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Meteorological Office

REPORT FOR THE YEAR
ENDING
31 DECEMBER 1961

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HER MAJESTY'S STATIONERY OFFICE
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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 1961

LONDON
HER MAJESTY'S STATIONERY OFFICE
1962

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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 three times in 1961.

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. G. E. Bell, O.B.E. (Ministry of Aviation)
Dr. A. C. Best, O.B.E. (Director of Services, Meteorological Office)
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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)
Dr. H. M. Wilson, M.B.E. (Ministry of Aviation)

Secretary: Mr. M. J. Thomas, O.B.E.

The Committee met twice in 1961 and its sub-committees twelve times.

ADVISORY COMMITTEE ON METEOROLOGY FOR SCOTLAND

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.

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Dr. A. E. M. Geddes, O.B.E., F.R.S.E. (University of Aberdeen)
Mr. W. O. Kinghorn (Department of Agriculture 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 28 November 1961.

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(on 31 December 1961)

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Assistant Director (Support Services)	G. A. Bull, B.Sc.
Marine Superintendent	C. E. N. Frankcom, O.B.E., R.D., Commander, R.N.R. (retd.).

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

SECRETARY, METEOROLOGICAL OFFICE
W. J. B. Crotch, M.A., A.K.C.

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FUNCTIONS OF THE METEOROLOGICAL OFFICE

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

The general functions of the Meteorological Office are:

(i) Provision of meteorological services to the Army, Royal Air Force, Civil Aviation, the Merchant Navy and Fishing Fleets.

(ii) Liaison with the Naval Weather Service of the Admiralty and provision of basic meteorological information for use by that Service.

(iii) Meteorological services to other Government Departments, public corporations, local authorities, the Press and the general public.

(iv) Organization of meteorological observations in Great Britain and Northern Ireland, and in certain colonies.

(v) Collection, distribution and publication of meteorological information from all parts of the world.

(vi) Maintenance of certain British observatories and publication and distribution of magnetic and seismological information obtained from them.

(vii) Research in meteorology and geophysics.

The Meteorological Office also takes a leading part in international co-operation in meteorology. The Director-General is the Permanent Representative of the United Kingdom with the World Meteorological Organization.

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

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

FOREWORD BY THE DIRECTOR-GENERAL

In February 1961, the Meteorological Office began to occupy the new Headquarters buildings, at Bracknell, Berkshire. By the end of the year most of the staff previously housed at London, Harrow and Dunstable had been transferred. The move, which went very smoothly is, I believe, an event of considerable significance not only for the Meteorological Office but also for the development of the science of the atmosphere in this country.

The war-time dispersion of the Headquarters units to three widely separated centres was recognized by Lord Brabazon's Committee in 1955 as a handicap to the overall efficiency of the Office. A combined headquarters, designed to meet the growing needs of the science, was clearly essential. The buildings at Bracknell, designed by the Ministry of Works, have been planned by meteorologists to satisfy both operational and research requirements. Key service units, such as the Central Forecasting Office and the Communications Centre, now occupy rooms specially designed for the purpose, the library is freely accessible and the new laboratories, wind tunnels, freezing chambers, workshops and drawing offices represent a notable advance on the facilities previously available. They should be adequate to meet foreseeable demands. In addition to a large, functionally planned stores, the Office now has, for the first time in its history, an experimental ground in open country a few miles from Bracknell.

With such facilities at its command, the Meteorological Office can face the future with reasonable confidence. Among the most notable features of the post-war period is the expansion of our activities in fields not specifically related to aviation which, since 1920, has been and continues to be our largest customer. In this Report the Director of Services gives an account of what are known as the public services. Many readers may be surprised at the wide field covered and it is gratifying to know that the work of the professional meteorologist has a marked influence on the economic well-being of the country.

Organized research within the Office began only about 14 years ago. The section contributed by the Director of Research shows how extensive and active it now is. The special topic selected for this Report—that of the forecasting of the dynamical features of the atmosphere for relatively short periods ahead by purely mathematical methods—indicates that meteorology is making considerable strides towards the goal of an exact (as opposed to a largely descriptive) science, but many difficulties remain to be overcome. Unfortunately the same progress cannot be reported in the notoriously difficult problem of long-range forecasting. The economic rewards of a significant break-through here, however, are so great that it has been thought justifiable to step-up the research effort, even if there are, as yet, few signs of the appearance of a real theory to guide the work.

For many years, the Meteorological Office has suffered from a lack of recruits to the Scientific Officer class. In part this arose because of a widespread shortage of young mathematicians and physicists, but undoubtedly the neglect of the study of the environmental sciences, especially meteorology, in British universities has contributed to the deficiency. I am happy to report that there are now signs that the tide is turning. In 1961 the Office was able to make up most of the deficiency in the Scientific Officer class by recruitment through the Civil Service Commission and otherwise, and we have reason to believe that this trend may persist. All things considered, the outlook for both the science and the profession is now brighter than at any time since the century began.

International work continues to take a great deal of my time and that of my staff. In addition to attending the annual session of the Executive Committee of the World Meteorological Organization in Geneva, I have acted as Chairman of a Working Group dealing with the revision of the Convention of the World Meteorological Organization.

O. G. SUTTON

THE DIRECTORATE OF SERVICES

1. Special Topic—Services for the Public

In recent years the Meteorological Office has devoted a great deal of effort to extending and improving the services that are provided for the general public and for organizations which serve the public—utilities, industry, commerce, farming and so on. In the country as a whole there are many activities, whether on a national, sectional or individual scale, which are affected by the weather to a greater or lesser degree and the Office has co-operated in such activities by studying the associated meteorological problems and providing the information or advice that may help to promote efficiency. The problems that have arisen are in many cases complex and require, on the part of the meteorologist, a close understanding of a customer's work as a preliminary to deciding the nature of the meteorological information that would best meet his requirements. It is believed that the Meteorological Office, in attempting to serve the community in this manner, can make a substantial contribution to the national economy.

This section is mainly concerned with forecast services because most of the requests for information received require a forecast of some sort or other. A future account will be devoted to that part of the Office responsible for meeting the substantial demand for climatological advice in connexion with specialized activities—estimates of extreme wind speeds for the design of structures, of maximum probable areal rainfall for the design of culverts, spillways of dams and so on.

Services for the General Public. Weather forecasts primarily for the information of the general public are issued several times a day through the press, BBC sound and television and the independent television companies. Forecasts covering the whole country, divided as necessary into a number of areas, are supplied to the national press every six hours. These are prepared at the Central Forecasting Office at Bracknell, are issued through the Weather Centre in London and are also copied by teleprinter to all forecasting offices in the country. Provincial newspapers, which require forecasts for a region rather than for the whole country, are served by main meteorological offices in their own areas which use as guidance material the nation-wide forecasts issued from the Central Forecasting Office.

Broadcasts in sound from the BBC contain a large number of weather forecasts throughout the day and these again are issued mainly from the Central Forecasting Office. However, main meteorological offices distributed throughout the country make important contributions to the forecasts, based on their knowledge of local or regional characteristics of the weather. A popular feature of sound radio is the Light Programme broadcast of " Your holiday weather " at 8.55 a.m. during the summer half-year. This broadcast is made from the London Weather Centre and, besides discussing the weather of the day on an area basis, gives the conditions to be expected at the main sporting and other outdoor events.

Television provides scope for personal presentation of weather forecasts and this was quickly recognized by the BBC. For some years now a forecaster of the London Weather Centre has appeared before the cameras each night and, with the aid of actual and forecast weather maps, has described the day's weather and given a forecast for the night and the following day. This programme is greatly valued by farmers, horticulturists and mariners. The independent television companies also receive forecasts from the Meteorological Office and two of these companies have their own " weather men " to give personal presentations.

Weather forecasts issued through the press and over sound and television broadcasts are necessarily limited as to length and time and in consequence have to be phrased in fairly general terms. Although the country is subdivided for these forecasts, each area may include several counties and thus anything in the nature of precise forecasting for small localities is not practicable. This limitation of the broadcast and published forecasts may not be important to those, for example, who have to go to their offices anyway and merely wish to know whether or not to carry an umbrella. On the other hand there are many groups or individuals whose plans could be better organized or suitably amended if advance information about the weather, with detail as to timing, were available about the places or areas of practical interest. It is to help such people or organizations that the Meteorological Office has made more widely known the help that it could provide over a wide range of activities and has invited the public to make greater use of the state weather service. At the same time existing contacts with public boards, firms and individuals were reviewed in order to verify that their meteorological requirements were being adequately catered for.

This deliberate expansion of public weather services was carried out through the London Forecasting Office and a number of aviation forecasting offices in various parts of the country. The London office was originally an offshoot of the Central Forecasting Office, which had its location in Dunstable before moving to Bracknell in 1961, and was the agency through which forecasts prepared at the Central Forecasting Office were issued to the press, the BBC and so on. In 1959 the London office moved into ground floor accommodation, with a shop window for the display of current and climatological data, and became known as the London Weather Centre. The aviation forecasting offices which undertook to answer inquiries from the public were given an agreeable measure of publicity. Their addresses and telephone numbers had, of course, been included in the " Post Office Guide " and also in local telephone directories some years earlier. This facility has proved popular and at the end of 1961 there were altogether 36 " Post Office Guide " stations but, in addition, some 60 other aviation forecasting offices have acquired contacts with the public and are receiving their weather inquiries.

The total number of requests from the public for weather information has been increasing every year. In 1956, the total for the whole country was just over a quarter of a million and in 1961 the number exceeded half a million. The range of inquiries is wide. Agriculture, farming and market gardening account for about 50,000 inquiries each year, with the maximum demand in June and July. Industrial concerns made 20,000 inquiries in 1956 and a steady increase brought the 1961 figure to about 35,000. Public utilities now make over 50,000 inquiries a year and other large customers include the press, shipping interests, road transport firms and sports organizers.

The growth in the total number of inquiries would undoubtedly have been greater still but for the inauguration, beginning in March 1956, of the automatic telephone weather service (A.T.W.S.), which is now available in sixteen major towns and provides local area forecasts which are changed every six hours, or more frequently if the conditions justify. Forecasts for coastal strips in south-east England are also available on the London exchange and, as part of the Teletourist Service, forecasts for the London area may be obtained on the A.T.W.S. in French, German and Spanish. In the past year the number of calls on the A.T.W.S. exceeded five and a half million.

An important development in the handling of public inquiries, and thereby taking some of the load off aviation forecasting offices, was the establishment of weather centres. The first of these was opened in London in September 1959 and soon afterwards other weather centres appeared in Glasgow and Manchester. A fourth centre was opened in Southampton in December 1961. The weather centres, located in busy shopping areas so that the window displays have a substantial impact, provide the public with easy access to a forecaster for personal discussion of their inquiries about the weather. Each of these centres was an immediate success both from the volume of business attracted and from the interest and variety of the problems that have arisen.

Mention has already been made of the wide range of activities covered by the half million or so inquiries now received from the public each year. A few examples will show that meteorological information may be applied to economic advantage. The Marine Superintendent of a shipping line inquires about wind speed in the port area for the next few hours and, on the answer received, decides how many tugs to employ for the arrival of a liner. In winter, a building contractor may save a considerable sum if he is advised accurately about the chances of frost each night. Confectionery manufacturers may wish to be warned about the onset of periods of high humidity so that processing may be deferred and the loss of perhaps thousands of pounds avoided. Nurserymen are always alive to the hazards of weather and, given accurate and timely advice, can take precautions whenever they are necessary instead of all through a season.

Many of the services are available to the public without charge, but routine supplies of information and the provision, when appropriate, of warnings of adverse weather are normally subject to payment. Charges are also made for information which requires a special study or analysis of data. Many users of the meteorological service do in fact require specialized advice and how this is provided may best be illustrated by describing the work that is done for public utilities and local authorities.

Services for the Central Electricity Generating Board (*CEGB*). It is fairly obvious that there should be a relation between the weather, especially the temperature, and the electricity load, and this is simply illustrated in Figure 1. The two lines show, in half-hour steps, the total load over England and Wales on two consecutive Thursdays early in 1956. On 26 January the weather was cloudy with a moderate south-westerly wind; on 2 February it was cold and sunny with little wind. Over the country as a whole the temperature was about 14° F higher on the first of these days than on the second one and the difference in load between the two days was about 2,000 megawatts, 15 per cent of the basic load. It may be inferred then that a temperature difference of 1° F is equivalent, over the whole of England and Wales, to about 140 megawatts, roughly the output of two of the smaller power stations. Changes in demand resulting from variations in the temperature of the air are therefore

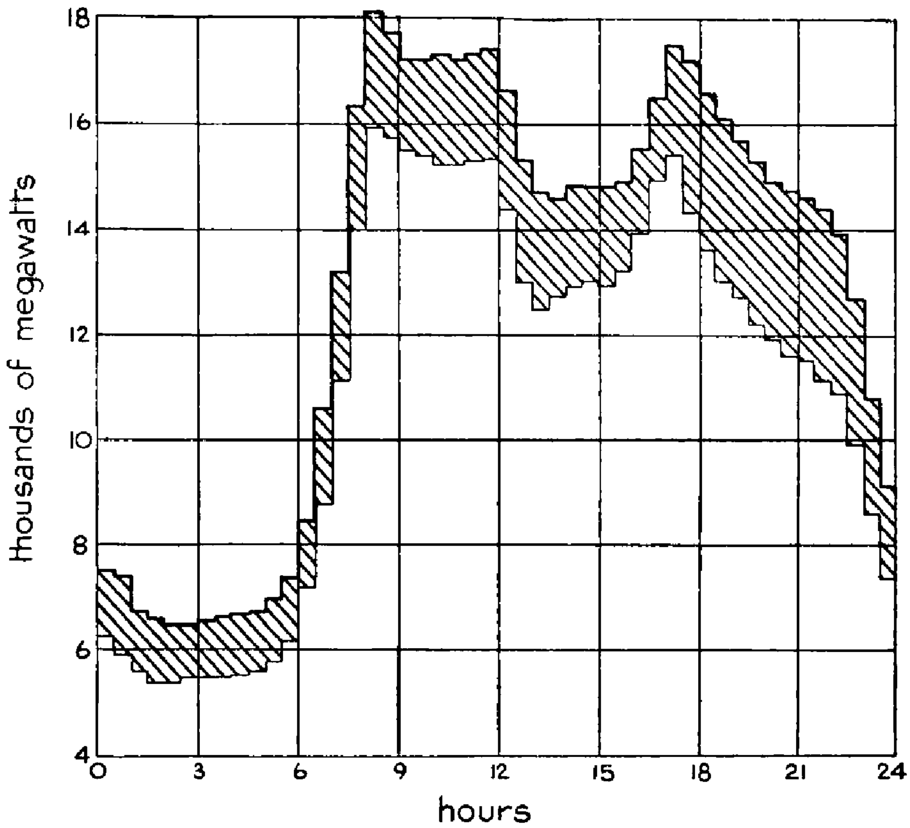


Figure 1—Daily curves of national electricity load
The thin and thick lines refer to 26 January and 2 February 1956 respectively.

	Time (hours) 0830	1200	1730
	average temperature		(° F)
Thursday, 26 January 1956	36	39	42
Thursday, 2 February 1956	22	24	20

of prime importance to CEGB and their staff require early notice of such changes so that the necessary adjustments to the load may be made.

Temperature, however, is not the only meteorological element affecting the consumption of electricity. Wind, cloud amount, fog, and rain (or snow) all exert some influence; strong north-easterly winds may increase the load by 5–10 per cent in London and East Anglia; thick low cloud may add nearly 10 per cent to the load, and continuous rain might add another few per cent. Thus the forecasts prepared for the electricity authorities include most weather elements and there is a heavy premium on accuracy and reliability.

It would be wrong to assume that forecasts for CEGB are required only in the winter half-year. The British climate ensures that the summer is not free from sharp variations. Figure 2 illustrates the effect of thick cloud spreading over London on an afternoon in mid-July. It will be seen that for two consecutive days the electricity loads were markedly different, especially in the early afternoon when, on the second day, the presence of a thick cloud accounted for an increase of about 700 megawatts. It has been estimated that about a third of this increase resulted from the lower temperature and the remainder from the diminution of daylight which caused millions of Londoners to switch on their electric lights.

Another aspect of summer operation which causes concern to CEGB is the risk that overhead cables may be struck by lightning. It is desirable, from the point of view both of safety and of continuing supply, that cables exposed to serious risk should be taken out of service until the danger is over. Measures such as these are costly, the more so if prolonged, and the forecasters have to exercise a nice judgment because erroneous advice may be expensive in more ways than one.

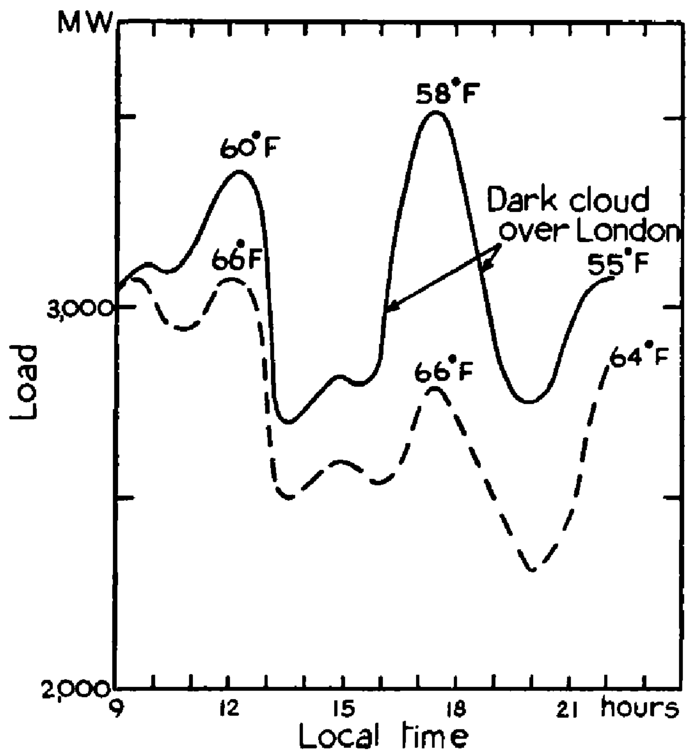


Figure 2—Electricity load for the London area, 16–17 July 1958
—— 16 July 1958 - - - 17 July 1958

A fairly new application of meteorology in the electrical industry is concerned with experiments on " bulk heating " which have as their objective the greater use of generating plants during the early hours of the morning when consumption is at a minimum (see Figure 1). These experiments call for forecasts of mean temperatures and mean winds over periods of some hours and, if successful, could lead to reductions in electricity demand at peak hours.

The Gas Council. The gas industry was early in the field seeking the collaboration of meteorologists. Since World War II the methods of producing and distributing gas have changed to a marked degree and now a far smaller proportion of gas is stored. For example, the North Thames Gas Board, one of the largest in the world in pre-war days, stored approximately 62 per cent of its peak load of 265 million cubic feet a day. Now, by using methods which are basically similar to those of the electricity industry and dependent on weather forecasts, this particular board need store only 43 per cent of its new peak load of 420 million cubic feet daily. This represents a saving of 19 per cent storage space, equivalent to that for approximately 80 million cubic feet, for which the capital cost alone would have been considerable.

At the present time 25 gas control-rooms spread all over the country are provided with forecasts, the work being shared among eleven meteorological offices. Controllers receive once a day, and in some cases twice daily, forecasts of temperature, wind, precipitation, etc. In an essentially urban area such as

London the only significant variable is temperature, but in rural districts such as East Anglia wind speed also is of importance—it is said that an increase of one force on the Beaufort scale increases consumption there by an amount equivalent to that produced by a temperature fall of 1° F. The gas industry attaches great importance to precise estimations of consumption and it is understood that the manufacture of even one per cent of gas surplus to requirements is regarded as wasteful.

There is one form of forecast which is perhaps unique to the gas industry. In some parts, notably in South Wales, gas is drawn direct from the coal face in the mines. Here atmospheric pressure is of importance and warnings of any significant changes that are expected have to be given by appropriate meteorological offices.

The British Transport Commission. The running of trains operated by the six Regions of British Railways and by the London Transport Executive (Underground services) is directed from about 50 control rooms each advised of significant expected weather by one of twelve main meteorological offices. In general only a warning service is provided since, unless the weather departs very much from normal, trains can continue on their tracks without much trouble. The effect of poor visibility on transport is so well known that little need be said on fog warnings except, perhaps, to mention that warnings of fog expected on a particular morning should, to be really useful, be given by about 3 p.m. on the previous afternoon, early enough to enable the necessary administrative steps to be taken to mobilize fog gangs and to notify train crews of altered rosters. Since it often takes several hours for a fog time-table to be unscrambled and turned into a normal schedule even if the weather does improve it is obviously essential that false alarms should not be given.

In some places, especially along exposed coastal strips, strong winds can carry spume from high seas on to the railway tracks. Strictly speaking the Meteorological Office does not directly warn the railways of floods of this nature. Since, however, it has been found that electric signalling can be put out of action by even small amounts of spray, controllers are apt to seek forecasts of its occurrence and to discuss with forecasters side effects of strong winds.

Overhead conductors on some electrified sections of railway lines are, like those of the Electricity Authority, susceptible to lightning strikes. Although it is not customary to put them out of action during thunderstorms, controllers have to be warned of the probability of lightning in order to protect maintenance workers from danger.

