Met.O.756

Meteorological Office

REPORT FOR THE YEAR
ENDING
31 DECEMBER 1963

LONDON

HER MAJESTY'S STATIONERY OFFICE

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Met.O.756

ANNUAL REPORT
ON THE
METEOROLOGICAL OFFICE

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

FOR THE YEAR
1 JANUARY TO 31 DECEMBER 1963

LONDON
HER MAJESTY'S STATIONERY OFFICE
1964

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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.

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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 four times in 1963.

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.

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Sir Graham Sutton, C.B.E., F.R.S. (Director-General, Meteorological Office)
Mr. A. E. Woodward-Nutt (Ministry of Aviation)

Secretary: Mr. F. E. Dinsdale

The Committee met twice in 1963 and its sub-committees nine 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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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 did not meet in 1963.

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(on 31 December 1963)

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Assistant Director (Support Services)	G. A. Bull, B.Sc.
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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. During 1963 it formed 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 and provision of basic meteorological information for use by that Service.

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

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

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

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

(vii) Research in meteorology and geophysics.

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

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

The gross annual expenditure by the Exchequer, including that on the common services, is of the order of £6,200,000. Of the amount chargeable to Defence (Air) Votes, about £4,300,000 represents expenditure associated with staff and £1,700,000 expenditure on stores, communications and miscellaneous services. Over £1,300,000 is recovered from other Government Departments and outside bodies in respect of special services rendered, sales of meteorological equipment and the like.

FOREWORD BY THE DIRECTOR-GENERAL

The year 1963 is likely to remain long in the memory of British meteorologists, for its winter was the most severe experienced in this country for over 200 years. No single 'cause' of this marked departure from our usually mild climate has yet been identified, although this area of the globe is better equipped for meteorological observations and their analysis than ever before. This illustrates not only the great difficulty of meteorology but also the need for continued research if ample warning of such catastrophic conditions is ever to be given.

In the Meteorological Office there have been several events of importance during the year. It has now become clear that the present Ferranti high-speed computer (METEOR) which has given such good service in past years, must be replaced by a larger and faster machine if progress is to continue. A decision has been taken to install the English Electric-Leo KDF9, a computing system of advanced design with a large storage capacity and the facility to perform several calculations simultaneously. The installation is expected to be completed early in 1965. Prolonged trials have shown that, even with the limited facilities of METEOR, purely mathematical methods can now yield short-term forecasts of pressure, temperature and wind in the mid and upper troposphere that are, on the average, closer to actuality than those produced by experienced meteorologists using conventional methods. Considerable success has also attended the preparation of surface forecast charts by dynamical methods, but here the problem is rendered more difficult by the effects of the terrain.

When the larger and faster computer has been installed such forecasts will be prepared and used as routine. This means that numerical forecasting has advanced beyond the experimental stage and a milestone in the history of the Meteorological Office has been passed. Research, of course, will continue as actively as before, for there are many problems still to be solved in this field.

For some years the Research Directorate has devoted a steadily increasing effort to the problems of transient climatic variations and long-range forecasting. In the autumn of 1963 it was decided to initiate a series of 30-day 'weather prospects' by the regular publication of a monthly bulletin with a mid-month supplement. This decision did not mean that a major breakthrough had been achieved in this formidable problem but that a practical system has been evolved that, judged by some five years experience, is capable of producing general statements about the weather of this country during the ensuing 30 days that are in tolerably good agreement with events on a majority of occasions. To support this work the Climatology Research Branch has been divided. One Branch (Met.O.13) deals with synoptic climatology and is responsible for the preparation of the 30-day prospects. A new Branch (Met.O.20) deals with dynamical climatology and is mainly concerned with the mathematical analysis of the general circulation of the atmosphere and the behaviour of large-scale atmospheric systems that determine such important but transient features of climate as the exceptionally cold winter just experienced. It is my hope that the creation of these Branches will initiate a new and fruitful phase in climatological research in the Office.

Details of the work of the Meteorological Office throughout the year are given in the pages that follow. Aviation still remains our largest 'customer', but I wish to call attention to the considerable increase in non-aviation inquiries. This continues a pattern that has been well in evidence for almost a decade, and it is clear that in this country there is a large and only partially satisfied demand for information about weather and climate. The resources of the Office are being stretched to meet the requirement, despite the relief afforded to the airfield meteorological offices by the four local weather centres in London, Glasgow, Manchester and Southampton and by the automatic telephone weather service, which attracted nearly eight million calls in 1963.

The Trend Committee on the organization of civil science heard evidence respecting meteorology from the Permanent Under Secretary of State for Air and the Director-General of the Meteorological Office. The Committee decided to recommend that the Meteorological Office should remain with the Air Ministry, which becomes the Air Force Department within the reorganized Ministry of Defence.

International meteorological activities continued to occupy a considerable part of the time of the senior staff. I led the United Kingdom delegation to the Fourth Congress of the World Meteorological Organization (Geneva, 1–27 April) and was re-elected to its Executive Committee. In August I visited Canada and later led the United Kingdom delegation to the General Assembly of the International Union of Geodesy and Geophysics, held at Berkeley, California. In November I attended the General Assembly of the International Council of Scientific Unions at Vienna as a delegate.

O. G. SUTTON

THE DIRECTORATE OF SERVICES

1. Special Topic—Climatological Services

The climate of a country is one of its most characteristic and stable features. We may not like it, but we cannot change it—which is perhaps just as well at present. Usually there are advantages to exploit and disadvantages to combat. These are exercises which can pay off, in any terms from well-being to hard cash, benefiting individuals as well as whole industries.

The aim of this article is to indicate the role of the Climatological Services Branch in this connexion. But the climatologist is not the only one who matters; his particular knowledge and expertise are of little value unless the customers realize their worth.

To exploit our climate most efficiently we need facts. In this, it is necessary to distinguish between *weather* and *climate*. Weather is the physical state of the atmosphere now or at some specified time in the past: to say 'It is raining' is a statement about one aspect of the weather. Climate is the time-average of weather: thus to know that, when averaged over many years, the annual rainfall of Plymouth is about 40 inches, of which about 60 per cent falls in the winter half-year, is to know something of the climate of this part of Devon.

Although climatological averages are remarkably constant for a particular station, our weather can, and does, vary greatly from one year to the next. A short-period average may be misleading. Climate also changes, though much more slowly, so that a relatively long-term average for the immediate past is not always the best statistic for the years to come. The choice of the period of averaging is one of the central problems of climatology. Usually the climatologist works with facts about the weather over long periods: less than 10 years is hardly ever suitable and sometimes hundreds of years are not enough to allow him to pronounce with certainty on trends and other important features.

Gathering the facts. The facts about climate are built up from regular observations of the weather. At any time the climatologist depends on weather data amassed by his predecessors, and he recognizes a duty to his successors—to provide them with relevant facts in the right form.

Table XVII in the Statistics Section of this Report gives the present sources of climatological data for the United Kingdom. Manuscript forms are at present used for entering the weather observations at the appropriate times. Of the hundred or so stations referred to in the first two columns, about 2 dozen make returns of observations for each hour of every day, about 4 dozen for 8 hours (evenly distributed round the clock) each day, and the remainder mostly for 4 hours each day. Most of these stations are manned by Meteorological Office staff whose main duties are other than climatological in nature. The 500 or so stations referred to in columns 3 and 4 come under the general heading of 'voluntary co-operating climatological stations' where, in most instances, instrumental observations are made only once a day (at 0900 GMT), though the elements observed give some indication of the weather through the relevant 24-hour period. These stations exist because local authorities, industrial undertakings and others maintain stations primarily for their own purposes. In addition many individual enthusiasts run their own stations as a hobby. For these the Meteorological Office acts as adviser on instruments and siting as well as on the observational procedures: also through its system of

scrutiny of the observations and periodical inspection of the stations it helps to ensure that the returns are reliable. However, the data which these stations supply to the Office are valuable to the country as a whole, as well as locally. Almost all the 6000 or so rainfall stations (a large proportion of which make measurements once a day) fall into the 'voluntary co-operating' category, the small balance being in respect of official meteorological offices.

The organization of Climatological Services is such that stations in England and Wales send their returns to Met.O.3 at Bracknell, those in Scotland and Northern Ireland to offices in Edinburgh and Belfast, respectively; in most instances monthly by post. The meteorological offices in Edinburgh and Belfast operate, in this respect, like their parent Assistant Directorate in Bracknell.

The quality control problem. A rough estimate indicates the amount of data that these offices combined deal with each month. If we count each element observation as one number (of one or more digits), between $1\frac{1}{2}$ and $1\frac{3}{4}$ million numbers come under scrutiny in the course of a month. This scrutiny for accuracy is sometimes called *quality control.* The error rate is small, certainly under one per cent overall, and the first problem is to decide on the most efficient methods to 'clean' such large amounts of data. Many of the tests applied to the data are objective (for example, the maximum temperature recorded must be at least as great as any of the hourly temperatures) and repetitive (applied serially to data for various hours and places). An electronic digital computer carries out repetitive processes with remarkable speed, so much so that the tests can take forms which it would be impossible for a small group of staff to apply in the time available.

Rainfall data. With this background it was decided two or three years ago to experiment with the quality control of rainfall data by electronic computer. Rainfall, being so variable in time and space, is a difficult element to deal with. On the other hand, the relatively small amount of data (about 120,000 numbers per month in England and Wales—the area of initial operations) entailed the least additional tape punching (for input to the computer). By grouping the data by natural drainage basins or combinations thereof, they can be subjected to tests of a searching character. In addition to simple checks (such as the sum of daily values at a station being equal to the given monthly total) more powerful tests can also be used; for example, daily values, suitably scaled, can be subjected to a statistical procedure by which unlikely values are identified and printed out for further scrutiny. At the same time daily values that are missing for one reason or other can be estimated by averaging nearby stations' scaled values. Space is too limited to enter into more detail but the power of the method is clear. It allows the majority of the good data to pass quickly through the 'sieve', leaving more time for subjective scrutiny of a relatively small amount about which there is some doubt.

The experiments with rainfall data were so promising that the machine quality-control method was introduced in January 1962 for England and Wales data received monthly and extended in January 1963 to all England and Wales rainfall data, the voluntary observers having agreed to render monthly returns. The work was made possible only by the active co-operation of the observers with Met.O.18, the Branch controlling machine work in the office.

By-products. The final data tapes are available for rapid machine processing to meet any requirements for which the data are suitable (the main limitation being the period for which tapes are available). For example the Branch has to

make estimates of monthly areal rainfall over drainage areas upstream of river flow measurement points, for inclusion in the *Surface Water Year Book*. The number of river gauging stations is increasing steadily and already areal estimates of rainfall are provided for about 200 such areas, covering a large part of the country. The estimates can now be made rapidly by machine methods, and further additions to the number of areas required can be absorbed with relative ease. Moreover computer print-out devices are available, enabling the tables to be printed out directly in a form suitable for photocopying, thus eliminating the time-consuming checks necessary with hand-copying. Furthermore, statistics for publication in *British Rainfall*, the annual volume summarizing rainfall in the United Kingdom, can be similarly prepared, with the important additional facility that it is possible to review the type of statistics presented solely in the light of usefulness and without overmuch regard to the effort which would be necessary to provide them by human labour.

Climatological data—machine methods. The electronic computer is comparatively new in the Meteorological Office. The present machine was purchased in 1959 primarily for development of numerical forecasting. In the climatological field the medium mostly used has been punched cards. But even here, punching of land surface climatological data on to cards was begun as routine only in 1957 so the data-library in this medium is far smaller relatively than those for marine (1921) and upper air data (1948). With the exception of much of the autographic data, land surface climatological data are now punched on cards as routine, but the methods of scrutiny and preparation of summaries for publication continue to be by hand. This, however, is the next field in which the application of computer methods is to be explored. Nearly one million of the total number of data in returns each month come from stations reporting for forecasting purposes at specified time intervals each day over the extensive meteorological communications network in this country. The receipt machines (teleprinters) in the Bracknell Office provide both page-copy for eye examination and also punched tapes, the latter primarily for ease of re-broadcast to outstations of the Meteorological Office in this country and to services in other countries. The coded message used for such synoptic reports does not contain all the material needed by the climatologist but it is attractive to examine whether such routine reports can be expanded to meet this latter need, without disrupting the routine necessary for the forecast services. In the past two years trials of this possibility have been held with very successful results. Thus the way is open for further experiments on the receipt of climatological data from synoptic stations reporting hourly by existing means of communications, and for the quality control of the data by electronic computer as well as the computation and layout of statistics for publications. This project cannot be pursued further until the larger capacity of the new KDF9 computer is available. It is an exciting problem in data processing which, if successful, could add to efficiency.

