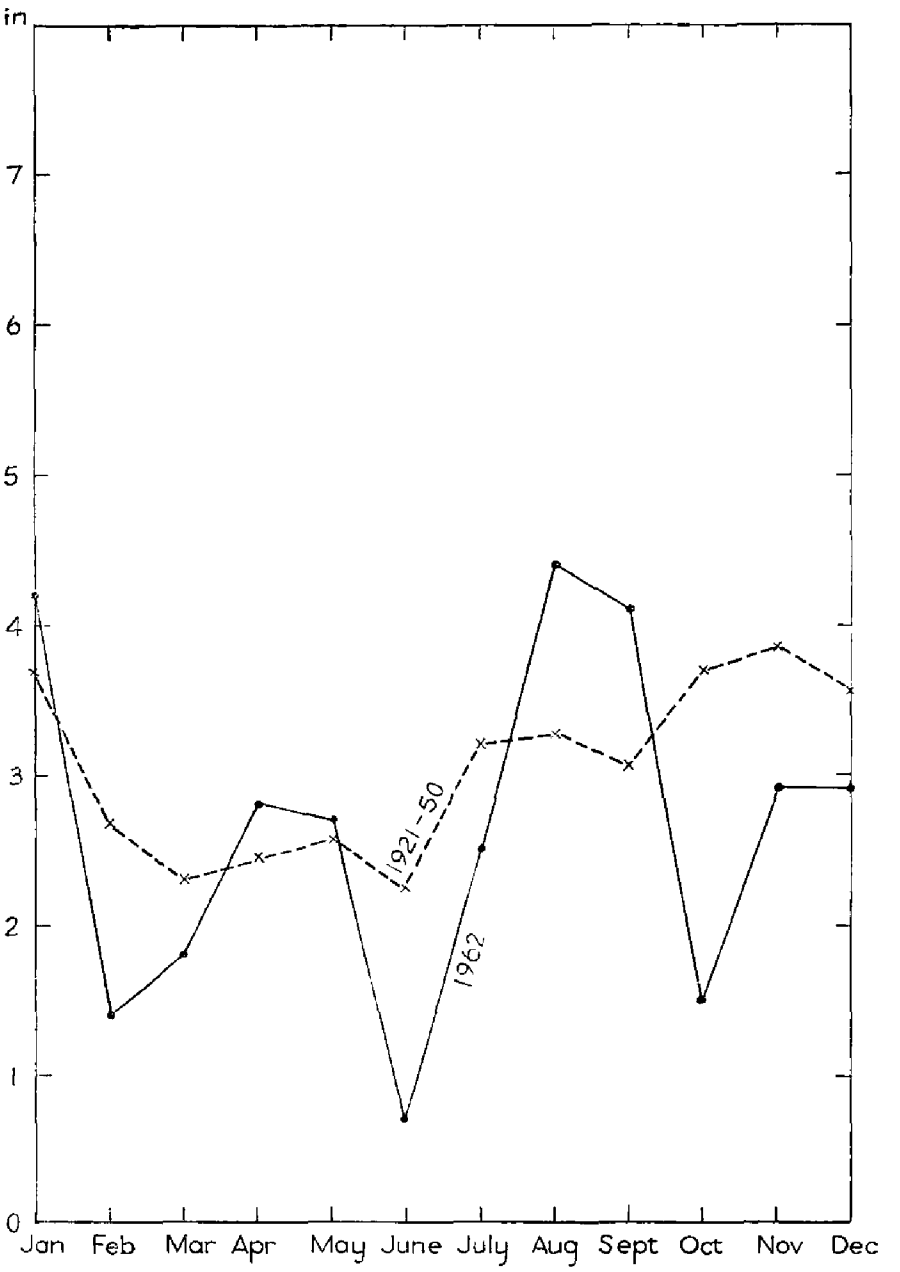


FIGURE 10—England and Wales: monthly general values of rainfall in inches

Scotland: percentage of 1916–50 average rainfall in 1962

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
143	112	74	90	101	93	74	159	130	48	75	114

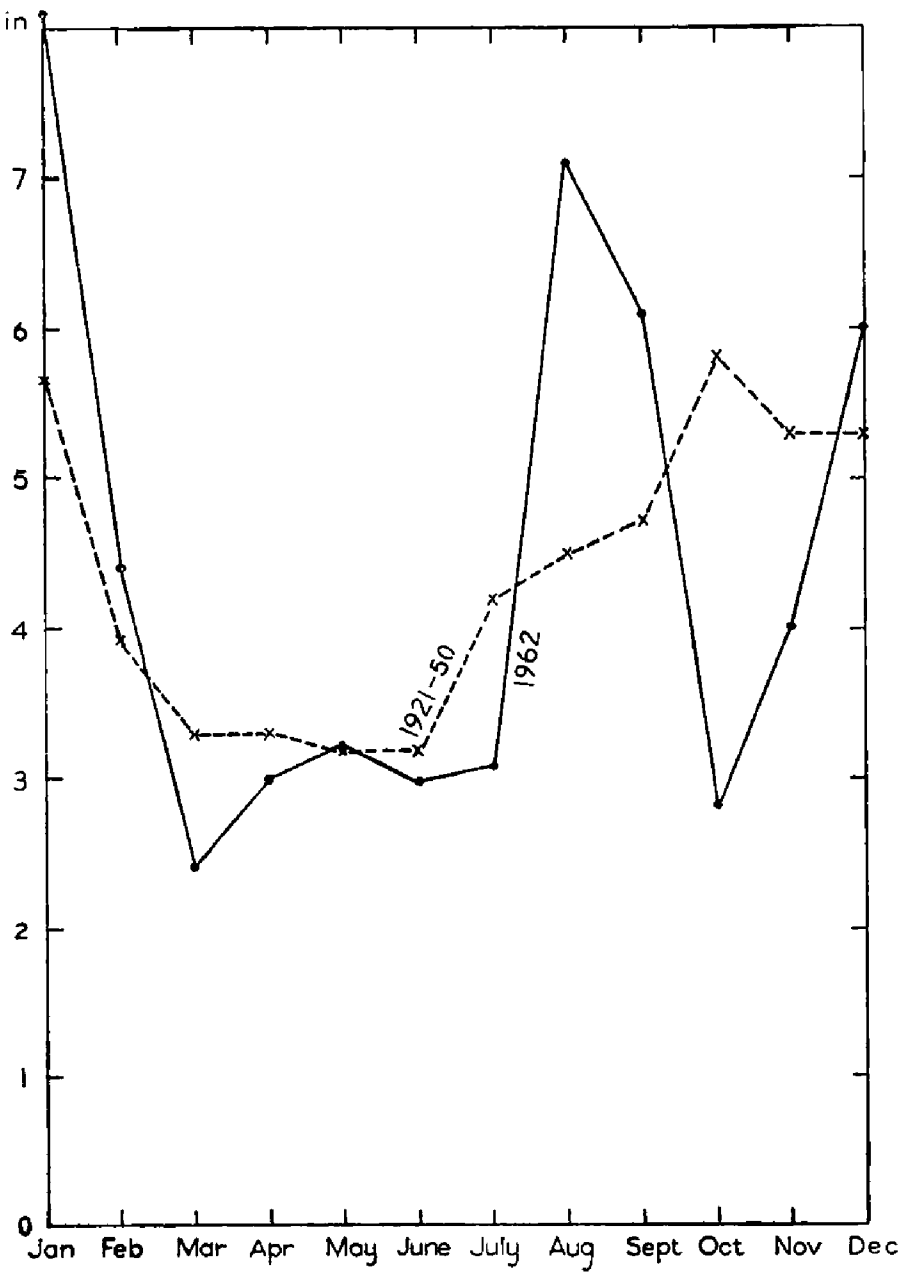


FIGURE 11—Scotland: monthly general values of rainfall in inches

Northern Ireland: percentage of 1916–50 average rainfall in 1962

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
106	75	88	81	95	66	59	117	182	45	66	101

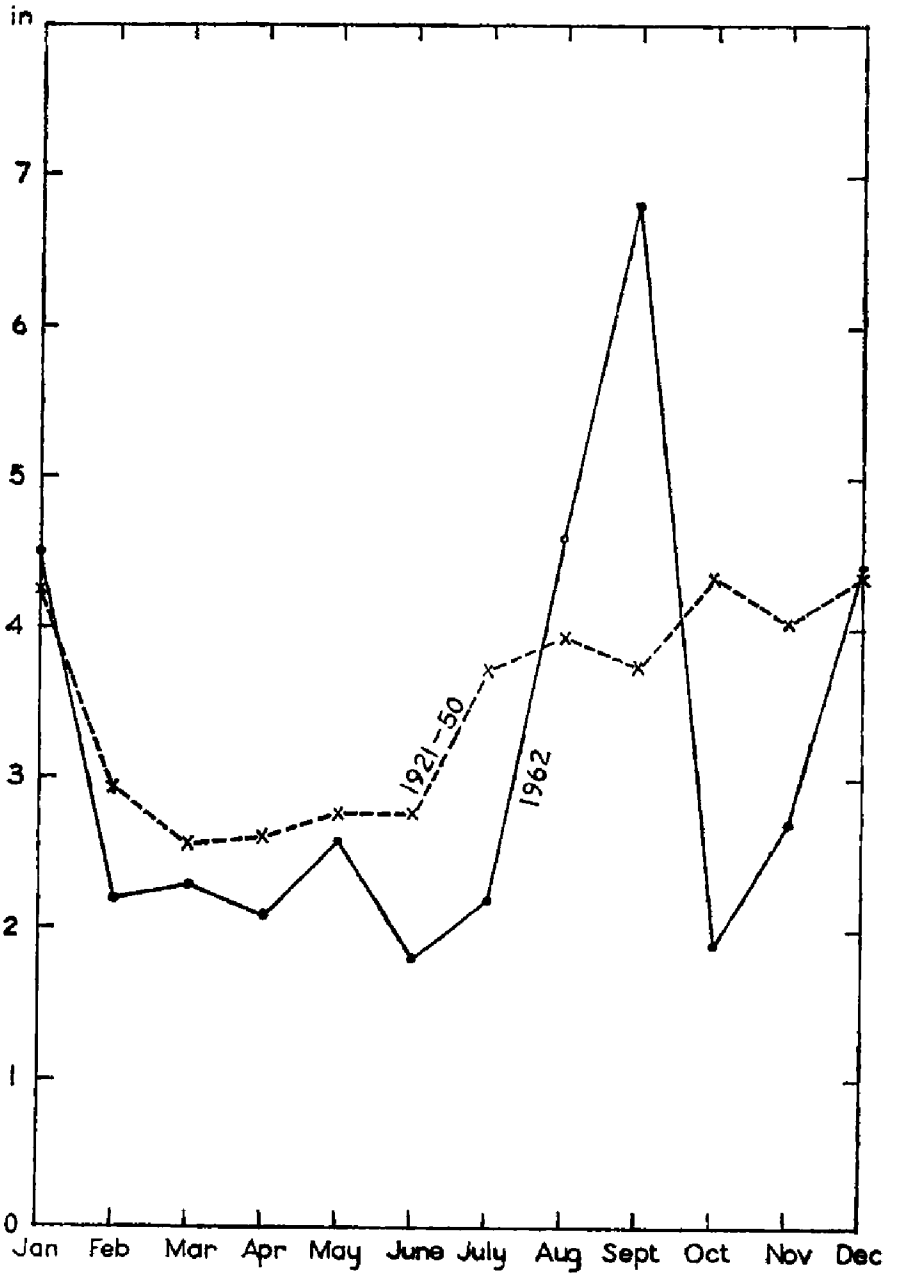


FIGURE 12—Northern Ireland: monthly general values of rainfall in inches

24th. Day temperatures were mostly above average during this time, especially around the 8th and nights were generally mild, particularly in Scotland. The last week of the month was mainly cyclonic and rather cold with snow and sleet in many places.

November—Weather was predominantly cyclonic in character except for a short period around the 12th and during the last week of the month. The first ten days were rather mild, but easterly winds later backing to north kept temperatures considerably below average from 11th to 24th. Snow showers became frequent and in some districts ground was snow-covered from 16th to 23rd; snowdrifts 7 feet deep were reported from Wales.

December—The first week was anticyclonic, very foggy and cold but the second and third weeks were mainly cyclonic and very changeable, stormy weather alternating with fairer spells. The last week was mainly anticyclonic with a ridge of high pressure extending from the southern Baltic first over the British Isles and then to near Greenland. Weather became exceptionally cold. A belt of snow moving south became slow moving over southern England on the night of the 26th/27th and much of southern England lay under a foot of snow the following day. The month will be long remembered for the blizzard which swept south-west England and the Channel coast on the 29th. Drifts up to 20 feet deep cut off many towns and villages in the south-west, both by road and rail.