Perhaps one of the most difficult hazards to forecast and yet one highly troublesome to the operator is the icing of electrical conductors. The freezing of moisture, either of rain or of fog, on the overhead lines can be of some nuisance but that on " third rail " conductors may well cause a complete disruption of services. The " third rail " is used over much of the Southern Region, at least from Portsmouth and Reading eastwards to the Kent coast, while two conductor rails are found on the Underground system. Special precautions are taken whenever the risk of " RAILICE " is sufficiently high. Electric locomotives are kept running all through the night to help spread de-icing fluid on the rails and this entails not only the rostering of train and signal-box crews but also keeping the current on during the night with consequent reduction in track maintenance work. The cost in de-icing fluid alone may well be of the order of £1,000 a night. The forecasting of RAILICE cannot always be made with the greatest confidence. It has been found over an area the size of Greater London, for example, that night minimum temperatures may vary, on any one night, over a range of up to 20 °F—a spread of 10–15° is quite common. The forecaster, therefore, is faced with the problem that over the area he is considering there will be some places where it will remain relatively mild during the night; at others any water on the rails will freeze. As a working rule an average screen minimum temperature of 37° F or below is taken as being likely to result in sub-freezing temperatures somewhere in the system, the risk varying from " nil " in the case of expected dry rails to " strong " when heavy precipitation or

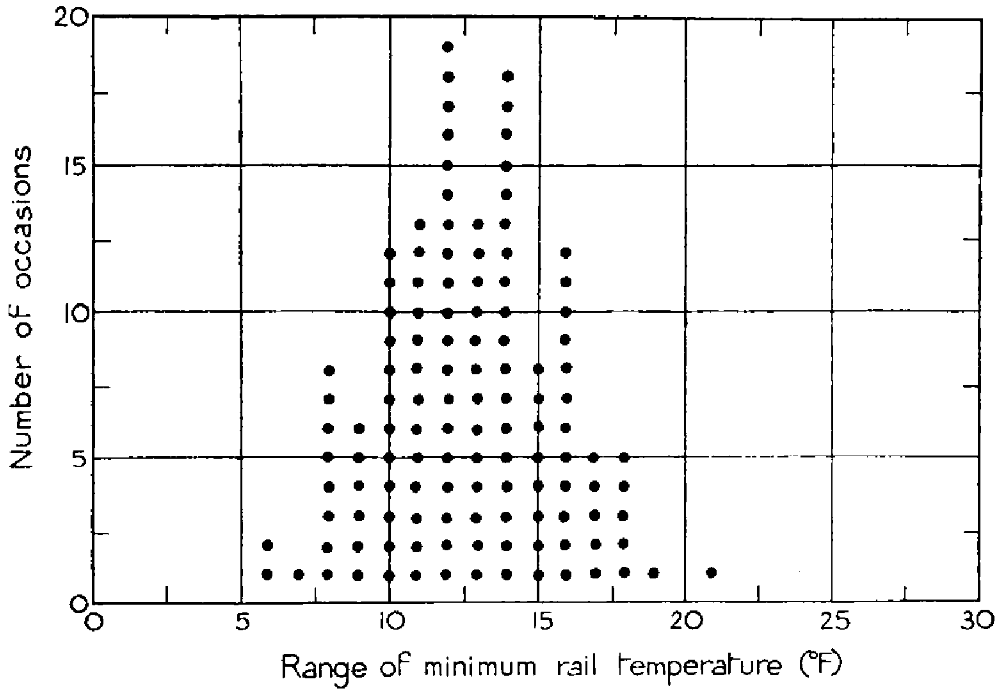


Figure 3—Distribution diagram showing numbers of occasions on which particular ranges of minimum temperatures were recorded over London Transport Executive railways (overground sections only) during the winter of 1958–59

considerable depth of lying snow is forecast. On receipt, every afternoon in winter, of RAILICE risks the controllers decide, according to the area being considered, whether to take de-icing action or not. An accurate " nil " forecast may well save several thousands of pounds but, correspondingly, a failure to forecast a strong risk when rail icing does subsequently occur will result in interference with the movement next morning of hundreds of thousands of commuters.

The association between forecasting and railway staff, made close by daily consultations, is often productive of much good-will. In some cases a controller will arrange for signalmen all along a main line to report, on a link-up telephone call, the visibility as measured from their several boxes. Such information is obviously of much value in supplementing the ordinary synoptic reports received from airfields and from more routine sources.

Local Authorities. Snow and ice can be just as great a hazard on highways as on the railways and most county, urban or rural districts take steps to reduce this effect or, in the case of snow, to clear it. For some years the Meteorological Office has operated a scheme of notifying risk of " certain road dangers ".

Year by year an increasing number of authorities subscribe to this service which involves about 15 forecasting offices. Here again warnings have to be issued well in advance and normally they are timed to reach the various road engineers by about 4 o'clock in the afternoon. The number of customers is so great, however, that notification is often, by arrangement with the General Post Office, given by block telegram.

The difficulties mentioned in connexion with RAILICE forecasting are also experienced with the anticipation of ice on roads. Certain road hollows are particularly susceptible to the collection of ice and other sections are liable to suffer from drifting snow. In many cases precipitation which is observed as rain at lower levels falls as snow on higher parts of a local authority's area. That a London borough may well spend on snow clearance and in gritting icy roads a sum of £2,500 in the 24 hours following a heavy fall of snow is some indication of the importance attached to this problem by municipal surveyors and engineers.

Medium-Range Forecast Services. So far mention has been made only of forecasting services covering mostly periods of but a day or so ahead. Forecasts published in the press, by radio and television or by automatic telephone seldom look further than 24 hours, or as outlook, 48 hours ahead. Beyond such a period precision and accuracy fall off very rapidly.

Nevertheless there are increasing demands for forecasts in the middle range, i.e. covering three or four days. Perhaps the largest number of users of such information are those farmers who subscribe during the summer months to the " fine spell " service. In 1961 over 700 individual farmers were registered and received notification, according to the location of their farms, whenever a period of 72 hours without measurable rain was expected. Further telegrams were dispatched to them when the dry spells were thought to be terminating. Thousands of telegrams were sent during the summer of 1961. It may be taken as satisfactory that requests for a similar service in 1962 were being made before the end of the previous harvest. As an interesting contrast to the needs of farmers, one large industrial subscriber to the " fine spell " service wanted the advice for an opposite reason. A chemical manufacturer whose processes depended on a copious amount of water and whose reservoirs were running low was only able to recommence operations when rain, in large amounts, had been promised for three or four days ahead.

Among other users of medium-range forecasts are food manufacturers, especially those making and distributing ice-cream, the consumption of which depends very much, although not always directly, on the weather. Although ice-cream is made, and eaten, throughout the year, the amount sold is closely related to the temperature. It has, in fact, been estimated that during the holiday period a difference of temperature of 1° F over the country as a whole affects total sales by about £150,000 a week, a figure large enough for the manufacturers to study very carefully any correlation factors and to make every effort to obtain the best and most reliable meteorological advice. The time-scale of manufacture and sale is such that what is really needed is a system of forecasting for a month ahead but, in the absence of this, the use of four-day forecasts enables operational decisions to be taken, especially on the distribution side. Retailers' powers of holding such a perishable commodity are not unlimited and, in any case, extended cold storage is expensive (and in the case of best quality ice-cream not always entirely desirable) and therefore it is the aim to provide a steady flow between factory and consumer, wherever he is and when he needs the food. Attempts, not as successful as the forecasters themselves would wish but nevertheless worthwhile to the customer, have been made to forecast for certain agreed localities over the country the maximum temperatures and sunshine hours expected for day 3 and day 4 from time of issue. Information as to actual temperatures experienced in each locality is passed at frequent intervals to the various company statisticians who attempt to correlate sales with temperatures for the purpose of anticipating requirements for various weather conditions.

Conclusion. The Meteorological Office has already done much to place its specialized knowledge at the disposal of the community but there are probably many fields, as yet unexplored, in which meteorological advice could be applied with economic gain. The Meteorological Office therefore welcomes inquiries from industrial or commercial interests which may feel that some at least of their special problems have a bearing on the weather. At the same time the Office is fully aware of the great importance of improving the accuracy of its forecasts and of extending their periods of validity up to a week or more ahead.

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 for either forecasts of weather or for climatological information. For this reason some assistant directorates are concerned directly and almost exclusively with services in one or other of these two categories. Others are concerned primarily with the provision of data and facilities without which the forecaster and climatologist could not do their jobs. 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. A greatly amplified account of one category of work in the Services Directorate is given in Section 1, the subject this year being " Services for the public ". Important events and innovations during the year are described in Section 3, and Section 4 contains notes on the weather of 1961. 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, mainly 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 the Headquarters of a RAF Group and control and advise subsidiary offices at RAF stations in the Group. At these subsidiary offices a forecaster is available at times which depend on the needs of the Royal Air Force. At observing offices there is no forecaster and the duties comprise the making and issue of weather observations. At RAF 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 main offices at air traffic control offices and on major civil aerodromes, subsidiary offices at civil aerodromes of intermediate importance and observing offices at some minor civil aerodromes. To meet the need for observations at aerodromes where there is no meteorological office, training is given to Air Traffic Control Officers and to Flight Information Service Officers in the making and reporting of weather observations. The functions of the main offices include not only the provision of forecasts to pilots before a flight but also the provision of forecasts, warnings and observations to aircraft in flight.

Overseas meteorological services for civil aviation are provided at a number of joint user (i.e. 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 last-named having been opened in December, 1961. 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 and Northern Ireland. 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.

The rainfall and hydrology section, in addition to supplying information and advice on rainfall and evaporation and more general hydrological problems in which these elements are important, also supervises and inspects co-operating rainfall stations maintained in Great Britain and Northern Ireland by local government and other authorities. Liaison is maintained with many organizations and establishments which are active in the field of hydrology or in civil engineering where hydrology is involved.

Another section of M.O.3 is responsible for the supply of meteorological advice and information relating to all aspects of climate other than rainfall and agricultural matters. In addition to dealing with the data received from official stations, this section also supervises and arranges for the inspection of co-operating climatological stations in Great Britain and Northern Ireland.

To a large extent the office at Edinburgh deals in 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.

The Marine Branch also analyses ships' 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 and Trinity House organizations and other authorities. To obtain information about the upper air, a network of combined radio-sonde and radar-wind stations is also maintained both in the United Kingdom and overseas. In addition meteorological reconnaissance flights are made over sea areas around the British Isles by Hastings aircraft of No. 202 Squadron of the Royal Air Force, based at Aldergrove. Thunderstorms can be located by means of a network of radio direction-finding stations. Four linked stations in the United Kingdom can locate thunderstorms up to a distance of about 1,500 miles, and a similar network has been developed employing stations in Gibraltar, Malta and Cyprus.

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 teleprinter, 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 the *Handbook of Meteorological Instruments*.

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 installations are widely used by all the research and climatological services branches of the Office. The computer operates with punched paper-tape and a card-to-tape converter provides a link between the punched-card store and the computer. The possibilities of applying the latest electronic computing machinery and data storage media, such as magnetic tape, are being actively studied.

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 17 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. 52).

Considerations of the 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

Central Forecasting (*M.O.*2). The transfer of forecasting services from Dunstable to Bracknell took place on 30 September. Communications facilities were duplicated for a time and it was thus possible to operate the old and the new forecast room simultaneously during the morning of that day. Bracknell then assumed forecasting responsibility in the early afternoon without any break in the service.

The forecast room at Bracknell, located on the top floor, adjoins the editing room and also has communication with the teleprinter room and the facsimile room on the floor below. The *Daily Weather Report* and associated publications are prepared in another adjoining room, the printing being done elsewhere in the building. Nearby on the top floor is the conference room, where a daily discussion is held on the outcome of recent forecasts and likely weather developments over the next few days. Most of the equipment and furniture of the new quarters was specially designed.

Aviation Services (*M.O.*6). There was no major change during the year in the pattern of outstation meteorological service for aviation.

When British Forces were moved temporarily into the Kuwait area during the summer a meteorological office staffed by United Kingdom based British personnel was opened at the airport and maintained there until the withdrawal of British Forces. The staff worked very hard under arduous conditions to provide an efficient service for the Armed Forces operating in the area.

During the year a number of long flights by RAF aircraft, some involving in-flight refuelling, has taken place between the United Kingdom and distant bases. Meteorological service has been provided for these flights, in some cases entirely from British meteorological offices. In other cases meteorological services of Dominions, Colonial territories and of foreign governments have co-operated fully in providing the required services. The longest non-stop flight for which service was provided was that of a Vulcan bomber aircraft from Scampton, England to Sydney, Australia in June.

On occasions the meteorological office at Gibraltar has made operational use of cloud information obtained via American sources from TIROS satellites which were in orbit around the earth at times during the year.

The forecasting office at Southampton Airport (Eastleigh) was closed and all staff withdrawn on 10 April, following the sale of the aerodrome to Southampton Corporation by the Ministry of Aviation.

A number of new procedures for civil aviation previously agreed internationally were introduced during the year. The most important were the introduction of modified forms for aircrew documentation, and the substitution of area meteorological watch for individual flight meteorological watch procedures for aircraft flying on North Atlantic routes. Area meteorological watch is supplemented by an en-route forecast service.

On 13 April 1961 the system of United Kingdom VOLMET meteorological broadcasts, using radiotelegraphy (morse) was withdrawn. The system had for many years been the basic method of providing regular broadcasts of meteorological information for aircraft in flight. It has been replaced by a system of radiotelephony (speech) broadcasts. This followed the general move by airline companies to dispense with radio operators for flights in the European-Mediterranean region.

General Services (*M.O.7*). A new weather information centre was opened in Southampton in December to take over the public service work of the meteorological office at Eastleigh Airport which closed earlier in the year. The number of inquiries handled by the London Weather Centre was about the same as in 1960 but there was a marked increase in inquiries in Manchester and about a 100 per cent increase in Glasgow. The scheme whereby weather charts and forecasts have been supplied by the London Weather Centre to ships leaving the London Docks has been extended to Merseyside, the Clyde and Southampton.

The outstanding event in the distribution of forecasts by BBC television was the experiment in weather presentation during the last three months of the year. This involved presentation at close-down, but this proved too late for many viewers, and in particular specialist viewers, and it reverted to early evening with effect from 1 January 1962. The experiment was successful in giving the " weather men " more time for their presentation and freedom to experiment. Regional forecasts were also introduced to BBC Television at the beginning of October.

Three new independent television companies commenced operation and are receiving regular supplies of forecasts. Weather forecasts are now presented personally on Anglia Television by their own meteorologist; Anglia Television Centre is linked to the Meteorological Office facsimile network and also receives forecasts from the Central Forecasting Office by TELEX. Scottish Television increased its weather coverage during the year, and is now served by the Glasgow Weather Centre. Responsibility for forecasts for Granada and Tyne-Tees Television was transferred from London to the Manchester Weather Centre, and for forecasts for Southern Television from London to the Southampton Weather Centre during the year.

The upward trend in the use of the automatic telephone weather service continues. A new service was introduced in Southampton, and plans have been completed for coverage of the Lancashire coast. The twice-daily forecast for the London area, designed for tourists and hitherto available in French and German, is now available also in Spanish.

Meteorological services for the Army continued on much the same scale as in the previous year. The training of certain Army units to perform their own meteorological work continued, and the scope of the work has been widened.

Investigational work in agricultural meteorology has covered such subjects as plant and animal diseases, milk yields, shelter, frost liability, soil temperatures, soil climates under mulches, horticultural surveys and irrigation. A progress report on agrometeorology during 1958 to 1961 was written in preparation for the World Meteorological Organization Commission for Agricultural Meteorology in Toronto in 1962.

Climatological Services (M.O.3). One of the great problems in climatological services is in checking and examining the vast amount of data received and also in processing the data for application to specific problems. Punched cards have been used for recording upper air data and marine surface data for many years and were introduced for surface climatological data from land stations in 1957. The building of a sufficient library of data in a form suitable for machine processing is undoubtedly going to aid the work of application in the future. Although machine quality (accuracy) control of climatological data has not yet been done in M.O.3, as indicated in the last Report experiments have been going on in respect of rainfall data using punched tape and the electronic computer METEOR. The trials and necessary administrative arrangements progressed sufficiently well this year to enable a decision to be made that quality control of rainfall data and the production of statistics for publication purposes by use of punched tape and METEOR will commence as a routine for England and Wales with effect from the January 1962 data. As can be seen from Table 12 in Section 5 (p. 37), the number of inquiries of a climatological nature received in M.O.3 (including Meteorological Offices, Edinburgh and Belfast) continued at a high level. Amongst the tasks involved by these inquiries the most important of a hydrological nature was the completion of the work on the estimation of maximum probable precipitation over the basin of the Blue Nile in Ethiopia down to Roseires in the Sudan, in connexion with the design of spillways for a dam at Roseires. The most important problem of a climatological nature, handled as a joint project with other branches of the Office, concerned likely weather hazards on various possible routes for the projected M.6 motorway from Lancaster to Penrith. This latter project involved analysis of data from some 23 short-period *ad hoc* reporting stations, and the extrapolation of these observations to the likely average conditions in respect of fog, icing and snow.

Marine Branch (M.O.1). The British ocean weather ships completed 14 years of service in the North Atlantic during the year. In May *Weather Recorder*, the third of the original British weather ships (formerly " Flower" class corvettes), was withdrawn from service to be replaced by the former " Castle " class frigate H.M.S. *Pevensey Castle*, now renamed *Weather Monitor*. In December *Weather Watcher*, the last of the older ocean weather ships, was replaced by *Rushen Castle* now renamed *Weather Surveyor*. The conversion of these two ships was done by a shipyard at Blyth (Northumberland). The " Flower " class vessels, which have now been disposed of, did a very good job and were economical to operate. Their successors are giving a successful service; being larger they provide roomier and more comfortable accommodation, and their communication facilities are better.

Since 1 July hourly surface observations have been made at ocean stations " A ", " I ", " J ", " K " and " M ", instead of three-hourly as was the case previously.

During a severe depression at station " India " in September, meteorologists aboard *Weather Reporter* regularly carried on with their upper air observations (radio-sonde and radar-wind) when winds of 76 to 90 knots were being experienced. This job involves launching a 9-foot diameter balloon with instruments attached; a very difficult job in a small ship in such bad weather.

In December, the Port Meteorological Office in Southampton was moved from the docks to the new Weather Centre at 160, High Street.

Some 1,000 meteorological logbooks were received during the year from ships of the voluntary observing fleet and scrutiny of these has shown that a high standard of observing has been maintained. Four barographs were awarded to masters of merchant ships for long and consistently good observing work and books were awarded to the master, senior observing officer and radio officer of the 100 best observing ships during 1960.

Ocean current and sea ice data for six volumes of Admiralty Sailing Directions were revised. The texts of the meteorological standard articles hitherto published in the separate volumes of the Admiralty Pilots were revised for the new " Sailing Directions Handbook ", and a concise ice nomenclature with photographs and a chart of ocean currents was supplied for the same volume.

Observations and Communications (*M.O.5*). The message editing and communication centre was transferred from Dunstable to Bracknell on 30 September. The success of this complex task was largely due to the co-operation of Post Office officials and engineering staff.

Approximately one fifth of the coded data reaching the Bracknell communication centre is available by radio only and only by radio can facsimile transmissions of other countries be received. Since only limited radio reception is possible in Bracknell, this work will temporarily remain in Dunstable where it is being rehoused in the former Napier Shaw Research Laboratory. Plans for the transfer to the Army Wireless Station, Bampton, of radio-facsimile and radio-teleprinter reception will be implemented by the end of 1962, and at the same time the radio operation of traffic with ocean weather ships will be transferred to Bracknell. Morse reception of meteorological broadcasts, a system which is expected to fall into disuse, will remain at Dunstable until the volume of such traffic becomes very small. Land-lines will link these remote reception points as necessary with Bracknell.

The conversion from morse to radio-teleprinter operation of the two meteorological broadcasts for which the Office is responsible was completed in March.

To the home facsimile land-line network 34 stations have been added during the year. The total number of locations so connected is now 77. To solve the problem of technical maintenance of outstation facsimile recorders a scheme was agreed and is now being implemented by which this task will be undertaken by an augmented technical staff at radio-sonde stations, and by one specially manned unit. The original scope of the scheme has been enlarged to treat other electrical apparatus at outstations also.

For reasons of finance, of cleanliness in handling and of saving of time, advantage was taken of the commercial availability of chemically treated paper for providing simultaneously multiple copies of teleprinter traffic. This paper has now replaced the bulk of carbon interleafing formerly used in signal traffic in the meteorological communications centre.

The automatic apparatus for recording radio-sonde observations introduced in 1960 at home stations has, in 1961, been installed at overseas stations. Plans are complete for its installation on weather ships too.

With the co-operation of various external agencies, 14 new auxiliary observing stations in the United Kingdom manned by non-Meteorological Office personnel have been established. These now total 89 compared with 114 observing stations manned by the Office.

To establish a closer liaison between road users and forecasting offices, limited observations from 16 town offices of the Automobile Association have been arranged.

Agreement was obtained to purchase officially the site at Ross-on-Wye from which weather observations have been recorded for the past 102 years.

The central control station of the thunderstorm location land-line network in the United Kingdom was transferred, with no break in the series of observations, from Dunstable to the Experimental Site, Bracknell on 30 November. Further trials have been made using thunderstorm location equipment at Malta, Gibraltar and Nicosia, both in conjunction with the United Kingdom network and independently, with the aim of improving the coverage of observations of thunderstorm location over the Mediterranean, North Africa and the Near East.

Support Services (*M.O.*18). The library, sub-editing section and cartographic drawing office moved to Bracknell in April and the punched-card installation in August. The library had to be closed for normal services for three weeks at the time and the punched-card installation for about six weeks. Only a small proportion of the machine operators and assistants in the punched-card installation moved with it but replacements were recruited and began training at Bracknell from April onwards with such success that by the end of the year the installation was operating at nearly full efficiency once more.