Besides the data already mentioned the Branch also collects returns of upper air data and processes these by computer. Ocean weather ship radiation data are also received, the land stations' radiation data coming through another Branch (Met. O.14). In addition there are returns of data from some overseas stations maintained by the Meteorological Office.

The work of receipt and scrutiny of the original data largely falls to one section of the offices in Bracknell, Edinburgh and Belfast. To satisfy the needs of the extensive co-operating network, such as ensuring supplies of necessary

forms, replacing equipment, and arranging for inspections, calls for considerable staff effort.

Publications. Summaries of the data received are published in two main series. The *Monthly Weather Report* with its *Annual Summary* contains land surface climatological material whilst the annual publication *British Rainfall* contains information about the rainfall. In addition five-yearly summaries of upper air data are prepared, whilst the ocean weather ship data are summarized in an annual publication. There are also occasional publications, e.g. Averages of Temperature, Averages of Sunshine, which at present are being published every 10 years (the last relating to the period 1931–60). The Branch also provides the material for the climatological section of the new *Monthly Weather Survey and Prospects* bulletin.

Uses of the data—some of the services provided. Table XXV of the Statistics Section gives some information about the inquiries of a climatological nature dealt with in 1963 by the Branch and its sister offices in Edinburgh and Belfast. The inquiries ranged over a wide field and it is not possible to give a full account in a limited space. Moreover, to categorize by number conceals the fact that some inquiries are quickly answered whereas others may take months of effort. However, the fact that the inquiries increase year by year is testimony to the usefulness of the service and that more and more inquirers find it necessary to take climate into account in their activities.

Legal. The greatest numbers of inquiries continue to come in the legal field. This is because, by reason of the volume of data collected and the care taken to ensure its accuracy, the Meteorological Office possesses an authentic record of the weather. Most of these inquiries can be satisfied by a 'certified statement' of the weather at given times and places, the places being chosen as most likely to represent conditions, or a close approximation to conditions, at the place of the occurrence which may be the subject of the litigation (e.g. wind damage, possibility of ice on roads). Occasionally the Office needs to send a representative to give expert advice, if any doubt cannot be resolved by a certified statement. Although most legal inquiries do not take up a great deal of time in answering, they can be, nevertheless, of great importance in the administration of justice.

Building design. The provision of design data for different purposes also figures substantially in the work of the Branch. Thus a knowledge of the frequency distribution of dry- and attendant wet-bulb temperatures is necessary for the specification of heating and ventilating plant for buildings and especially for the design of industrial cooling towers. Such frequency tables have been prepared for many places in this country and are available to users in the series of *Climatological Memoranda.* In this general field many inquiries are made about wind speeds likely to affect structures. The longer-period anemograph records in this country have provided suitable wind data for the carrying out of an 'extreme' analysis, so that speeds likely to be exceeded only once in a given period (say 50 or 100 years) can be estimated, at least for the anemograph sites. The routine analysis of anemograph records gives only mean hourly wind speeds and gusts (of a few seconds duration). Special methods have to be used to specify mean winds over periods between these intervals, according to the requirements of the customer. Estimation for a given site, from anemograph records obtained possibly many miles away, presents difficulties but work which has been done in this and other countries is utilized whenever possible. A deficiency at the present time is the lack of observational evidence of the

variation of wind with height over large cities. The problem is difficult because wind in the free atmosphere cannot be measured by using an anemograph on a building of a size likely itself to have considerable influence on the natural wind. However, attempts are being made to achieve reliable records at about 600 feet over London, which, used in conjunction with records from about 150 feet should supply a check on the variation-with-height factors adopted now, or alternatively lead to their revision.

Suitable analysis of past weather records has much to offer the designer, whether he is thinking in terms of individual buildings or of town planning. It is no longer sufficient to know only the direction of the prevailing wind. To give one example, a knowledge of the wind direction most frequently accompanying low temperatures in various parts of the country could avert unnecessary frost damage.

Motorways. On several occasions in the past few years the Meteorological Office has been asked to estimate likely weather hazards along various alternative routes being considered for new motorways. The specification of hours with fog of various densities is the prime requirement but occurrences of frost, snow and high winds play their part. In the case of the Lancaster–Penrith (M6) and Lancashire–Yorkshire work, it was necessary to obtain, with the help of the consulting engineers, special *ad hoc* observations, largely because the routes under consideration crossed high ground where routine observations were lacking. However, in such work, it is possible to extrapolate to likely long-term averages only through the use of long-period records from stations in similar climatic régimes, so the 'permanent' network plays a significant part.

Forward planning. The summer of 1959 raised questions about our future water supplies; the long hard winter of 1962/63 brought questions about the characters of winters to come. To be able to give definite answers to such questions would be of great economic importance. Unfortunately the present state of our knowledge is such that very long-term predictions (for several years ahead) cannot be made with confidence. The best substitute is a suitable analysis of past events, for which very long-period records are required. Long-term homogeneous records are hard to come by and, some years ago, bearing the importance of these in mind, the Office designated 12 stations across the country as 'Key Climatological Stations' where the observational procedures and sites are to remain as unchanging as possible—a step which our successors should find most useful. Analyses of past records show relatively few severe winters in the first 40 years of this century—a fact necessary to recall because this is the period dominant in the minds of many of today's planners. From 1940 the frequency of severe winters has been more nearly in line with the long-term average, and a return to the rather more frequent cold régimes of the late 19th century, or even to those of the early 19th century, cannot be ruled out.

Marine Climatology. The Marine Branch (Met.O.1) collects and scrutinizes all marine data returned by U.K. ships and answers many marine inquiries as part of its responsibility. The Climatological Services Branch has a small marine climatology section and collaboration between the branches is close. The work includes a contribution of interest in the study of the general circulation of the atmosphere, namely, the derivation of empirical relationships between cloud type and amount and the total radiation reaching the sea surface at various well-scattered points in the North Atlantic. Another investigation, of long-term variations of sea surface temperature in the North Atlantic, is of interest in the field of climatic change. In collaboration with the National

Institute of Oceanography, work has been done on the computation of state of sea from a knowledge of wind distribution. This could be applied to ship routeing as well as to specification of the seas which offshore structures might have to withstand. Also, in collaboration with the Ship Division of the National Physical Laboratory an analysis of sea-state conditions over some of the main shipping routes of the world has been carried out, material which should be of use in ship design. In the international field (through the World Meteorological Organization) the Branch has assisted in making arrangements whereby climatological statistics for the oceans of the world will in future be more readily and usefully made available. A synopsis of North Sea climate is being compiled primarily for the use of physical oceanographers, marine biologists and those concerned with the fishing industry.

Also in the marine field, one officer and one assistant are employed in providing the meteorological sections of *Sailing Directions* (*Admiralty Pilots*) of which there are 73 volumes covering the coastal areas of the world. On average 6 of these volumes are revised each year.

Overseas climatology. A small section of the Branch deals with climatological inquiries for overseas areas. The National Meteorological Library at Bracknell contains a large amount of published data from overseas areas as well as British publications of a similar type. Extensive use is made of this facility, but, where unpublished data are needed, these can be requested from the appropriate Meteorological Service.

Rainfall. In the rainfall field the activities of the Branch are so diversified as almost to merit a special topic article of their own. At the present time rainfall is the gross income for our water supply; on the other hand we sometimes get so much so quickly that problems of disposal arise. A few illustrative paragraphs must suffice.

Water supply and hydro-electric power. Consultants and others are supplied with estimates of areal rainfall and evaporation for the purpose of design of impounding reservoirs. The estimates must include not only the average, but also amounts recorded in dry and wet series of seasons.

River flooding. In recent years the Office has considered how it might aid River Board Engineers in England and Wales in the problem of river flood prediction. For the past two winter seasons maps of estimated soil moisture deficit (a guide to the 'sponge' capability of the soil) have been issued at intervals dictated by natural events, as some indication of the margin of safety should there be heavy rain. The possibility of rapid thaw with rain on existing snow cover was frequently in mind early in 1963 (the floods in March 1947 were so caused) and some maps of estimated water equivalent of snow lying were also issued, at appropriate times, to the Engineers. In addition the Engineers can, of course, use the normal forecasting services. The quantitative prediction of rainfall is a difficult problem at present under study in the Research Directorate.

Dry periods. In the early autumn of 1959 and the late winter of 1963 there was fairly widespread concern over water supplies in the ensuing months. An examination was made of similar occurrences in the past, using records extending over as long a period as possible. Although with extreme events one cannot expect many analogues, nevertheless in 1959 and 1963 past events were a good guide to the future, though this may have been somewhat fortuitous.

Storm water drainage systems. An important factor in the design of storm water drainage systems is the intensity of rainfall likely to occur in a given return period over the area drained by the systems. In this investigation the

Branch has set up two field experiments, each covering about four or five square miles, one near Bedford (flat terrain) and another near Winchcombe in Gloucestershire (hilly). Synchronized autographic rain recorders from which rainfall amounts in one- or two-minute intervals can be obtained are used, there being about two dozen of these in each location. The object is to obtain relationships between intensity of rainfall at a point and over areas of various sizes (corresponding to the range of areas usual in urban drainage systems) and also the time/intensity profile of the average storm. Additionally, attempts are being made to set up a suitable network of appropriate rain recording gauges up and down the country, from the records of which it will be possible, in due course, to test the validity of the empirical formula at present used for specifying the short-term heavy rainfall likely to occur at a point in a given return period.

Probable maximum precipitation. For dam design, the engineer requires to know the probable maximum flood in order to provide for adequate spillways to discharge the excess water without damage to the dam structure. One way of arriving at this is for a meteorologist to estimate the probable maximum rainfall over the catchment upstream of the dam and for a hydrologist to convert this into river flow. In the last few years the Branch has provided estimates of probable maximum precipitation over the Blue Nile catchment in Ethiopia down to Roseires in the Sudan and over two large catchment areas of the upper Orange River in South Africa. Both have been major projects involving considerable effort on the part of the responsible scientists and ancillary staff.

Conclusion. There is no lack of work for the future. Although it is hoped that machine methods will play a much greater part in the quality control problems and in computation of statistics, the type and amount of data themselves are kept under careful review in order to determine how best to establish the facts about climate. As regards application, little has yet been done in the field of medical climatology, to mention only one large subject. In the problems of rainfall the coming years are certain to bring increased work—the River Authorities to be set up in England and Wales in 1965 must bring further demands. The International Hydrological Decade, expected to begin in that same year, will undoubtedly involve increased investigational work.

2. General Description of the Services Directorate

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

In the following paragraphs of this section an outline of the work of each element is given, dealing with the forecasting branches first, climatological branches second and other branches last. An amplified account of one category

of work in the Services Directorate is given in Section 1, the subject this year being 'Climatological Services'. Important events and innovations during the year are described in Section 3, and Section 4 contains notes on the weather of 1963. Finally the statistics in Section 5 provide some measure of the volume of work.

Central Forecasting (*Met.O.*2). The Central Forecasting Office (C.F.O.) has a dual function. Firstly it is, by international agreement, a Master Analysis Centre, with an output designed to help other forecasting offices both domestic and foreign. The material for this purpose is broadcast over the meteorological communications system (described later in this report) and consists mainly of actual and forecast charts, both surface and upper air, supplemented by written commentaries. Secondly the C.F.O. is responsible for the preparation of forecasts and 'warnings' which have a nation-wide application. These forecasts fall into three main categories, general forecasts for land and sea areas for dissemination by the Press and by broadcasting, forecasts for some public utilities such as the Central Electricity Generating Board and certain special forecasts for periods up to three or four days ahead. Parallel services in the first two categories are provided by local meteorological offices which prepare more detailed forecasts applicable to smaller areas.

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

Aviation Services (*Met.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 and the Mediterranean, Middle East and Far East areas.

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

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

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

Second, basic climatological investigation into meteorological matters of concern to agriculturists, 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.

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

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

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

To a large extent the office at Edinburgh deals in climatological services in so far as Scotland is concerned and an office in Belfast carries out a similar function for Northern Ireland. In such matters these two offices act on behalf of, and are supported by, the assistant directorate.

Marine Branch (*Met.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 Table XVI.

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 making and recording of radiosonde ascents for the measurement of wind, temperature, humidity and pressure in the upper atmosphere. In addition to their meteorological duties the ships also provide the following services:

(i) Air–sea rescue service

(ii) Navigational aid to transatlantic aircraft

(iii) Other scientific observations (usually at the request of other Government scientific branches).