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 I

NUMBERS OF OFFICES OF VARIOUS TYPES STAFFED BY METEOROLOGICAL OFFICE STAFF AND OPERATING ON 31 DECEMBER 1962

	Within U.K.	Overseas
Principal forecast offices associated with the RAF	1	—
Main meteorological offices associated with the RAF	9	6
Subsidiary meteorological offices associated with the RAF	52	12
Observing offices associated with the RAF	4	7
Principal forecast offices associated with civil aviation	1	—
Main meteorological offices associated with civil aviation	2	1
Subsidiary meteorological offices associated with civil aviation	13	1
Observing offices associated with civil aviation	6	—
Upper air observing offices	8	8
Public service offices	4	—
C.R.D.F. offices	4	3
Port meteorological offices	5	—
Offices associated with National Agricultural Advisory Service	3	—
Other offices	21	6

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 II

OCEAN WEATHER SHIPS

The United Kingdom, to meet its obligation under the ICAO North Atlantic Ocean Station Agreement, operates four ocean weather ships to serve, in rotation with two ships each from France, the Netherlands and Norway/Sweden, at five ocean weather stations in the Eastern North Atlantic. Each vessel makes on the average eight voyages a year spending 24 days on station each voyage. The following are some statistics regarding the British ocean weather ships during 1962:

Total number of voyages	30
Total number of days on station	711
Total number of days on passage	205

	At Station			
	A	I	J	K
Average number of aircraft contacted per voyage of 24 days	434	488	1907	551
Average number of radar fixes to aircraft per voyage of 24 days	241	257	930	307
Average number of weather messages to aircraft per voyage of 24 days	105	46	299	91

TABLE III

MERCHANT NAVY SHIPS

Many ships of the merchant navies of the world make and transmit meteorological reports to the appropriate meteorological centres ashore, under arrangements co-ordinated by the World Meteorological Organization. Most of these, including British ships, do this on a voluntary basis. Ships which report in full at four specified times daily are known as 'Selected' ships; ships which report at the same times daily, but in a less complete form are known as 'Supplementary' ships. A number of coasting vessels, lightships, distant water trawlers and auxiliary ships also make and transmit meteorological observations. On 31 December 1962, the numbers of British ships reporting were:

Selected Ships	475
Supplementary ships	50
Coasting ships	126
Lightships	13
Trawlers	17
Auxiliary ships	69

Number of British Selected and Supplementary Ships on Main Routes to and from the United Kingdom

Australia	107	South America	38
Far East	65	Pacific Coast of North America	10
Persian Gulf	29	Europe, mainly northern Europe	41
South Africa	33	Falkland Islands and Antarctic	6
North Atlantic	93	World-wide 'tramping'	76
West Indies	24		

During two typical days, one in July, the other in December, the numbers of reports from ships received in the Central Forecasting Office were approximately as follows:

		Reports July	Reports December
Direct reception from	British ships in North Atlantic ..	82	81
	Foreign ships in North Atlantic ..	48	6
	British trawlers in North Sea ..	10	9
	British ships in North Sea	9	5
Via other European countries	Ships in North Atlantic	194	196
	Ships in Mediterranean	39	53
	Ships in North Sea	59	43
	Ships off North Russia	13	30
	Ships in other waters	3	32
Via North America	Ships in North Atlantic	489	487
	Ships in Pacific	335	347

TABLE IV

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 31 December 1962.

	Stations					Autographic records		
	Observatories	Synoptic	Agro-meteorological	Climatological	Rainfall*	Sunshine	Rainfall	Wind
Scotland, north	1	8	0	25	294	21	9	6
Scotland, east	0	8	8	59	550	46	17	8
Scotland, west	1	9	3	37	551	27	18	8
England, north-east	0	10	4	25	433	29	14	3
England, east	0	11	11	17	498	23	17	8
England, Midlands	0	12	19	51	1200	57	33	6
England, south-east (including London)	1	16	16	64	875	67	77	17
England, south-west	0	8	8	29	513	32	11	4
England, north-west	0	6	4	25	458	25	30	11
Wales, north	0	2	3	18	245	9	7	1
Wales, south	0	3	9	15	295	23	11	4
Isle of Man	0	2	0	1	18	3	1	2
Scilly and Channel Isles	0	3	0	3	22	6	1	2
Northern Ireland	0	4	1	34	174	13	6	3
Total ..	3	102	86	403	6126†	381	252†	83

* Includes stations in earlier columns.

† Figures for rainfall stations and autographic rainfall records refer to data for the year 1961, received during 1962. All other figures show the position on 31 December 1962.

TABLE V

HEIGHTS REACHED IN UPPER AIR ASCENTS

The following table shows the number of upper air ascents giving observations of (i) temperature, pressure and humidity and (ii) 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 United Kingdom	5825	87·2	40·6	8·3
Eight stations overseas	5046	93·8	48·2	5·9
Four ocean weather vessels ..	1505	84·5	39·0	6·6

Observations of wind

	Number of observations	Percentage reaching 100mb approx. height 53,000 ft	50mb approx. height 67,000 ft	30mb approx. height 78,000 ft	10mb approx. height 100,000 ft
Eight stations in United Kingdom	11,501	73·3	32·0	9·1	1·1
Eight stations overseas	8186	84·2	36·1	7·1	1·9
Four ocean weather vessels ..	2904	79·0	38·8	4·6	0·0

TABLE VI

THUNDERSTORM LOCATION

Number of thunderstorm positions reported by C.R.D.F. network	77,000

TABLE VII

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 Communications Centre for one typical day (24 hours) on 11 December 1962 and, for comparison some corresponding figures for one day near the end of 1961.

Communication traffic for one day

Coded messages	Number of groups in one day			
	In	Out	Total	Total in 1961
Land-line teleprinter ..	391,762	407,351	799,113	808,707
Radio	99,930	217,603	317,533	282,717

Facsimile charts	Number of charts in one day			
	In	Out	Total	Total in 1961
Land-line	36	68	104	96
Radio	36	37	73	64

TABLE VIII

SPECIAL SEASONAL FORECASTS

There is a need for forecasts of a particular type at certain seasons. These are described in M.O. Leaflet No. 1. The numbers of customers receiving such specialized forecasts are as follows:

	Year	No. of customers	Year	No. of customers
Fine spell notification (a summer service)	1961	710	1962	808
Weekend temperature forecasts (a winter service)	1961–62	54	1962–63	56
Snow and icy road warnings	1961–62	248	1962–63	252
Smith period notifications (1 March–31 May)	—	—	1962	19
Beaumont period notification (15 May–15 August)	—	—	1962	24

TABLE IX

FORECASTS FOR AVIATION

The Central Forecasting 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 BBC 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 numbers of meteorological 'briefings' which took place during 1961 and 1962. They do not include warnings and routine general forecasts.

	1961	1962
Number of meteorological briefings for		
aviation in United Kingdom	345,564	349,697
aviation at overseas stations	72,138	58,790
Number of aviation forecasts issued for		
aviation in United Kingdom	855,961	831,524
aviation at overseas stations	201,683	174,842

TABLE X

NON-AVIATION INQUIRIES

Non-aviation inquiries are handled by four weather centres established at London, Manchester, Glasgow and Southampton to meet the needs of the general public for forecasts for specific purposes and by many of the forecast offices established primarily to meet aviation requirements but which also answer telephone requests for forecasts and other weather information from the general public, public corporations, press, commercial firms etc. (the 'Post Office Guide' lists the telephone numbers of 39 such

offices). All but an insignificant proportion of these inquiries refer to current or future weather and are categorized according to the purpose of the inquiry in the figures below. Climatological inquiries are dealt with in Table XII

	1961	1962
Grand total of inquiries	659,962	794,195
Percentage of inquiries connected with*		
agriculture, etc.		10.4
holidays		14.8
public utilities		9.2
road transport..		12.6
local press		11.6
marine		20.1

TABLE XI

AUTOMATIC TELEPHONE WEATHER SERVICE FORECASTS

By the end of 1962 forecasts for seventeen 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 1962 (figures for 1961 in brackets) on this service is indicated by the following figures (supplied by courtesy of the Postmaster-General):

Forecast area	Number of calls 1962	1961	Remarks
London	3,174,972	(2,722,960)	
Essex coast	142,624	(125,654)	Available on a London number
Kent coast	119,934	(105,313)	Available on a London number
Sussex coast	168,216	(160,080)	Available on a London number
Colchester	65,604	(92,330)	Same as Essex coast
Brighton and Hove ..	88,759	(112,988)	Same as Sussex coast
Birmingham	256,704	(316,507)	
Liverpool	322,700	(327,337)	
Manchester	330,871	(325,127)	
Cardiff	167,061	(179,922)	
Belfast	169,784	(167,384)	
Glasgow	426,544	(453,119)	
Edinburgh	191,853	(191,396)	
Bristol	152,261	(143,119)	
Portsmouth	95,414	(88,860)	
Southampton	185,486	(34,172)	Started in October 1961
Canterbury	32,167		Started in September 1962 Same as Kent Coast
Total ..	6,090,954	(5,546,479)	
	(Total in 1960—4,910,546)		

* These percentage figures are not strictly comparable with the corresponding figures in last year's report for two reasons. The London Weather Centre inquiries have now been included with those received at other offices and the provision of forecasts and charts to ships leaving port are now classified as inquiries.

TABLE XII

Most of the inquiries dealt with by the offices outside Headquarters refer to current weather or to forecasts. M.O.3, Edinburgh and Belfast receive a number of inquiries relating to past weather or to climatology. M.O.7 receives a number relating to the application of meteorological data to agriculture. The following figures give the total number of such inquiries and the percentage of this number arising from the main reasons for the inquiries.

Total number of climatological inquiries	8116
Percentage relating to	
agriculture, horticulture, forestry	15.2
building and building design, including siting	8.8
commerce (sales, marketing and advertising)	7.4
educational and literary	4.8
industrial or manufacturing activities	8.6
legal (damage, accidents, insurance)	16.8
medical and health questions	2.8
research	6.4
water supply	7.2

TABLE XIII

LIBRARY

The following figures indicate the distribution of work in the Library during 1962:

Library statistics

Publications received during 1962 (excluding *Daily Weather Reports*)	7925
Individual books, pamphlets, articles, microfilms classified and catalogued	(approx.) 5900
Transparencies acquired	781
Publications lent (excluding *Daily Weather Reports* and internal 24-hour loans)	8667
New exchange of publications agreements	10
Total number of exchange agreements	405

TABLE XIV

EDITING STATISTICS

The following figures give the number of publications edited during 1962:

Publication	Number	Remarks
Geophysical Memoirs	1	No. 107
Scientific Papers	2	Nos. 16 and 17
Meteorological Magazine	12	March, 1962 to February, 1963 inclusive
Observatories' Year Books	1	1961 (Varityped by M.O. 18)
Annual Report	1	1961
Occasional Publications	17	(includes some for internal use)
Reprints	15	

TABLE XV

DATA PROCESSING

Punched-card installation

Number of cards punched by the Meteorological Office installation ..	845,000
Number of cards punched outside for the Meteorological Office	717,000
Number of cards converted to paper tape	450,000
Number of non-routine investigations completed	182

Computer installation

The electronic computer 'METEOR' was used for computing during 2961 hours.

TABLE XVI

TRAINING

The following figures give some details of courses which were completed during 1962 at the Meteorological Office Training School at Stanmore and the Radiosonde Training School at Hemsby.

	Number of courses	Length of course in weeks	Number of students
Scientific Officers	1	23	8
Senior forecasters	4	3	43
Forecasters (Advanced)	6	6	48
Forecasters (Initial)	2	17	51
Preliminary course for forecasters	2	4	28
Assistants	5	9	74
Assistants (Short Course) ..	2	5	30
Climatology..	1	9	8
Mediterranean Meteorology ..	2	2	9
Tropical Meteorology	2	3	24
Voluntary observers	1	1	20
Auxiliary observers (coastguards)	2	1	40
Special Course for Antarctic observers	1	9	4
Part-course attendances	—	—	2
Radiosonde (Initial)	5	8	37
Radiosonde (Refresher)	1	4	2
Radiosonde (Advanced)	5	4	21
Special Course for Antarctic observers (Radiosonde)	1	9	3
		Total	452

Students from the following territories attended courses:

Country	Number of students
Belgium	1
British Antarctica	5
East Africa	14
Egypt	6
Ghana	2
Hungary	1
Iceland	1
India	2
Jordan	5
Libya	1
Mauritius	2
New Zealand	1
Nigeria	1
Pakistan	2
Philippines	1
Switzerland	2
Turkey	1
West Indies	1
Total	49

THE DIRECTORATE OF RESEARCH

1. Special Topic—Radar in Meteorological Research

When electromagnetic radiation meets a water drop in the atmosphere some of its energy is absorbed by the drop and some is scattered in all directions. At long wavelengths the loss of energy by absorption or scattering is negligible but at centimetric wavelengths both effects become important. The application of radar to meteorological research involves both the scattering and absorbing properties of raindrops, snowflakes or hail by using wavelengths of 10 cm or less. The radar principle makes use of the radiation scattered back to the aerial that is used for transmission and it has been shown theoretically, and confirmed in practice that, for an assemblage of drops of diameter D with a concentration of N per unit volume at range R, the power scattered back to the receiver is proportional to $ND^6/R^2\lambda^4$* where λ is the radar wavelength. Because clouds and rain are never composed of water drops all of one size, the total power received is a summation over all the different drop-sizes present in the volume of the pulse. The dependence on D^6 means that the larger drops present have a dominating effect on the received signal and in practice this has meant that at ranges of more than a few kilometres most radars 'see' only the precipitation composed of drops of 1 mm diameter or more. Clouds in which the average droplet diameter is about 1/50 mm, are not detectable at these ranges but may become so when both wavelength and range are decreased. By using a wavelength of about 8 mm and looking vertically, about half the clouds which pass overhead give detectable responses. In meteorological research radars operating on wavelengths of 10 cm, 3 cm and 8·6 mm have been used and some of the techniques used and results obtained are described in the following sections.