Control of the electronic computer METEOR was taken over from M.O.11 (Dynamical Research) in October and first steps were taken towards putting into force already drafted plans for the provision of central computer programming facilities.

The practice of varityping for subsequent photolithography of certain publications which would otherwise have been typed at Her Majesty's Stationery Office was begun, by agreement with HMSO, in the editing section. This method gives better technical control over the varityping.

On the archives side, plans were drawn up to regularize the arrangements for the selection of records and administrative papers for permanent retention in accordance with the Public Records Act 1958 and to provide for the central control of the existing archives. The latter will come under the direct control of M.O.18 on their transfer to Bracknell from Harrow and Dunstable early in 1962.

Techniques and Training (*M.O.*8). Special observations were made during the winter of 1960–61 at about a dozen offices situated on hilly terrain to test various hypotheses concerning the formation of fog at high-level stations. An analysis of the data gave some support to the theories, but more information will be needed before firm conclusions can be reached.

The delay in clearance of rain and low cloud behind certain cold fronts is a problem at some offices. Twenty-five occasions were analysed in detail and possible mechanisms were proposed for testing.

Charts showing the detailed spatial distribution of rainfall in selected synoptic situations have been issued to all forecasting offices in the areas which have been mapped. These charts were compiled by investigators at outstations from data supplied by M.O.3. Similar charts for snowfall were prepared and distributed; to increase the density of observations, reports of snow from official observers were supplemented in some cases by reports from locally-recruited observers.

The investigation into the formation of fog and low cloud over the Fens was continued, private observers again making reports. The tentative conclusions reached last year were largely corroborated.

Following a study of the relationship between surface and geostrophic winds at London (Heathrow) Airport, Manchester Airport and Prestwick, an examination of a similar relationship but including the effect of temperature lapse rate, is being carried out for ocean weather station " Juliett " and London (Heathrow) Airport.

A pilot investigation into the structure of sea-breezes and their associated convergence zones was carried out on four selected days in August and September. Observations from ground stations, balloon ascents and aircraft traverses were concentrated into three-hour periods on a 60-mile line normal to the south coast. Results are being analysed.

The programme of training courses continued throughout the year according to the pattern arranged for 1960. The major event was the temporary suspension of courses for Scientific Assistants in November brought about by a shortage of members in this class of staff. A time-lapse cine camera is being used at the Training School to make a colour film of cloud phenomena. A number of 100-foot reels have been shot and the material is being edited to produce a film of about a half hour's duration to serve as a training aid.

During the winter, except in November, monthly discussion meetings were held at the Royal Society of Arts, the topics being medium-range forecasting, gliding, the high atmosphere, jet streams and climatic variations.

A. C. BEST

Director of Services

4. NOTES ON THE WEATHER OF 1961

The weather of 1961 had no outstanding major feature comparable with those of its immediate predecessors—in England and Wales, July to November 1960 had a general rainfall higher than any corresponding five-month period for over two hundred years, whilst May to September 1959 was probably the driest such period in the same length of record.

In most of the country the weather of the early part of the summer was better than that of the latter part. Other features of the weather worthy of special mention were: February 1961 was the mildest since 1901 in England and Wales, and an unusually severe gale late in the month gave a gust of 101 knots at Tiree; the dry March except in Scotland—by late in the month parts of southern England had had no measurable rain for 30 days; the damaging frosts in late May; the severe gale in Ireland and the north of Britain in mid-September, when mean hourly wind speeds exceeded 60 knots in some places, and gusts reached 90 knots; the very cold Christmas period followed by snow later in December—heavy falls in the north were followed by up to one foot in parts of the Midlands and south of England on the last day of the month.

The Weather, Month by Month. January—The weather was mostly cyclonic and changeable in character during the first two weeks and became stormy during the last few days of the month. Anticyclonic spells during the third week or so gave some dry, cold weather. In Scotland the month was drier and sunnier than average.

February—The month was unusually mild, but wet on the whole. The predominantly cyclonic character of the weather contributed to the mildness but during the third week an anticyclone centred over Germany brought very mild air from the south and a welcome dry spell. Gales were frequent during the first and last weeks.

March—For much of the month an anticyclone was centred over or near the south of the country. This resulted in mild, dry and often sunny weather, especially in the south, though northern Scotland did not fare so well. A northerly outburst on the 17th–18th brought maximum temperatures in the south down by 10° C (18° F) within two days and, although this colder weather was short-lived, maximum temperatures in England did not again reach the level (about 20° C, or 68° F) attained around the middle of the month. By late March parts of southern England had had no measurable rain for 30 days.

April—This month was dull and wet—a reflection of its predominantly cyclonic character. Northern Ireland had more than twice its average rainfall. Although the month began cold in Scotland, mean temperatures were above average in most places over the month as a whole.

May—The wet weather of April continued for about the first week of May, but thereafter anticyclones brought dry weather to most areas. Temperatures reached 23° C at many places in the south on the 12th and 13th, but later pressure became high to the north of the country and north to north-east winds gave cooler weather. A cold northerly outburst on the 24th–25th was unfortunately followed by quiet weather with clearing cloud and there were damaging frosts on the nights of the 26th and 27th especially in the Midlands and south.

June—Although the weather was mainly anticyclonic in character, temperatures were only about average on the whole, in spite of values of 32° C (90° F) being reached in southern England towards the end of the month. All areas were drier than average but Scotland and Northern Ireland had less than average sunshine.

July—There were long anticyclonic, mainly dry, spells in Ireland and the south of Great Britain but the period 11th–16th was cyclonic in character and wet in most places. The month as a whole was rather cool and cloudy.

August—A succession of disturbances moving from the west or north-west gave cool and changeable holiday weather for most people. Those choosing the end of the month in the south were more fortunate, an anticyclone over Europe giving sunny weather with temperatures up to 32° C (90° F) in parts of southern England.

September—This month provided a wide variety of weather situations over the British Isles ranging from warm anticyclones through thundery cols to vigorous depressions. The very warm weather at the end of August persisted during the first two days of the month but was broken soon afterwards by severe thunderstorms. During the 12th–16th the country was affected by vigorous disturbances which had originated as hurricanes on the other side of the Atlantic, but for about a week afterwards an anticyclone developed over the British Isles and weather was generally dry, sunny and rather warm. The month ended with generally unsettled cyclonic weather.

October—Except for a few days of anticyclonic weather around the middle of the month, the country was affected by a series of disturbances, some of which were vigorous—wind gusts of about 80 knots were recorded in parts of Lancashire and the Western Isles towards the end of the month. Over the month as a whole mean temperature, rainfall and sunshine were all above average in most places.

November—The month was much drier and somewhat sunnier than average. Towards the end of the second week a depression to the south gave north-easterly gales over the North Sea, southern England and the English Channel. Anticyclonic conditions prevailed during the third week but thereafter cyclonic westerlies were predominant and the weather changeable.

December—The first half of the month was cyclonic in character, the weather being changeable. Colder weather set in during the third week but was soon followed by a slow thaw in most places, with fog. The 23rd produced biting easterly winds and very cold weather lasted for the remainder of the month. There was heavy snow in Scotland and northern England, and on the last day of the year there were falls of up to 12 inches in parts of the Midlands and south.

The following table gives for England and Wales, Scotland and Northern Ireland the general rainfall, expressed as a percentage of the 1916–50 average, during 1961 and the previous two years and shows how different the rainfall has been, especially over England and Wales, during each of these three years.

GENERAL RAINFALL—PERCENTAGE OF 1916–50 AVERAGE

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
England and Wales												
1961	126	105	25	161	64	69	86	100	104	126	65	115
1960	143	119	89	74	71	90	141	140	147	202	152	131
1959	111	14	114	130	44	81	83	44	11	92	123	181
Scotland												
1961	85	125	95	115	69	85	109	132	120	124	82	90
1960	89	124	63	122	71	95	95	126	72	85	114	104
1959	71	44	91	125	53	112	122	51	37	106	139	141
Northern Ireland												
1961	102	134	57	208	97	73	73	85	119	112	67	79
1960	96	128	91	119	87	105	157	134	87	104	102	88
1959	64	41	123	122	50	87	102	35	47	122	110	132

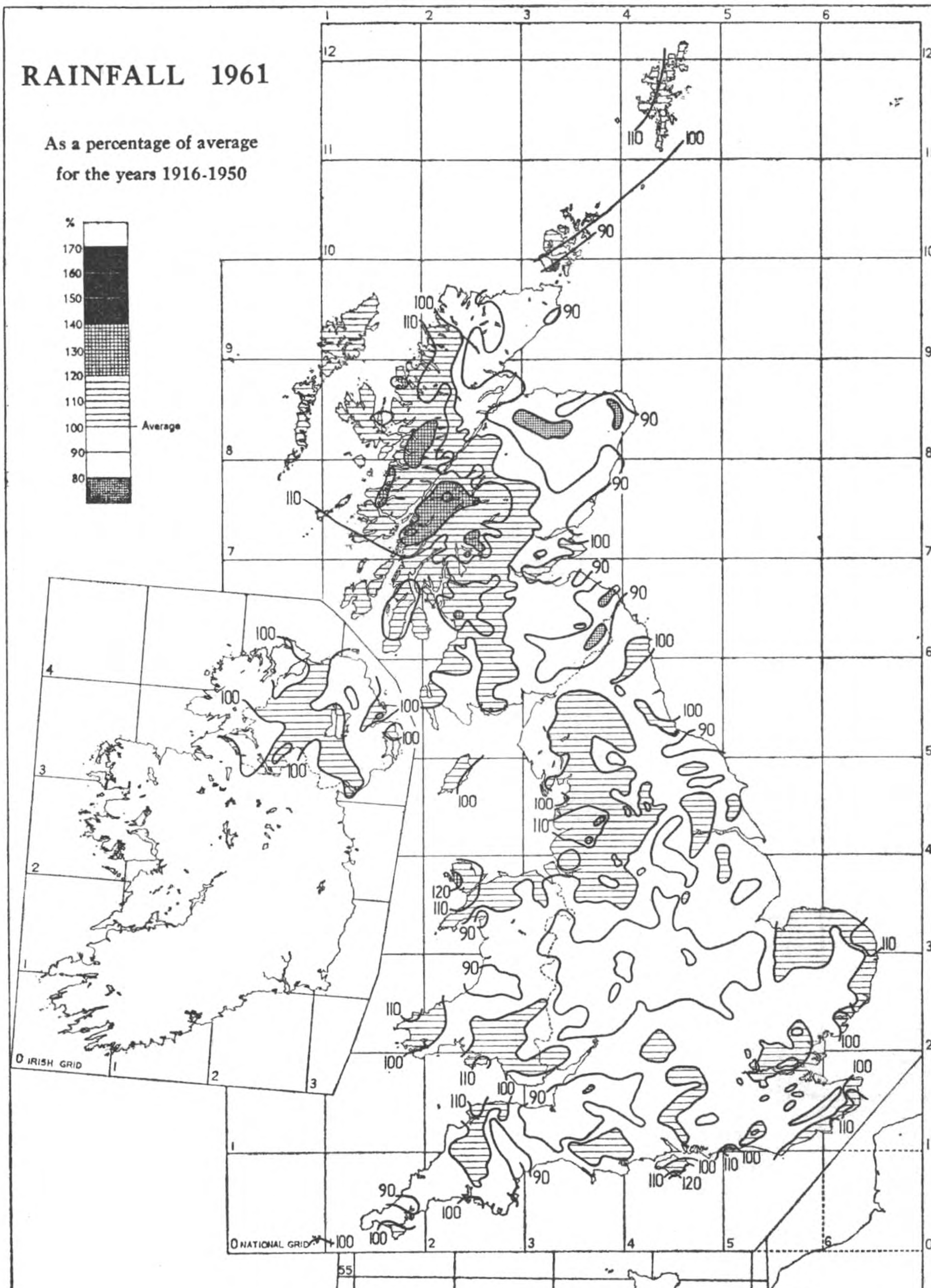


Figure 4—Rainfall for 1961

England and Wales: highest maximum, lowest minimum, average mean maximum and average mean minimum temperature (°C) in 1961

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Highest max.	13.9	18.3	22.8	20.6	24.4	31.1	33.9	31.8	31.6	22.8	17.7	15.6
Lowest min.	-9.4	-6.1	-6.1	-7.6	-6.7	-2.2	-1.1	-1.1	-1.7	-3.9	-8.3	-17.2
Average mean max.	6.2	9.6	12.6	13.4	15.2	19.2	19.4	19.7	19.2	14.4	9.2	5.5
Average mean min.	2.5	5.3	4.6	7.1	7.6	10.6	11.6	12.3	12.0	8.6	4.8	1.5

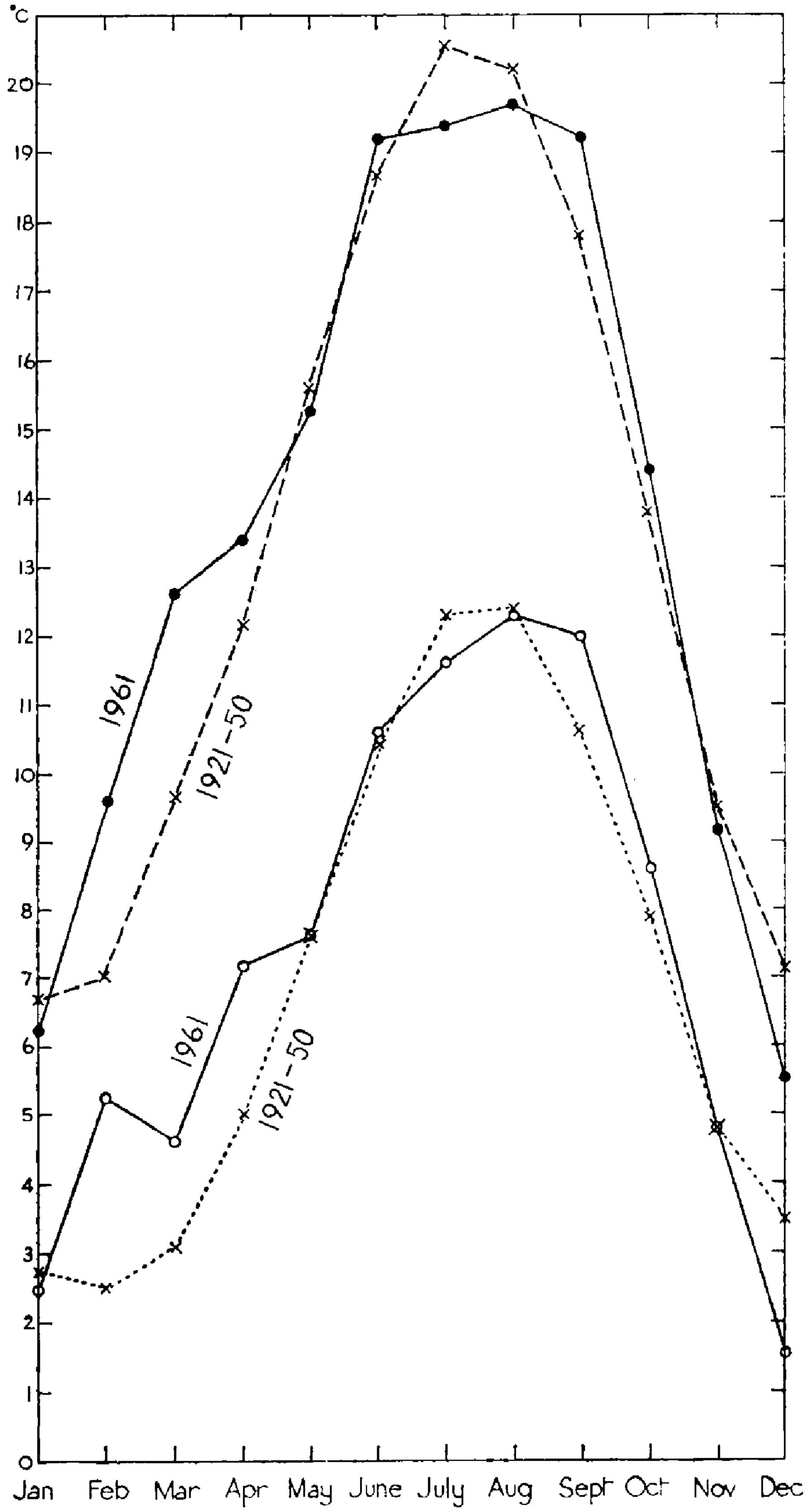


Figure 5—England and Wales: monthly general values of mean maximum and mean minmum temperature in ° C

Scotland: highest maximum, lowest minimum, average mean maximum and average mean minimum temperature (° C) in 1961

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Highest max.	13.9	15.6	20.0	18.3	23.3	24.4	24.4	28.9	25.6	20.0	15.0	13.9
Lowest min.	-12.2	-11.1	-6.7	-11.2	-5.8	-3.0	-0.5	-0.6	-1.1	-3.9	-12.2	-26.1
Average mean max.	5.4	8.2	10.4	10.9	13.3	15.6	16.1	16.7	16.0	12.3	7.9	4.4
Average mean min.	1.4	3.8	5.4	5.1	6.8	9.7	11.0	10.7	10.3	7.5	3.0	-0.1

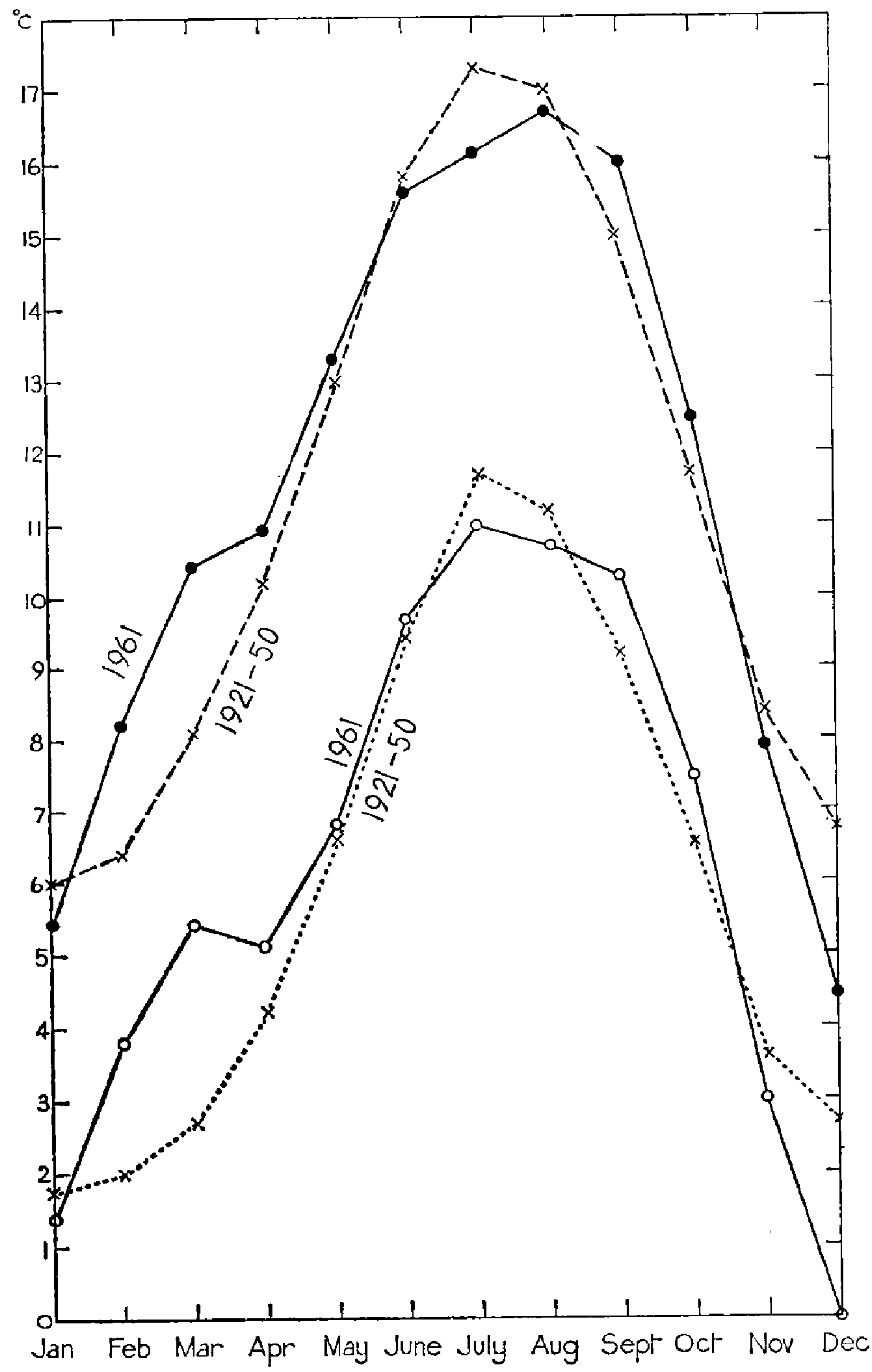


Figure 6—Scotland: monthly general values of mean maximum and mean minimum temperature in ° C

Northern Ireland: highest maximum, lowest minimum, average mean maximum and average mean minimum temperature (° C) in 1961

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Highest max.	12.2	13.9	17.8	17.2	22.8	23.9	21.1	24.2	25.0	18.4	15.0	13.9
Lowest min.	-8.3	-3.6	-1.7	-4.4	0.0	0.0	3.9	3.3	2.8	0.4	-5.3	-11.1
Average mean max.	6.5	9.6	11.7	12.2	14.4	17.0	16.8	17.6	16.9	12.8	8.8	5.4
Average mean min.	0.4	3.9	5.6	5.0	6.4	9.4	10.4	10.2	9.3	6.3	2.8	-0.8