The Marine Branch publishes monthly charts based on ships' reports, showing the distribution of sea ice in the northern hemisphere. Ocean currents are also calculated from ships' reports and the results used in the preparation of ocean current atlases; the publications section arranges (through HMSO) for the printing of these and also of meteorological and climatological atlases of the oceans. This section also arranges for the correction and printing of various technical books, *State of Sea* and code cards and forms used by the voluntary observing fleet, ocean weather ships and Port Meteorological Officers. The *Marine Observer*, a journal of maritime meteorology, is published quarterly.

Observations and Communications (*Met.O.*5). Most meteorological offices in the United Kingdom have the duty of making surface observations, but there are also nearly as many auxiliary reporting stations, manned by members of the Coast Guard, Trinity House and Northern Lighthouse Board organizations and other authorities. To obtain information about the upper air, a network of combined radiosonde and radar-wind stations is also maintained both in the United Kingdom and overseas. Meteorological reconnaissance flights are also made over sea areas around the British Isles by Hastings aircraft of No. 202 Squadron of the Royal Air Force, based at Aldergrove. Specially equipped radio direction-finding stations locate thunderstorms. A network of four stations is maintained in the United Kingdom. Another in the Mediterranean with stations in Gibraltar, Malta and Cyprus is equipped on an experimental basis. These networks function independently or, more effectively, in combination. It is planned to make the Mediterranean network permanent.

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. Coded messages and facsimile transmissions received from other countries are relayed over domestic circuits to meet general or special needs. Facsimile relays have included cloud analyses derived from United States

satellites and computed forecast charts received from America. Morse telegraphy is still largely used by ships reporting weather to shore stations and for a decreasing number of foreign national transmissions. Recently, by agreement between ICAO and WMO, reports from Iceland to the United Kingdom have been made over a cable linking Scotland and Iceland thus resuming, after some years of morse transmissions, the method by which the first weather reports were obtained from Iceland in 1906.

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

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

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

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

Until 1959 the only data-processing machine facilities in the Office were those provided by a punched-card installation, backed by a store of some 30 million cards. This installation can quite rapidly extract and tabulate data from the store but is restricted to very simple calculations. Met.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. Plans are well advanced to supplement or replace these facilities during the coming year by the latest type of electronic data-processing system using magnetic tape, punched paper tape and Hollerith cards.

The cartographic drawing pool prepares maps and diagrams for the Office, in particular those required for Meteorological Office forms and publications and the base maps for weather plotting charts.

Techniques and Training (*Met.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 improve progress. One section of Met.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 XXIX of Section 5. 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 Met.O.8.

Defence and International (*Met.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 Met.O.17. An account of the principal meetings attended will be found in the 'International Co-operation' section (p. 61).

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 Met.O.17.

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

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

3. Major Events and Changes in the Services Directorate

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

Aviation Services (*Met.O.*6). Outstation aviation meteorological services continued to meet the diverse requirements for the operation of aircraft of all types ranging from those flying at high level and high speed to those with many

hours endurance at low levels. Attention has been paid to the meteorological requirements of aircraft under development or planned for the future, including the TSR2 and the Concorde.

Overseas. A new subsidiary office was set up at Labuan in North Borneo. In the United Kingdom the meteorological office at the civil airport at Nutts Corner was closed in September when all civil aviation commitments were transferred to Aldergrove and the latter became the new Belfast Airport. Offices were also opened temporarily to meet special requirements of the RAF in the United Kingdom and in the Far East.

Services were provided for RAF exercises in various parts of the world, sometimes in co-operation with Commonwealth and Foreign Meteorological Services. Flights by members of the Royal Family and a non-stop flight from the United Kingdom to Australia using in-flight refuelling techniques were also covered.

Improved communication facilities are now available between the main British meteorological office in West Germany and its outstations.

Facsimile equipment has been provided at the main meteorological office at Singapore for the transmission of prepared charts to subsidiary offices in the Far East Command. Facilities for the reception of National Facsimile Broadcasts from Bracknell were extended to civil aviation meteorological offices. Arrangements were also made for the transmission by facsimile to Prestwick and London (Gatwick) Airports of the flight forecast documentation charts prepared at London (Heathrow) Airport for North Atlantic flights, and also for the inclusion of these charts in the Bracknell radio-facsimile broadcasts.

Closed-circuit television facilities for the dissemination of meteorological information were installed at London (Heathrow) Airport and Belfast (Aldergrove) Airport.

General Services (*Met.O.*7). Non-aviation inquiries topped the 900,000 mark, an increase of 15 per cent on the 1962 figure. The Weather Information Centres in London, Manchester, Glasgow and Southampton handled 464,476 inquiries, an increase of 12 per cent, whilst London Weather Centre itself dealt with 275,973, 8 per cent more than in 1962. Non-aviation inquiries at aviation meteorological offices reached 447,460, an increase of 20 per cent. The severe weather at the beginning of the year contributed substantially to the public's interest in weather information: London Weather Centre answered 5282 telephone calls on the first three days of January, and there were about a million calls on the automatic telephone weather service in London in January.

A 24-hour service was introduced at Glasgow Weather Centre in January, enabling the centre to take over routine public service commitments from the aviation meteorological offices at Prestwick and Renfrew. Planning has proceeded for new premises for both the Glasgow office (in Waterloo Street) and the London Weather Centre (in High Holborn). The new offices should be in operation by mid-1964.

Close liaison has continued with the BBC in both sound and television fields. In the former after five summers of personal broadcasts of 'Your Holiday Weather' by staff from the London Weather Centre a new all-the-year-round series entitled 'Metcast' was started early in October. From the same time early morning forecasts on the Home Service were broadcast, except on Sundays and on certain public holidays, on a regional basis similar to that which

has been operating for some years at 12.55 and 5.55 p.m. This regionalization enables forecasters to give more detail for their areas than was previously possible. During the spring and summer the Office co-operated with the Ministry of Transport, the Home Office and Chief Constables in providing up-to-date weather information for the experimental BBC 'Roadtraff' service. Discussions with BBC Television have continued with a view to improving the visual presentation of the evening weather forecast, while on the last day of the year the first sub-regional personal presentation of the weather forecast was made, again experimentally, from the BBC Southampton studio.

Last year's newcomer to Independent Television, Wales (West and North) ceased separate operation during the year and was taken over largely by Television Wales and the West. This resulted in slight easing of the load of work at the Gloucester office. Close co-operation has been maintained with the other independent companies, especially with Anglia, Associated Re-Diffusion and Southern Television which employ their own weathermen, and overseas with Malta Television.

A number of special broadcasts were made on non-routine topics. The severe winter of 1962/63 was of such public interest that a number of special broadcasts on this subject were arranged. The issue, too, of the first *Monthly Weather Survey and Prospects* at the end of November resulted in a number of special broadcasts on both sound and television, often at very short notice.

The grand total of calls over the country on the automatic telephone weather service was 7,778,523, an increase of 28 per cent over the previous highest figure (in 1962). Weather calls in London reached over four millions. It was pleasing to note that the fall in the number of inquiries noted last year in Birmingham has been checked and reversed. In March was started a new forecast for the Lancashire coast which the GPO make available in Blackpool, Southport and neighbouring towns and also in Manchester and Liverpool. Forecasts can now be obtained in 16 GPO Information Service Centres. Discussions on further expansion are proceeding.

Services on a steadily increasing scale continued to be given to the Central Electricity Generating Board, the twelve Gas Boards (and this year to several sub-divisions of these) and to the Controllers of British Railways.

When the decision was taken to issue to the public weather prospects in Britain for a month ahead, Met.O.7 was made responsible for progressing publicity, publication and distribution. The new service began at the beginning of December and the prospects appear in two new publications. The first, under the title *Monthly Weather Survey and Prospects*, is sent to subscribers at the beginning of each month; it contains a section on the climatology of Britain for the coming month, an account of the weather in the month just past, a general survey and inference, and the weather prospects for the coming month. This is supplemented in mid-month by a document containing survey, inference and weather prospects.

Early in 1962 the Meteorological Office introduced the centigrade scale of temperature in communications to the public; throughout 1963 the practice has continued of giving centigrade values first, followed by the equivalent Fahrenheit values.

More people have visited the Bracknell Headquarters than in previous years, there having been no fewer than 88 organized parties.

Meteorological services were provided for the Army and a number of establishments engaged in ballistic work. In addition to surface observations,

about 3500 radar-wind and/or radiosonde ascents were made. Training of Army personnel in general meteorology and in making surface and upper air observations continued. Work has started on a theoretical and practical study of the variations of ballistic wind and temperature over distances of a few tens of kilometres and periods of a few hours.

The investigational work concerned with agricultural meteorology has covered a wide field; some 30 memoranda were issued, and included were such diverse subjects as animal comfort and ventilation, grass growing days, insect reaction to weather, wind and shelter, horticulture etc. Experiments continued with a comparison of minimum thermometers exposed over grass, concrete and bare soil. Advice and assistance were again provided on the new town plan for Cumbernauld and on projected motorways. Notifications of 'Beaumont' and 'Smith' periods were made available to farmers as a chargeable service. The Office was represented at several meetings and symposia with an agricultural background, both in this country and abroad.

Climatological Services (*Met.O.*3). The severe weather which set in just before Christmas 1962 and was not finally to break until early March (it was the coldest December to February in central England since 1740) posed climatological problems as well as many other types of problem—especially those of the forecast services. The immediate task was to give help to those authorities concerned with river floods, in case a rapid thaw with rain on lying snow should give a repetition of the floods that occurred at the end of the winter in 1947. Engineers to River Boards in England and Wales were given, at appropriate times, estimates of the water equivalent of snow lying and the usual forecast services were available to them. In the event the winter died rather slowly and the final thaw on 4–5 March caused river flooding in only a few areas. However, the winter also brought inquiries of a forward planning nature—did it presage a change in the character of our winters? This problem—essentially one in the sphere of climatic change—was examined in collaboration with the Research Directorate. As a result of analysis of long term records and estimates, the advice was given that the predominantly mild winters of 1895 to 1939 (a period possibly dominant in the minds of people born around the turn of the century), were unrepresentative of the average run of British winters; that the winters since 1939 were more nearly representative of the long-term average experience; and that a return to the more frequently cold winters of 1880 to 1895 or even to those of the early 19th century could not be ruled out.

A perhaps puzzling occurrence to those who were unfortunate enough to have to dig their way out of deep snowdrifts, was that by the end of the winter water reserves were getting very low in many parts of the country—in fact the period October 1962 to February 1963 was very dry by average standards. Moreover, perhaps with the fine summer of 1947 in mind, concern was expressed in some quarters about the summer water supply prospects. An analysis carried out in March of some long-period rainfall records showed that similar dry periods in the past had usually been followed by summer half-years with about average rainfall. However, the very wet March of 1963 allayed anxieties and the summer half-year was not to revive them.

The final report on weather hazards likely to affect the projected Lancashire–Yorkshire Motorway was completed in the spring. Amongst the many other inquiries dealt with perhaps special mention should be made of the work on

the estimation of probable maximum precipitation over two large areas of the upper catchment of the Orange River in South Africa, to yield design data for the spillways of two proposed dams; and similar work in respect of some wadis in Jordan draining into the east bank of the river Jordan.

There was a further encouraging increase in the number of voluntary co-operating climatological and rainfall stations in Northern Ireland. The setting up of two such climatological stations in the Cairngorms in Scotland promises in due course to give useful information on the climate of this area.

Marine Branch (*Met.O.*1). The British ocean weather ships completed 16 years' service in the North Atlantic during the year. These ex 'Castle' class frigates are continuing to show themselves as good sea boats and to be well suited to their job. In addition to surface and upper air observations, oceanographical and biological work has continued aboard the ships on behalf of the Admiralty, Ministry of Agriculture, Fisheries and Food and the Department of Agriculture and Fisheries for Scotland.

Radiation observations aboard ocean weather ships have continued and these observations are now also being made aboard Admiralty survey ships, R.R.S. *Discovery*, R.R.S. *Shackleton* and R.R.S. *John Biscoe*. All the weather ships have been collecting rainwater for a survey of the distribution of radioactive isotopes.

The introduction of improved balloons has resulted in radar wind observations attaining during the year an average height of about 69,600 feet, (maximum 79,800 feet). This compares with an average height of only about 60,000 feet in previous years.