The detailed pattern of precipitation—radars on 10 cm or 3 cm wavelength. One of the first uses to which radar was put depended on its unique ability to give an instantaneous picture of the distribution of precipitation over a wide area surrounding the equipment. By photographing the display and comparing pictures taken at different times it is possible to determine accurately the movement and development of precipitation areas. By concentrating on a particular storm and using also a radar sweeping in a vertical plane, it is possible to follow the development in three dimensions. This has found valuable application in joint studies, in which the Meteorological Office and the Meteorological Department of Imperial College have collaborated over the past few years, designed to determine the structure of severe storms. With a large network of voluntary ground observers it has been possible to relate certain of the radar echo characteristics, particularly the radar echo intensity, to the occurrence of large hail at the ground.

The reliable measurement of echo intensity and its interpretation in terms of physical quantities present considerable difficulties, especially when large hail is present and the particle size is no longer small compared with the wavelength. By using artificial ice targets on a range at the Royal Radar Establishment the back-scattering properties of large hail have been determined. These results have assisted considerably in the interpretation of the echoes from thunderstorms. Much remains to be done but it appears that the echo intensities them-

* The constant of proportionality has recently been considered theoretically by a member of the research branch and a long-standing discrepancy between theory and experiment resolved.

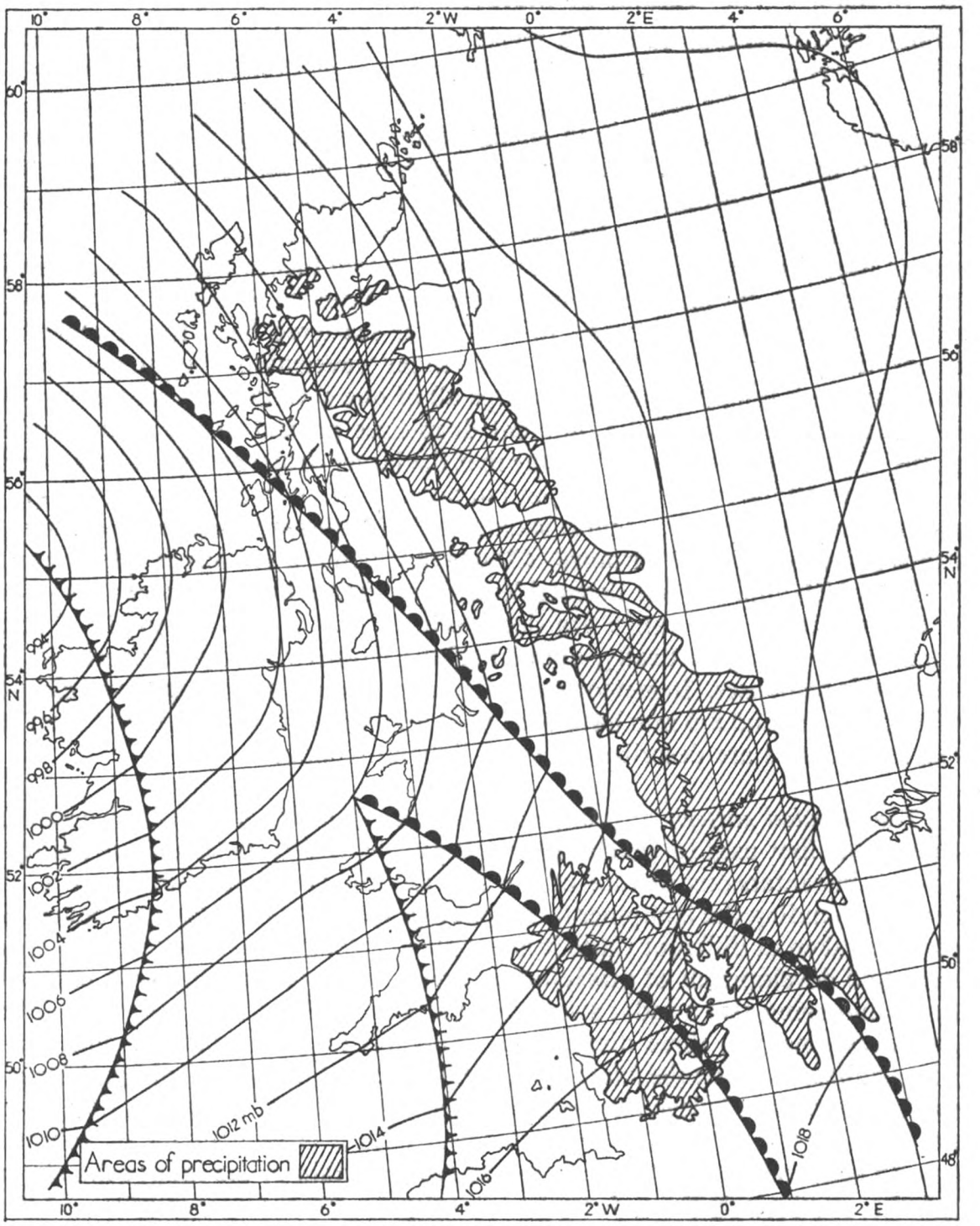


FIGURE 13—Detailed pattern of precipitation at 2100 GMT on 18 July 1962 as revealed by radar echo tracings from a network of stations. The pressure pattern and frontal analysis at this time are also shown.

selves, if measured on more than one wavelength, may give valuable evidence of the size of hail present in a storm. This is of more than academic interest since the size of hail present at altitude in a storm is of direct importance to aircraft pilots and designers, and so are the inferences which can be made about the magnitude and extent of the upcurrents ultimately responsible for the generation of large hail.

The detailed use of radar patterns is handicapped by the limited range of a single set (up to 150 km, say, on moderate precipitation) and efforts are being made to extend this by combining the radar echo information obtained simultaneously from a network of stations into a single composite picture. Figure 13 is such a composite obtained when a frontal rain belt was crossing the whole country, and is typical of a series of such pictures now under examination.

Radars operating on 8·6 mm wavelength. Because the back-scattered energy from water drops is inversely proportional to the fourth power of the wavelength, there is an apparent gain to meteorological research in reducing the wavelength. This is only partly true, however, for as the wavelength decreases the total attenuation of the beam by absorption and scattering increases. This attenuation is negligible for the ranges normally used on a wavelength of 10 cm but is already becoming an important handicap to quantitative studies and to range capabilities in heavy rain at 3 cm wavelength. Wavelengths of 1 cm or below are so severely attenuated in rain that they are of little use for the types of study discussed in the previous paragraphs. At short ranges in the absence of precipitation, however, the attenuation is small enough to allow of their use in exploring the fine-scale structure of clouds.

With the active assistance of the Royal Radar Establishment a radar having a wavelength of 8·6 mm and a high-gain aerial has been used. This gives a beam about 25 metres wide at a range of 10 km with a discrimination in range of about 30 metres. The equipment has been used mostly with the beam pointed vertically and the changing appearance of clouds as they drift overhead in the prevailing wind at their height is shown in Plate III. Again, because of the dominating effect of the larger particles, the record is primarily one of responses from those particles and some clouds in which particle size is small remain undetected. Experiments, supported by simultaneous measurements from aircraft of the Meteorological Research Flight, suggest that droplets of about 50 microns radius or ice crystals having a largest dimension of about 100 microns (1/10 mm) are usually present when an echo is received. There are considerable difficulties in the detailed interpretation of a pattern such as Plate III because, with such a narrow beam, variations of wind direction with height may bring into the beam particles of a type which have not been sampled at greater heights. Nevertheless particles of an order of magnitude smaller than those associated with precipitation are indicated, even when other layers of cloud intervene, giving new insight into the heights and temperatures at which precipitation growth commences. However, considerable analysis must be done before the potentialities of this equipment can be assessed realistically.

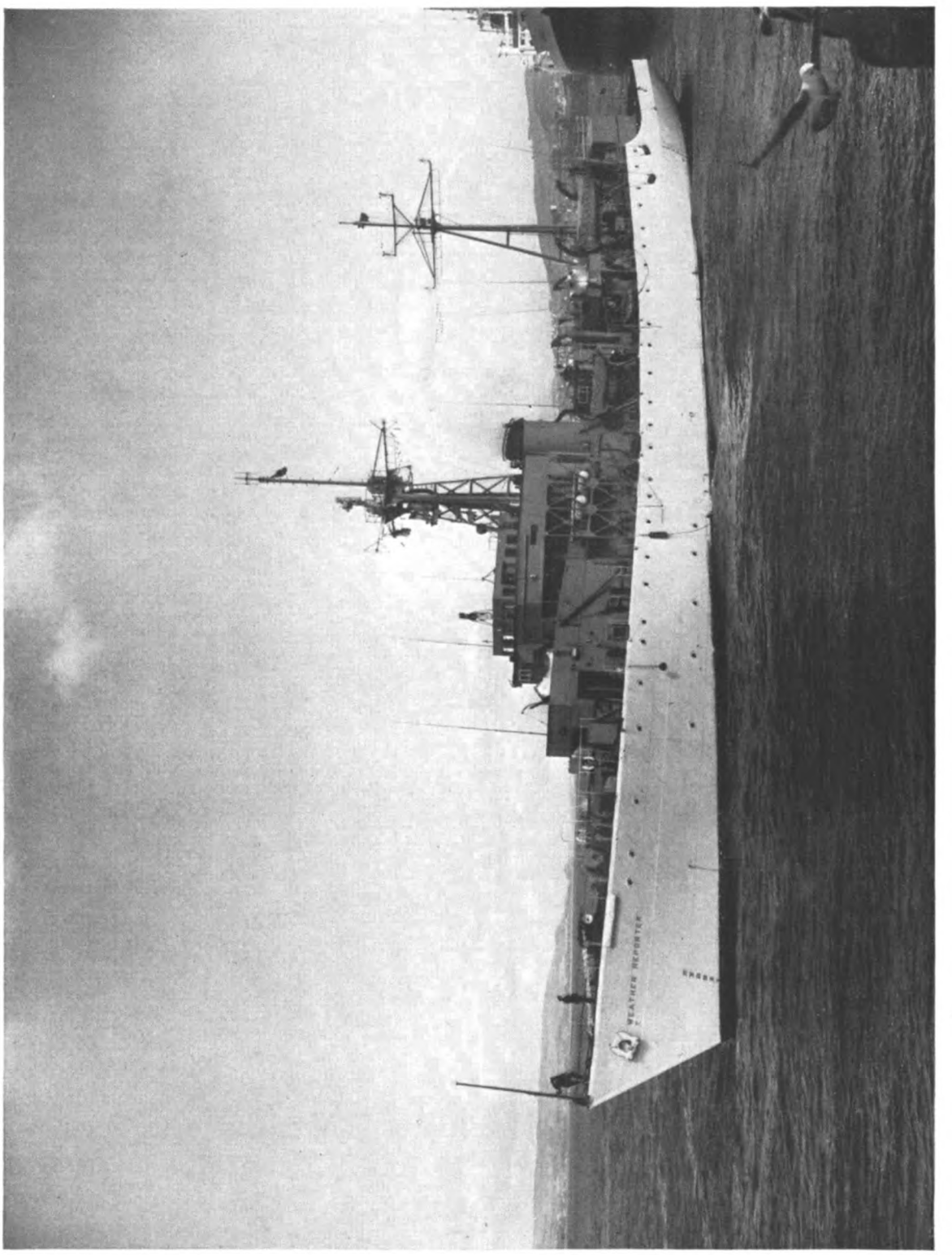
Measurement of rainfall intensities by radar. Although there is a close network of rain-gauges in this country measuring total rainfall at 12- or 24-hour intervals, there are vast areas of the globe, particularly the oceans, where such a network is impossible. Further, most rain-gauges are not designed to measure the rate of rainfall. A knowledge of the rate of rainfall is required for fundamental

studies to ascertain not only why rain falls but also the factors that determine the intensity and amount of precipitation. A solution of the measurement problem would have immediate value in hydrology and might provide a warning service to authorities in areas subject to flooding after heavy rain. The quantitative use of radar (made possible by improvements in stability of radar transmitters and receivers) in measuring rainfall over large areas is now under examination. In this application the radar intensity is used as a measure of rainfall-rate. The relationship between back-scattered signal intensity and rainfall rate is not simple demanding a knowledge, at any given instant, of the size-distribution of the raindrops in the air and theirfall-speeds. Neither of these can be found to a high degree of accuracy but, by making measurements of the drop sizes in rain as it reaches the ground and measuring the fall-speeds of the drops, the volume distribution of raindrops in the air close to the ground can be deduced. This has been done on a large number of occasions and has led to an empirical average relationship between radar-echo intensity and rate of rainfall. With the new Doppler equipment, described in the next section, these measurements can be extended to the free atmosphere and thus improve the empirical relationship. By integrating over suitable areas and periods of time it is feasible to make, with very little delay, a reasonable estimate of the rainfall distribution over a large area. Methods of integration are being examined in collaboration with the Royal Radar Establishment.