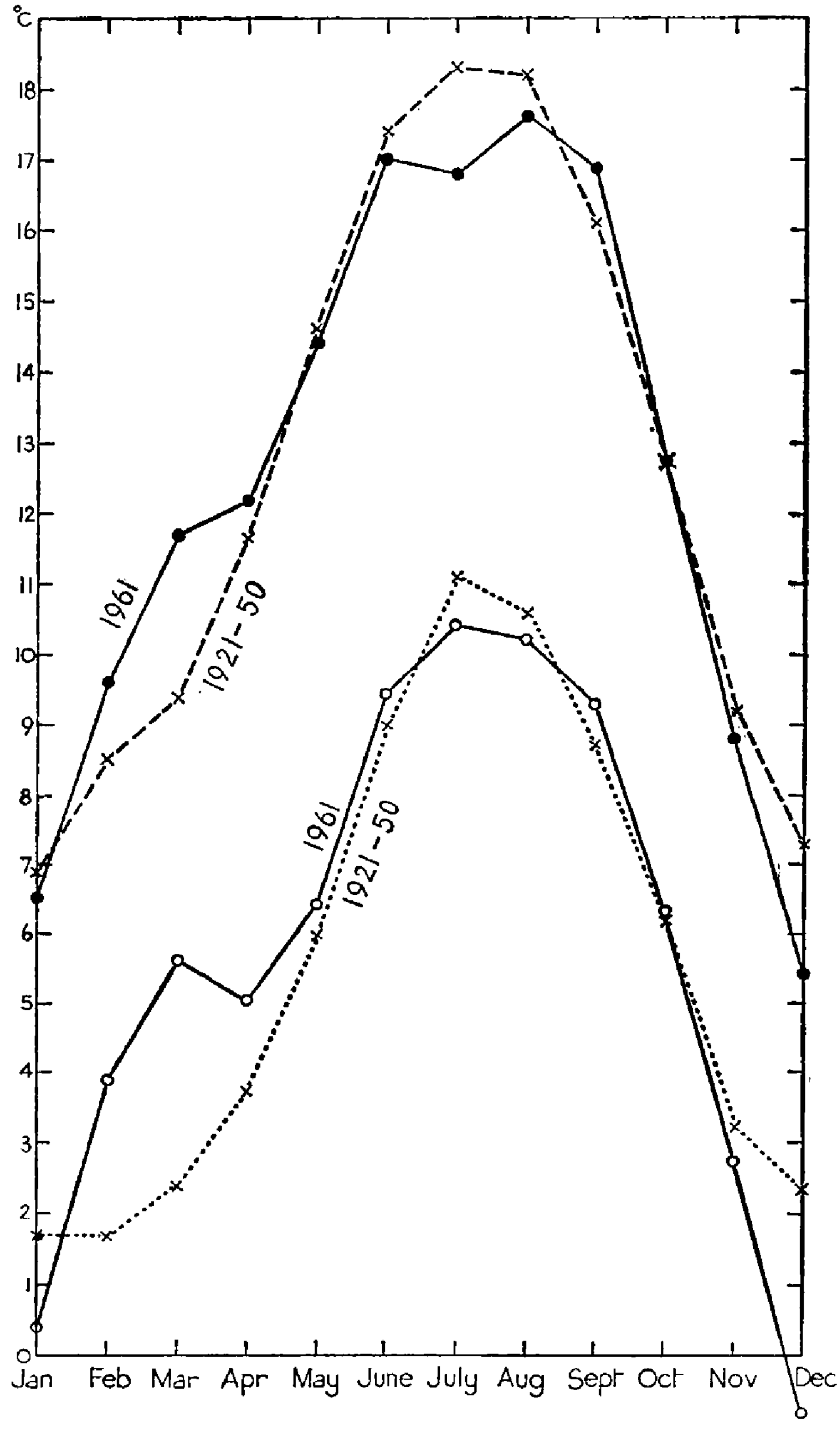


Figure 7—Northern Ireland: monthly general values of mean maximum and minimum temperature in ° C

England and Wales: percentage of 1921–50 average sunshine in 1961

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
90	99	128	66	111	109	92	103	97	115	110	133

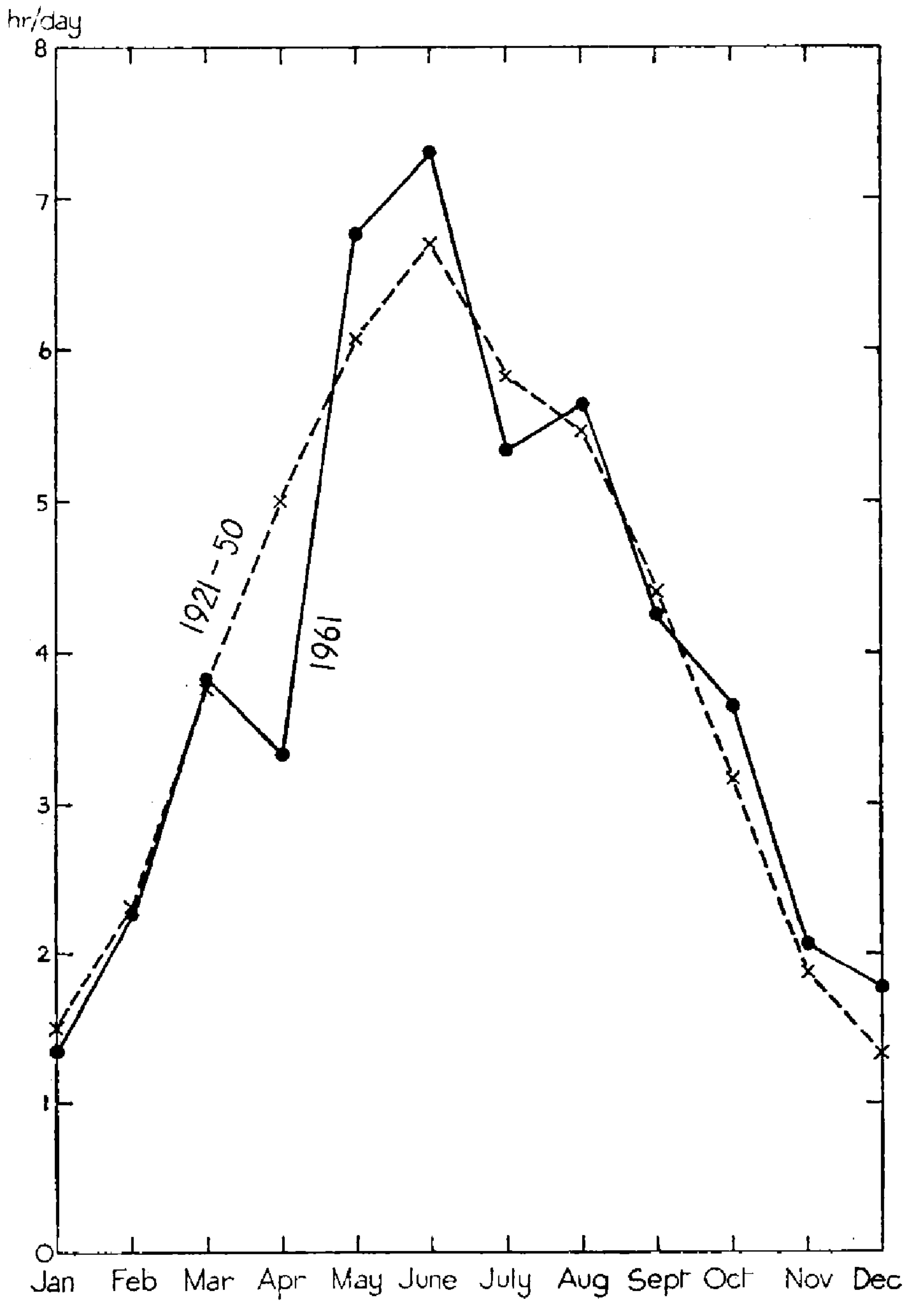


Figure 8—England and Wales: monthly general values of sunshine in hours per day

Scotland: percentage of 1921–50 average sunshine in 1961

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
118	104	88	82	106	85	74	104	98	105	117	115

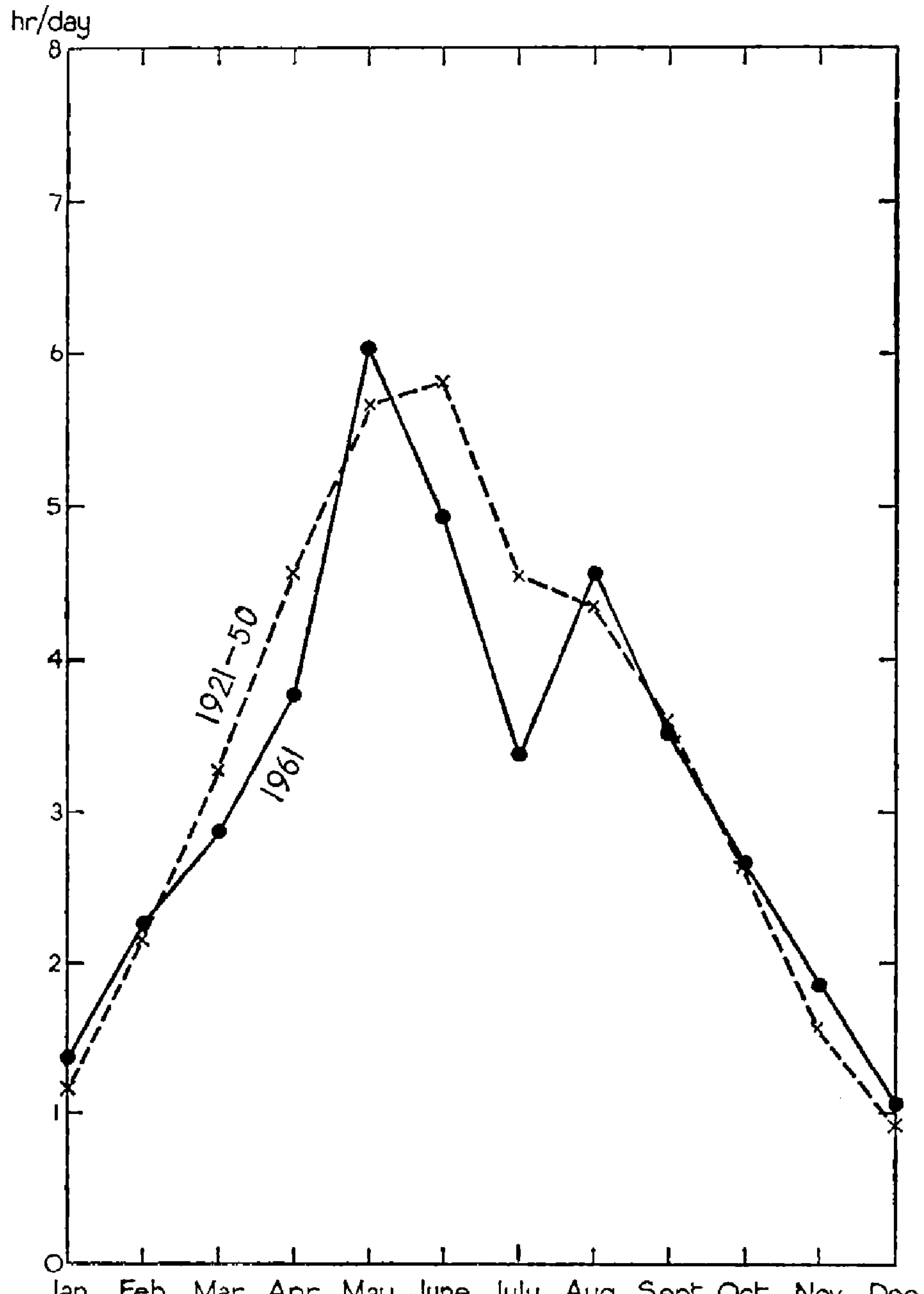


Figure 9—Scotland; monthly general values of sunshine in hours per day

Northern Ireland: percentage of 1921–50 average sunshine in 1961

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
132	103	85	70	98	82	75	98	103	121	93	88

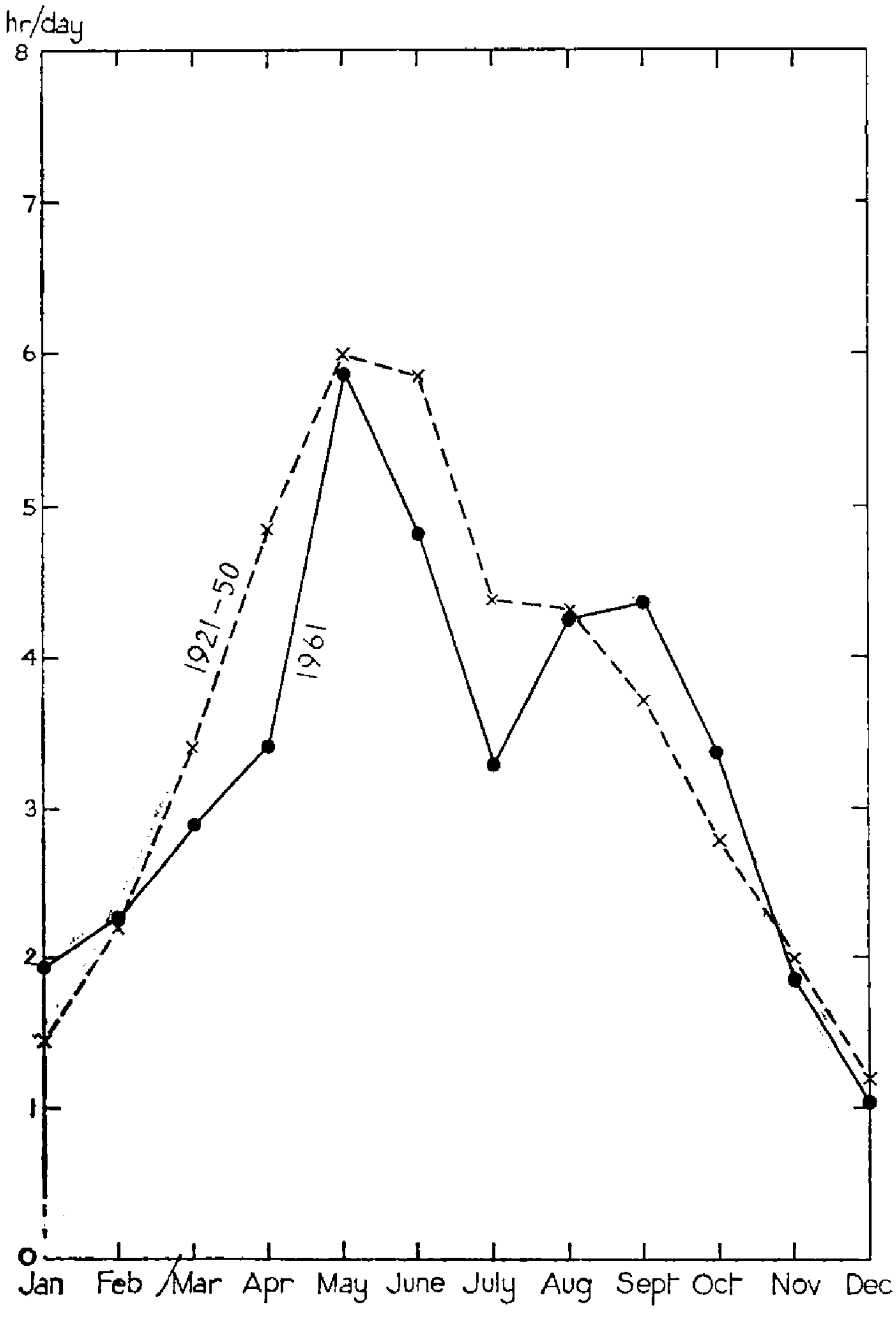
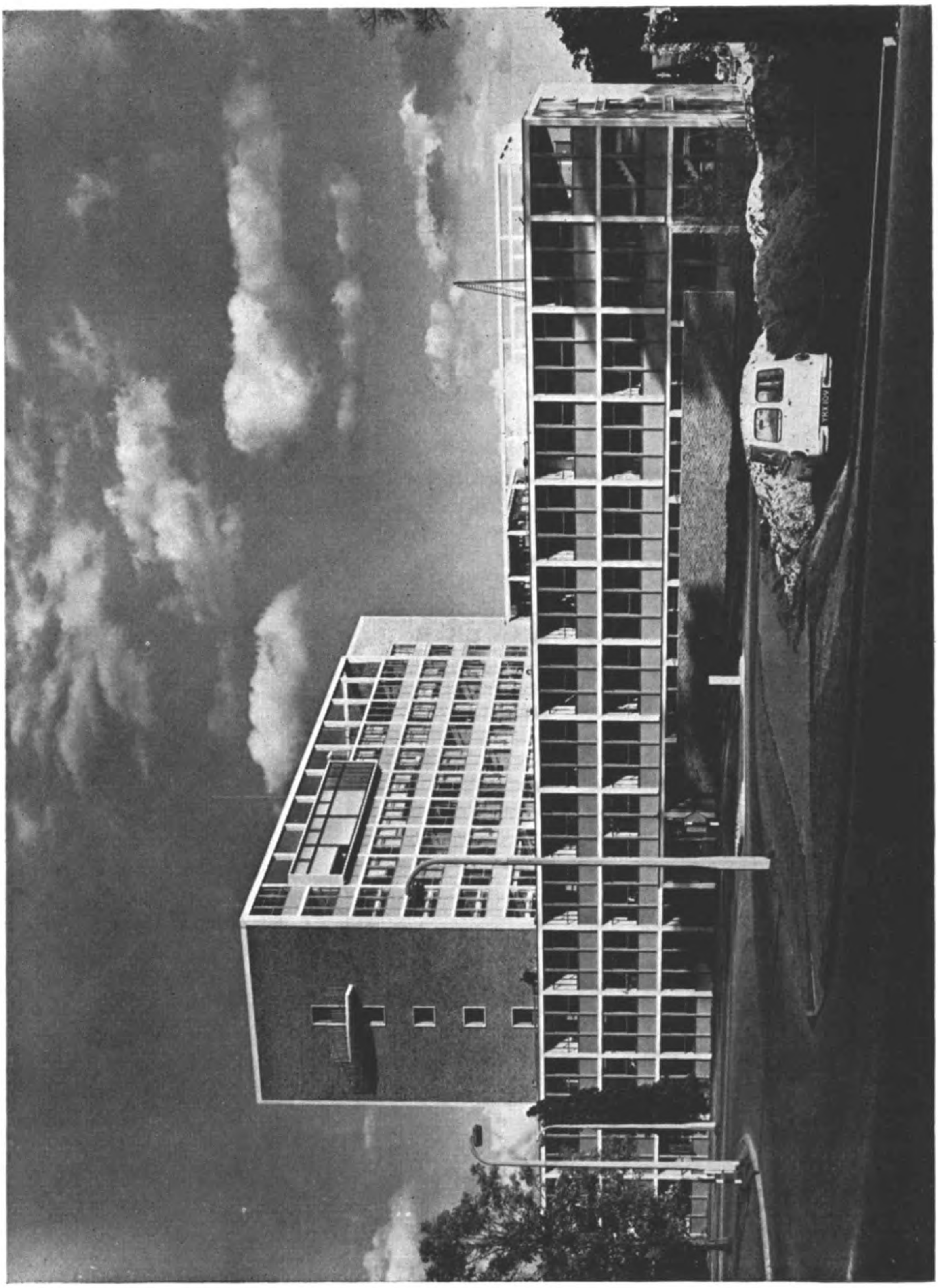


Figure 10—Northern Ireland: monthly general values of sunshine in hours per day

PLATE I



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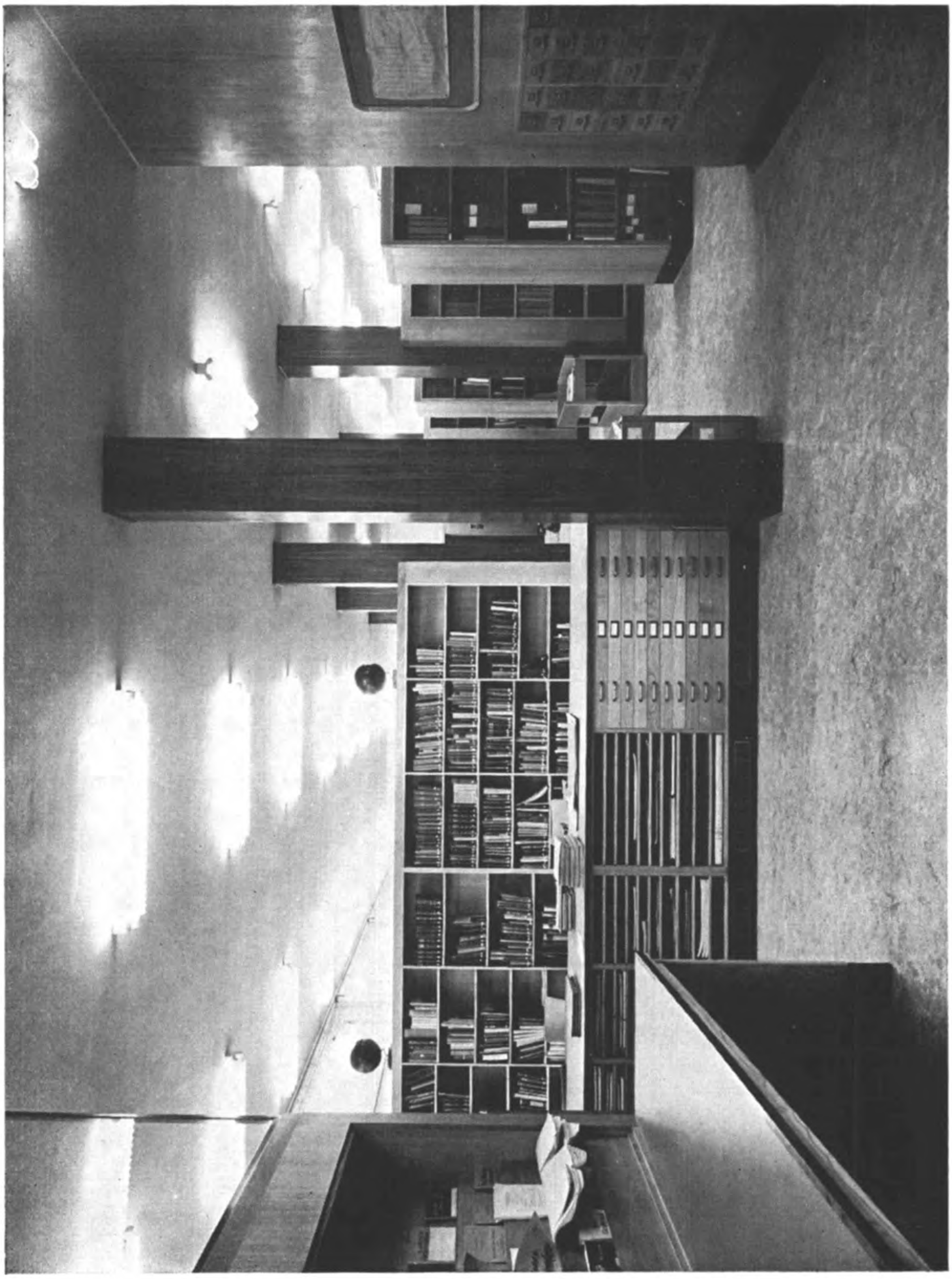
Meteorological Office Headquarters, Bracknell, from the west.