Oceanographical work has included soundings with oceanographic thermometers and sampling bottles to a maximum depth of about 1500 fathoms, four soundings being made each voyage; bathythermograph observations twice a day; and fishing for red fish when at station Alfa. Bathythermograph observations are also being obtained from the United States vessels when on duty at stations Delta and Echo in the Western Atlantic, and also from the French weather ships, for publication on the reverse of the monthly ice charts.

On 14 October, *Weather Reporter*, when at station Alfa, proceeded at maximum speed to the assistance of a Norwegian ship in distress, 160 miles away, with a force 12 wind and very high seas. When she was within 47 miles of the casualty, the distress was cancelled, as the ship had carried out repairs.

During the year mail and newspapers have been dropped to the weather ships by RAF aircraft of Coastal Command whenever the aircraft's other duties permitted; these deliveries are very much appreciated by the ships' companies, particularly the Christmas mail drop which has become a routine feature.

During the year, 947 meteorological log-books were received from ships of the voluntary observing fleet. The scrutiny of these log-books shows that the high standard of observing in the merchant navy has been maintained. Errors in radio weather messages cause considerable trouble when observations are being fed into an electronic computer, and steps are being taken to lessen the number of such errors.

Efforts to get more radio weather reports from ships in relatively unfrequented ocean areas have continued, with special reference to the requirements

of the International Indian Ocean Expedition; during the year, 287 special forms provided for this purpose were received from 'auxiliary ships' which had been recruited for this work. Observations have also been received from H.M. Survey ships, which keep the same type of meteorological log-book as that used by British selected ships.

The increasing number of shipmasters and officers who visit the Meteorological Office at Bracknell during their leave is an encouraging sign of their awareness of the practical value of meteorology to mariners, and an increasing use is being made by ships' officers of the meteorological log-book as a means of furthering scientific knowledge. Among the scientific bodies who have acknowledged the information they receive in this way are the National Institute of Oceanography, now engaged on a census of whales and of the world distribution of plankton, and the Auroral Survey at Edinburgh. A phenomenon recorded by three voluntary observing ships at widely separated points in the Indian Ocean was later identified by the United States Space Administration as the re-entry of their artificial satellite 1963-07-A. The more interesting observations are published in the *Marine Observer*.

The accuracy of the ice maps prepared by the Marine Branch has been much improved during the year by using climatic data supplied by the branch concerned with long-range forecasting. Three maps a month are now available. An increasing amount of ice information and analysed climatic data has enabled us to provide more useful information about ice development and movement.

The upward trend in the number of inquiries handled, referred to in previous years, was maintained, with the increase in 1963 being about 12½ per cent compared with 1962. Inquiries were received from a wide range of interests, the majority being, as usual, from solicitors and insurance companies. A number of requests for information about wind and wave conditions in the North Sea and English Channel were received from engineers in this country and abroad in connexion with intended underwater drilling operations and other construction work such as marinas. Hovercraft interests required information about winds and waves in a number of countries in connexion with the planning of tours to demonstrate the craft or to operate services. The Ministry of Transport was supplied with information concerning shipping casualties on 14 occasions. Advice was given to a yachtsman planning a solo crossing of the Atlantic from Bergen to New York.

Ocean surface current and sea ice data for six volumes of Sailing Directions (Admiralty Pilots) were revised during the year.

Observations and Communications (*Met.O.5*). Codes used for the international exchange of weather messages were modified by agreement within the World Meteorological Organization. These changes entailed the publication of a new edition, the fourth, of Part II and Part III of the Met.O. Handbook of Weather Messages. Changes designed to facilitate automatic message handling and data processing were also made in the methods used in teleprinting weather messages.

At 31 December, the total number of synoptic reporting stations within the United Kingdom was 222. Of these 102 were auxiliary stations maintained but not manned by this Office. Five such stations were recruited during the year in Northern Ireland as the result of a special drive including an appeal through BBC Television. Additionally four Fire Service offices agreed to supply non-instrumental reports of weather from within built-up areas where conditions frequently differ from those prevailing in nearby open country.

To afford additional upper air data to the International Indian Ocean Expedition a radiosonde station was established in the Seychelles and has made regular measurements and reports since 1 September.

Arrangements have been made to increase the programme of high altitude balloon ascents at selected radiosonde stations during the IQSY.

The programme of radio-facsimile broadcasts made from Bracknell was augmented by the inclusion of forecast charts prepared at London (Heathrow) Airport Meteorological Office and having special application to transatlantic flying. Radio-facsimile reception was provided at Ronaldsway Airport by arrangement with the Ministry of Aviation, and on an experimental basis in Aden and Singapore. The provision of facsimile transmitters and recorders to set up a meteorological network at RAF stations in Singapore was also arranged. The connexion of meteorological offices on civil airports in the United Kingdom to the domestic facsimile network was completed.

The reception of foreign meteorological radio-teleprinter broadcasts was transferred in November from Dunstable to RAF control at the Joint User Radio Receiving Station, Bampton. Radio-facsimile reception will be similarly transferred early in the New Year.

Special transmissions made from Bracknell included a relay of cloud analyses obtained from United States TIROS satellites to Aden to assist in tracking a tropical storm in the Arabian Sea, the relay of selected data to the Anti-Locust Research Centre, and the relay of hurricane and other severe weather warnings to the Ministry of Defence.

Support Services (*Met.O.*18). It was decided in April to place an order for a KDF9 electronic computer made by English Electric-Leo Computers Ltd. This was a major step towards the setting up of a powerful new electronic computer system for use in research, numerical weather forecasting, climatological data-processing and trials of the automatic editing of synoptic weather transmissions. The new computer is expected to be installed and in full operation early in 1965. It is a transistorized machine, fitted with a large high-speed magnetic-core store, and magnetic-drum store; six magnetic tape units; high-speed magnetic tape, paper-tape, and card input, and paper-tape and line-printer output. It can operate up to four programmes simultaneously on a time-sharing basis. All the functions—arithmetical, input and output—are performed at a much higher speed than on the present computer METEOR. As an overall figure the new machine will have about 20 times the capacity for work of METEOR. Staff have been trained in the KDF9 programming system and arrangements were made with the Ministry of Public Building and Works for the installation of the machine which will require a more elaborate air-conditioning system than METEOR. It is not intended to retain METEOR.

The use of METEOR continued to increase during the year. It was used on the average throughout the year for 75 hours a week and during the last quarter for 85 hours a week.

The information, reference and loans services of the Library continued to cater for a wide range of user interests. Examples of the inquiries were requests for literature on climatic modification and control, fog dispersal, and climatic hazards in the transport of goods. Information on Meteorological Office procedure in library and archives work or advice on books was supplied, on request, to the meteorological services of Canada, Australia, South Africa and Libya. A major task performed by the Library was the restoration to the

Library shelves after sorting, of a large quantity of older material which had been stored at Air Ministry Archives because of lack of space at Harrow. The Library took over the circulation of periodicals throughout the Headquarters.

Publications prepared for printing by the Editing Section during the year included two unusual items in the 'Pictorial guide for the maintenance of meteorological instruments', and an illustrated brochure describing the organization and buildings of Headquarters. The Cartographic Drawing Pool produced among many hundreds of diagrams new base maps for synoptic plotting charts on a polar stereographic projection.

The centralized Archives set up in 1962 is working well and records are now arriving in a steady stream. Work proceeded steadily in indexing, binding and storing the records and many inquiries from both staff and external research workers were dealt with. An article on the Archives was published in the February 1963 number of the Meteorological Magazine.

The Head of Met.O.18 was nominated to represent the Office on the Cartography Sub-Committee of the Royal Society's British National Committee for Geography.

Techniques and Training (*Met.O.*8). A survey has been made of the various forecasting methods and techniques in use at outstations. This has yielded considerable information as to the effectiveness of existing techniques and the requirements for further development. In consequence of one requirement specified by forecasters, the possibility is being explored of obtaining detailed reports of temperature, humidity and wind in the lowest thousand feet of the atmosphere by means of instruments mounted on high masts. A group has been set up to advise on action to be taken as a result of the survey.

Studies on the relationship between winds at the surface and at 900 mb have continued; the results from two ocean weather stations and two land stations have been examined in considerable detail, and a paper will be published.

Work continues on the objective method for predicting visibility at London (Heathrow) Airport at various times of day during the winter half-year.

Statistical data have been supplied to outstations in furtherance of 18 investigations during the year. Diagrams, summaries and reports incorporating the results of 14 of such investigations have been received from outstations. The type of statistical investigation varies from place to place according to details of the local forecasting problems. These problems, however, have some aspects which are common to all places (for instance, the effect of wind on visibility and cloud height); such aspects can be analysed using a standard form of statistics. Standard statistical summaries are being produced to supplement the descriptive information given in diagrams illustrating aerodrome weather characteristics.

Several synoptic problems continue to be investigated—mainly in co-operation with forecasters at the outstations. Now that over 100 maps have been prepared at outstations to show the spatial distribution of rainfall in selected synoptic situations, this project is to be concluded by the issue of a volume containing the collected maps together with an appraisal of their significance. The results of an investigation into the structures of sea breezes have been published in the Meteorological Magazine. A detailed analysis has been made showing how, on occasions, the preferential development of thunderstorms in a particular area may be related to a sea breeze.

Two new training courses were started during the year. The first is for officers-in-charge of outstations and includes lectures on administration and on the structure and functions of the Meteorological Office. These courses were held at the Air Ministry Civil Training and Education establishment. The second course is for Scientific Assistants who have served about ten years since their initial training; the purpose is to broaden their background knowledge of the Office and to extend their knowledge of meteorology.

During the year, more than 600 students attended courses at the Training School—the largest number for over ten years. Of these students, more than 300 were Scientific Assistants. Details of attendances at training courses may be found in Table XXIX (p. 44).

During the year, 125 members of the staff were enrolled under the external training scheme which gives financial aid and time off for study and examinations. On 31 December, 329 students were in receipt of study concessions.

Discussion meetings were held at the Royal Society of Arts in January, March, October and December; the topics being variation of temperature and wind in the lower stratosphere, recent advances in seismology, investigation of frontal rain by aircraft, and developments in instrumentation.

A new Meteorological Office publication entitled 'Pictorial guide for the maintenance of meteorological instruments' (M.O. 725) which was compiled by Met.O.8 staff was brought into general use.

A. C. BEST
Director of Services

4. NOTES ON THE WEATHER OF 1963

Long after its other vagaries are forgotten 1963 will be remembered for its long and hard winter. The very cold weather which set in just before Christmas 1962 continued, with only brief and minor thaws, until early March. In central England, for example, the mean temperature of the months December (1962), January and February together has not been matched since 1740. The severe frosts with prolonged snow cover in most places, the freezing of rivers and even of the sea in some coastal areas, the long spells of dry biting easterly winds were, perhaps, the features that remain most vividly in the memory. However, following five dry months, the very wet March allayed anxieties over the water supply position. The summer half-year was, on the whole, cool and unsettled. Most holiday makers did not fare very well (especially in August), even those who tried Western Europe. The first six months made for a poor hay harvest but growing conditions were good for main crops. However, by the end of August there was considerable concern about cereal harvest prospects, but luckily, September was to transform the scene in many areas. Perhaps the most notable feature of the autumn was the relative infrequency of night frosts. December was mostly cold, but milder weather coming about Christmas was a welcome contrast from that of 12 months earlier.

Table I gives for England and Wales, for Scotland and for Northern Ireland the highest and lowest temperatures recorded each month, the mean daily maximum and mean daily minimum temperatures (with long-period averages for comparison), monthly sunshine expressed as a percentage of the 1931–60 average and monthly rainfall as a percentage of the 1916–50 average together with these averages. Corresponding annual values are added. The distribution of rainfall over the country, as a percentage of the average, is shown in Figure 1.

The weather, month by month. Tables II–XIII give for the twelve stations shown in Figure 2 (p. 24) similar details, for each month, of temperature (highest and lowest and mean daily maximum and minimum), sunshine (percentage of 1931–60 average and average) and rainfall (percentage of 1916–50 average and average) as given in Table I together with a statement for each station of the number of days when temperature fell below 0°C in the screen (frost), when thunder was heard by the observer at any time during the 24 hours (thunder), when snow or sleet was observed to be falling sometime during the day (snow falling), when at least half the ground within sight of the observing station appeared to be covered with snow at 0900 GMT (snow cover), when visibility was below 220 yards at 0900 (fog) and when wind rose to 34 kt or more over a period of ten minutes at any time during the 24 hours (gale).