An alternative method of measuring rainfall-rate is also being explored. This depends on the very property that makes millimetric radar unsuitable for the portrayal of precipitation patterns—its attenuation by rain. Assuming a drop-size distribution, the attenuation caused by rain has been shown to be a function of the rainfall rate, and at a wavelength near 8 mm the ratio of attenuation to rainfall-rate is almost constant over a large range of such rates. The total attenuation over the path of the radar beam is then a measure of the average rainfall-rate along that path. It is intended to make use of a close network of rain-gauges, which has been set up in the Cotswolds for other meteorological purposes, as a check on the accuracy of this method. The precise method of measuring the attenuation is being investigated. A possible method is to measure the radar signal intensity after reflection at a target of known reflectivity, thus using a double path through the precipitation. Radio methods using one-way propagation would be more expensive in manpower and material.

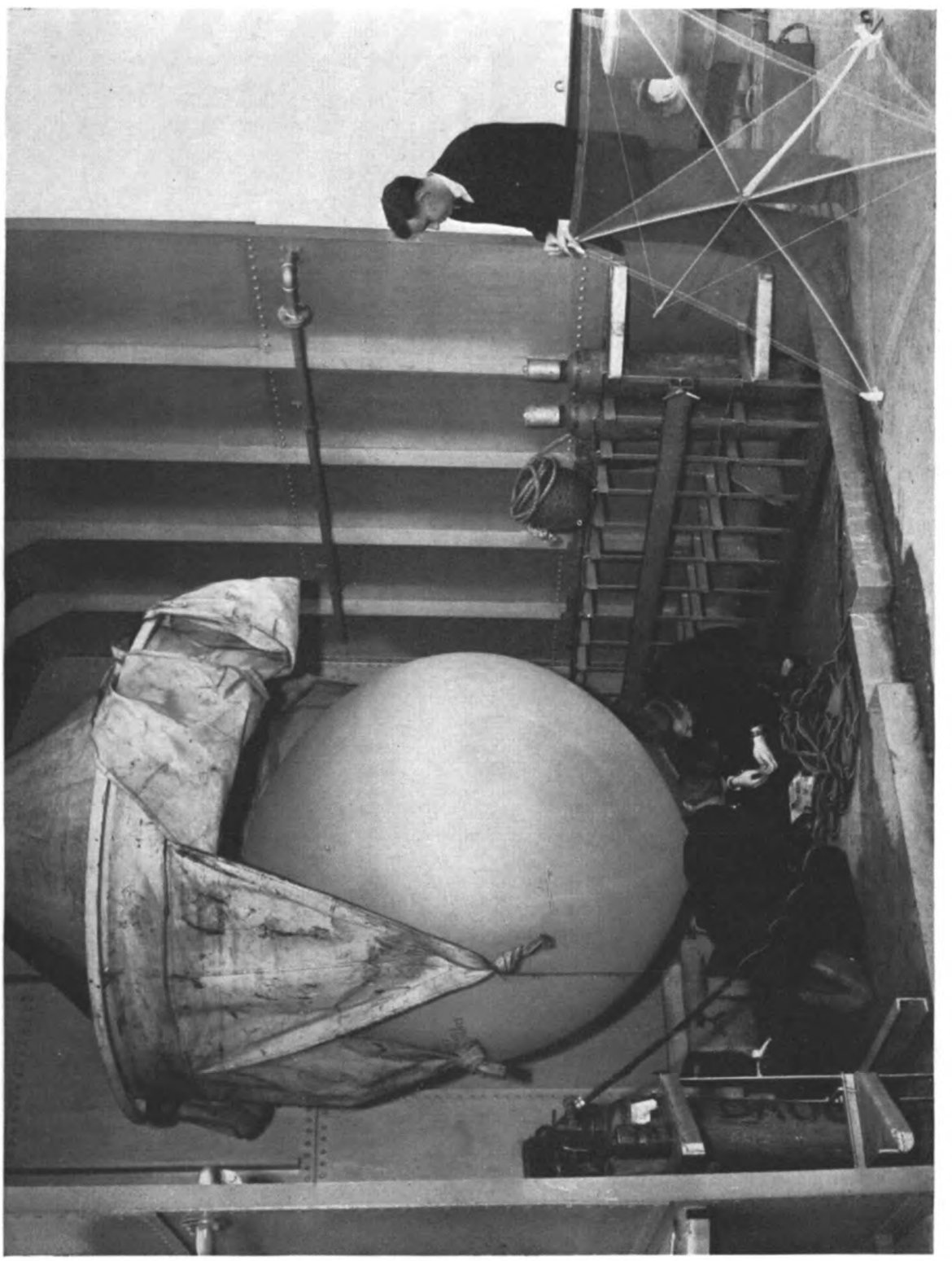
Doppler radar. The principle of change of apparent frequency by relative motion between observer and transmitter—the Doppler effect—is used in pulsed-Doppler radar to determine whether the scattering target has a component of motion towards or away from the aerial. Equipment of this type has been made by the Royal Radar Establishment and loaned to the Meteorological Office. When the equipment is used in precipitation with the aerial pointing vertically, the signal received from a small height interval is composed of contributions from raindrops of different sizes. Since the fall-speed of a drop in still air depends on its size, the signal received can be sorted into contributions from different drop-sizes by the Doppler effect. If it is assumed that the vertical motion of the air is small, the Doppler frequency-shift determines the drop-size, and the intensity of the signal having that frequency shift determines the number of drops. These provide a direct measure of the drop-size distribution in a certain height interval and, because the transmitted energy is pulsed, both the height and the variation of drop-size distribution with height can be ascertained. In