PLATE II



The Library

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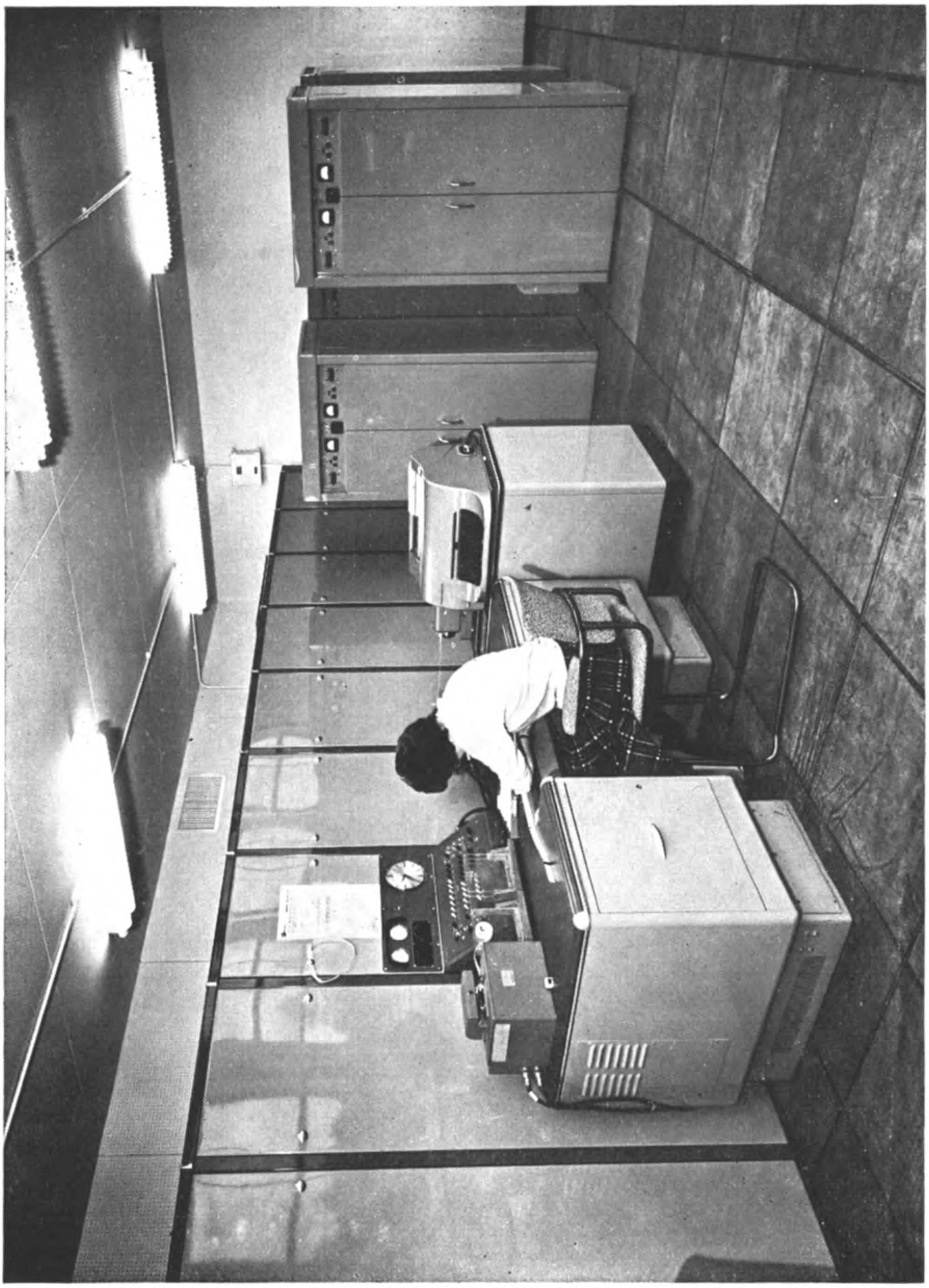
PLATE III



Electronic computer " Meteor "

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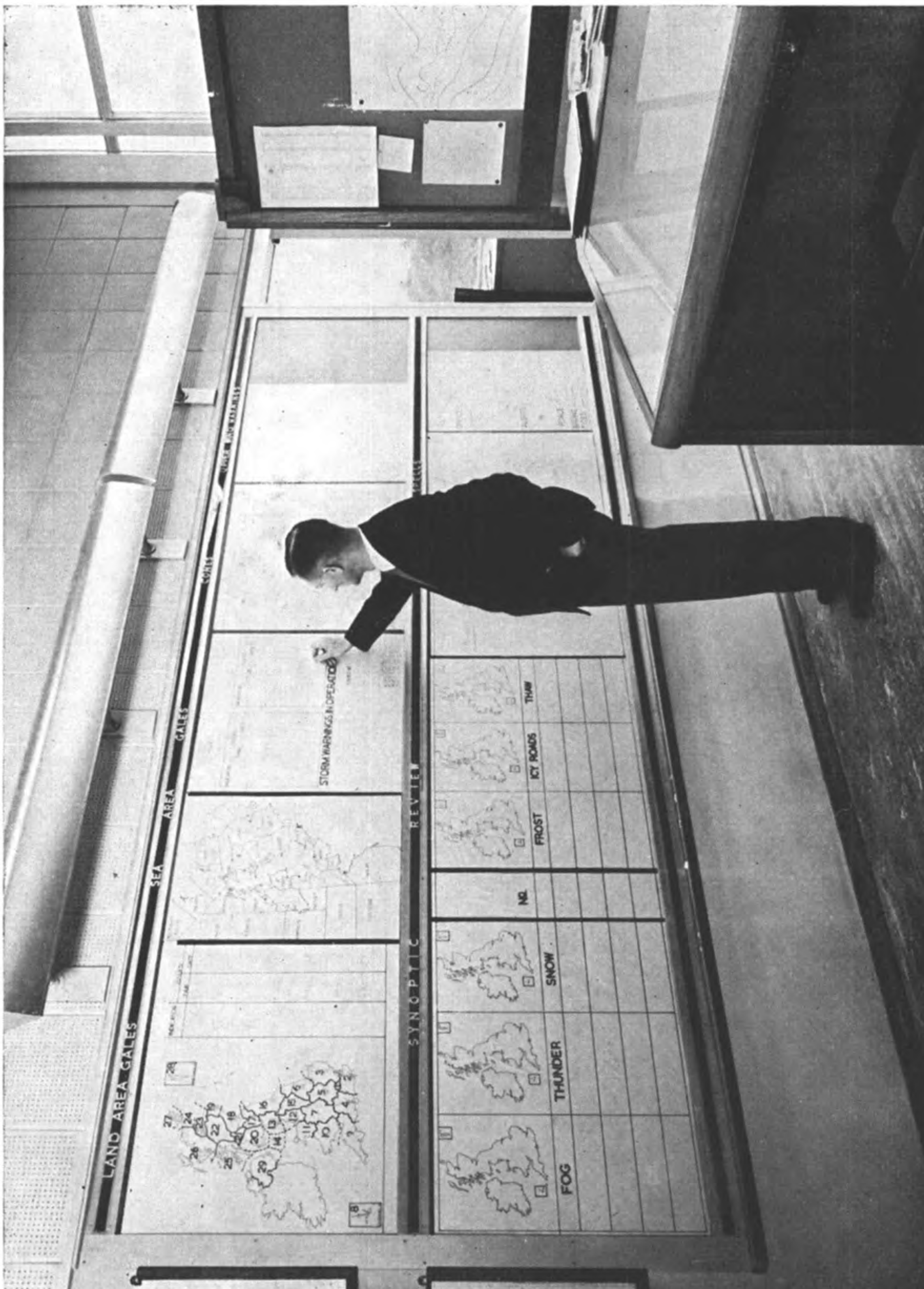
PLATE IV



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Central Forecasting Office warnings board

England and Wales: percentage of 1916–50 average rainfall in 1961

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
126	105	25	161	64	69	86	100	104	126	65	115

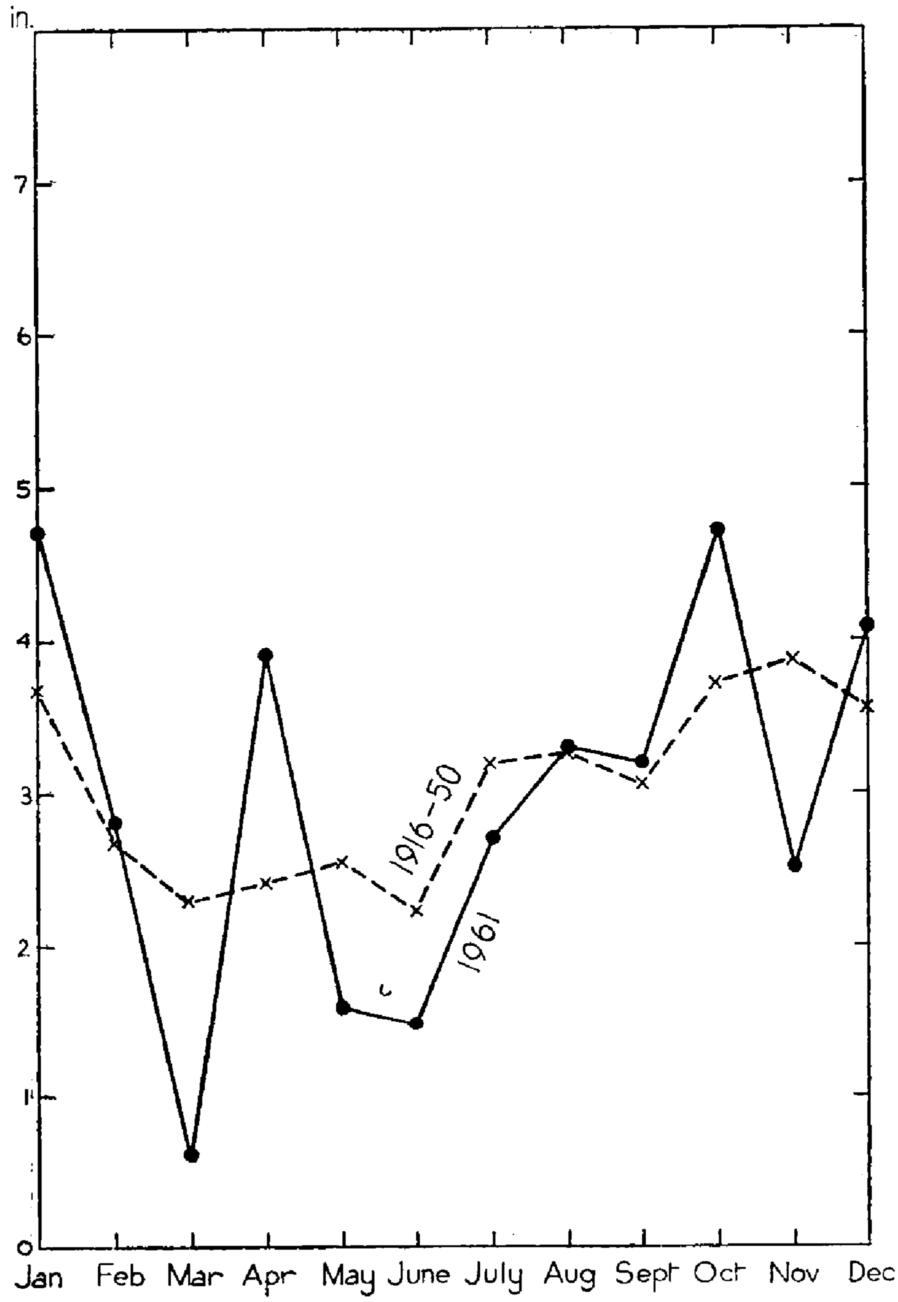

Figure 11—England and Wales: monthly general values of rainfall in inches

Scotland: percentage of 1916–50 average rainfall in 1961

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
85	125	95	115	69	85	109	132	120	124	82	90

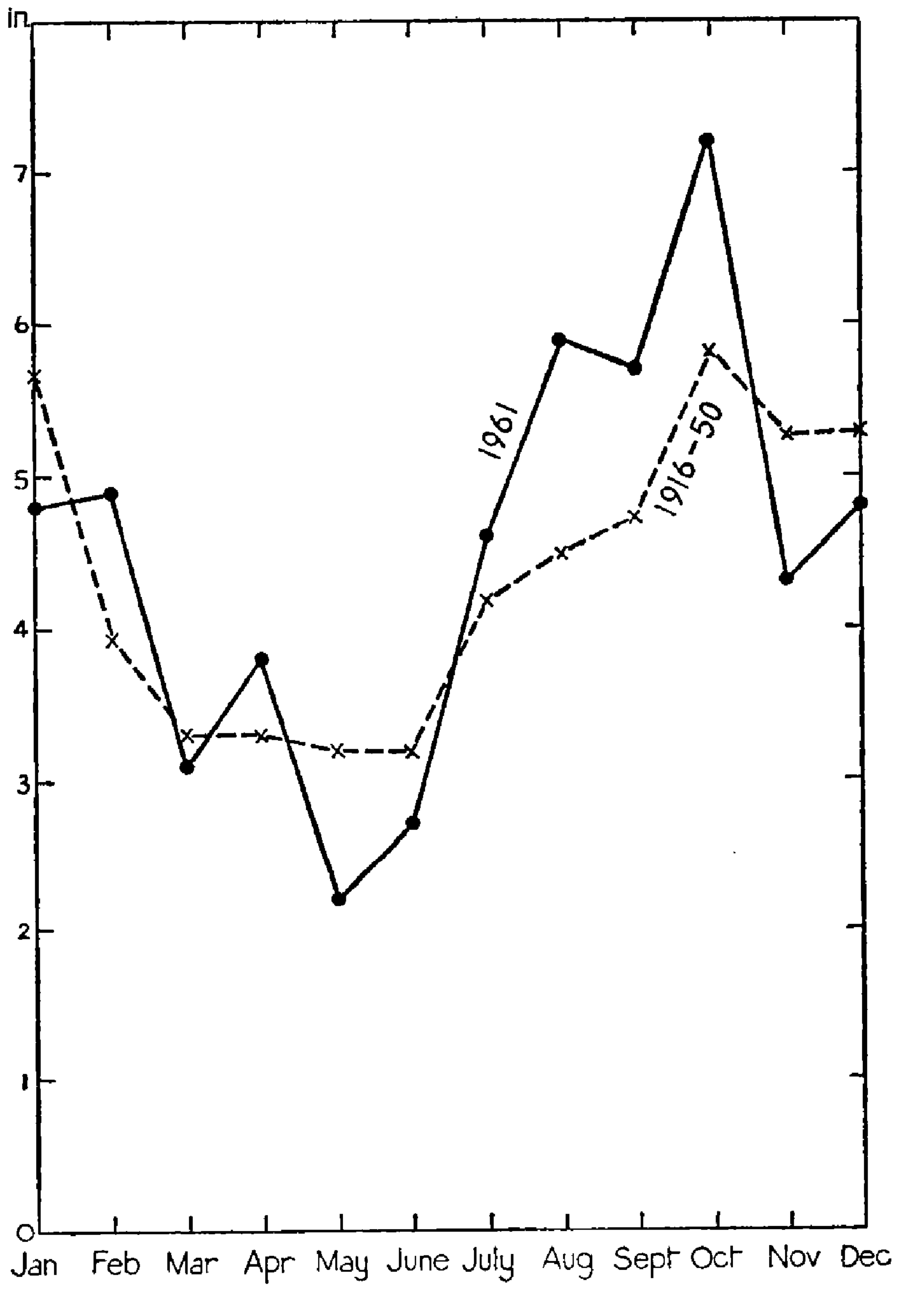

Figure 12—Scotland: monthly general values of rainfall in inches

Northern Ireland: percentage of 1916–50 average rainfall in 1961

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
102	134	57	208	97	73	73	85	119	112	67	79

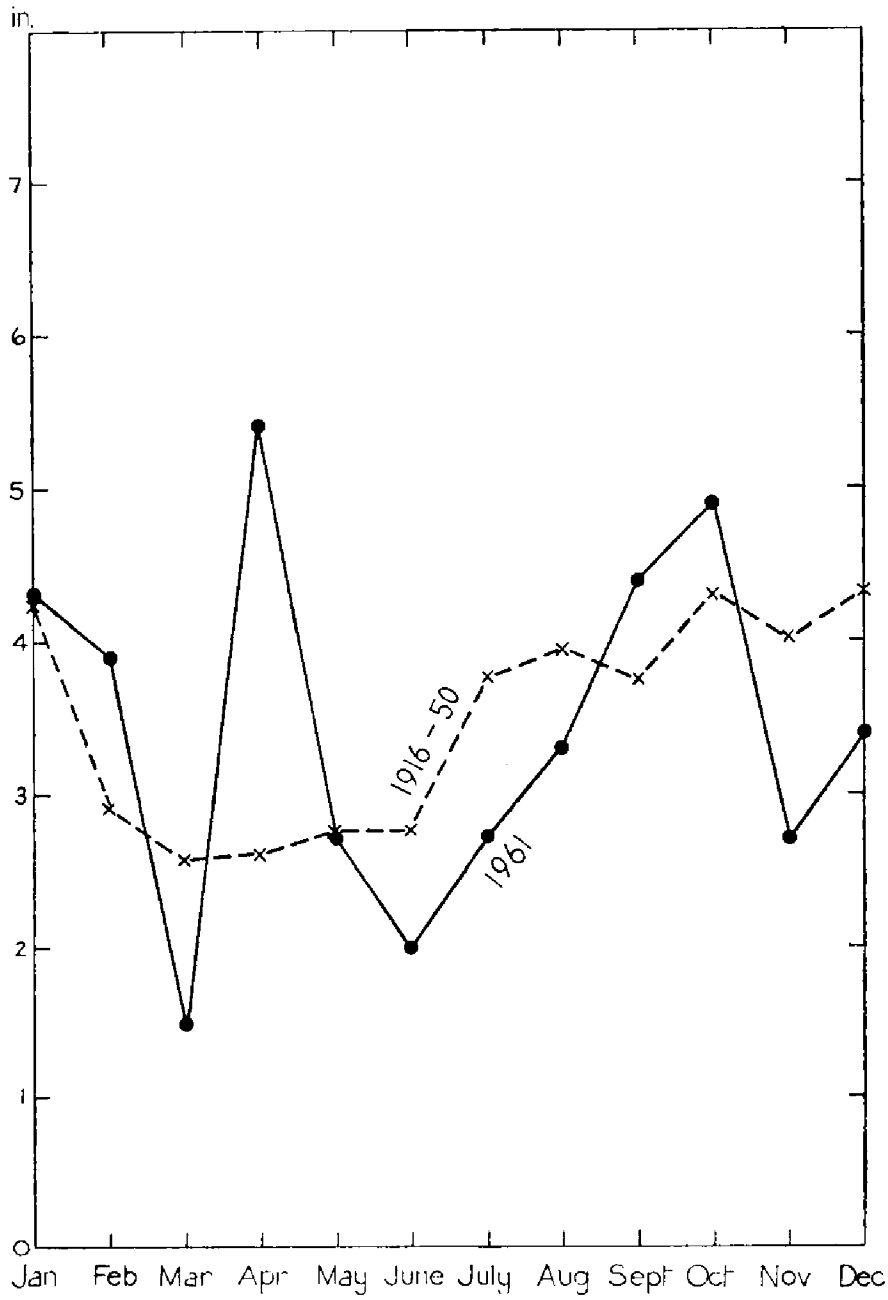

Figure 13—Northern Ireland: monthly general values of rainfall in inches

5. Statistics

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

Table 1

NUMBERS OF OFFICES OF VARIOUS TYPES STAFFED BY METEOROLOGICAL OFFICE STAFF AND OPERATING ON 31 DECEMBER 1961

	Within U.K.	Overseas
Principal forecast offices associated with the RAF	1	—
Main meteorological offices associated with the RAF	11	7
Subsidiary meteorological offices associated with the RAF	49	13
Observing offices associated with the RAF	5	1
Principal forecast offices associated with civil aviation	1	—
Main meteorological offices associated with civil aviation	2	—
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	16	4

Notes

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

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

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

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

Public service offices are located in big cities.