TABLE I—CLIMATOLOGICAL DATA FOR 1963

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
ENGLAND AND WALES													
Highest maximum temperature °C	9·4	12·8	16·7	21·1	27·2	28·3	28·9	26·7	26·1	23·3	17·8	13·3	28·9
Lowest minimum temperature °C	−20·6	−18·3	−15·0	− 5·5	− 3·9	0·6	− 1·1	− 0·6	− 1·7	− 1·7	− 7·2	−13·9	−20·6
Mean daily maximum temperature °C	0·9	1·8	9·2	11·9	14·6	18·6	19·3	18·0	17·0	14·1	10·9	5·4	11·9
1931–60 average maximum temperature °C	6·3	6·7	9·5	12·5	15·7	18·9	20·4	20·3	17·8	13·8	9·8	7·4	13·3
Mean daily minimum temperature °C	− 3·9	− 3·0	2·8	5·0	6·5	10·6	11·0	10·9	9·4	7·9	5·6	0·6	5·3
1931–60 average minimum temperature °C	1·2	1·3	2·5	4·5	7·0	10·1	12·1	11·9	10·1	7·0	4·3	2·5	6·2
Percentage of average sunshine	127	111	93	76	101	95	101	75	106	88	96	111	98
1931–60 average sunshine (hours/day)	1·57	2·38	3·69	5·20	6·15	6·61	5·73	5·44	4·35	3·12	1·81	1·31	3·95
Percentage of average rainfall	35	51	173	130	82	153	67	128	93	64	162	33	94
1916–50 average rainfall (inches)	3·69	2·67	2·30	2·42	2·56	2·23	3·20	3·25	3·06	3·71	3·84	3·53	36·46
SCOTLAND													
Highest maximum temperature °C	9·4	12·8	14·4	19·5	24·5	27·2	28·9	26·1	22·2	18·3	15·0	13·3	28·9
Lowest minimum temperature °C	−22·2	−18·9	−15·6	− 7·5	− 3·5	− 0·8	0·6	− 1·7	− 3·3	− 3·6	−11·7	−11·7	−22·2
Mean daily maximum temperature °C	2·6	3·4	8·5	10·3	12·5	16·4	16·6	15·6	14·7	12·5	8·2	5·8	10·6
1931–60 average maximum temperature °C	5·6	6·2	8·1	10·6	13·5	16·2	17·6	17·3	15·3	12·0	8·7	6·8	11·5
Mean daily minimum temperature °C	− 1·8	− 2·3	2·3	3·7	5·1	9·2	9·4	9·5	8·2	6·7	3·5	1·7	4·6
1931–60 average minimum temperature °C	0·9	1·1	2·1	3·5	5·8	8·5	10·5	10·4	8·7	6·3	3·6	2·2	5·3
Percentage of average sunshine	131	134	100	94	103	91	114	71	110	94	88	107	103
1931–60 average sunshine (hours/day)	1·26	2·30	3·21	4·68	5·86	5·76	4·55	4·38	3·66	2·47	1·48	0·95	3·37
Percentage of average rainfall	34	37	166	97	138	120	71	129	98	85	145	39	92
1916–50 average rainfall (inches)	5·66	3·93	3·30	3·30	3·20	3·19	4·19	4·50	4·71	5·81	5·29	5·29	52·37
NORTHERN IRELAND													
Highest maximum temperature °C	8·3	8·9	14·0	17·8	21·2	26·1	25·8	22·8	22·4	18·9	14·6	12·2	26·1
Lowest minimum temperature °C	−15·0	− 9·4	− 5·0	− 5·0	− 0·6	2·8	1·7	2·8	− 1·7	− 0·6	− 6·1	−10·6	−15·0
Mean daily maximum temperature °C	2·4	4·0	10·3	11·8	13·6	18·2	18·0	16·9	15·8	13·8	9·8	5·8	11·7
1931–60 average maximum temperature °C	6·5	7·3	9·6	12·1	15·1	17·7	18·5	18·5	16·3	12·9	9·5	7·5	12·6
Mean daily minimum temperature °C	− 2·7	− 1·4	2·6	4·3	5·8	9·5	9·9	10·2	8·6	7·7	3·9	0·8	4·9
1931–60 average minimum temperature °C	1·7	2·2	2·9	4·2	6·5	9·5	11·3	11·0	9·4	6·9	4·2	2·9	6·0
Percentage of average sunshine	128	120	110	89	95	101	118	77	115	95	100	135	107
1931–60 average sunshine (hours/day)	1·53	2·31	3·34	4·97	6·14	5·83	4·40	4·39	3·62	2·71	1·91	1·15	3·53
Percentage of average rainfall	33	83	163	100	124	141	72	99	83	110	163	25	96
1916–50 average rainfall (inches)	4·23	2·93	2·56	2·60	2·76	2·76	3·73	3·94	3·73	4·32	4·02	4·32	41·90

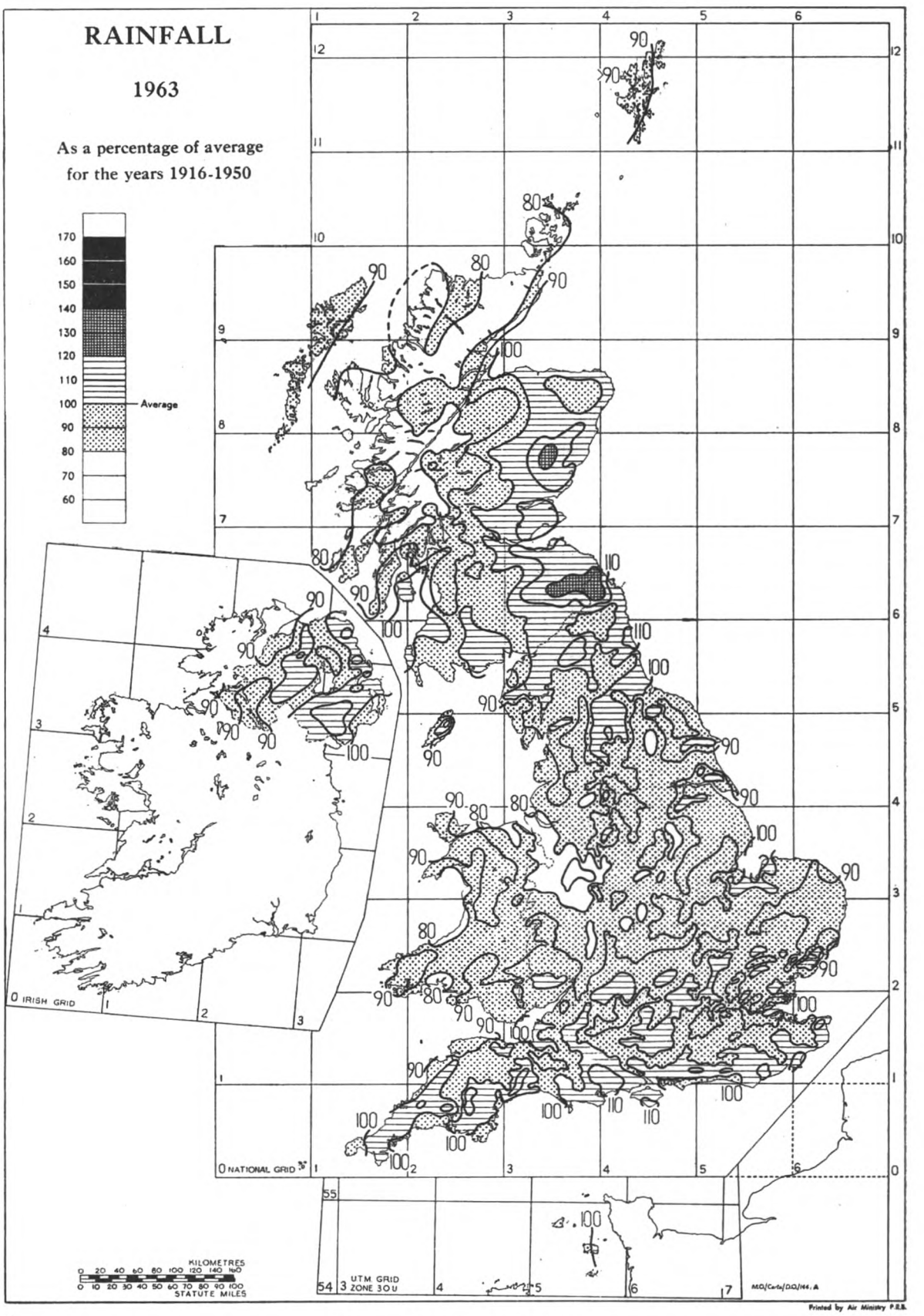


FIGURE 1—Rainfall 1963.

FIGURE 2—Stations included in Tables II–XIII.

TABLE II—JANUARY 1963

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Highest	Lowest	Mean maximum	Mean minimum	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Frost	Thunder	Snow falling	Snow cover	Fog	Gale
Kew	5·5	— 9·7	0·6	—2·7	107	46	36	2·14	25	0	21	27	1	0
Gorleston	5·0	—10·3	1·1	—2·3	94	54	40	2·21	25	0	16	8	0	3
Boscombe Down	2·7	—12·4	—0·8	—5·3	146	56	31	2·90	29	0	12	31	1	0
Plymouth	5·5	— 6·5	2·0	—2·4	156	60	19	4·33	26	0	12	6	0	0
Elmdon	4·3	—16·0	—0·1	—5·5	165	44	39	2·51	28	0	16	31	3	0
Valley	9·0	— 8·0	3·1	—2·2	160	58	21	3·60	22	0	9	1	0	0
Manchester Airport	5·0	—10·3	0·8	—3·6	200	34	15	3·00	28	0	14	22	2	1
Tynemouth	5·9	— 6·2	2·6	0·1	94	43	87	2·34	11	0	18	8	0	7
Renfrew	8·8	—13·8	2·6	—2·7	116	35	15	4·66	21	0	12	1	2	1
Dyce	5·1	—12·3	1·8	—3·0	93	54	63	3·14	21	0	22	27	0	0
Stornoway	7·3	— 7·2	4·5	0·4	188	35	24	4·18	14	0	12	3	0	0
Aldergrove	5·0	—10·6	1·9	—2·9	121	45	34	3·68	25	0	19	8	2	1

The very cold weather with easterly winds, heavy falls of snow and near-freezing day temperatures, which set in around Christmas 1962, continued over most of the country throughout January. Early morning frosts were exceptionally severe, —10°C being widely recorded on the 12th and 13th and —16°C on the 23rd and 24th. Snow fell at one place or another every day and nearly all inland districts were snow-covered throughout the month. Winds reached gale force locally on the 3rd piling heavy falls of snow into deep drifts which isolated many towns and villages. Blizzards moving slowly northwards swept across the Yorkshire Moors on the 16th—by the 18th Scotland was virtually cut off from England.

TABLE III—FEBRUARY 1963

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Highest	Lowest	Mean maximum	Mean minimum	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Frost	Thunder	Snow falling	Snow cover	Fog	Gale
Kew	7·4	— 6·4	2·2	—1·4	112	64	16	1·55	20	0	20	13	0	0
Gorleston	3·3	— 7·5	1·2	—2·0	113	69	56	1·60	25	0	16	14	2	0
Boscombe Down	5·3	— 7·7	1·2	—3·3	111	74	40	2·05	27	0	17	27	0	0
Plymouth	8·8	— 5·2	4·6	0·2	115	80	100	3·11	15	0	13	5	0	1
Elmdon	5·5	—11·8	1·4	—3·8	106	65	39	1·90	27	0	21	14	2	0
Valley	11·4	— 5·5	4·9	—1·6	168	79	21	2·29	21	0	8	1	0	2
Manchester Airport	8·3	— 6·7	2·6	—2·7	177	55	9	2·37	28	0	16	7	0	0
Tynemouth	4·1	— 7·4	2·0	—1·7	82	66	179	1·65	21	0	20	11	1	1
Renfrew	8·7	— 8·7	3·8	—3·2	131	60	14	3·19	24	0	12	6	1	0
Dyce	7·0	— 8·5	2·4	—2·9	119	80	67	2·36	22	0	20	21	0	0
Stornoway	9·6	— 6·2	5·2	0·0	124	62	15	2·68	12	0	12	0	0	4
Aldergrove	7·6	— 6·8	3·7	—1·9	130	65	69	2·39	21	0	13	6	0	1

The very cold easterly airstream from the continent continued for most of February though there were short interludes of northerly winds. Day temperatures rose little above freezing and were especially low in south-east England during the first and third weeks. Deep depressions approaching from the Atlantic were not successful in changing the régime for more than short periods; however, they gave heavy falls of snow. One, accompanied by gales on the 5th and 6th, gave continuous snow for 36 hours on Exmoor which accumulated to a level depth of nearly 2 feet with drifts 20 feet deep in places. Some farms and villages were isolated for the tenth time since Christmas. Another brought rain to south-west England on the 13th which turned to snow as it spread north-eastwards, and heavy falls of snow continued in northern England and Scotland until the 17th. From the 21st–27th freezing overnight fog was slow to clear during the day, but on the last day of the month temperature rose to near average.