PLATE I

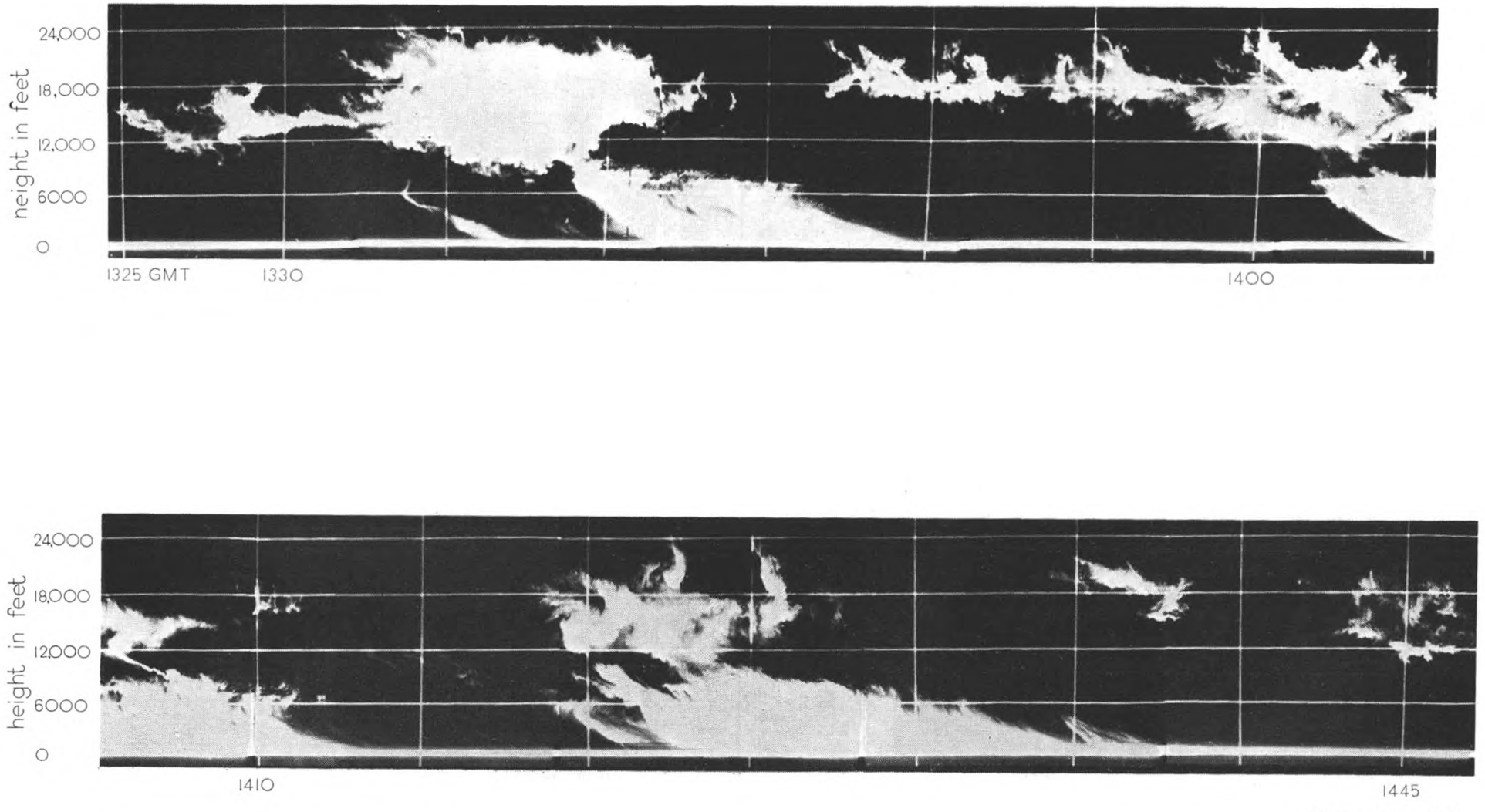


Ocean weather ship *Weather Reporter*

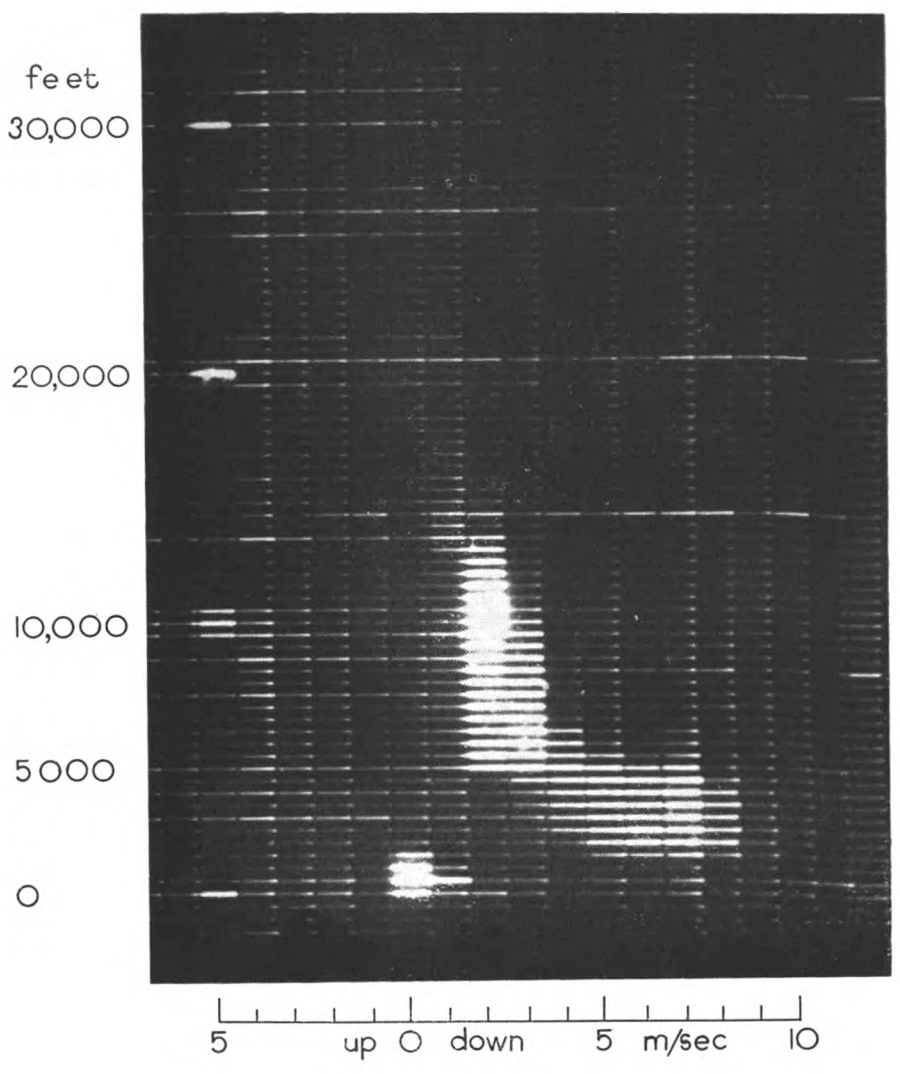
PLATE II

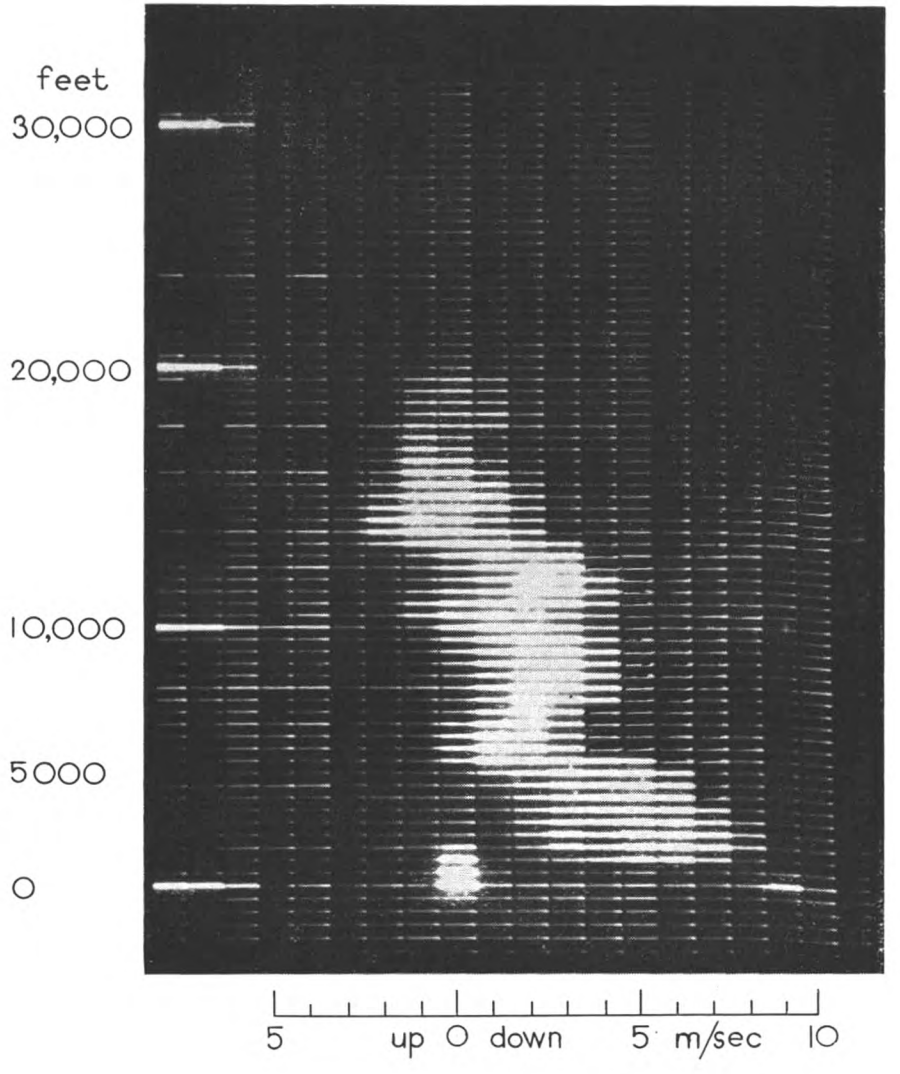


Preparing to launch a radiosonde aboard *Weather Reporter*



Radar responses from clouds using a wavelength of 8.6 mm with the aerial pointing vertically, giving a time cross-section from 1325 to 1445 GMT on 10 July 1962. Throughout the period there was an unbroken layer of Stratus cloud but the radar 'sees' through this layer to give responses from ice-crystal cloud at heights up to 25,000 ft. A bright band caused by the melting of snowflakes is occasionally seen at 7000 ft.





Pulsed Doppler Radar records from steady warm-front precipitation (*a*) and from a shower (*b*).

showers or thunderstorms, however, the vertical component of air motion is often large, perhaps 10 or 20 m/sec. By making plausible assumptions on the nature and fall-speeds in still air of some of the scattering particles, it is possible to examine the details of the up and down air currents at different heights. Several measurements of this kind have been made, both in frontal precipitation, when upcurrents were small, and in showers. Plate IV gives examples of the display received in these two differing situations. In one instance (Plate IV*a*) it will be seen that at heights above 5500 feet the echo occupies a narrow velocity band corresponding to snowflakes and ice-crystals with fall-speeds in the region of 1 to 2 m/sec. At 5000 feet there is an acceleration zone corresponding to the melting of the snowflakes to form rain drops of different sizes which are sorted into a wider velocity band ranging from 4 to 8 m/sec at heights below 4500 feet. In the other example (Plate IV*b*), corresponding to showery conditions, it will be seen that there is a wider spread of fall-speeds at all heights reflecting the turbulent motions within the beam, so that the average fall-speed is very variable. Indeed, in the height interval 10,000 feet to 20,000 feet, some particles are moving away from the radar giving a clear indication of upward air motion at these levels.

Knowledge of the vertical air motion is essential in studies of the dynamics of convection clouds and becomes of particular importance in precipitating clouds, when the latent heat of condensation released is an important source of energy. The Doppler radar will give valuable information for precipitating clouds and data are being acquired on all suitable occasions. To improve the rate of collection of data, a mobile version is under construction for trials in areas particularly prone to severe storms. Such observations have direct applications in aviation, for a knowledge of the magnitude and extent of vertical currents in cumulonimbus clouds is an important design requirement.

The Doppler equipment can also be used with the beam at moderate angles of elevation when the approach speeds contain components of the horizontal wind and the fall-speed of the particles. This enables the horizontal wind to be measured with tolerable accuracy and the variation of wind with height, time and distance to be determined when there is precipitation. Measurements of this kind, which can be repeated at time intervals of a few minutes only, could not be obtained by other means and are now under investigation for the information they yield on convergence in frontal zones.

Conclusion. Many of the results of radar research have found practical application and radar has now come into regular use, both on the ground and in the air, as a meteorological tool. On the ground it is being increasingly used as an aid in precise short-period forecasts of precipitation for the public and for aviation. In the air, almost all the large commercial air liners carry storm detection radar to enable them to identify and avoid the cores of cumulonimbus clouds, the dangers of which were exemplified by earlier researches relating the turbulence experienced by aircraft to radar echo characteristics.

The major research effort is now devoted to quantitative studies using specially designed equipment but the unique observing capabilities of conventional radar are not overlooked.

2. Organization of the Research Directorate

There was no important change in the organization during the year nor in the weight of effort devoted to the different broad lines of research. The division

into two deputy directorates, the one for dynamical research employing about 25 staff of the Scientific Officer class and the other for physical research employing about 35 such staff, continued to prove generally satisfactory.

The greater part of the work is carried out at the headquarters at Bracknell where up-to-date facilities are to hand: workshops, laboratories, an excellent library and a comprehensive records store, a Hollerith card installation and a Ferranti 'Mercury' electronic computer which, after 3 years' use, continues to give excellent service within its compass, although the need for a more advanced system is now evident.

The presence also at Bracknell of the forecasting and other services branches of the Office provides invaluable contacts between theoretical research on the one hand and the realities of applied meteorology on the other, while the experimental physicists have also the facilities of a large experimental site, 30 acres of cleared heathland within 3 miles of the Office.

The intimate association of research with services is undoubtedly a factor of the greatest value, but when the advantage lies in working elsewhere than at Bracknell small research groups are detached as, for example, to the Meteorological Research Flight at Farnborough, the Chemical Defence Experimental Establishment at Porton, and to the Observatories at Lerwick, Eskdalemuir and Kew. Collaboration with the Royal Radar Establishment at Malvern, where two scientists have been attached for some 3 years, has also proved remarkably profitable in the field of radar meteorology, the subject of this year's special article.

The research work is executed within the framework of a Research Programme for which the Meteorological Research Committee and its sub-committees (composed of scientists from the universities and Government departments) provides guidance and support. The appreciation of the Office for the help so given cannot be too frequently emphasized.

The following paragraphs describe the main research fields and indicate the progress made during the year. The list of publications by members of the staff, given in Appendix III, p. 63, is some guide to work too diverse to receive special mention in this report.

3. Dynamical Research

Forecasting research. As for some years past, the main line of research in forecasting has been in what has come to be called 'numerical weather prediction', and there are good reasons to expect that the methods now in use or projected will lead to improvements in the reliability of forecasts in the relatively near future. The subject was treated at length in the last Annual Report but it may be recalled that the method is to calculate how the distributions of winds and pressures over a large area of the northern hemisphere will evolve from 'present conditions', as revealed by actual observations, to the conditions 24 hours or farther into the future. The problem is treated fundamentally, starting from the dynamical equations of fluid motion on the rotating earth; the electronic computer is programmed to accept the initial data as received by teleprinter, carry out the involved computations as prescribed by the mathematicians and present the predicted geographical distributions in terms of numerical values at a large number of places, in the present case about 500, forming an equidistant grid over the area.

The problem becomes at all tractable only by making rather sweeping

simplifications and approximations in the very complicated mathematics that attempt to describe the behaviour of the weather in all the complexity of nature. It is readily appreciated that there is no obvious end in sight to the improvements which may come by obtaining fuller and better observations, by extending the area of calculation until eventually the whole earth is included, by taking account of the processes of atmospheric physics more completely, by refining the mathematical techniques and by using high-speed computation to the maximum advantage.

During the year the most important progress came from the introduction into the system of allowances for friction between the wind and the ground or sea surface and for orographic interference with air flow; but just as important, and in some ways more difficult, is the practical problem of extracting by automatic process from the total mass of teleprinter data those required for the calculations and programming the computer to produce in effect a current weather map. The forecasts now prepared by the machine owe nothing to the judgement of the duty forecaster at any stage; they have been completely automated and may be compared, without prejudice, with the work of an expert forecaster. Although full statistical comparisons have not yet been made, it can fairly be said that over a recent test period the computed charts showed definite improvements compared with those of previous experiments and in fact were so good that the forecasters responsible for the public service are eager to have them regularly for guidance. Limitations of available computing facilities make it necessary to postpone the regular operational use of numerical prediction for some time.

Present calculations deal primarily with wind and pressure from the surface to a height of 200 mb (about 12,000 m) with some generalized representation also of air temperature and vertical motion. Details of clouds, visibility, fogs and frosts, etc., elements of practical public interest, have not yet been brought within the scope of calculation and, although possibilities are readily envisaged, a great deal of research will be needed before the expert judgement of highly qualified meteorologists can be dispensed with in routine work, if indeed that day will ever come. To assist forecasters in these tasks a number of *ad hoc* and semi-empirical researches are being undertaken, and work was again started on the very difficult problem of forecasting the quantity of rainfall to be expected on any occasion, a matter specially recommended for urgent attention by the Meteorological Research Committee.

An interesting problem of special interest in forecasting is the formation, maintenance and dissipation of sheets of stratocumulus cloud. The underlying physical processes were further clarified by the analysis of special observations made by aircraft of the Meteorological Research Flight, which confirmed that the inversion above the cloud top is generally greater and sharper than radiosonde data reveal, and also that moisture and energy balance generally require subsidence of the whole system with reasonable values of turbulence to provide for other vertical fluxes.

Long-range forecasting and the general circulation. The quantitative methods of short-range forecasting by calculation are applicable for periods no longer than three or four days. After this the accumulating errors become intolerably large and the predictions valueless. The question then arises whether success in long-range forecasting will come only by improving and extending the methods used for short-range forecasting or by some new methods which deal with the

long-period trends independently of the day-to-day weather. It is probably true that most of those who have studied long-range forecasting have hoped to discover some specific controlling factor, such as sea temperatures or sunspots, or some periodicity or correlation revealed by statistics, but the outcome of such studies has never led to convincing results and scientific opinion is hardening to the view that success, if it is to come, requires a great deal more work to be done on the scientific study of the general circulation of the atmosphere. This is a tremendous problem requiring for its attack resources greater than those now available in the Meteorological Office, but attention has been given to a number of relevant points. Amongst these are the energy exchange between atmosphere and ocean (the analysis of which has revealed the serious inadequacy of the available oceanographical data) and the horizontal transports of momentum, energy and water vapour within the atmosphere, the study of which has further emphasized the importance of the liberation of latent heat associated with rainfall in defining the geographical pattern of energy input to the atmosphere.

In the meantime attempts to forecast the general nature of the weather of Great Britain for a month ahead have been made as a research experiment by methods that are almost wholly empirical, giving most weight to analogues. In this technique the current year, especially the past month, is matched as closely as possible by one or more previous years in the historical record (some 80 years) with the hope that subsequent weather will accord with previous patterns. The method is reasonable in principle but not always reliable in practice, perhaps because the matching of conditions between different years is not close enough and certainly it is often difficult or impossible to find really close analogues. The question whether forecasts now made in this way are sufficiently useful to be made available to interested bodies remains to be decided.

Climatic changes and trends. Our knowledge of climatic changes, whether the great fluctuations between the ice-ages of geological time or the shorter period fluctuations over centuries or decades, remains almost completely empirical, leavened by interesting theoretical speculations which are extremely difficult to substantiate. A critical study of the ice and temperature conditions and mean sea level during the 'Little Ice Age' (say A.D. 1550–1850) in comparison with those inferred for the last major ice age did however lead to the conclusion that the phenomena were different in kind and not only in degree. It was also fairly conclusively established that over the region from southern England to Denmark the frequency of northerly and easterly winds was greater in the period A.D. 1550 to 1700 than in any considerable later period, a result which is acceptable to the synoptic climatologist and points to circulation changes as features in climatic trends. In an attempt to resolve a controversy about tree growth in the exposed area of north-west Scotland, fossil trees were dated by radiocarbon tests (by arrangement with the National Physical Laboratory) and revealed none of date later than the post-glacial climatic optimum of about 5000–2000 B.C., so giving no support to the view that trees were growing freely near the coast in historic times.