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

Port meteorological offices are maintained at the bigger ports.

Table 2

OCEAN WEATHER SHIPS

There are five ocean weather stations manned by ships of the European operating countries (United Kingdom, France, Netherlands, Norway and Sweden) in rotation. The United Kingdom operates four ships to meet its obligation (under the ICAO North Atlantic Ocean Station Agreement) of continuously manning two of the stations. The following are some statistics for 1961:

Total number of voyages	31
Total number of days on station	731
Total number of days on passage	226

During the year, at station " Juliett," which is the busiest station, an average of about 1,200 aircraft per voyage of 24 days were supplied with meteorological information and navigational aids; this compares with an average of about 150 a voyage in 1950.

Radar-wind observations aboard the weather ships attained an average height of 60,200 feet, the maximum height being 90,500 feet.

TABLE 3

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 and distant water trawlers also make and transmit meteorological observations. On 31 December 1961 the numbers of British ships reporting were:

Selected ships	480
Supplementary ships	49
Coasting ships	123
Lightships	13
Trawlers	24

During a typical day the number of reports from ships received in the Central Forecasting Office were approximately as follows:

		Reports
Direct reception from	British ships in North Atlantic	85
	Foreign ships in North Atlantic	50
	British trawlers in North Sea	12
	British ships in North Sea	20
Via other European countries	Ships in North Atlantic	200
	Ships in Mediterranean	60
	Ships in North Sea	35
	Ships off North Russia	35
	Ships in other waters	10
Via U.S.A.	Ships in North Atlantic	450
	Ships in Pacific	250

TABLE 4

CLASSIFICATION OF STATIONS WHICH RENDER CLIMATOLOGICAL RETURNS

A large amount of meteorological data is obtained for climatological purposes, from meteorological observing stations which are not part of the Meteorological Office organization. The following table shows how the sources of climatological information in the United Kingdom (including Meteorological Office stations) were distributed on 31 December 1961.

	Stations					Autographic records		
	Observatories	Synoptic	Agro-meteorological	Climatological	Rainfall*	Sunshine	Rainfall	Wind
Scotland, north	1	9	0	24	282	22	10	7
Scotland, east	0	9	8	60	513	51	21	7
Scotland, west	1	9	2	39	527	26	22	8
England, north-east	0	10	4	24	418	29	14	3
England, east	0	10	12	16	500	24	14	7
England, Midlands	0	12	19	49	1,175	61	35	6
England, south-east (including London)	1	16	16	63	881	67	73	17
England, south-west	0	8	8	26	512	31	11	4
England, north-west	0	6	4	24	457	25	30	10
Wales, north	0	2	3	18	235	10	4	1
Wales, south	0	3	9	15	287	24	11	4
Isle of Man	0	2	0	1	18	3	1	2
Scilly and Channel Isles	0	3	0	3	3	6	1	2
Northern Ireland	0	4	1	28	127	12	5	3
Total ..	3	103	86	390	5,935†	391	252	81

* Includes stations in earlier columns.

† Figures for rainfall stations and autographic rainfall records refer to data for the year 1960, received during 1961. All other figures show the position on 31 December 1961.

TABLE 5

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	50mb	30mb
		approx. height 53,000 ft	67,000 ft	78,000 ft
Eight stations in United Kingdom	5,666	87.4	46.5	11.7
Eight stations overseas ..	4,691	90.1	46.5	6.8
Four ocean weather vessels ..	1,378	80.2	33.2	2.7

Observations of wind

	Number of observations	Percentage reaching 100mb	50mb	25mb	10mb
		approx. height			
		53,000 ft	67,000 ft	82,500ft	100,000ft
Eight stations in United Kingdom	10,907	73.6	33.1	3.7	1.5
Eight stations overseas ..	7,382	78.4	33.7	0.6	0.0
Four ocean weather vessels ..	2,738	73.7	28.8	1.9	0.0

TABLE 6

THUNDERSTORM LOCATION

Number of thunderstorm positions reported by C.R.D.F. network, 1 October 1960–30 September 1961 69,105

TABLE 7

METEOROLOGICAL COMMUNICATION TRAFFIC

Almost all the national and international exchange of meteorological data which are used in the construction of synoptic charts and the production of forecasts is effected by either coded messages or facsimile charts. The coded messages are composed of groups of five figures and there may be three to thirty such groups in one message. The messages are exchanged by radio and teleprinter. The following figures give an analysis of the traffic through the Meteorological Office Communication Centre for one typical day (24 hours) on 12 December 1961 and, for comparison, some corresponding figures for one day near the end of 1960.

Communication traffic for one day

Coded messages	Number of groups in one day			
	In	Out	Total	Total in 1960
Land-line teleprinter	382,675	426,032	808,707	657,885
Radio	101,346	181,371	282,717	269,560

Facsimile charts	Number of charts in one day			
	In	Out	Total	Total in 1960
Land-line	27	69	96	59
Radio	27	37	64	55

TABLE 8

Some types of weather are of great importance to particular sections of the community at certain seasons. Arising from this there is a need for forecasts of a particular type at certain seasons. Services of this type are described in M.O. Leaflet No. 1. The number of customers receiving such specialized forecasts are as follows:

	Year	No. of customers	Year	No. of customers
Fine spell warnings (a summer service) ..	1960	365	1961	710
Weekend temperature forecasts (a winter service)	1960–61	54	1961–62	54
Snow or icy roads warnings (a winter service)	1960–61	231	1961–62	248

TABLE 9

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 number of meteorological " briefings " which took place during 1960 and 1961. They do not include warnings and routine general forecasts. The services to military and civil aviation in the United Kingdom are given separately since these services were provided almost completely by separate networks of stations. This does not apply at overseas stations.

	1960	1961
Number of meteorological briefings for		
military aviation in United Kingdom ..	170,100	159,556
civil aviation in United Kingdom	174,862	186,008
aviation at overseas stations	71,186	72,138
Number of aviation forecasts issued for		
military aviation in United Kingdom ..	376,999	571,564
civial aviation in United Kingdom	261,406	284,397
aviation at overseas stations	197,661	201,683

TABLE 10

NON-AVIATION INQUIRIES

There are four forecast offices devoted to meeting the needs of the general public for forecasts for specific purposes. But many of the forecast offices established to meet aviation requirements also answer telephonic requests for forecasts, from the general public, public corporations, local press, commercial firms, etc. The " Post Office Guide " lists the telephone numbers of 36 such offices which are available for this service. During 1961 the incidence of these inquiries varied from month to month, with maxima in summer (12.7 per cent in June) and winter (14.5 per cent in December). The following figures show the total number of such inquiries answered by offices outside London in 1960 and 1961 and the percentage coming from the principal classes of customer.

	1960	1961
Total number of inquiries	357,465	410,825
Percentage of inquiries connected with		
agriculture, etc.	17.2	17.1
holidays	17.1	20.0
public utilities	17.1	12.2
road transport	9.7	11.6
local press	8.8	8.8
marine	7.6	7.5

In addition to these a further 171,031 (177,855 in 1960) inquiries were answered by the London Weather Centre.

TABLE 11

AUTOMATIC TELEPHONE WEATHER SERVICE FORECASTS FOR 1961

By the end of 1961 forecasts for sixteen 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 1961 on this service is indicated by the following figures (supplied by courtesy of the Postmaster-General).

Forecast area	Number of calls	Remarks
London	2,722,960	
Essex coast	125,654	Available on a London number
Kent coast	105,313	Available on a London number
Sussex coast	160,080	Available on a London number
Colchester	92,330	Same as Essex coast
Brighton and Hove	112,988	Same as Sussex coast
Birmingham	316,507	
Liverpool	327,337	
Manchester	325,127	
Cardiff	179,922	
Belfast	167,384	
Glasgow	453,119	
Edinburgh	191,396	
Bristol	143,330	
Portsmouth	88,860	
Southampton	34,172	Started in October
Total	5,546,479	
Total in 1960	4,910,546	

TABLE 12

Most of the inquiries dealt with by the offices outside Headquarters refer to current weather or to forecasts. M.O.3 receives a number of inquiries relating to past weather or to climatology. 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	5,368
Percentages related to	
agriculture, horticulture, forestry	5.4
building and building design	8.9
commerce (sales, marketing and advertising)	10.1
education and literary	6.5
industrial or manufacturing activities	11.7
legal (damage, accidents, insurance)	17.4
medical and health questions	4.2
research	5.5
water supply including hydro-electric and irrigation	9.9

TABLE 13

AGRICULTURAL INQUIRIES

In addition to the agricultural inquiries answered by the offices outside London (Table 10) and by M.O.3 (Table 12) such inquiries are also dealt with by that part of M.O.7 which is concerned with the application of meteorology to agriculture. During 1961 these inquiries totalled 706.

TABLE 14

LIBRARY

The following figures indicate the distribution of work in the Library during 1961:

Library statistics

Publications received during 1961 (excluding *Daily Weather Reports*) ..	7,998
Individual books, pamphlets, articles, microfilms, classified and catalogued .. .. (approx.)	6,500
Transparencies acquired	655
Publications lent (excluding *Daily Weather Reports* and internal 24-hour loans)	5,768
New exchange of publications agreements	11
Total number of exchange agreements	395

TABLE 15

EDITING STATISTICS

The following figures give the number of publications edited during 1961:

Publication	Number	Remarks
Geophysical Memoirs	2	Nos. 105, 106
Scientific Papers	11	Nos. 5 to 15 inclusive
Meteorological Magazine	14	Jan. 1961 to Feb. 1962 inclusive
Observatories' Year Books	8	1951 to 1956 inclusive, 1959, 1960 (1957 and 1958 were published in 1960)
Occasional publications	11	(mainly for internal use)
Reprints	9	

TABLE 16

DATA PROCESSING

Punched-card installation

Number of cards punched by the Meteorological Office installation ..	795,000
Number of cards punched outside for the Meteorological Office	717,000
Number of cards converted to paper tape	240,000

TABLE 17

TRAINING

The following figures give some details of courses at the Meteorological Office Training School which were completed during 1961:

	Number of courses	Length of course in weeks	Number of students
Scientific Officers	1	23	5
Forecasters (Initial)	2	17	57
Forecasters (Advanced)	4	6	22
Senior Forecasters	1	3	12
Assistants	10	9	124
Climatology	1	8	2
Radio-sonde (Initial)	6	8	64
Radio-sonde (Advanced)	6	4	22
Voluntary observers	2	1	32
Auxiliary observers (coastguards)	2	1	38
Special course for FIDS observers	1	4	9
Special forecasting course	1	2	4
Special forecasting course	1	6	4
Part-course attendance	—	—	4
		Total	399

Students from the following meteorological services attended courses:

Country	Number of students
Belgium	1
British East Africa	8
Falkland Islands	17
Ghana	3
Greece	1
Hong Kong	1
Iran	3
Jordan	1
Libya	1
Nigeria	3
Pakistan	3
Saudi Arabia	1
Somalia	1
Switzerland	2
Syria	4
Thailand	1
Turkey	3
West Indies	3
Total	57

THE DIRECTORATE OF RESEARCH

1. Special Topic—Research on Numerical Forecasting

Meteorological observations are made on a world-wide basis at fixed times each day; charting and analysis of these observations reveal the state of the atmosphere at the given time, and in particular the pressure, temperature and wind fields. Weather forecasting for periods of one or two days ahead, which is a routine commitment for all national weather services, is carried out in two distinct stages for extratropical regions. The first stage is the prediction of the pressure and temperature fields at the time to which the forecast refers, and the second stage is the interpretation of these predicted fields in terms of weather, such as rain, fog, cloud etc. The first stage is usually carried out by consideration of the series of synoptic charts available up to the time that the forecast is made.

The basis of numerical forecasting in meteorology is the assumption that the atmosphere, at least below 100 km, may be regarded as a fluid to which the usual equations of hydrodynamics and thermodynamics apply. From these equations, it is possible in principle to predict the future state of the atmosphere given its present state and the forces which are acting. This, of course, has long been recognized but in the practical problem difficulties arose. First, the observations were insufficient to describe adequately the existing state of the atmosphere. During and after the Second World War the number and quality of the observations of the upper atmosphere were considerably increased; only now is it possible to obtain an adequate representation of the atmospheric state in depth over large areas of the earth's surface. Second, the differential equations which are to be solved are non-linear and the theory has not been extensively studied. In particular, the method of obtaining approximate solutions to differentia. equations by solving their finite-difference analogues had received scant attentionl Third, the approximate solution by finite-difference methods involves much arithmetical computation so that to carry out a 24-hour forecast, using desk calculators and with quite gross physical approximations to simplify the mathematical equations, might have taken a year or so. The recent development of high-speed electronic machines capable of computing perhaps a million times as quickly as a human being has largely removed this difficulty and made possible the study of approximate methods of solving differential equations, even though non-linear.

A pioneer attempt to make a numerical forecast was carried through single-handed in 1922 by L. F. Richardson,[1] using finite-difference methods. The calculations were made by hand; the forecast itself was a failure and the burden of such a computation prevented any further attempts being made for many years. Just prior to 1950 however it became clear that the problem needed reconsideration since some of the difficulties had been eased. Preliminary computations aimed at calculating the future pressure field were sufficiently promising for the planning of full-scale research with the aid of a high-speed electronic computer.

There are atmospheric motions of all sizes upwards from tiny swirls made visible by cigarette smoke to the weather-carrying systems in the atmosphere, such as depressions and anticyclones, which are large-scale systems with diameters of 1,000 km or more. The full hydrodynamical equations describe the evolution of motions of all sizes and it is economic to adjust the equations to deal with the large-scale systems and ignore the other motions which are irrelevant. Even when this filtering has been done the equations still present difficulties and simplifications have to be made. An example of such a simplification is in the variation of horizontal velocity with height, which is assumed to be linear although observation reveals it is only approximately so. These simplifications lead us to examine the motions of a model atmosphere in which the irregularities of the real atmosphere have been smoothed. Sawyer and Bushby[2] developed the forecasting equations for such a model, from which a 24-hour forecast of the pressure distribution at the surface may be inferred as well as the forecast of the 500 mb contour height chart.

The differential equations have been solved over an area of about 3,000 × 2,500 miles with Great Britain approximately at the centre. A high-speed electronic computer is a necessity for carrying out such complicated calculations and the Meteorological Office acquired a Ferranti Mercury computer known as METEOR which was installed in January 1959. An extended test has been made of the success of numerical forecasts computed according to the Sawyer-Bushby equations and a full report has been published[3]. The experiment showed that the simple model is capable of yielding numerical forecasts which are about as good as the conventional forecasts at the 500 mb level (i.e. about 6 km above the sea level) although rather poorer at the surface. This most encouraging result led to the testing of a more complicated model which smooths the natural irregularities less drastically; this model also takes into account the observational information from high levels at about 12 km and yields a forecast at that level. The practical importance of such a model is that it gives a forecast of wind and temperature at the atmospheric levels at which aircraft currently fly.

The second model proved sufficiently successful for a test under operational conditions to be carried out. For a forecast to be practically useful it must be available shortly after the observations upon which it is based have been made. The numerical forecasts of the pressure fields had to be completed at a specified time to be seen by the forecaster before he made his weather forecast. A number of ancillary problems concerning the use of the electronic computer in data handling and analysis were successfully solved and the experiment began in November 1960 and continued until the computer was dismantled in June 1961 for removal to the new Headquarters at Bracknell. The time schedule of this experiment had to be very closely followed and several new ideas concerning the incorporation of late data were tested; the forecasts were made for 30 hours ahead and, in addition to being available to the forecaster as an extra opinion, were discussed at the daily forecasting conference. In general, the quality of the numerical forecasts near the earth's surface was high and only a little inferior to that of the conventional forecasts. At the upper levels the numerical forecasts were equally good. An example of the numerical forecasts is shown in Figure 3.

Figure 1 shows the surface analysis at 0001 GMT on the morning of 10 January 1961. The main features of the chart are the depression off the coast of Canada, the high-pressure ridge in mid-Atlantic, the low-pressure system centred off the south of Ireland and the complex low-pressure system over Europe. Of these, that of most immediate interest to the British Isles was the low-pressure system to the south of Ireland which had been moving steadily eastwards with its attendant rain area. At the time of the chart there was rain over most of England and Wales, partially connected with the low-pressure system over Europe.

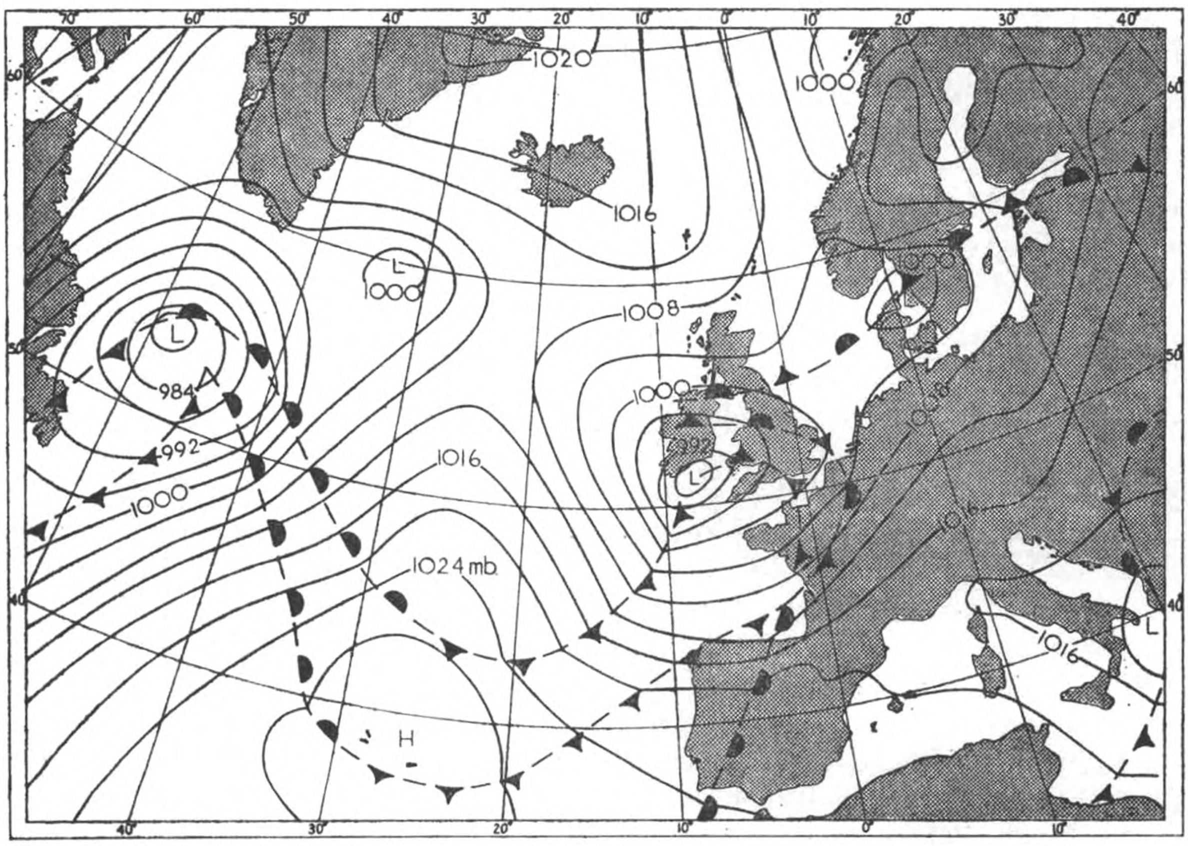

Figure 1—Surface chart for 0001 GMT, 10 January 1961
Full lines are isobars drawn at 4 mb intervals and pecked lines show fronts.

Figure 2 shows the surface analysis at 0001 GMT on 11 January 1961, 24 hours after the analysis shown in Figure 1. During the 24 hours the low-pressure system moved from south of Ireland to southern France and the mid-Atlantic ridge moved over the British Isles and at this time there was no rain falling in the British Isles. The low-pressure system moved from the coast of Canada towards Iceland and the European situation was now dominated by the complex low-pressure systems stretching from southern France to northern Scandinavia.

Figure 3 shows the numerical forecast for 0001 GMT on 11 January 1961 based upon data observed at 0001 GMT, 10 January 1961, which is partially represented by Figure 1, the remainder being the upper air data not reproduced here. Comparison of Figures 2 and 3 shows that the low-pressure system off Ireland was correctly predicted to move south-eastwards, but not quite far enough. The Atlantic ridge was correctly predicted to move over the British Isles, while the position of the low-pressure system near Greenland was well forecast, as was the alignment of the European low-pressure areas. The pressure levels were not forecast quite so well as the positions of the main features; a weather forecast based on Figure 3 would certainly have predicted the cessation of rain.