TABLE IV—MARCH 1963

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Highest	Lowest	Mean maximum	Mean minimum	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Frost	Thunder	Snow falling	Snow cover	Fog	Gale
Kew	13·9	—2·7	9·9	4·0	92	113	158	1·46	5	1	1	0	0	0
Gorleston	14·6	—2·2	7·6	2·5	92	125	143	1·35	2	0	3	0	0	1
Boscombe Down	13·6	—4·5	9·3	2·3	90	126	244	1·79	8	0	1	0	0	1
Plymouth	12·4	0·0	9·8	4·6	90	133	196	2·73	0	0	0	0	0	2
Elmdon	14·8	—8·0	9·1	2·2	81	107	172	1·69	7	0	0	0	0	0
Valley	13·1	—3·7	9·4	3·8	104	128	202	2·09	3	0	0	0	0	3
Manchester Airport	13·6	—3·6	9·5	3·1	99	99	114	1·77	6	0	1	0	0	1
Tynemouth	12·0	—5·0	7·8	2·8	109	100	91	1·54	4	0	0	0	2	1
Renfrew	12·3	—6·8	9·3	2·0	102	91	182	2·51	7	0	0	0	1	0
Dyce	12·1	—6·0	7·5	1·6	89	108	142	2·12	6	0	0	0	0	1
Stornoway	10·6	—3·0	9·0	3·1	102	108	197	2·29	5	0	2	0	0	3
Aldergrove	13·4	—3·9	9·8	2·6	101	104	116	2·01	7	0	0	0	1	1

Apart from the first three days and a short anticyclonic spell on the 21st–24th, weather was generally cyclonic and very wet with depressions frequently passing over or near the British Isles. The month began fine and sunny with afternoon temperatures only slightly below normal although there was severe frost at night. Temperature rose considerably on the 4th but many northern districts remained snow-covered until the 5th. The 6th was the first day of the year with no reports of frost from anywhere in the country. The remainder of the month was unsettled and very wet, apart from a short spell of northerly winds with snow showers during the third week. More than twice the average amount of rain fell over large areas of Scotland, parts of the Pennines and north-west England, and also over much of southern England; a few places in western Scotland had more than three times their average.

TABLE V—APRIL 1963

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Highest	Lowest	Mean maximum	Mean minimum	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Frost	Thunder	Snow falling	Snow cover	Fog	Gale
Kew	19·6	—0·7	13·2	6·3	85	160	107	1·81	1	1	1	0	0	0
Gorleston	15·8	0·0	9·6	4·7	92	166	161	1·67	0	1	1	1	1	1
Boscombe Down	17·9	—1·2	12·4	4·8	66	167	137	1·96	2	0	0	0	0	0
Plymouth	16·4	2·3	11·7	6·5	79	182	162	2·20	0	0	1	0	0	0
Elmdon	17·2	—0·2	12·3	4·5	75	151	118	1·98	1	1	2	0	0	0
Valley	17·3	2·2	10·8	5·5	73	178	159	1·89	0	0	1	0	0	1
Manchester Airport	17·5	0·5	11·8	5·2	73	138	104	1·89	0	0	2	0	0	1
Tynemouth	16·9	1·2	9·3	4·9	92	147	105	1·62	0	0	1	0	1	1
Renfrew	16·9	—0·6	11·3	4·7	86	142	85	2·32	2	0	2	0	0	0
Dyce	16·6	—3·0	10·3	3·0	97	148	90	2·29	5	0	2	0	0	0
Stornoway	14·5	—2·7	10·4	4·0	128	142	91	2·33	2	0	2	1	0	0
Aldergrove	16·8	—1·5	11·6	4·1	91	149	95	2·19	1	0	2	0	0	1

April weather was changeable being predominantly cyclonic in character. After two mild days with occasional rain, pressure rose rapidly over Ireland on the 3rd and northerly winds brought thundery showers to many eastern districts. The next day an anticyclone became established to the north of Scotland and cold north-east to east winds on its southern flank brought wintry showers of snow or hail to most parts of the British Isles. A complex depression from the Bay of Biscay moving northwards over the country brought heavy rain to southern England on the 9th and to the Midlands and northern England on the 10th and 11th. Good Friday and Easter Saturday (12th and 13th) were mainly fine, but Easter Day was wet with heavy rain during the evening which persisted in southern England over the Bank Holiday (15th), although weather was fine in the north. Depressions moving northward off the west of Ireland gave widespread rain on the 16th, 17th, 20th and 21st but a ridge of high pressure extending from southern Scandinavia south-westwards across England maintained generally fine weather from the 21st until the 24th. Temperatures during the next few days rose steadily reaching 20°C in places on the 27th and 28th. The last two days of the month were sunny in the north at first but dull wet weather in southern England on the 29th spread to the north during the afternoon of the 30th and to the remainder of the country by nightfall.

TABLE VI—MAY 1963

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Highest	Lowest	Mean maximum	Mean minimum	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Frost	Thunder	Snow falling	Snow cover	Fog	Gale
Kew	25·4	3·8	15·4	7·8	104	199	84	1·81	0	0	0	0	0	0
Gorleston	16·0	2·6	12·5	7·2	97	209	136	1·51	0	3	0	0	0	0
Boscombe Down	25·7	1·0	15·0	5·6	101	199	69	1·85	0	0	0	0	0	0
Plymouth	24·7	3·9	13·7	7·7	91	219	85	2·39	0	1	0	0	0	0
Elmdon	24·3	—0·1	14·7	5·9	107	185	84	2·22	1	2	0	0	0	0
Valley	25·1	2·3	12·9	7·1	93	223	94	2·26	0	1	0	0	0	3
Manchester Airport	25·6	1·9	14·2	6·6	103	177	72	2·24	0	2	0	0	0	0
Tynemouth	18·0	3·7	12·4	6·6	105	172	48	1·99	0	0	0	0	1	0
Renfrew	20·8	0·9	13·5	5·9	114	185	114	2·63	0	0	0	0	0	0
Dyce	17·6	0·3	12·6	3·8	101	181	87	2·78	0	1	0	0	0	0
Stornoway	16·5	0·5	11·8	5·0	104	195	176	2·29	0	0	2	0	0	1
Aldergrove	20·2	1·0	13·2	5·4	94	196	126	2·46	0	1	0	0	0	0

May, a changeable and rather cool month, was generally cyclonic in character during the first two weeks. Rain, heavy at times, which spread southwards over England on the 1st, was followed by two generally cool sunny days with scattered showers. The remainder of the first week was generally dry in the south though Atlantic depressions gave further rain in the west and north. During the second week every other day was wet as a succession of troughs moved eastwards across the country, but an anticyclone became established off south-west Ireland during the third week, and depressions moving south-east around its eastern flank gave occasional rain in the north on the 16th and 17th and, after two showery days, widespread rain on the 20th. A ridge of high pressure covering the country during the last week gave warm sunny weather; temperature exceeded 20°C locally from the 25th until the 29th. The last day of the month was the warmest day since the summer of 1961; 27°C was recorded at a number of places.

TABLE VII—JUNE 1963

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Highest	Lowest	Mean maximum	Mean minimum	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Frost	Thunder	Snow falling	Snow cover	Fog	Gale
Kew	25·6	8·4	20·0	11·9	95	213	112	1·72	0	8	0	0	0	0
Gorleston	21·0	8·8	16·4	11·1	80	215	71	1·67	0	0	0	0	1	0
Boscombe Down	26·0	6·9	18·9	10·2	82	208	209	1·62	0	3	0	0	0	0
Plymouth	24·8	7·5	17·4	11·5	92	222	128	2·01	0	1	0	0	0	0
Elmdon	25·3	4·4	19·5	9·9	116	192	169	1·66	0	1	0	0	0	0
Valley	24·9	7·7	17·3	10·7	93	221	187	1·99	0	2	0	0	1	0
Manchester Airport	26·5	8·0	19·4	10·8	115	179	166	2·34	0	3	0	0	0	0
Tynemouth	22·0	7·0	14·6	9·7	80	182	184	1·75	0	3	0	0	3	1
Renfrew	25·3	5·7	18·3	10·5	97	183	91	2·41	0	1	0	0	0	0
Dyce	20·4	2·6	15·8	8·6	83	181	160	2·15	0	4	0	0	0	0
Stornoway	20·9	6·0	15·2	8·9	99	173	76	2·56	0	0	0	0	0	0
Aldergrove	25·0	6·8	17·8	9·7	103	179	157	2·25	0	3	0	0	0	0

The first ten days of June were warm and thundery with light easterly winds, pressure being high to the north and low to the south of the British Isles. Thundery rain occurred on most days and afternoon temperatures exceeded 25°C in parts of the West and Midlands from the 6th to the 10th. Thunderstorms were widespread on the 6th and 7th; on the 7th, Kensington Palace was flooded when 2¼ inches of rain fell in 35 minutes. The warm weather extended to eastern districts as the winds fell light on the 11th, but the change heralded the gradual breakdown of the warm spell. A thundery trough moving south-east, which gave an inch of rain in Northern Ireland on the 12th, and equally heavy falls in southern England the next day, was the forerunner of a succession of disturbances from the Atlantic which maintained cool changeable weather for the remainder of the month.

TABLE VIII—JULY 1963

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Highest	Lowest	Mean maximum	Mean minimum	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Frost	Thunder	Snow falling	Snow cover	Fog	Gale
Kew	26·8	8·4	20·6	12·3	103	198	52	2·44	0	2	0	0	0	0
Gorleston	22·1	8·0	18·0	12·6	109	210	83	2·30	0	1	0	0	0	0
Boscombe Down	26·7	6·2	19·5	10·6	101	191	52	2·48	0	0	0	0	0	0
Plymouth	24·6	7·5	18·1	11·7	98	198	66	2·58	0	0	0	0	0	0
Elmdon	26·7	4·5	19·6	9·8	120	178	80	2·60	0	5	0	0	0	0
Valley	23·7	7·2	17·4	11·0	97	187	33	2·52	0	2	0	0	0	0
Manchester Airport	26·9	6·6	19·2	11·2	111	154	74	3·09	0	5	0	0	0	0
Tynemouth	23·2	7·7	15·9	10·7	97	169	34	2·97	0	1	0	0	4	0
Renfrew	24·8	6·0	17·7	10·1	100	159	89	3·10	0	1	0	0	0	0
Dyce	21·5	4·0	16·3	8·9	103	157	59	3·45	0	0	0	0	0	0
Stornoway	21·4	2·5	15·1	9·0	140	128	84	3·08	0	0	0	0	0	0
Aldergrove	24·6	2·2	17·6	9·8	119	136	69	3·05	0	2	0	0	0	0

July was mostly cool and dry, but very warm towards the end of the month. A shallow depression off southern Ireland gave frequent showers and thunderstorms with locally heavy rain during the first five days of the month, but on the 6th a deepening depression moving north-east across southern England gave long periods of rain with falls exceeding one inch over wide areas. Three days of cool northerly winds, with scattered showers, preceded another day of widespread rain on the 10th, and this was followed, after a cool quiet spell, by a succession of fronts which brought dull, wet weather to all districts from the 14th until the 19th with only minor breaks. An anticyclone developed over the British Isles on the 20th and weather became sunny and warm generally (apart from a period of rain on the 23rd and 24th) with almost uninterrupted sunshine and with afternoon temperatures reaching 29°C daily.