The Sheffield Gale of 16 *February* 1962. During the course of a year there are many occasions when winds of gale force affect some part of our Islands and bring a measure of damage but usually they call for no special meteorological

investigation because the wind behaves in a normal manner in relation to the intense depression which is its cause. Such events are generally well understood and usually predictable. The destructive gale of 16 February 1962 was however exceptional in that in some restricted localities the force of the wind and the corresponding damage were out of proportion to the intensity of the associated depression. It will be recalled that in Sheffield, for example, many thousands of dwelling houses were damaged, over 200 severely, and a proportion of these were beyond repair. The occasion prompted a combined study by operational forecasters, climatologists and research staff, a full report of which will be published later, but it is of particular interest in connexion with research to note that the explanation of the occurrence was firmly established in accordance with theoretical work of recent years. The striking feature of the gale was that the severest conditions came on the lee side of the Pennines with generally north-westerly winds, not, as might have been expected, on the exposed slopes. It was found that this feature could be explained, according to theory developed by Professor R. S. Scorer some years ago, as the effect of a standing wave set up by the hills. Applying the theory, special calculations with the aid of the electronic computer gave results in good agreement with actuality. The success of the dynamical theory does not, however, imply that exceptional events of the kind can be forecast infallibly in future, for the criteria are precise, the data available rather limited and the computations lengthy; but the event introduces a new feature into the statistics of gale damage, which may have important applications. Only a few years ago the event would have passed into history as a 'freak storm' beyond explanation.

4. Physical Research

High atmosphere. The 'high atmosphere' is a vague expression and recent work with rockets, space probes and satellites have added to the wide variety of interesting physical phenomena which characterize the earth's envelope out to distances of hundreds of miles. The meteorologist may study any of these matters but high atmosphere exploration is costly in staff and materials and the Meteorological Office has, so far, thought it proper to restrict its attention to matters likely to be more closely related to the demands put to it as a public service concerning weather and climate near the ground and wherever aircraft may fly regularly. This restriction is by no means frustrating for the importance of ultra-violet radiation and ozone extends the interest beyond the stratosphere into the mesosphere, while the use of artificial earth satellites as platforms from which to view the weather downwards from outside the atmosphere brings the most earth-bound weather man in contact with space research.

The only launchings of satellites primarily for meteorological purposes have been the American TIROS series, soon to be followed by the new NIMBUS series. These highly sophisticated systems have as their main feature television photography of the cloud layers and the earth's surface below, the information being temporarily stored on magnetic tape to be read out on command from two stations in the United States. It is understood that the U.S.S.R. will move into this field before long but there is no plan to launch weather satellites elsewhere and workers in other countries will be dependent on co-operation. So far the Meteorological Office has not defined any related programme of research but a scientist member of staff was attached to the satellite group of the United States Weather Bureau for most of the year and the Office is now in a good position to consider the possibilities. It should however be borne in mind that these

series of satellites are regarded in the United States as designed for operational purposes, primarily for use in weather forecasting, and it would be natural to await operational experience before embarking on a research project that could demand large resources.

An independent part was taken, however, in the joint Anglo-American research satellite of the SCOUT series, for which an ozone measuring system was designed, tested in two Skylark rocket ascents in Australia, and is now being built into the satellite in America. For this purpose also it has been and will be necessary to have an expert working full time with American and other British scientists in Washington until the launch, which is planned for the third quarter of 1963. The technique of measuring ozone above levels of about 30 km from the absorption of ultra-violet light viewed from the satellite when the sun is near the satellite's horizon has not been used before on any satellite and the outcome is awaited with interest. It is already suggested that the proportion of molecular oxygen in the high atmosphere should be determined by a similar technique in a later experiment and the idea is being studied.

The Meteorological Office rocket project progresses according to plan. The vehicle is to be a 5-inch rocket with a 10 lb payload, ascending to a height of 60 km (nearly 40 miles) where a radiosonde with parachute will be released. The first batch of 12 sondes, including the temperature sensing element, were made in the Bracknell laboratories, but later supplies are to be obtained by outside contract. Winds will be obtained by radar-following of the descending target and a new wind-radar, the first of a new system to be introduced at all radar-wind stations of the Meteorological Office, is being installed. The rocket motor has encountered unexpected trouble but otherwise all has gone reasonably well and it is hoped to get results during 1963 from the launching site at South Uist in the Outer Hebrides, and later perhaps from stations abroad.

The continued usefulness of balloons has not been overlooked for no better vehicle is available for heights up to about 25 miles. As part of ozone studies an ozone-sonde, based on a design by Professor A. W. Brewer, is to be commercially manufactured under contract and ground equipment is being prepared in the Office. A phosphorus pentoxide balloon-borne hygrometer has also shown promise in preliminary trials conducted in co-operation with P. Goldsmith of AERE, Harwell, who was largely responsible for the design of the instrument. Very low humidity in the low stratosphere, with markedly increased mixing-ratio above, is the pattern which seems to be confirmed, setting a fascinating problem for the theoreticians.

Turbulence and diffusion. The main effort on turbulence and diffusion continued at Porton, with the Chemical Defence Experimental Establishment, but an active group was also formed at Headquarters, Bracknell, while the small unit at Cambridge pursued related problems in continuing investigations of evaporation and surface energy-balance. This is a subtle branch of fluid mechanics of deep scientific appeal as well as practical importance, and research in the Office is at present in an interesting phase. Emphasis has shifted away from analogy with molecular diffusion, mean gradients and the well-worn '*K*-theory', to the study of the structure of the turbulence, to measurements of fluctuating motions including the vertical component, to turbulent energy as a basic parameter, and to the so-called Lagrangian:Eulerian scale ratio, the proper names having reference to the two systems of co-ordinates used in fluid dynamics. The significance of this last concept is readily appreciated if it is

recalled that diffusion is essentially the mixing of moving elements of the fluid and that parameters which relate to the moving element (Lagrangian) are in some respects more fundamental than those referring to a fixed position. The latter are however much easier to measure, and it would be a notable step forward if the one could be readily estimated from the other. This idea has stimulated a number of experiments.

On the larger scale advantage was taken of a year's visit of Dr. Angell of the United States Weather Bureau whose work with various kinds of constant-level free balloon is well known. A number of his 'tetroons', superpressured inextensible plastic balloons, which float at constant air density, were tracked at about 1000 m height for distances of 10 to 20 miles and the characteristics of the motion were compared with 'Eulerian' measurements at the same height on the cable of a captive barrage balloon. On a somewhat smaller scale, zero-lift pilot balloons, about 50 in each experiment, were released 4 metres from ground level at 3-minute intervals, each balloon being visually tracked by three theodolites until the next was released. Again, observations at the fixed position were made for comparison. On a still smaller scale, aniline vapour was used as a tracer and its vertical distribution 200 m downwind from a source, taken in relation with measured fluctuations in the vertical wind component near the source, served to estimate the Lagrangian:Eulerian scale ratio. A number of other experimental programmes are in hand and it is advisable to defer the assessment of progress for the present.

Turbulence near the Rock of Gibraltar. In response to a request by the Royal Air Force for a study, as a matter of urgency, of local turbulence at Gibraltar (a cause of difficulty in approach and take-off), a model of the Rock was tested in the larger wind-tunnel at Bracknell. This was the first time that this kind of investigation has been undertaken in the Office and the results are encouraging. With the equivalent of winds between ESE and WSW through South, the experiments show well-defined air currents with upward and downward components rather precisely located and defining a vortex with nearly horizontal axis extending downwind from the lee of the Rock, the direction of rotation being dependent upon the wind direction relative to the main axis of the Rock. The transition from turbulent to smooth air flow was in some circumstances notably abrupt. The tunnel tests need confirmation from on-site observations and it is hoped that aircraft will be made available for the purpose. Changes in recommended flight procedures, particularly in the approach paths, could be an outcome of this work.

Radiation. The development of a new daylight illumination recorder has gone well. Tests on the specially manufactured selenium cells have shown them to be a significant improvement on those previously used; in particular, they have a negligible temperature coefficient in the operating conditions required. This has allowed construction of a new and much more compact model of daylight recorder. Outside contract action is now in hand.

The tape recording of the output from radiation instruments led to the design of a Meteorological Office Data Logging Equipment, MODLE, which should have wide applications in association with electronic computer processing. A contract for 15 MODLE was placed and the first delivery is expected soon.

Meteorological Research Flight. The record of the M.R.F. was marred by an accident on 21 February when the Canberra aircraft crashed on landing with

serious injury to the crew. The aircraft was returning from a high-level sortie to latitude 70°N, measuring ozone and water vapour, and the accident brought a most interesting series of observations to a temporary stop. It is unlikely that an instrumented replacement aircraft for the Canberra will be available until late in 1963.

Equipment for measuring vertical currents, devised by Aerodynamics Department, R.A.E., is in use on M.R.F. aircraft. It comprises wind vanes on a forward-facing probe, sensitive accelerometer and rate-of-pitch meter. Flights with the wind vane have been made. In conjunction with the Radio Research Station, a microwave refractometer has been used in the Hastings aircraft to study the fine structure of temperature inversions as well as processes of vertical convection. The microstructure of temperature inversions reveals refractive index gradients which correlate with responses from a clear atmosphere with 10 cm radar and may be important for radio propagation.

Radar meteorology. Work at Malvern in co-operation with staff of the Royal Radar Establishment has been active especially in exploring the use of 8 mm radar and in applying the Doppler-radar equipment. The topic is the subject of this year's special article (see p. 41).

Instrument development. The branch for instrument development is, in point of numbers of staff, the largest in the directorate of research, a circumstance necessitated by the responsibilities for much routine testing (more than 20,000 radiosondes were calibrated during the year), for the installation and maintenance of electrical and electronic equipment at operational stations, and for drawing office and other work incidental to the preparation of specifications and the supervision of outside contracts. A measure of internal reorganization was introduced to ensure that scientific staff were not distracted more than necessary by this essential technical activity. The new radiosonde reached the stage of final specification for submission to the industry, following successful trials of a few hand-made models. This marks a very important stage in a protracted development project as the new sonde, when introduced operationally, could well remain the standard for ten or twenty years.

A complete prototype of an automatic weather station, which both provides a continuous local record and transmits its observations over telephone lines for remote recording, was assembled and demonstrated. The practical application of this or modified equipment has not yet been studied as the present stage, accomplished in a matter of months, is in the nature of a feasibility study to enable the operational side of the Office to consider needs in terms of practicable systems and likely costs.

It is gratifying also to record what promises to be a successful outcome to an effort, over a number of years, to produce a reliable automatic frost-point hygrometer capable of working down to the lowest humidities reached by aircraft or balloons. The aircraft version will be available shortly; the balloon-borne version was designed with tested telemetering components.

Geophysics and the Observatories. Although full meteorological observing and recording continued at the three observatories, Kew, Eskdalemuir and Lerwick, the main research interest concerns geophysical work, geomagnetism and seismology, stimulated as this was by the newly appointed Gassiot Research Fellows, one for each of the two subjects. The development of the proton-precession magnetometer to read the horizontal component directly by backing

off the vertical component encountered difficulties but these are likely to be overcome; it will then be convenient to introduce the same system for the absolute measurement of total force and its components at Lerwick as well as Eskdalemuir.

The reawakened interest in seismology prompted the Royal Society to express the hope that Eskdalemuir would be developed as the main seismological observatory for the United Kingdom. The choice, dictated by low noise-level and suitability of the geological formation, meant a reversion to the arrangement before 1925, in which year the equipment was removed to Kew. Approval for the expenditure was obtained from Air Ministry and the building of a new vault was planned to include separate chambers for routine recording and research work. An American offer to supply Eskdalemuir with a modern seismological recording equipment without charge was accepted, the idea behind the scheme being the need to set up a world-wide network of instruments of uniform characteristics.

The personal research of the Gassiot Fellows has continued and each published several papers during the year. Their work has been mainly in rock magnetism, microseisms and earth noise.

5. International Research Activity

International co-operation for the Office in general receives attention in a separate section of this Report (see p. 55) but additional information is given here as international co-operation in meteorological research projects is becoming more and more common and a considerable amount of time must be devoted, particularly by some of the senior research staff, to international arrangements.

Following the remarkable interest aroused by the International Geophysical Year of 1957–58, to which the Office made a substantial contribution, there has been an impressive growth of international co-operation in the environmental sciences. This is indicated by the corresponding committees set up within the International Council of Scientific Unions, for Antarctic Research (SCAR), Oceanic Research (SCOR), Space Research (COSPAR), or by special projects such as the International Indian Ocean Expedition (1962–64) and International Quiet Sun Year (1964–65), to mention but a selection. Also during the year the United Nations in General Assembly picked out meteorology as a subject for special encouragement in formal Resolutions 1721 (XVI) and 1802 (XVII) which led to a further examination of research requirements by the World Meteorological Organization, the outcome of which it is too early to predict. For most international research activities, other than those co-ordinated through WMO, the initiating organization has been non-Governmental and the adhering body in the United Kingdom, The Royal Society, has therefore found it necessary to set up committees representative of the sciences concerned. The Office is invited to nominate members to all relevant Royal Society international committees and sub-committees, numbering about twelve at the present time. Information on a few of the most important international research activities is given below.