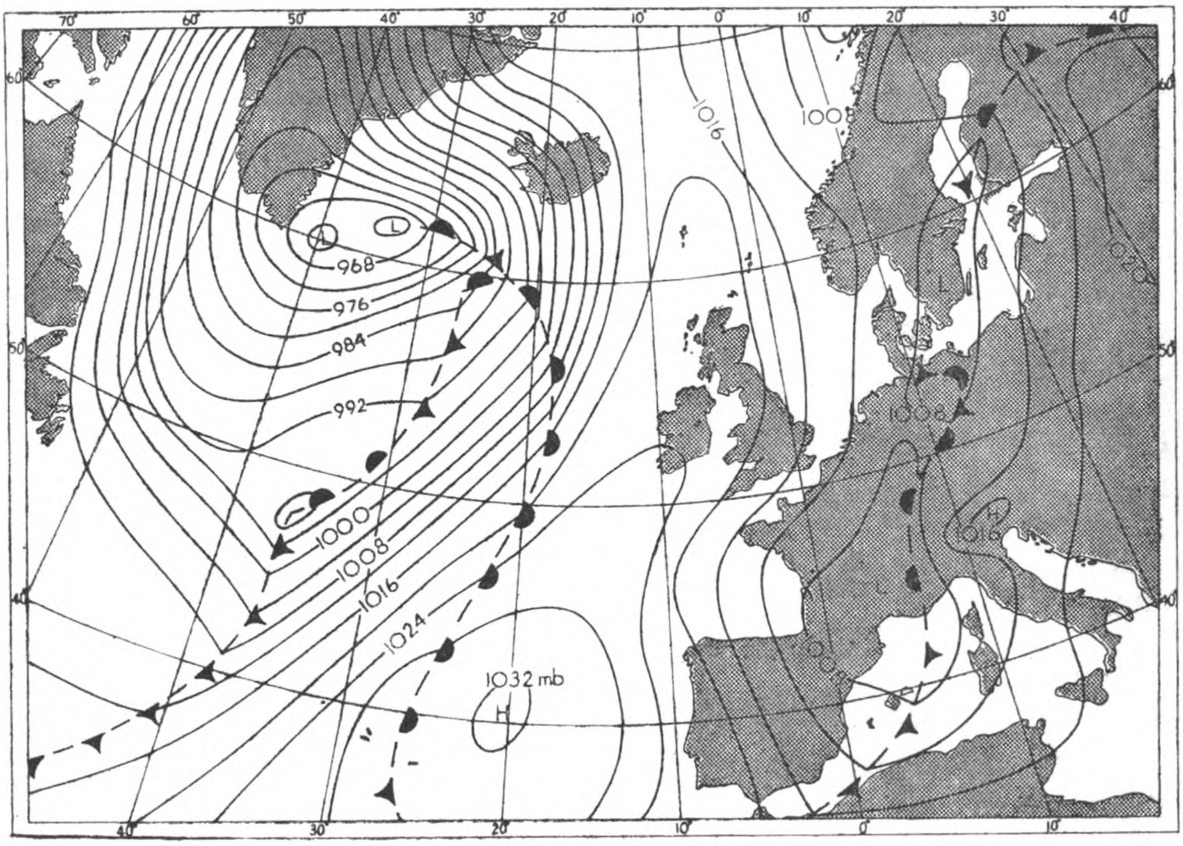

Figure 2—Surface chart for 0001 GMT, 11 January 1961

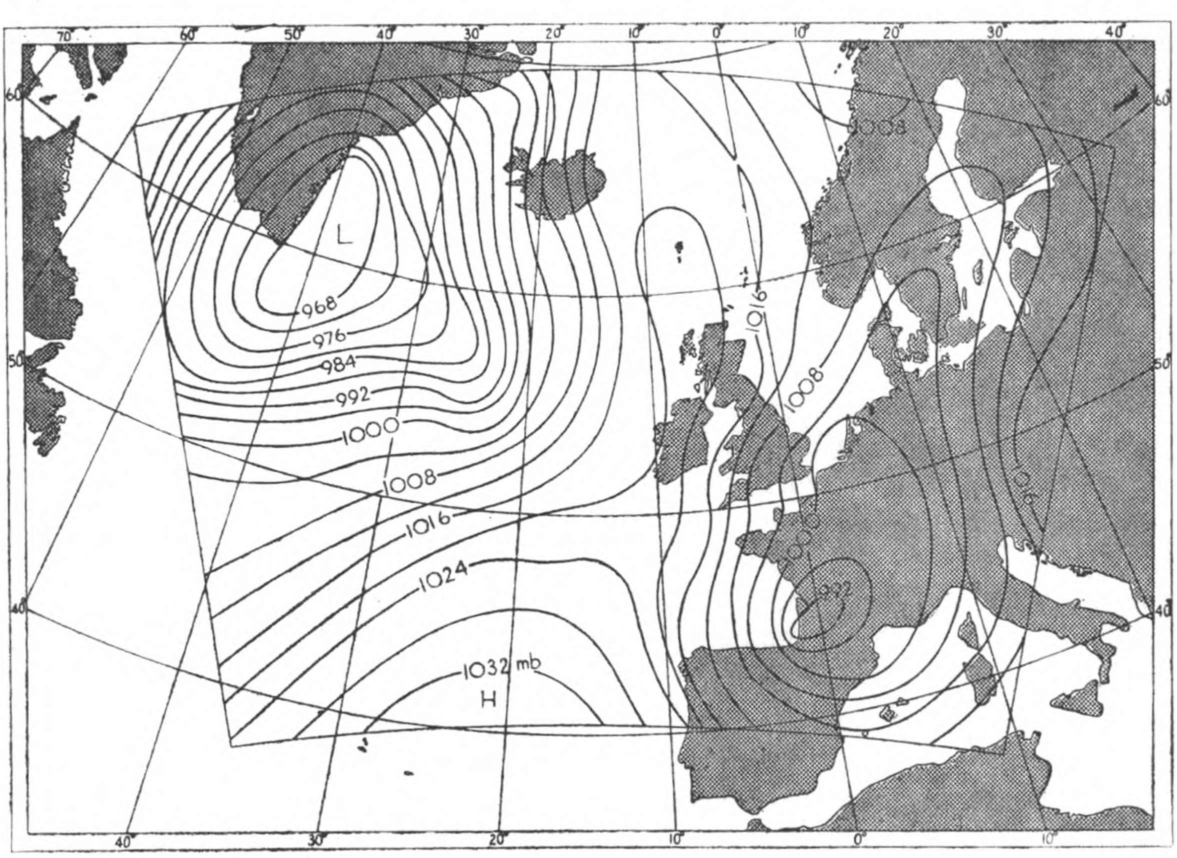

Figure 3—Numerical forecast of the surface chart for 0001 GMT, 11 January 1961
The curved outline shows the region for which the numerical forecast is produced.

The operational experiment shows that it is possible with a quite simple model to forecast the pressure field with an accuracy approaching that achieved by conventional methods, and that it is possible to carry out the computations sufficiently quickly for the results to be practically useful. However, if numerical forecasts are to be produced on a routine basis, an electronic computer faster, bigger and more reliable than METEOR will be required to maintain the essential time-schedule. One natural line of development is the formulation of models which improve the numerical forecasts of the pressure field and hence give an improvement in the first stage of weather prediction. Another is an attempt to use numerical methods to carry out the second stage of weather prediction, that is to forecast temperature, cloud, rain etc. Both lines have been developed in the Meteorological Office, with the emphasis perhaps on the former, principally by the introduction of the effects of friction and topography and an examination of new mathematical methods for the solution of the equations. However, it appears in fact that the two lines are not distinct. For example, the atmospheric models could be improved by enlarging the physical content of their equations; one of the major defects in the model used in the operational experiment is the omission of the effects of water in the atmosphere. The introduction of the motion of the water content should lead to predictions of rainfall and certain cloud types as well as to an improvement in forecasting the pressure fields. At present four separate models are being studied with the idea in mind of carrying out an operational test in late 1962 using the most successful of them. It is not possible to use a model which includes water vapour effects for a routine experiment using METEOR. Further research into numerical forecasting methods will require the services of a larger, faster computer.

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2. ORGANIZATION OF THE RESEARCH DIRECTORATE

The structure of the directorate of research, with two deputy directorates carrying the designations Physical Research and Dynamical Research, has proved highly satisfactory and seems likely to remain the pattern for some time to come. Although the titles are little more than convenient labels and do not imply that science recognizes a valid distinction between physics and dynamics, there is none the less a rather natural grouping into the two fields. Within dynamical research are included climatology, synoptic meteorology, the general circulation of the atmosphere and weather forecasting, broadly those branches of the science where the technique consists of the collection and analysis of data from generally large geographical areas and their discussion by cartographical, statistical and above all by the theoretical methods of fluid dynamics: weather systems are the primary interest. Within physical research, by contrast, the emphasis lies in the constitution of the atmosphere and the physical processes taking place: radiation, diffusion, evaporation and condensation, in particular. The techniques tend to centre upon special observations designed for the study of the problems in hand and the primary approach is that of the experimental physicist. The development of instruments naturally falls to this group.

The move to Bracknell was of course the great event of the year and was particularly significant for research in that it not only brought the different research groups into daily contact but provided, especially for physical research, laboratory, workshop and field facilities such as had never previously been available. This possibility of working in modern and well equipped laboratories has given a new impetus to physical research at Headquarters, but it will be some years before the full potential is realized. At the same time the facilities available at the research outstations remain extremely valuable, whether they be strictly Meteorological Office units or other Government establishments to which Office staff are attached. Important work in physical meteorology and in geophysics is carried out at the observatories, especially at Kew and Eskdalemuir, and at Cambridge where the unit has close relations with the University. Co-operation with other Government laboratories is active at the Royal Radar Establishment, Malvern, the Chemical Defence Research Establishment, Porton (where much classical work on turbulence and diffusion was pioneered) and, outstandingly, at the Royal Aircraft Establishment, Farnborough, where the Meteorological Research Flight is located with three aircraft and the necessary aircrew solely for meteorological research. The meteorological research group at Farnborough, headed by a Senior Principal Scientific Officer, is now well accommodated in new laboratories.

For the most part research is conducted by small groups of Scientific Officers, supported by ancillary staff, and each headed by a Senior Principal Scientific Officer, who, at Headquarters, carries the title of Assistant Director. It is well to recall that research has been an integral and substantial part of the Office structure since the post-war reorganization of 1948 and, especially, since the creation of a separate Directorate in 1957. More and more of the senior posts may now be filled by men with established positions in scientific research, in some cases with world-wide reputations. There is justification for the belief that the research effort is provided with a cutting edge of growing strength and keenness in the experienced men who are now coming forward to lead the research groups.

With more than fifty Scientific Officers engaged in research and each producing results of interest, it is quite impossible to do justice to all in a readable account of acceptable length. Following the precedent of last year, a special feature of this Annual Report is an account in some detail of one selected research enterprise, on this occasion the choice having fallen on numerical methods of forecasting using the electronic computer in the solution of the dynamical equations. This account will be found beginning on page 40 and is supplemented here by briefer notes on a few of the more noteworthy results in other fields.

3. Dynamical Research

Fronts. The radar theodolite at Crawley was used for a series of wind-finding ascents at short intervals of time (about 90 minutes) during the passage of six cold fronts. The analysis revealed a surface pressure trough some 50 miles ahead of the main veer of wind. A humidity boundary with very dry air to the rear was found above the level of 700 millibars and just ahead of the wind veer.

Stratocumulus cloud. The analysis of special data indicates that, to balance the loss of heat by radiation, subsidence rates of 1 mb/hr by day to 3 mb/hr by night are required. Rates larger or smaller than these values would presumably lead to thinning or thickening of the cloud.

Statistical short-range forecasting. Following the success of visibility forecasting by a statistical method, an attempt was made to use comparable methods for predicting the 24-hour movement and depth of depressions over the Atlantic. Although in the long run hope naturally centres on more scientific calculations based on dynamical theory, it is of interest that for one class of depression a statistical forecast gave a root-mean-square error of only 7 mb whereas over a trial period (admittedly not the same sample) dynamical calculations using METEOR led to mean errors of twice this magnitude. It is evident that here theory and calculation have yet to overcome the challenge of methods based entirely upon an examination of past data.

Upper wind forecasting. Charts were drawn regularly for heights of 50 mb and 30 mb (about 22 km and 26 km) with a view to forecasting for these heights. Errors of observation introduce peculiar difficulties but these can be overcome to a useful extent and a technique is evolving. Attempts to draw charts for 10 mb (about 30 km) met graver difficulties.

Forecasting rainfall at fronts. There is still no quantitative criterion for the amount or intensity of rainfall associated with a front and serious errors in forecasting are not uncommon. It was discovered, rather surprisingly, that a simple dynamical rule, on the advection of vorticity at the 300 mb level, gave a correct indication on nearly all occasions in a trial sample covering two years. This will justify further study.

Synoptic studies of long-wave features. Again regarded as supplementary to dynamical calculations but still capable of yielding results of practical value are the synoptic study and classification of different kinds of long-wave development. Papers published during the year relate to earlier work on anticyclones and cold northerly spells. Further work has dealt with a very significant process, known as relaxation, in which marked cold troughs, that is southward extensions of cold polar air, rapidly become warmer, largely by subsidence: cold front rainfall is then liable to terminate abruptly and wave activity to cease. New criteria requiring another trough upwind within 35°–40° longitude and an anticyclone within a similar distance downwind led to an 82 per cent success with 201 forecasts. This kind of empirical rule, which is of course dynamically reasonable, can prove to be of critical value for medium-range forecasting as it may well resolve a clear dilemma between dry and wet weather.

Long-range forecasting. In spite of the very limited degree of success of past attempts at long-range forecasting for a month ahead, the tremendous economic value of good forecasts is an insistent argument for continued effort, while the scientific challenge must remain quite compelling until we can either forecast well or understand why we fail. A further series of attempts was therefore begun, with the interest of the Secretary of State, combining the indications of several criteria, analogues of temperature anomaly charts, synoptic weather types, singularities, statistical rules and so on. At the same time a strengthened research team is attempting to apply quantitative methods and criteria to these different indicators, some of which have never been submitted to strict tests of validity.

A method of choosing analogues objectively by electronic computer was developed and it was possible to show convincingly that a large area must be used to obtain the most successful predictions. This of course puts the small area of the British Isles at some disadvantage compared with a large continent.

Representation of large-scale patterns by means of linear combinations of empirical orthogonal space-filtering functions provides a way of specifying a monthly-mean field with a small number of parameters and so a basis of objective classification and selection.

Power-spectrum analysis of time series of temperature and pressure showed the prominence of oscillations with a half-period ranging from 5 to 15 days, which therefore would be a natural period to choose for long-range forecasting of sequential weather.

General circulation. Over a period of 15 years since World War II the Office has made a major effort in presenting for general use a world upper air climatology, giving winds and temperatures, monthly means and variances. This kind of exacting work, although not in itself of enthralling interest, is of course of immediate practical value as well as a source of many theoretical problems. The curious variation in the mean monthly zonal wind component of the tropical stratosphere, with a period of 23–29 months, was confirmed at every station from which data could be obtained but no satisfying dynamical theory has yet emerged. There had been a hint that the amplitude was decreasing with time and those interested in solar-terrestrial relations were quick to suspect a link with sunspot frequency but later results up to the summer of 1961 do not confirm the trend.

Other interesting phenomena of the high atmosphere include the sudden stratospheric warming of late winter over the polar cap, which is being studied intensively in co-operation with the Canadian meteorological office, and the spring and autumn reversals of the high-level circumpolar vortex. The spring reversal is a moveable feature which may come as early as mid-March or be deferred to late May, but the autumn change is much more regular. This almost world-wide seasonal change of wind has been called the stratospheric monsoon system. It is extremely puzzling to find such irregularity in the timing of the change to the " summer monsoon " although one has in mind that the time of onset of the Indian monsoon has a range of a month and that even in England spring may be late or early by a like amount. These gross variations of circulation from year to year set a problem of the deepest significance, plainly linked with the notorious difficulties of long-range forecasting.

The next step after the direct climatological analysis of data in the study of the general circulation is the diagnosis of the mechanisms which permit the various conservation laws to be satisfied, conservation of matter, momentum, energy and water in particular, and some new progress has been made with enthalpy and water vapour. It was shown that the flux and divergence of water vapour over the Atlantic region are to a substantial degree accounted for by mean motions but that the eddy motions, on the synoptic scale, are of much the same importance. When opportunity offers it is hoped that attention may also be devoted to the purely theoretical attack on the general circulation using idealized world models and high-speed computing.

Climatic change. Climatic change may be regarded as the low-frequency end of the spectrum of meteorological variability, which is continuous from small-scale turbulence to events on the geological time-scale. Researches into past records are therefore an integral part of dynamical meteorology and an important contribution made in the Office was the construction of monthly mean pressure charts for the North Atlantic region back to 1750. Januarys and Julys are now complete and intermediate months have received attention. Other evidence is helping to confirm our climatic history with such episodes as the better climate of the early middle ages, the cold period of the 1600's and certain drastic changes a century later. The very recent change, referred to as the warming of the Arctic, which seems to have culminated about 1940, was further studied. These short-term fluctuations of climate have, for agriculture and commerce, a degree of importance which is only just beginning to be generally appreciated. Prediction of trends is by no means a foolish aim and would be by no means lacking in economic value if it could be attained, but it must be conceded that a satisfying theory of recent climatic changes is still awaited.

4. Physical Research

Instrument development. Aerological instrumentation continued to attract much attention and, although production of a new radar system for routine wind-finding and a new Meteorological Office radio-sonde, likewise for general use at the network of the upper air stations, will be in the hands of outside contractors, our own staff must devote a great deal of time and thought to problems of design. The radio-sonde has in fact been designed in detail and is well under way, including temperature-measuring capacitors and aneroid pressure capsules. The electronic circuits were finalized, test flights having shown the temperature coefficients of the audio-frequency circuits to be negligible and the signals adequate for automatic recording.

The provision of balloons to carry the instruments to the heights now demanded, 120,000 feet with 90 per cent reliability, provides no easy problem and so far no British balloon has been found to equal the performance of certain American balloons, which in fact averaged over 100,000 feet on test.

Other notable work on instruments includes: the automatic frost-point hygrometer, at last, after several years, brought to the prototype stage, and it is hoped with an acceptable performance but this is not yet proved; a precision aneroid which will replace the mercury barometer on selected ships; the Meteorological Office modulated searchlight for determination of cloud height by day, now accepted for operational use and being produced under contract; daylight illumination recorders using photocells and filters with longer life; digital automatic recording equipment which, using punched paper-tape, was installed at Kew for radiation records and is likely to be more widely employed; and automatic weather stations. The last named requirement, whether for climatological recording in remote areas which may be visited only occasionally or for synoptic stations reporting automatically by radio to some control station, was explored in some detail, showing that the needs if they become pressing could be met at a price, and it may be that growing urgency will justify the cost before very long.

Cloud physics. The physics of clouds and precipitation has in recent years developed into a major branch of meteorology with many ramifications, from the problems of nuclei of condensation and freezing to the dynamics of convective clouds, and with a wealth of special instrumentation, especially aircraft instruments and radar. The subject absorbs much of the attention of one branch at Headquarters and of the Meteorological Research Flight located with the Royal Aircraft Establishment at Farnborough. A theoretical paper on the radar back-scatter from a target such as an assemblage of raindrops, taking account of the shape of the lobe for transmission and reception, has largely removed a long-standing discrepancy between theory and observation. The use of Doppler radar for the study of the fall-speed and size spectrum of raindrops, and associated vertical currents, was developed in collaboration with the Royal Radar Establishment at Malvern (where a joint unit is established), with promising results.

Atmospheric turbulence and diffusion. Continuing a programme of research in association with the Chemical Defence Research Establishment at Porton, a collaboration which it is interesting to recall has been maintained for some forty years, short-range diffusion in nocturnal inversion conditions was studied experimentally. Diffusion over distances of order 100 miles was also investigated, using a fluorescent tracer, with results which were compatible with ideas on vertical and lateral spreading apart from an overall loss of tracer which meteorology could not explain. New and important knowledge on the physical behaviour of the fluorescent tracer emerged in this way as a by-product of meteorological experiments. While the work at Porton will continue, plans have also been made for a separate but co-ordinated programme to be based at Bracknell under the leadership of Dr. F. Pasquill. A collaborator for about one year will be Dr. J. K. Angell of the United States Weather Bureau, attached to the Office under an exchange arrangement.

A small unit attached to the Department of Agriculture of the University of Cambridge is working on problems of evaporation and energy exchange with the surface, using the aerodynamic method as well as direct measurements of radiation, soil heat-flux and evaporation. This kind of experimentation has been going on for many years in various countries but anomalous results continue to arise and it is evident that very high standards of instrument design, calibration and maintenance are essential if reliable quantitative results are to be obtained. Attention has recently been directed, especially by the work of a member of the staff during a recent period of secondment to Australia, to edge effects in advective situations, that is to inhomogeneities in the surface boundary, which are obviously important in some real problems.

Turbulence in the free atmosphere is significant not only as a mechanism of flux but also in relation to special problems, such as radio propagation affected by variations in radio refractive index, performance of sounding balloons, design of rockets or bumpiness in aircraft. Doppler radar, aircraft accelerometers with yaw and pitch recorders, and radio refractometers are among the instruments now in use for the study of the phenomena. An analysis of reports of clear-air turbulence made by aircrew in 1958–60 confirmed previous findings to the effect that severe bumpiness occurs mainly near the jet stream, especially below core level on the low-pressure side, and also near a marked trough in the upper flow pattern.

Radiation. It fell to the Deputy Director of Physical Research, Dr. G. D. Robinson, to write the official report on the observations of solar radiation and radiation balance made during the International Geophysical Year and collected at the World Data Centre, Geneva. The report will be published in "Annals of the I.G.Y." Other contributions of theoretical interest dealt with albedo and absorption of solar radiation and with atmospheric aerosol, shown to be a highly significant agent in absorption and scattering. A new venture is the regular recording of the spectral distribution of solar radiation, a matter of practical importance in horticulture and other activities. We intend to record intensity in some 12 discrete wavebands isolated by interference filters as well as, on selected occasions, detailed measurements in the ultra-violet using a double monochromator.