TABLE IX—AUGUST 1963

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Highest	Lowest	Mean maximum	Mean minimum	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Frost	Thunder	Snow falling	Snow cover	Fog	Gale
Kew	24·9	7·6	19·2	12·2	76	188	103	2·24	0	3	0	0	0	0
Gorleston	21·6	9·5	18·4	11·9	69	189	139	2·01	0	2	0	0	0	0
Boscombe Down	24·8	4·8	18·6	10·0	86	184	119	2·31	0	1	0	0	0	0
Plymouth	22·0	8·1	17·3	12·4	75	198	109	2·88	0	1	0	0	0	0
Elmdon	22·6	4·2	17·8	10·0	80	173	107	2·43	0	1	0	0	0	0
Valley	24·6	7·4	17·3	11·9	82	183	161	2·90	0	0	0	0	0	0
Manchester Airport	24·2	7·3	17·1	10·9	75	151	94	3·19	0	0	0	0	0	0
Tynemouth	18·4	7·5	15·6	10·8	74	147	212	3·03	0	1	0	0	1	0
Renfrew	24·6	3·0	17·0	10·2	75	137	90	3·33	0	1	0	0	0	0
Dyce	22·2	0·2	15·7	8·9	52	147	183	3·10	0	0	0	0	0	0
Stornoway	17·7	2·6	14·5	9·0	84	133	71	3·35	0	0	0	0	0	0
Aldergrove	21·6	5·2	16·5	10·1	78	135	106	3·29	0	0	0	0	0	0

August was dull and cool with more than twice the average rainfall over the eastern part of the country. The warm sunny weather at the end of July lasted only over August 1st. Disturbances moving northwards from France brought heavy rain to southern and midland districts on the 3rd and to the north-east on the 4th. Weather improved in southern England on Bank Holiday Monday (5th), some south-coast resorts having more than 10 hours of sunshine, but heavy rain continued in Scotland and northern England. After nearly a week of changeable weather, with a succession of troughs and ridges crossing the country from the west, a complex low-pressure system developed from Scandinavia to Scotland and a cool airstream from high latitudes brought showers and fair periods to most of England and Wales from the 11th until the 15th. In Scotland, however, weather was mostly cloudy with occasional rain. Periods of continuous rain alternated with brighter showery weather during the next nine days, the rain being widespread and locally heavy on the 16th and 25th, and during the nights of the 20th/21st and 22nd/23rd; there were frequent thunderstorms on the 17th and 20th. The 26th to 29th were sunny days, but rain was persistent and widespread during the last 48 hours of the month.

TABLE X—SEPTEMBER 1963

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Highest	Lowest	Mean maximum	Mean minimum	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Frost	Thunder	Snow falling	Snow cover	Fog	Gale
Kew	22·3	6·3	17·5	10·8	89	142	113	1·98	0	1	0	0	0	0
Gorleston	21·6	6·5	16·8	10·6	93	152	58	2·23	0	1	0	0	2	0
Boscombe Down	23·8	4·2	17·0	9·1	96	137	91	2·36	0	0	0	0	1	0
Plymouth	21·9	5·0	17·1	10·8	98	152	69	2·88	0	1	0	0	0	0
Elmdon	25·5	3·1	17·3	8·2	106	127	68	2·17	0	0	0	0	0	0
Valley	18·6	6·3	16·2	9·6	134	139	85	3·16	0	0	0	0	1	1
Manchester Airport	23·4	4·6	16·5	9·2	130	116	158	2·68	0	4	0	0	0	0
Tynemouth	22·7	5·5	15·4	9·5	140	124	68	2·31	0	0	0	0	0	1
Renfrew	19.7	3·2	15·8	8·8	116	111	76	3·57	0	2	0	0	0	0
Dyce	21·5	0·3	15·6	7·1	115	129	96	3·17	0	0	0	0	0	2
Stornoway	15·6	2·5	13·5	8·5	88	111	119	3·75	0	0	0	0	0	4
Aldergrove	21·3	2·9	15·4	8·7	120	107	102	3·02	0	0	0	0	1	1

The generally unsettled weather at the end of August continued until the 11th, broken by a short fine spell on the 5th and 6th as a ridge of high pressure moved south-east across the country. Rain was widespread, with scattered thunderstorms, during the first three days of the month as a depression from France moved north-east across the country. Heavy rain, mainly confined to southern England on the 4th, was associated with a small depression moving eastwards along the English Channel. Brighter weather extended to most of the country during the next two days, but on the 7th a belt of rain reached western Scotland during the early morning and moved slowly across the country lingering on in south-east England for much of the 8th. A depression over the Bay of Biscay maintained dull, wet weather in southern England on the 10th and 11th. The next day an anticyclone developed over the country and lasted for nearly a week. Weather became fine and warm nearly everywhere with more than 10 hours of sunshine daily at many places and with afternoon temperatures exceeding 25°C. On the 19th the anticyclone moved to Scandinavia, and easterly winds brought cooler more cloudy weather, but it remained dry until the 24th when a deepening depression near Iceland brought widespread rain. The next day was particularly stormy with more than 3 inches of rain in parts of Lancashire and Westmorland, and this was the start of an unsettled period which lasted until the end of the month.

TABLE XI—OCTOBER 1963

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Highest	Lowest	Mean maximum	Mean minimum	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Frost	Thunder	Snow falling	Snow cover	Fog	Gale
Kew	18·7	5·4	14·2	9·2	94	98	67	2·25	0	0	0	0	0	0
Gorleston	20·6	4·2	14·1	8·2	87	111	59	2·43	0	0	0	0	0	0
Boscombe Down	18·0	3·4	13·9	7·6	65	103	58	2·93	0	0	0	0	0	0
Plymouth	18·2	3·9	14·4	10·1	55	114	86	3·83	0	0	0	0	0	0
Elmdon	19·6	1·6	13·8	7·5	81	92	76	2·51	0	0	0	0	0	0
Valley	16·1	3·7	13·9	9·6	87	102	70	3·84	0	0	0	0	0	1
Manchester Airport	18·4	2·9	13·5	7·9	96	85	77	3·22	0	0	0	0	0	0
Tynemouth	18·4	4·1	13·3	8·5	117	92	47	2·47	0	0	0	0	0	1
Renfrew	16·3	1·7	13·0	7·5	106	72	91	4·70	0	0	0	0	1	0
Dyce	17·2	0·3	12·7	5·7	109	96	36	3·74	0	0	0	0	0	1
Stornoway	14·4	0·5	12·1	6·8	87	76	113	4·38	0	1	0	0	0	5
Aldergrove	16·2	1·6	13·2	8·0	99	81	109	3·60	0	0	0	0	0	1

During the first week troughs and depressions brought rain, heavy at times, to most districts on the 1st, 3rd, 5th and 6th. For most of the remainder of the month anticyclones dominated the weather in the south, but in the north weather remained more cyclonic in character. Rain, associated with a deepening disturbance near Iceland, reached most districts during the afternoon of the 7th continuing throughout the night and for much of the following day. On the 9th most of southern England had 8–10 hours of sunshine, but there was heavy rain in Scotland, and similar weather, wet in the north but sunny in the south, continued for the remainder of the second week. A blocking anticyclone over Europe caused fronts from the Atlantic to become slow-moving over the British Isles during the third week. For instance, rain, which reached western districts during the afternoon of the 14th, persisted over most of the country for 48 hours before finally clearing south-east England on the 17th. Two other belts of rain moved slowly eastwards across the country during the period 19th–21st. On the 24th, an anticyclone from the Bay of Biscay moved across the British Isles to establish a large high-pressure area near the southern Baltic the next day, and this persisted until the 28th. Weather was generally dry with good sunny periods in the north and east, but dull elsewhere. On the 29th, a complex area of low pressure extended from Iceland to the Bay of Biscay, associated fronts bringing rain to most western districts. This rain spread to most other districts the next day. The last day of the month was sunny in south-west England but dull and wet elsewhere.

TABLE XII—NOVEMBER 1963

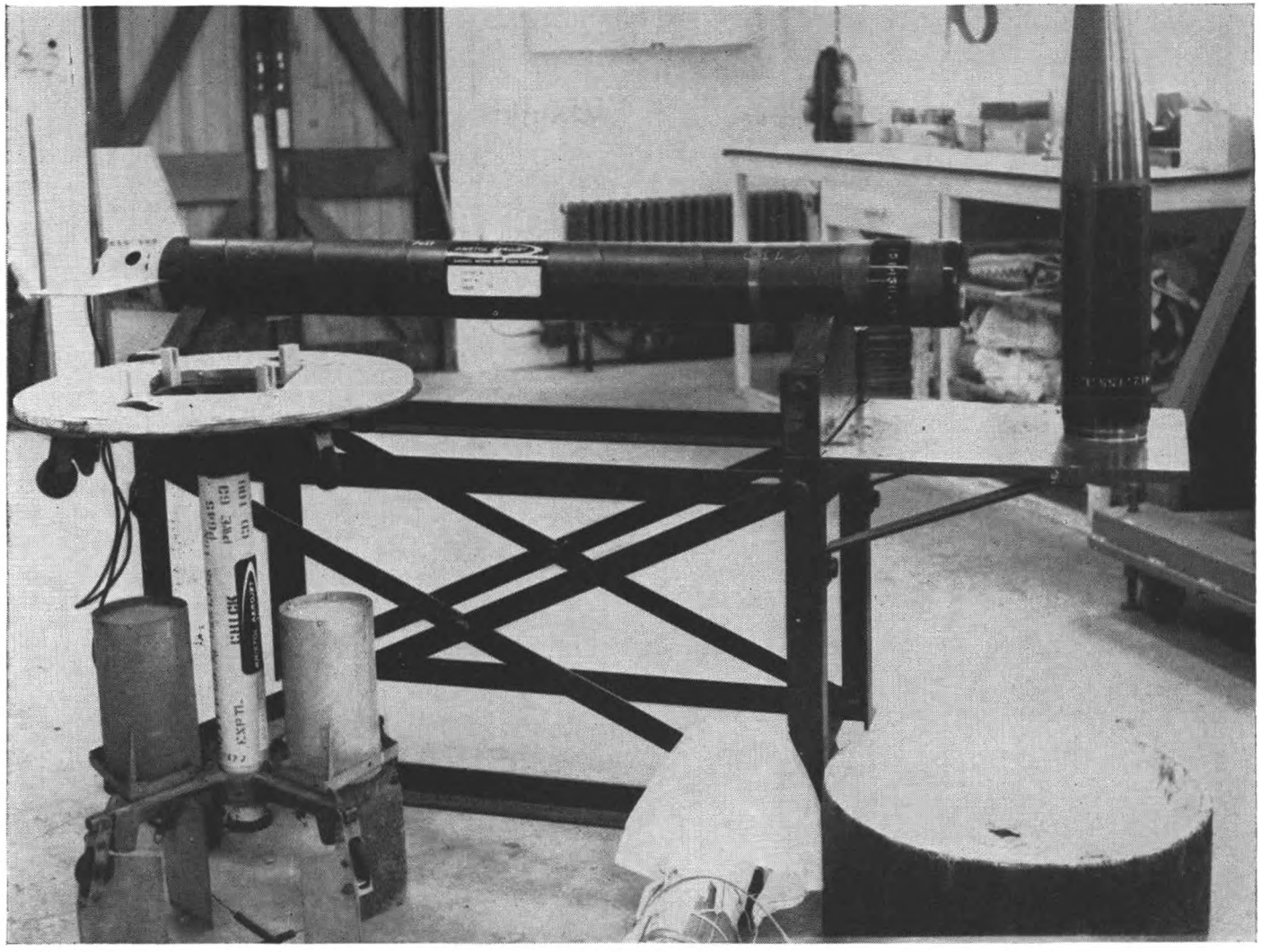
	Temperature °C				Sunshine		Rainfall		Number of days with					
	Highest	Lowest	Mean maximum	Mean minimum	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Frost	Thunder	Snow falling	Snow cover	Fog	Gale
Kew	15·6	—0·4	11·7	7·1	117	53	180	2·49	1	2	0	0	0	0
Gorleston	15·0	—0·3	11·3	6·8	122	58	78	2·74	1	2	0	0	0	1
Boscombe Down	15·8	—2·3	10·9	5·3	104	62	176	3·19	3	1	0	0	0	1
Plymouth	15·3	1·2	12·4	8·3	104	67	199	4·48	0	7	0	0	0	2
Elmdon	15·6	—1·7	10·5	5·3	89	50	151	2·68	2	0	0	0	4	2
Valley	15·4	0·0	11·5	6·6	132	59	139	3·60	0	0	0	0	0	11
Manchester Airport	14·2	—0·7	10·1	5·5	98	43	140	3·03	1	0	0	0	2	0
Tynemouth	12·2	—1.0	9·2	6·1	78	49	210	2·50	2	0	1	0	0	2
Renfrew	13·4	—5·6	8·5	3·7	78	42	158	4·12	8	0	2	0	3	0
Dyce	11·0	—5·6	7·7	3·4	70	59	163	3·67	9	0	4	0	2	0
Stornoway	12·3	—4·5	8·5	4·0	110	45	106	4·50	9	0	2	0	0	2
Aldergrove	13·6	—2·9	9·5	4·2	115	53	152	3·19	6	0	0	0	0	3

A complex low-pressure area to the south-west of the British Isles maintained mild unsettled weather during the first five days of the month. On the 7th, a small Atlantic depression brought rain, heavy at times, to most districts as it moved across central England. Two days later a depression deepened rapidly as it moved north-eastwards from the west of Spain towards the British Isles. Rain reached the south-west during the afternoon of the 9th and persisted in most districts throughout the 10th and 11th. The depression was centred over Scotland on the 12th, and rain, locally heavy, continued in the north, although weather was mainly fine in the south; at Great Langdale (Westmorland) 4·3 inches of rain fell in 12 hours. A cooler, showery spell began on the 13th which lasted about 4 days in England and Wales but nearly a week in Scotland. A deep depression from the Atlantic brought milder weather with widespread rain to southern and central England on the 17th, and this persisted for about three days before north-westerly winds brought cooler, brighter weather to all districts on the 20th. Depressions off our western coasts maintained mild wet weather from the 21st until the 26th and the last three days of the month were dull but cooler with persistent slight rain or drizzle, as fronts became slow-moving over the country.