International Quiet Sun Year (IQSY) 1964–65. The International Geophysical Year (1957–58) was chosen to occur when solar activity, as indicated for example by sun-spots and flares, was near the maximum of its eleven-year cycle and the influences of this activity, especially on the ionosphere and outer fringes of the atmosphere, were also at their peak. It was natural to suggest a com-

plementary project to obtain as much information as possible during a period of little solar activity and the years 1964–65 have been chosen. By means of balloons, rockets, satellites and ground-based instrumentation of many kinds, a world-wide onslaught is to be made once more to obtain data, especially on the upper atmosphere; meteorology is one of the component disciplines and the Office is to make its contribution. This will consist of an enhanced programme of upper-air balloon soundings of temperature, humidity and wind from our stations in this country and overseas, together with the following additional features: balloon soundings with ozone-sondes from Lerwick, Bracknell, Malta and Gan (Maldives); similar soundings for water vapour using a new phosphorus-pentoxide sonde; a series of soundings with meteorological rockets from South Uist; radiation measurements from an increased network of stations. At least two Skylark rockets, instrumented by the Office, will also be launched in Australia for ozone observations during the period, while the U.S.–U.K. satellite carrying Meteorological Office instrumentation should be in orbit.

International Indian Ocean Expedition (IIOE) 1962–64. One of the bodies set up after the IGY to continue international collaboration was the International Council of Scientific Unions (ICSU) Special Committee for Oceanic Research (SCOR). This Committee proposed that a concerted attack be made by all interested countries to obtain more data from the Indian Ocean. This region is particularly interesting meteorologically as well as oceanographically on account of the tropical circulations and the seasonal alternations of monsoon winds, and in view of the close interaction between atmosphere and oceans it was realized that a meteorological programme was essential for the project. Accordingly, with the support of The Royal Society, the Meteorological Office has received approval for a contribution which it was particularly fitted to make by virtue of its responsibility for meteorological observations on British ships and its interest in military and civil aviation over the region. The most significant item of the Office programme will be a special radiosonde and radar-wind station to be operated for two years in the Seychelles, beginning during 1963 and expected to provide information of the deepest interest. The Office upper air stations in the area, Aden, Bahrain and Gan, will continue with normal or enhanced programmes and the overlap in time with IQSY is particularly convenient in this respect.

Space Research. The work of the Office in instrumenting Skylark rockets in preparation for ozone experiments on the Anglo-American research satellite S–52 has already been mentioned but the subject deserves further comment as an example of research which is the subject of much international activity. The Committee for Space Research, COSPAR, of ICSU, is concerned with all the scientific problems that may be studied by means of satellites, rockets and space probes, and meteorology is of course only one aspect, but the circumstances are such that the most detailed co-ordination is necessary and much time has been spent in scientific liaison. There has been planning also for the proposed European Organization for Space Research (ESRO), which has a comprehensive programme in view, including earth satellites. The most far-reaching meteorological work is that involving the United States meteorological satellites which has already been referred to.

R. C. SUTCLIFFE

Director of Research

INTERNATIONAL CO-OPERATION

1. World Meteorological Organization

The fourteenth session of the Executive Committee was held at the Headquarters of the World Meteorological Organization (WMO) in Geneva from 29 Mayt o 20 June 1962. Much time was devoted to three items on the agenda, all of great significance to the advancement of world meteorology. These were Part C of Resolution 1721 (XVI) of the UN General Assembly concerning measures to advance the state of atmospheric science and technology and to develop existing weather forecasting capabilities, the programme and budget of the WMO for the 4th Financial Period (1964–67) and meteorological training in underdeveloped areas. The session was attended by the Director-General who is a member of the Committee; he was accompanied by Mr. C. W. G. Daking, Assistant Director (Defence and International).

The third session of the Commission for Instruments and Methods of Observation was held in New Delhi from 29 January to 16 February 1962. The United Kingdom delegation was led by Mr. A. L. Maidens, Assistant Director (Instrument Development), who was assisted by Mr. C. J. Hinkel (M.O.16) and a member of the Naval Weather Service, Admiralty.

The third session of Regional Association I (Africa) was held in Addis Ababa from 14–31 March 1962. Mr. F. H. Bushby, Chief Meteorological Officer, Middle East Air Force (Aden) attended as an observer for the United Kingdom.

The third session of the Commission for Synoptic Meteorology took place in Washington D.C., from 26 March to 20 April 1962. A long agenda included problems concerning codes, networks and telecommunications, and the observational requirements for synoptic meteorology. The units used in meteorological reports for international exchanges were also discussed. The United Kingdom delegation was composed of Mr. V. R. Coles, Assistant Director (Central Forecasting), Mr. L. H. Starr, Assistant Director (Observations and Communications), Mr. J. Harding, Assistant Director (General Services) and Inst. Capt. J. A. Burnett, Director, Naval Weather Service, Admiralty.

The third session of the Commission for Agricultural Meteorology was held in Toronto, from 9–27 July 1962. The United Kingdom was represented by Messrs. L. P. Smith and W. H. Hogg (M.O.7). Mr. Smith was elected President of the Commission.

The third session of Regional Association II (Asia) was held in Bangkok, from 15–27 October 1962. The United Kingdom was not represented at the session.

The third session of Regional Association V (South-west Pacific) was held in Noumea, New Caledonia from 5–17 November 1962. United Kingdom views on items on the agenda were presented by Dr. R. G. Simmers, Director of the New Zealand Meteorological Service.

A Joint WMO/COSPAR/IUGG Symposium on meteorological satellites and rockets was held in Washington D.C. in April and was attended by Dr. G. D. Robinson, Deputy Director (Physical Research) and Dr. R. Frith, Assistant Director (High Atmosphere).

A Joint ICAO/WMO Seminar on forecasting for turbo-engined aircraft in the South-east Asia area was held in Bangkok from 16 November to 7 December. Mr. D. H. Johnson (M.O.13) took part as an instructor. Mr. W. H. Smith from the Meteorological Office, Changi, also attended.

2. North Atlantic Treaty Organization

Dr. R. C. Sutcliffe, Director of Research, attended a meeting of the NATO Science Committee's *ad hoc* Advisory Group on Meteorology in Rome on 8 and 9 January.

The nineteenth meeting of the Meteorological Committee of the Standing Group took place in London from 15–18 May, under the chairmanship of Dr. A. C. Best, Director of Services, the United Kingdom member. Mr. P. J. Meade, Deputy Director (Outstation Services), Mr. L. H. Starr, Assistant Director (Observations and Communications) and Mr. R. A. Buchanan (M.O.17) attended as United Kingdom advisers.

Meetings of the two working groups of the Standing Group Meteorological Committee were held in Washington, D.C., from 14–23 March and in Naples from 16–23 October. Mr. L. H. Starr and Mr. R. A. Buchanan represented the United Kingdom.

The SHAPE Meteorological Committee met from 2–4 May, near Paris, with Mr. R. A. Buchanan and Mr. R. K. Pilsbury (M.O.5) representing the Meteorological Office. Mr. Pilsbury later attended a meeting in Paris of a working group set up by the committee.

Mr. J. K. Bannon, Assistant Director (Special Investigations) was a member of a United Kingdom team which took part in a NATO exercise on long term scientific studies held in Paris from 29 October to 9 November.

Mr. J. Crabtree and Mr. L. G. Hemens (M.O.7) were members of the United Kingdom delegation at meetings of the External Ballistics Group of the Armaments Committee in Paris from 3–7 September.

3. Central Treaty Organization

A conference of Civil Aviation Experts called by the Economics Committee of the Central Treaty Organization was held in Ankara from 30 April to 4 May. Mr. A. A. Worthington (M.O.17) attended the meeting as a member of the United Kingdom delegation.

4. South East Asia Treaty Organization

A working group of the Meteorological Committee of SEATO met in Bangkok from 19–21 June to study the question of establishing a network of cathode ray direction-finding stations in the area for the detection and location of thunderstorms. Mr. R. Frost, Chief Meteorological Officer, Far East Air Force, and Mr. A. P. Taylor (M.O.5) attended as United Kingdom representatives.

5. International Civil Aviation Organization

The second Pacific Regional Air Navigation Meeting was held in Vancouver, Canada, from 25 September to 16 October. Mr. A. A. Worthington (M.O.17) was a member of the United Kingdom delegation.

The fourth meeting of the ICAO Meteorological Operational Telecommunications Network (Europe) Development/Implementation Panel was held in Paris from 28 May to 16 June. Mr. A. A. Worthington attended the meeting as Adviser to the United Kingdom Panel Member.

6. Commonwealth Meetings

Mr. A. A. Worthington (M.O.17) was a member of the United Kingdom delegation to the sixteenth meeting of the South Pacific Air Transport Council held in Wairakei, New Zealand, from 28 November to 4 December.

7. Other International Meetings

Other international meetings on meteorology and allied sciences held during the year were attended by members of the Office as follows. The list is not necessarily complete but when read in conjunction with Sections 1 to 6 a notable participation by the Meteorological Office in the field of international co-operation is clearly demonstrated.

(*a*) Dr. R. C. Sutcliffe, Director of Research, a member of the WMO Executive Committee Working Group on Research Aspects of Meteorological Satellites attended a session of the group in Geneva from 26–30 November. The group began a study of the application of meteorological satellites to meteorological research and of the role to be played by WMO.

(*b*) Dr. G. D. Robinson, Deputy Director (Physical Research) attended a meeting in May in Geneva of the WMO Executive Committee Panel on Artificial Satellites to assist in the editing of the WMO report prepared in response to Part C of UN General Assembly Resolution 1721(XVI)—the peaceful uses of outer space.

(*c*) Mr. P. J. Meade, Deputy Director (Outstation Services) attended a meeting in April in Geneva of the WMO Executive Committee Panel on Atomic Energy to examine plans for the implementation of UN General Assembly Resolution 1629 (XVI) on the question of extending the present meteorological reporting system to include measurements of atmospheric radioactivity.

(*d*) Mr. J. Harding, Assistant Director (General Services) attended a session of the Working Group on Code Problems of the Commission for Synoptic Meteorology in Toronto from 9–19 January. Mr. Harding represented Regional Association VI (Europe) as well as the United Kingdom.

(*e*) Mr. L. P. Smith (M.O.7) attended a meeting in Geneva in March of the Working Group on the Guide to Agricultural Meteorological Practices of the Commission for Agricultural Meteorology to edit material prepared for the Guide by various working groups and individuals.

(*f*) Mr. V. R. Coles, Assistant Director (Central Forecasting) attended a meeting in March preceding the third session of the Commission for Synoptic Meteorology, of that Commission's Working Group on the synoptic use of meteorological data from artificial satellites.

(*g*) Dr. G. D. Robinson, Deputy Director (Physical Research) attended a conference of the International Geophysical Co-operation Committee which was held in Paris from 26–29 March to discuss meteorological arrangements for the International Year of the Quiet Sun (1964–65).

(*h*) Dr. R. C. Sutcliffe, Director of Research, attended a meeting of a NATO International Consultative Group for Research on 'Cyclogenesis to lee of the Alps in North Italy and the Gulf of Genoa' in Rome on 18 and 19 May.

(*i*) The Anglo-French Standing Group on radioactive fallout met in London on 5 and 6 December. Mr. H. Maggs (M.O.6) was a member of the United Kingdom delegation.

(*j*) Mr. M. H. Freeman (M.O.8) took part in the WMO Inter-regional Training Seminar on Statistical Forecasting held in Paris from 8 to 20 October.

(*k*) Mr. H. H. Lamb (M.O.13) attended an international conference on radio-carbon dating at Cambridge on several days in July.

(*l*) Mr. M. K. Miles (M.O.13) took part in a colloquium on long-range weather forecasting convened by Prof. F. Baur at Bad Homburg from 15–17 October.

(*m*) Cdr. C. E. N. Frankcom, Marine Superintendent, attended meetings of Committees of the International Maritime Consultative Organization in London, as a WMO observer in January and October.

(*n*) Mr. L. P. Smith (M.O.7) attended the sixteenth International Horticultural Congress in Brussels from 30 August to 9 September and presented papers illustrating applications of meteorology for the benefit of horticulturists.

(*o*) Dr. R. J. Murgatroyd attended an international symposium on stratospheric and mesospheric circulations which was held in Berlin from 20–31 August.

(*p*) Mr. H. H. Lamb (M.O.13) attended a conference at Aspen, Colorado, U.S.A. from 16–24 June called by the U.S. National Research Council to examine the present state of knowledge regarding the climates of the 11th and 16th centuries A.D.

(*q*) Mr. M. J. Blackwell (M.O.14) took part in an international symposium on the Methodology of Plant Eco-physiology held at Montpellier, France from 7–12 April. The symposium was part of UNESCO'S programme on Arid Zone Research.

(*r*) Dr. F. Pasquill (M.O.14) and Mr. C. E. Wallington, Porton, attended, by invitation, an international symposium on atmospheric pollution, organized by DSIR which was held at Warren Springs Laboratory, Stevenage, on 7 and 8 November.

(*s*) Dr. H. M. Iyer, Gassiot Research Fellow in Seismology attended a UNESCO seminar on seismology and earthquake engineering in Rome from 21–25 May.

(*t*) Mr. J. B. Stewart (M.O.15) attended a symposium on trace gases and natural and artificial radioactivity at Utrecht from 8–14 August.

At several of these meetings specialist papers were presented by members of the Office.

STAFF

The Meteorological Office Headquarters organization is shown in the diagram on p. 61 and the names of the principal officers are listed on p. iv.