Upper Atmosphere. The Meteorological Research Flight Canberra aircraft was used to obtain further information on the high troposphere and lower stratosphere. Detachments were made to Malta and to Bodö in northern Norway. The June detachment to Bodö found a dry stratosphere as far north as 80° N (frost-point –80° C) with rather high amounts of ozone suggesting subsidence. Flights from Scotland in the spring (1962) will, it is hoped, bring data of particular significance related with the " sudden warming " of the arctic stratosphere. The distribution of water vapour and ozone in the vicinity of jet streams was revealed from the analysis of flights through 28 jet streams.

Research in the high atmosphere, which was the topic of special interest discussed at length in last year's Report, naturally continued although the present phase is that of planning and preparation rather than achievement and discussion. A development contract was placed with Bristol Aerojet Ltd. for a 5-inch rocket to carry a pay-load of 5 kg to 60 km with the hope that atmospheric soundings may begin before the end of 1962. The rockets will, in the first place, be launched from South Uist in the Hebrides, chosen for its relative safety rather than its convenience, although there is every reason to believe that the risk of misadventure is very small and that, in course of time, the rockets will be launched from other ranges in the country. The parachute-borne equipment which will be launched from the rocket is not yet determined as much depends on available ground radar. A 27 Mc/s transmitter, transistorized and therefore light, robust and compact is an alternative to one working on 450 Mc/s or thereabouts. It is expected that in due course the new wind-finding radar being developed for general use at radio-sonde stations will be entirely suitable for tracking the rocket parachute sonde, in which case one may visualize a combined radio-sonde and rocket-sonde station as a feature of future aerological networks.

The plans for making ozone measurements from the second U.S.–U.K. satellite, S–52, expected to be launched in mid-1963, went ahead in a most satisfactory way and instruments of the type to be used in the satellite experiments were made and flown from Woomera, Australia, carried by a Skylark rocket. The experiment was, so far as can be judged, wholly successful. The lengthy stage of adapting equipment to the satellite will shortly begin and will necessitate the more or less continuous presence in the United States of a member of the research team until the time of the launch a year or more later.

5. GEOPHYSICS

It was towards the end of 1960 that an agreement was reached with the Royal Society and other interested bodies to make two special appointments to the staff, to be known as Gassiot Fellows, and to be responsible respectively for research in geomagnetism and in seismology. These appointments have now been made, the geomagnetician being Dr. F. D. Stacey who has been accommodated at our Cambridge office to facilitate co-operation with the University, and the seismologist Dr. H. M. Iyer who finds it most convenient to be centred on Bracknell for the present. Although there has not yet been time to feel the full benefit of the new scheme, plans of research work have been discussed and there can be no doubt that the geophysical work in the Office, and especially the observing work at our observatories, Kew, Eskdalemuir and Lerwick, will quickly take on a new and more up-to-date look as the outcome of the new appointments.

6. RESEARCH CO-OPERATION—NATIONAL AND INTERNATIONAL

Scientific research today, more so than at any time in the past, must be pursued against a background of continuous activity in committees, colloquia, symposia and other scientific meetings of national learned societies and international bodies of many kinds. The meetings of most direct importance to the Office are those of the Meteorological Research Committee and its Sub-Committees and it is a pleasure to record appreciation of the interest displayed in our work by the outside members of these bodies. At the same time the research staff are encouraged to play their individual rôles in the wider range of scientific activities and it would be a rare event if a representative meeting on a meteorological subject were to be held anywhere in the world without members of the staff being invited to attend. In most important cases ways and means can be found to cover the costs of these valuable visits.

Numerous special visits were paid to the research divisions by oversea meteorologists and to oversea research centres by our own staff. Notable examples were a three-months' visit by a member of the staff of the New Zealand Meteorological Office, the completion of a three-year secondment of a Principal Scientific Officer to Australia, and the exchange, for a period of about a year, of research officers with the United States Weather Bureau.

R. C. SUTCLIFFE

Director of Research

INTERNATIONAL CO-OPERATION

1. World Meteorological Organization

The thirteenth session of the Executive Committee took place in Geneva at the Headquarters of the World Meteorological Organization (WMO) from 11–31 May 1961. The session was attended by the Director-General who is a member of the Committee and the Permanent Representative of the United Kingdom with the WMO. The Director-General was accompanied by Mr. C. W. G. Daking, Assistant Director (Defence and International).

The first session of the Commission for Hydrological Meteorology was held in Washington D.C., U.S.A. from 12–26 April 1961. The Commission prepared a WMO programme in the field of hydrological meteorology including networks of observing stations, and carried out a study of meteorological requirements for hydrology. The United Kingdom delegation was led by Mr. R. H. Clements, Assistant Director (Climatological Services): the other members of the delegation were Messrs. A. Bleasdale and R. P. W. Lewis (M.O.3) and Mr. F. H. Allen of the Department of Scientific and Industrial Research.

The third session of the Commission for Aerology was held in Rome from 18 September–2 October 1961. Matters related to research in the physics and dynamics of the atmosphere were dealt with including numerical prediction, atmospheric chemistry, long-range weather forecasting, and the high atmosphere. The President for the session was Dr. R. C. Sutcliffe, Director of Research, who also led the United Kingdom delegation. Dr. Sutcliffe was assisted by Mr. J. S. Sawyer, Deputy Director (Dynamical Research), Mr. R. F. Jones, Assistant Director (Atmospheric Physics) and Professor P. A. Sheppard, Department of Meteorology, Imperial College of Science and Technology. Mr. J. S. Sawyer was elected Vice-President of the Commission. The session was followed by a WMO/UNESCO symposium on climatic changes. This was attended by Dr. R. C. Sutcliffe, Mr. J. S. Sawyer and Mr. H. H. Lamb (M.O.13).

There have been several meetings of working groups of the Executive Committee and of the Technical Commissions of WMO during the year, at which the Office has provided experts, either in a national or personal capacity.

Joint ICAO/WMO seminars on forecasting for turbine-powered aircraft were held in Cairo and Nicosia (Cyprus) in November–December 1961. Mr. T. H. Kirk, Senior Meteorological Officer, Malta and Mr. D. H. Johnson (M.O.13) took part as instructors at these seminars which were also attended by other members of the Office.

2. North Atlantic Treaty Organization

Dr. A. C. Best, Director of Services, assisted by Mr. L. H. Starr, Assistant Director (Observations and Communications) and Mr. R. A. Buchanan (M.O.17), represented the United Kingdom at the eighteenth meeting of the Meteorological Committee of the Standing Group held in Paris from 20–23 June. Policy questions concerning meteorological service to NATO and arrangements for meteorological support to NATO military formations were discussed.

Sessions of the two working groups of the Standing Group Meteorological Committee were held in Norfolk, Virginia, from 14–23 March and in London from 17–26 October to deal with problems concerning meteorological communications and plans. On both occasions Mr. L. H. Starr and Mr. R. A. Buchanan represented the United Kingdom. Mr. R. K. Pilsbury (M.O.5) attended the London session of the working group on communications matters.

The tenth meeting of the SHAPE Meteorological Committee took place near Paris from 30 May–1 June, with Mr. L. H. Starr and Mr. R. A. Buchanan attending on behalf of the United Kingdom.

The Channel Command Meteorological Committee met in London on 20 April. Mr. R. A. Buchanan represented the Meteorological Office.

Mr. J. Simmonds (M.O.7) attended a meeting of the External Ballistics Group of the Armaments Committee in Paris from 4–8 September.

3. Central Treaty Organization

The Regional Meteorological Policy Committee met in Ankara on 28 and 29 March. The United Kingdom delegation was led by Mr. P. J. Meade, Deputy Director (Outstation Services), assisted by Instructor Captain J. A. Burnett, R.N., (Director of Naval Weather Services Admiralty) and Mr. R. Murray, Chief Meteorological Officer, Near East Air Force. A meeting of the Working Group of the Central Treaty Organization Sub-Committee on Civil Aviation was held in Tehran from 23–25 November 1961. Mr. A. A. Worthington attended as United Kingdom delegate.

4. South East Asia Treaty Organization

The Meteorological Committee of SEATO met in Bangkok from 22–28 August. Mr. R. Frost, Chief Meteorological Officer, Far East Air Force, represented the United Kingdom.

5. International Civil Aviation Organization

The fourth North Atlantic Regional Air Navigation Meeting of the International Civil Aviation Organization was held in Paris from 14 September to 9 October 1961. Mr. A. A. Worthington was a member of the United Kingdom delegation.

6. Commonwealth Meetings

Mr. A. A. Worthington was a member of the United Kingdom delegations at the fourth meeting of the Committee of the South African Air Transport Council on Air Navigation Services in Salisbury, Rhodesia in March and at the meeting of the South Pacific Air Transport Council in Fiji from 30 October–4 November.

7. International Air Transport Association

The International Air Transport Association held its fourteenth Technical Conference at Montreal during 17–26 April 1961. A feature of the conference was a symposium on supersonic air transport. Mr. A. A. Worthington attended the Conference.

8. Other International Meetings

Other international meetings on meteorology and allied sciences were attended by members of the Office as follows. The list is not necessarily complete but read in conjunction with Sections 1 to 7, a revealing picture of the diversity and extent to which the Meteorological Office is engaged in international co-operation is obtained.

(*a*) Dr. R. C. Sutcliffe, Director of Research, was Chairman of a meeting of Presidents of Technical Commissions of the WMO which met in Geneva at the Headquarters of the Organization from 4–6 May 1961; and from 8–10 May he attended a meeting of the Executive Committee Working Group on Meteorological Data for Research, also held in Geneva. In March, Dr. Sutcliffe presided at a meeting of the Working Group on Meteorological Research of the Science Committee of the North Atlantic Council.

(*b*) Dr. G. D. Robinson, Deputy Director (Physical Research), attended a meeting of the WMO Executive Committee Panel of Experts on Artificial Satellites which met in Washington D.C., U.S.A., during February 1961, a joint WMO/IAMAP symposium on atmospheric ozone at Arosa from 7–12 August, and, with Mr. R. H. Collingbourne, a joint WMO/IAMAP symposium on radiation held in Vienna from 14–19 August.

(*c*) Dr. A. G. Forsdyke, Assistant Director (Climatological Research) was the representative of the United Kingdom on the Meteorological Planning Committee of SCOR for the International Indian Ocean Expedition, and was nominated by the British National Committee for Oceanic Research of the Royal Society. Dr. Forsdyke also attended a meeting of the Committee on Interaction between the Ocean and the Atmosphere of the IAMAP held in Marseilles on 3 September.

(*d*) Dr. R. J. Murgatroyd (Meteorological Research Flight) attended the International Conference on Cloud Physics held in Canberra and Sydney, Australia from 11–20 September 1961 and represented the WMO as well as the United Kingdom.

(*e*) Dr. R. Frith, Assistant Director (High Atmosphere) attended a meeting of the CIMO Working Group on Meteorological Instruments and Methods of Observation on Aerodromes which met in De Bilt, Holland in March 1961 and the Annual Conference of COSPAR in Florence from 9–17 April.

(*f*) Cdr. C. E. N. Frankcom, Marine Superintendent, represented the WMO at the second session of the Inter-Governmental Maritime Consultative Organization Assembly held in London during April 1961.

(*g*) Dr. F. Pasquill and Dr. G. B. Tucker (M.O.13) attended a joint symposium on fundamental problems in turbulence and their relation to geophysics organized by IUGG/IUTAM in Marseilles from 4–9 September. On the invitation of IAEA, Dr. Pasquill also attended a meeting of the Scientific Panel on Reactor Siting organized jointly by IAEA and ISO which was held at the IAEA Headquarters in Vienna from 31 October–2 November.

(*h*) Mr. A. A. Worthington (M.O.17) represented the United Kingdom at a meeting of the Working Group on Area Forecast Systems of the WMO Commission for Aeronautical Meteorology in June 1961 and was a member of the United Kingdom delegation at a meeting in London during August 1961 of the Anglo-French Joint Standing Committee on Civil Aviation.

(*i*) Mr. L. H. Starr, Assistant Director (Observations and Communications) and Mr. E. J. Bell (M.O.5) attended in Paris meetings of Working Groups of the WMO Commission for Synoptic Meteorology on Telecommunications during April and on Facsimile during October 1961.

(*j*) Mr. L. P. Smith (M.O.7) attended the WMO/UNESCO Symposium on Climatic Changes held in Rome in September at the invitation of UNESCO.

(*k*) Mr. F. E. Lumb (M.O.3) attended the 49th meeting of the International Council for the Exploration of the Sea, at Charlottenlund, Copenhagen from 2–6 October as an observer for the WMO.

(*l*) Mr. H. H. Lamb (M.O.13) attended the sixth International Congress of the International Association for Quaternary Research held in Warsaw from 27 August–5 September.

(*m*) Mr. W. H. Hogg (M.O.7) attended a European symposium on black rust held in Madrid in April and convened by the International Congress of Plant Protection.

(*n*) U.K./U.S. working group meetings on the international satellite U.S.-U.K., S-52 held in Washington, D.C. in May and November and London in August were attended by Dr. K. H. Stewart (M.O.19). Mr. D. E. Miller (M.O.19) also attended the London meeting.

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

STAFF

The Meteorological Office Headquarters organization is shown in the diagram on p. 58 and the names of the principal officers are listed on p.iv.

At the end of the year 1961 the total number of posts for all grades was 3,540 of which 48 were filled by airmen meteorologists on National Service. The total civilian strength on 31 December was 3,392 made up as follows:

Scientific Officer class	
Chief Scientific Officer	3
Deputy Chief Scientific Officer	4
Senior Principal Scientific Officer	22
Principal Scientific Officer	78
Senior Scientific Officer	30
Scientific Officer	13
Administrative class	
Assistant Secretary	1
Experimental Officer class	
Chief Experimental Officer	20
Senior Experimental Officer	205
Experimental Officer	356
Assistant Experimental Officer	181
Scientific Assistant class	
Senior Scientific Assistant	251
Scientific Assistant	1,226
Marine staff	
Nautical Officer class	8
Ocean Weather Ships and Base	
Officers	56
Crew	149
Technical and Signals grades	276
Executive and Clerical grades	134
Typing and miscellaneous non-industrial grades	119
Industrial employees	75
Locally entered staff and employees overseas	185
Total	3,392

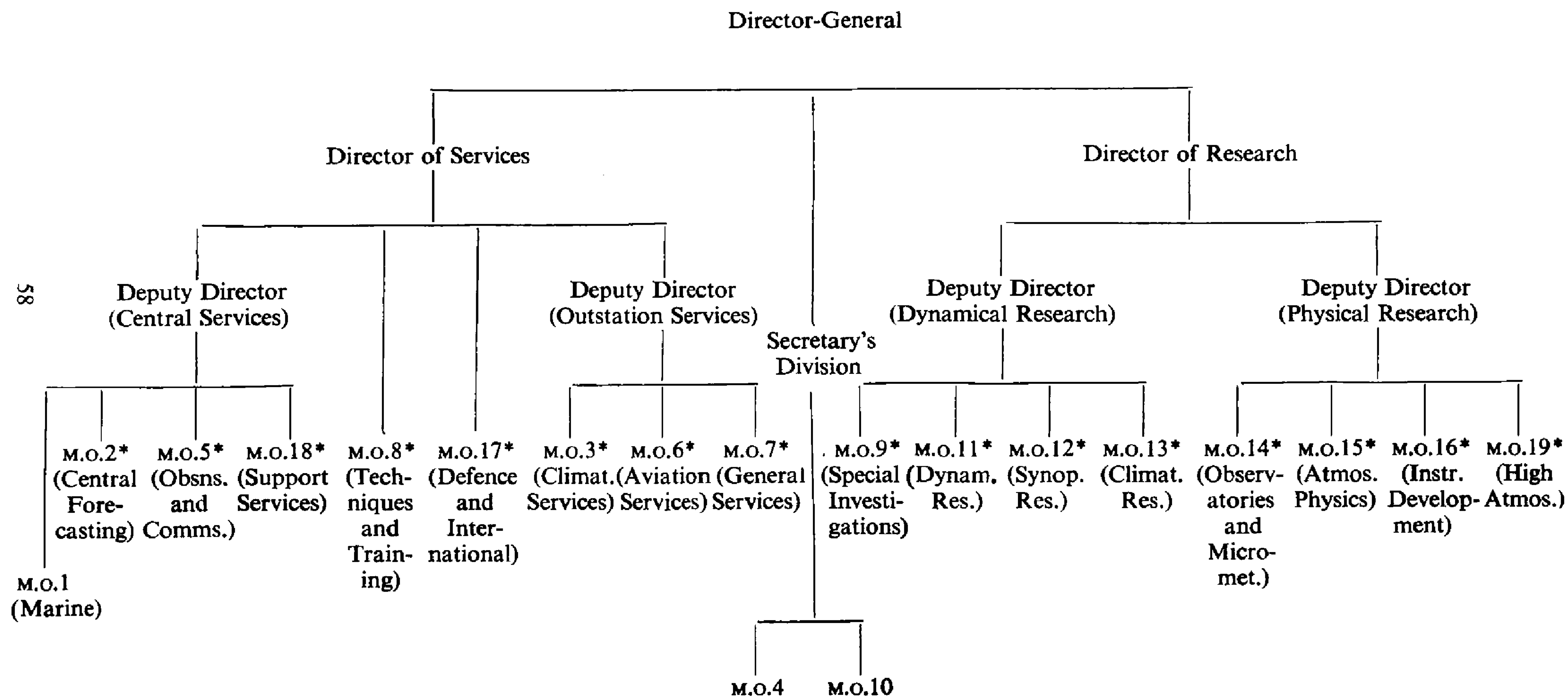
Recruitment to the Scientific Officer class was very successful and, as a result, most of the vacancies in the class were filled. The staff position in the Experimental Officer class improved too. In spite of the best recruiting figures from school leavers for many years, the high resignation rate and the ending of National Service for many of the staff led to there being more vacancies in the Assistant class at the end of the year than at the beginning.

Eleven undergraduates were chosen from an encouraging number of applicants to work in the Office as vacation students. Four members of the staff were taking sandwich courses, sharing the year between the Office and their technical college. Other study concessions were enjoyed by 225 candidates.

In the Birthday Honours List, Dr. R. C. Sutcliffe, O.B.E., F.R.S. was appointed a Companion of the Most Honourable Order of the Bath, Mr. T. W. V. Jones was awarded the Imperial Service Order and Captain H. Sobey, Master of the Ocean Weather Ship *Weather Observer*, was appointed a Member of the Most Excellent Order of the British Empire.

APPENDIX I

METEOROLOGICAL OFFICE HEADQUARTERS ORGANIZATION



*Assistant Directorates

APPENDIX II

PUBLICATIONS

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

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

PERIODICAL

Daily Aerological Record, containing information respecting meteorological conditions in the upper air over the British Isles (to 20 December 1961).
Daily Weather Report, containing weather maps for the northern hemisphere, British Isles, etc., and data (to 31 December 1961).
Daily Weather Report, Overseas Supplement, containing surface and upper air data (to 23 June 1961).
Meteorological Magazine (to December 1961).
Monthly Weather Report (to June 1961).
Seismological Bulletin. A diary of seismological disturbances recorded on the Galitzin aperiodic seismographs at Kew Observatory, Richmond (to October 1961).
Marine Observer (quarterly) (to October 1961).
The Observatories' Year Book, comprising the meteorological and geophysical results obtained from autographic records and eye observations at the Lerwick, Eskdalemuir and Kew Observatories, 1951, 1952, 1953, 1954, 1955, 1956 and 1959.

SERIAL

Geophysical Memoirs: Vol. XIII:
105. Upper winds over the world, Part III. By G. B. Tucker, Ph.D.

Scientific Papers:

5. An experiment in numerical forecasting. By E. Knighting, B.Sc., G. A. Corby, B.Sc., F. H. Bushby, B.Sc. and C. E. Wallington, M.Sc.
6. Seasonal variation of the sea surface temperature in coastal waters of the British Isles. By F. E. Lumb, M.Sc.
7. Forecasting in the Falkland Islands and Dependencies. By S. D. Glassey.
8. Factors associated with the formation and persistence of anticyclones over Scandinavia in the winter half of the year. By M. K. Miles, M.Sc.
9. An experiment in the verification of forecast charts. By C. E. Wallington, M.Sc.
10. Incidence of, and some rules for forecasting, temperature inversions over the north-east Atlantic. By H. C. Shellard, B.Sc. and R. F. M. Hay, M.A.

OCCASIONAL

Handbook of meteorological instruments. Part II. Instruments for upper air observations.
State of sea card.
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 6. Malta.
1951–55. Part 7, O.W.S. Juliett.

APPENDIX III

BOOKS OR PAPERS BY MEMBERS OF THE STAFF

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

SIR GRAHAM SUTTON, D.SC., F.R.S.; The challenge of the atmosphere. New York (Harper and Brothers), 1961.

SIR GRAHAM SUTTON, D.SC., F.R.S.; Weather and climate. London (B.B.C.), 1961, 4to, pp. 36, pl.2.

R. C. SUTCLIFFE, B.SC., PH.D., F.R.S.; Are long-range weather forecasts possible? *New Scientist, London*, **11**, 1961, p. 211.

R. C. SUTCLIFFE, B.SC., PH.D., F.R.S.; Changes of climate. *Nature, London*, **192**, 1961, p. 1139.

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R. C. SUTCLIFFE, B.SC., PH.D., F.R.S.; The rôle of WMO in research. *World Met. Org. Bull., Geneva*, **10**, 1961, p. 203.

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E. KNIGHTING, B.SC.; Numerical forecasts made with two-and three-parameter models. *Met. Mag., London*, **90**, 1961, p. 117.

E. KNIGHTING, B.SC.; Numerical weather analysis and prediction. *Met. Mag., London*, **90**, 1961, p. 333.

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