At the end of the year 1962, the total number of posts of all grades was 3601. The strength was made up as follows:

Scientific Officer class	
Chief Scientific Officer	3
Deputy Chief Scientific Officer	4
Senior Principal Scientific Officer	22
Principal Scientific Officer	77
Senior Scientific Officer	29
Scientific Officer	14
Administrative class	
Assistant Secretary	1
Experimental Officer class	
Chief Experimental Officer	20
Senior Experimental Officer	208
Experimental Officer	369
Assistant Experimental Officer	189
Scientific Assistant class	
Senior Scientific Assistant	254
Scientific Assistant	1359
Marine Staff	
Nautical Officer class	8
Ocean Weather Ships and Base Officers	52
Crew	119
Technical and Signals grades	314
Executive and Clerical grades	150
Typing and miscellaneous non-industrial grades	125
Industrial employees	92
Locally entered staff and employees overseas	192

Recruitment to the Scientific Officer class continued satisfactorily and only one vacancy remained unfilled. In the Experimental Officer class six posts were vacant at the end of the year and there was every prospect of filling these early in 1963. Recruitment to the Scientific Assistant class was unusually good and for the first time for many years all posts were filled and further intake suspended; moreover the resignation rate was appreciably lower than in former years. With the ending of National Service during the year, the RAF trade of airman meteorologist became obsolete. Ten scientific assistants were seconded to the RAF as aircrew for Meteorological Reconnaissance Flight duties.

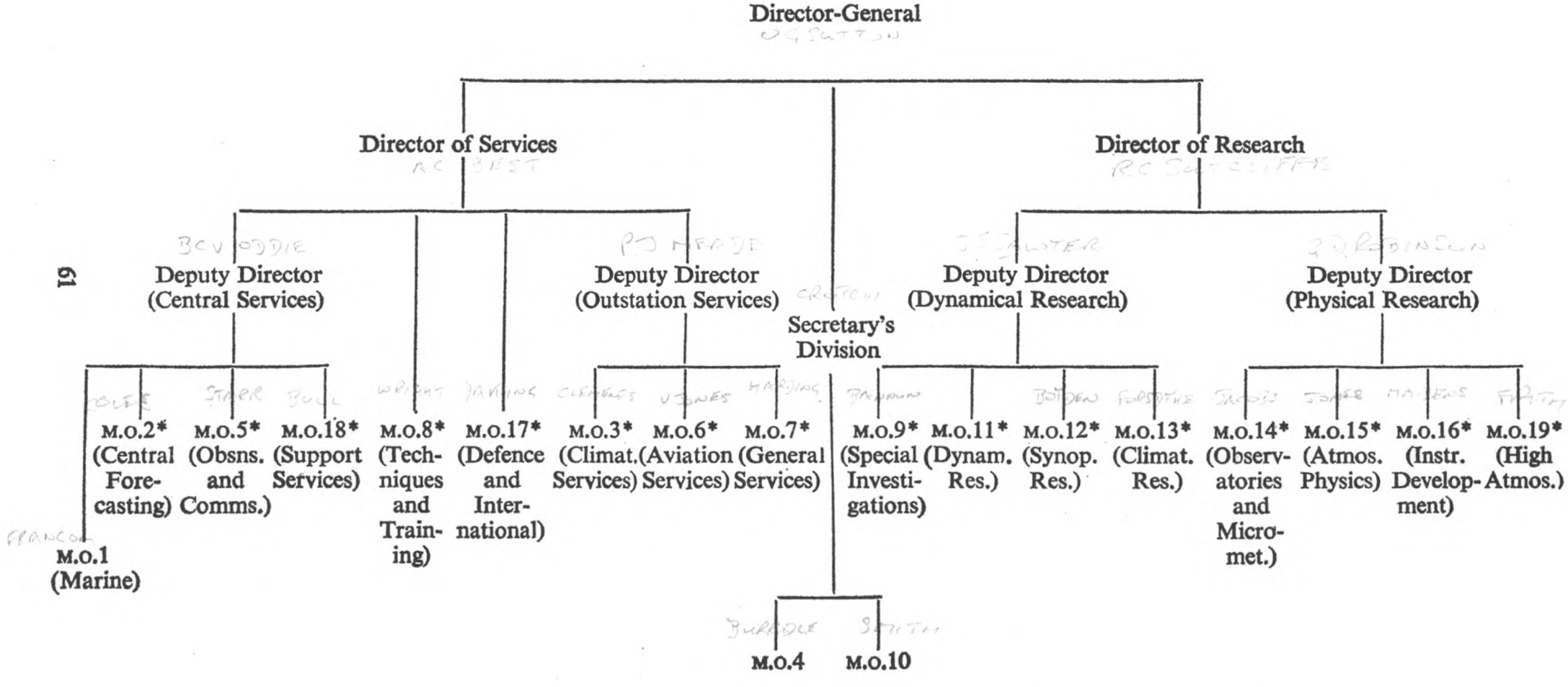
Six Assistant Experimental Officers were undertaking sandwich courses, sharing the year between the Office and Colleges of Advanced Technology. Other study concessions were enjoyed by 301 members of the staff. From a

large number of applicants, ten undergraduates were chosen to work in the Office as vacation students and two were received as external sandwich course students.

In the Birthday Honours List, Dr. A. C. Best, O.B.E. was elevated to be a Commander of the Most Excellent Order of the British Empire and Mr. H. F. Clifton, Boatswain of the ocean weather ship *Weather Reporter*, was awarded the British Empire Medal.

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 sales 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 24 December 1962).

Daily Weather Report, containing weather maps for the northern hemisphere, British Isles, etc., and data (to 31 December 1962).

Daily Weather Report, Overseas Supplement, containing surface and upper air data (to 7 August 1962).

Meteorological Magazine, (to December 1962).

Monthly Weather Report (to August 1962).

Seismological Bulletin. A diary of seismological disturbances recorded on the Galitzin aperiodic seismographs at Kew Observatory, Richmond (to September 1962).

Marine Observer (quarterly) (to October 1962).

The Observatories' Year Book comprising the geophysical results obtained from autographic records and eye observations at the Lerwick, Eskdalemuir and Kew Observatories, 1960.

SERIAL

Geophysical Memoirs: Vol. XIV

106. A meso-synoptic analysis of the thunderstorms on 28 August 1958. By D. E. Pedgley, B.Sc.

Scientific Papers:

11. Some calculations of terms in the energy balance for monthly periods at the Ocean Weather Stations I and J in the North Atlantic, by H. C. Shellard, B.Sc.
12. Some statistical relationships between the temperature anomalies in neighbouring months in Europe and Western Siberia, by J. M. Craddock, M.A., and R. Ward.
13. Three-parameter numerical forecasts at Dunstable—A study of the error fields. By C. E. Wallington, M.Sc.
14. Variation of the difference between two earth temperatures. By P. B. Sarson, M.A.
15. The errors of the Meteorological Office radio-sonde Mark 2B. By D. N. Harrison, O.B.E., D.Phil.
16. An experiment in operational numerical weather prediction. By E. Knighting, B.Sc., G. A. Corby, B.Sc., and P. R. Rowntree, B.A.

OCCASIONAL

A course in Elementary Meteorology.

Hygrometric Tables. Pt. I. For use with Stevenson Screen readings in degrees Fahrenheit.

Hygrometric Tables. Pt. II. For use with Stevenson Screen readings in degrees Celsius.

Hygrometric Tables. Pt. III. For aspirated psychrometer readings in degrees Celsius.

Cloud Types for Observers.

Weather in the Mediterranean. Vol. 1 (2nd edition).

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

1951–55. Part 8, Gibraltar.

1951–55. Part 9, Nicosia.

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 ending 31 December 1962:

SIR GRAHAM SUTTON, D.SC., F.R.S.; Applied mathematics and computing machines. Computers in education (Ed. J. A. P. Hall), London (Pergamon Press), 1962, pp. 1–7.

SIR GRAHAM SUTTON, D.SC., F.R.S.; The challenge of the atmosphere. The science of meteorology. London (Hutchinson), 1962.

SIR GRAHAM SUTTON, D.SC., F.R.S.; Numerical weather forecasting in the British Meteorological Office. Int. Coun. sci. Unions, Spec. Comm. IGY, Ann. IGY, *London*, **11**, 1961, pp. 23–25.

R. C. SUTCLIFFE, B.SC., PH.D., F.R.S.; Research organization and facilities. *Met. Mag., London*, **91**, 1962, pp. 314–319.

G. D. ROBINSON, B.SC., PH.D.; Absorption of solar radiation by atmospheric aerosol, as revealed by measurements at the ground. *Arch. Met. Geophys. Biokl., Vienna*, **12B**, Heft 1, 1962, pp. 19–40.

G. D. ROBINSON, B.SC., PH.D.; Physical meteorology: achievements and prospects. *Met. Mag., London*, **91**, 1962, pp. 319–326.

J. S. SAWYER, M.A., F.R.S.; Gravity waves in the atmosphere as a three-dimensional problem. *Quart. J.R. met. Soc., London*, **88**, 1962, pp. 412–425.

J. S. SAWYER, M.A., F.R.S.; Performance requirements of aerological instruments—An assessment based on atmospheric variability. *World Met. Org., Tech. Note* No. 45., WMO No. 119, TP. 54, Geneva, 1962.

J. S. SAWYER, M.A., F.R.S.; The physics of weather forecasting. *Brit. J. appl. Phys. London*, **13**, 1962, pp. 380–383.

J. S. SAWYER, M.A., F.R.S.; Research in synoptic and dynamical meteorology and in climatology, 1941 to 1962. *Met. Mag., London*, **91**, 1962, pp. 327–335.

B. C. V. ODDIE, B.SC.; The chemical composition of precipitation at cloud levels. *Quart. J.R. met. Soc., London*, **88**, 1962, pp. 535–538.

C. J. BOYDEN, B.A.; Forecasting of maximum surface temperature from 1000–500 millibar thickness lines. *Met. Mag., London*, **91**, 1962, pp. 242–246.

F. PASQUILL, B.SC., D.SC.; Recent broad-band spectral measurements of turbulence in the lower atmosphere. *J. geophys. Res., Washington*, **67**, 1962. pp. 3025–3028.

F. PASQUILL, B.SC., D.SC.; Some observed properties of medium-scale diffusion in the atmosphere. *Quart. J.R. met. Soc., London*, **88**, 1962, pp. 70–79.

F. PASQUILL, B.SC., D.SC.; The statistics of turbulence in the lower part of the atmosphere. London, Aeronautical Research Council, ARC 23272, 1961.

A. L. MAIDENS, B.SC.; The third session of the Commission for Instruments and Methods of Observation, New Delhi, February 1962. *J. sci. Instrum., London*, **39**, 1962, p. 457.

V. R. COLES, M.SC.; Some empirical research in short-range forecasting. *Met. Mag., London*, **91**, 1962, pp. 89–98.

V. R. COLES, M.SC.; World Meteorological Organization. Third Session of the Commission for Synoptic Meteorology. *Met. Mag., London*, **91**, 1962, pp. 225–227.

L. JACOBS, M.A., M.SC.; A report on a discussion "Interaction between the atmosphere and the oceans". *Met. Mag., London*, **91**, 1962, pp. 209–224.

R. J. MURGATROYD, B.SC., PH.D., A.M.I.E.E.; The atmosphere between 20 and 80 km. *Aust. met. Mag., Melbourne*, No. 36, 1962, pp. 30–36.

R. J. MURGATROYD, B.SC., PH.D., A.M.I.E.E.; Cloud physics research International Conference in Australia. *World Met. Org. Bull., Geneva*, **11**, 1962, pp, 11–13.

E. KNIGHTING, B.SC., G. A. CORBY, B.SC. and P. R. ROWNTREE, B.A.; An experiment in operational numerical weather prediction. *Sci. Pap. met. Off., London*, No. 16, 1962.

E. KNIGHTING, B.SC.; Mathematics and meteorology. *Met. Mag., London*, **91**, 1962, pp. 49–53.

E. KNIGHTING, B.SC.; Numerical methods of weather analysis and forecasting. *World Met. Org., Tech. Note* No. 44, WMO No. 118, TP.53, Geneva, 1962.

E. KNIGHTING, B.SC.; Numerical weather forecasting in the British Meteorological Office. Proceedings of the International Symposium on Numerical Weather Prediction in Tokyo, November 7–13, 1960. Tokyo, Met. Soc. Japan, 1962, pp. 15–17.

E. KNIGHTING, B.SC.; Numerical weather prediction. Numerical solution of ordinary and partial differential equations. (Ed. L. Fox), London (Pergamon Press), 1962, pp. 478–493.

J. M. CRADDOCK, M.A. and R. WARD; Some statistical relationships between the temperature anomalies in neighbouring months in Europe and western Siberia. *Sci. Pap. met. Off., London*, No. 12, 1962.

R. FRITH, M.A., PH.D.; Air movement in the high atmosphere. *Times Sci. Rev.* No. 43, *London*, 1962, pp. 14–17.

R. FRITH, M.A., PH.D.; Ozone in the earth's atmosphere. *Contemporary Phys., London*, **3**, 1962, pp. 375–381.

R. FRITH, M.A., PH.D.; Rockets in meteorology. *New Scientist, London*, **14**, 1962, pp. 147–149.

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