TABLE XIII—DECEMBER 1963

	Temperature °C				Sunshine		Rainfall		Number of days with					
	Highest	Lowest	Mean maximum	Mean minimum	Percentage of average	Average (hours)	Percentage of average	Average (inches)	Frost	Thunder	Snow falling	Snow cover	Fog	Gale
Kew	9·2	— 5·4	5·4	1·8	109	40	33	2·06	9	0	3	0	1	0
Gorleston	9·8	— 3·0	5·7	2·2	115	46	48	2·16	8	0	7	4	1	1
Boscombe Down	10·1	— 6·5	4·4	—0·1	93	49	28	3·02	16	0	1	0	2	0
Plymouth	12·7	— 3·9	6·8	2·2	102	52	49	4·51	11	0	1	0	0	1
Elmdon	9·5	—13·5	4·7	—0·7	113	40	20	2·41	17	0	4	0	3	0
Valley	10·6	— 4·4	7·0	2·1	179	43	19	3·53	10	0	2	0	0	5
Manchester Airport	9·9	— 6·9	5·3	0·8	172	32	16	2·75	11	0	3	0	0	1
Tynemouth	10·8	— 5·5	5·8	2·8	94	33	48	2·39	8	0	6	3	1	0
Renfrew	11·2	— 6·6	6·1	1·1	106	26	32	4·19	14	0	4	1	1	0
Dyce	10·8	— 8·3	5·0	0·9	83	45	33	3·28	17	1	9	8	0	1
Stornoway	11·4	— 4·9	6·9	2·2	105	26	56	4·06	9	0	6	1	0	6
Aldergrove	10·6	— 6·6	5·9	1·2	150	35	17	3·54	10	0	3	0	0	1

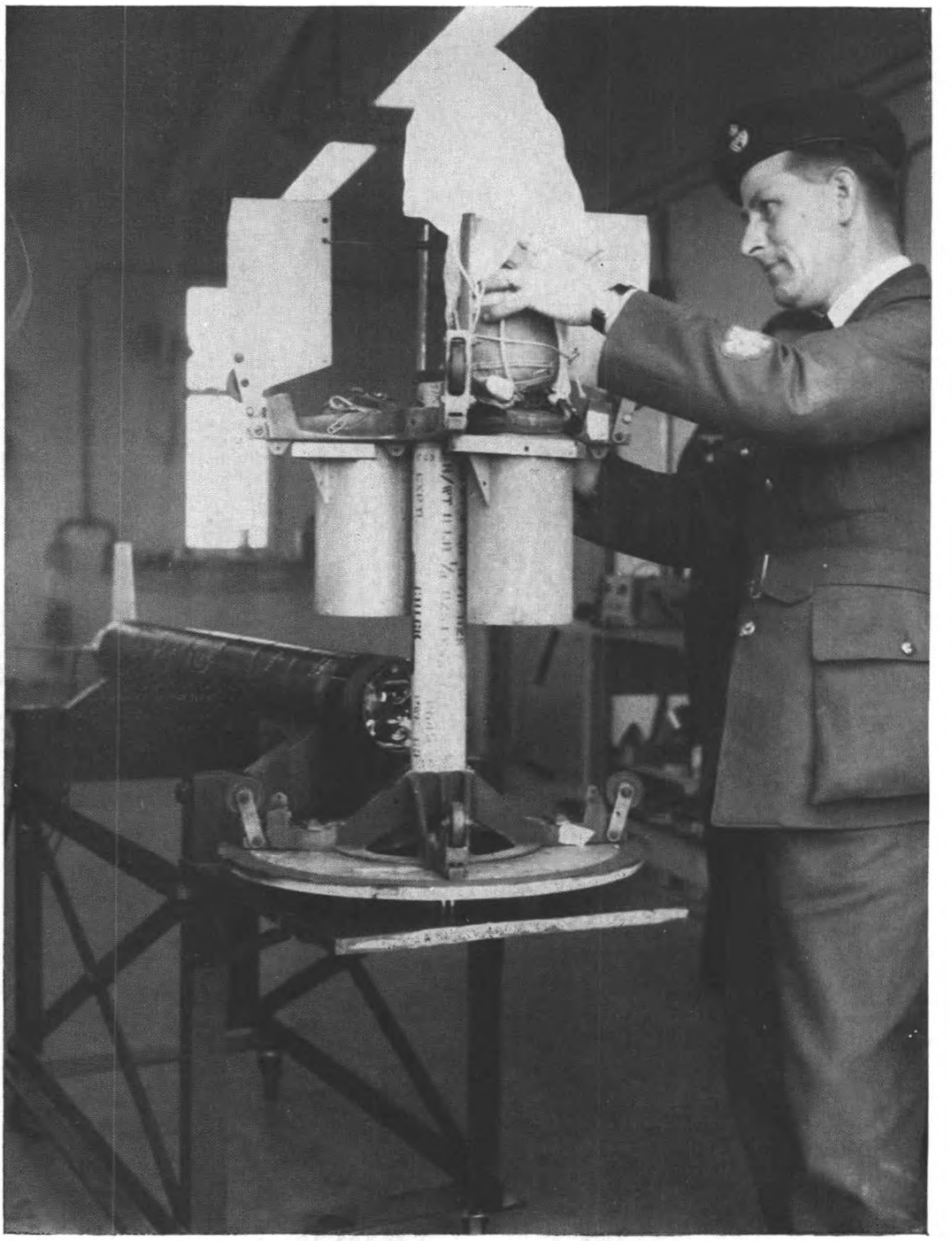
For most of the first half of the month pressure was low to the south-west of the British Isles. Weather was dull and mainly dry with temperature about normal during the first week although rain was fairly widespread on the 1st. Overnight fog on the 8th persisted throughout the day in parts of the south-west with temperature remaining near freezing-point in foggy areas. Patchy fog spread to northern England on the 9th and 10th. Rain and drizzle spread across southern and central England on the 11th and 12th, but on the 13th, with an anticyclone to the north of Scotland, easterly winds brought colder weather with wintry showers to most southern districts. The next day the anticyclone moved to north-west Scotland and a cold northerly airstream spread over the country. Generally dull weather became progressively colder during the next few days until on the 18th a cold front moving south brought some snow to many districts. A spell of sunny, very cold weather followed, but on Christmas Day milder weather with widespread rain spread eastward across the country. Southern districts had rain on Boxing Day too, and in the evening fog formed over much of England. The month ended with generally mild unsettled weather, with rain at times, in a south-westerly airstream.



Crown copyright

The rocket motor and nose cone ready for assembly. On the floor to the left the boost motor assembly. On the floor to the right one of the small parachutes used for the recovery of the boost carriage, together with a sabot used for centralizing the rocket in the launcher.

PLATE II



Crown copyright

Inserting one of the boost carriage recovery parachutes into its container.

PLATE III

Crown copyright

Connecting the aerial to the sonde. The large metallized parachute, which is tracked by radar, is contained in the vertical cylindrical section (it can just be seen) and is connected to the sonde through an 8 ft aerial strop. The sonde itself sits inside the nose cone.

PLATE IV

Crown copyright

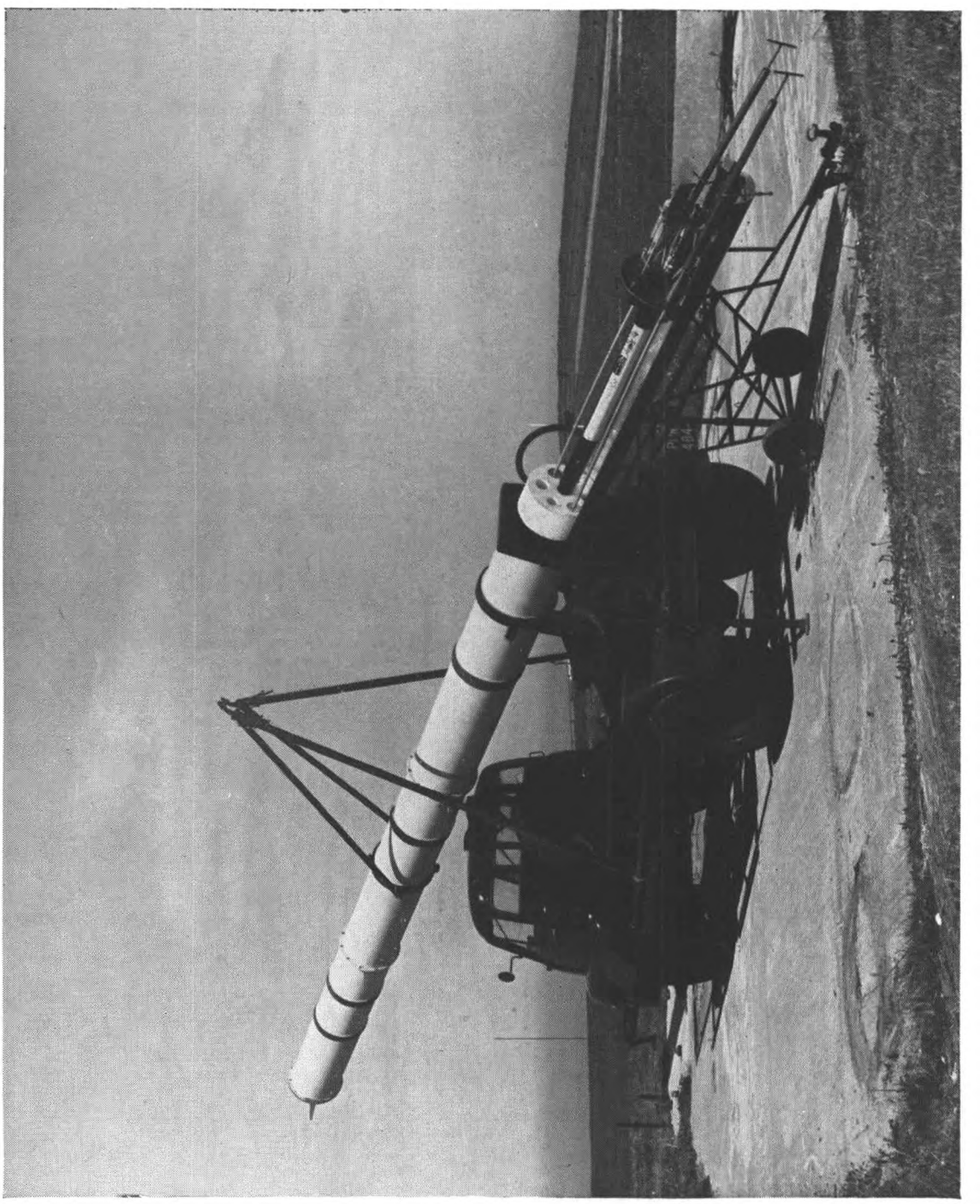
Testing the sonde and parachute ejection system. The ejection system consists of a clockwork clock (visible on the left) which, 113 seconds after launch, fires a tiny rocket visible at the bottom) which blows the nose cone off close to the apogee of the rocket (65 km).

PLATE V

Crown copyright

Lining up the rocket motor with the boost carriage. The boost carriage contains a CHICK motor which burns for 0·2 second and produces an acceleration of about 60*g*, inside the 30 ft long launcher. The rocket sits freely on top of the boost carriage and leaves the boost carriage behind when the CHICK is exhausted.

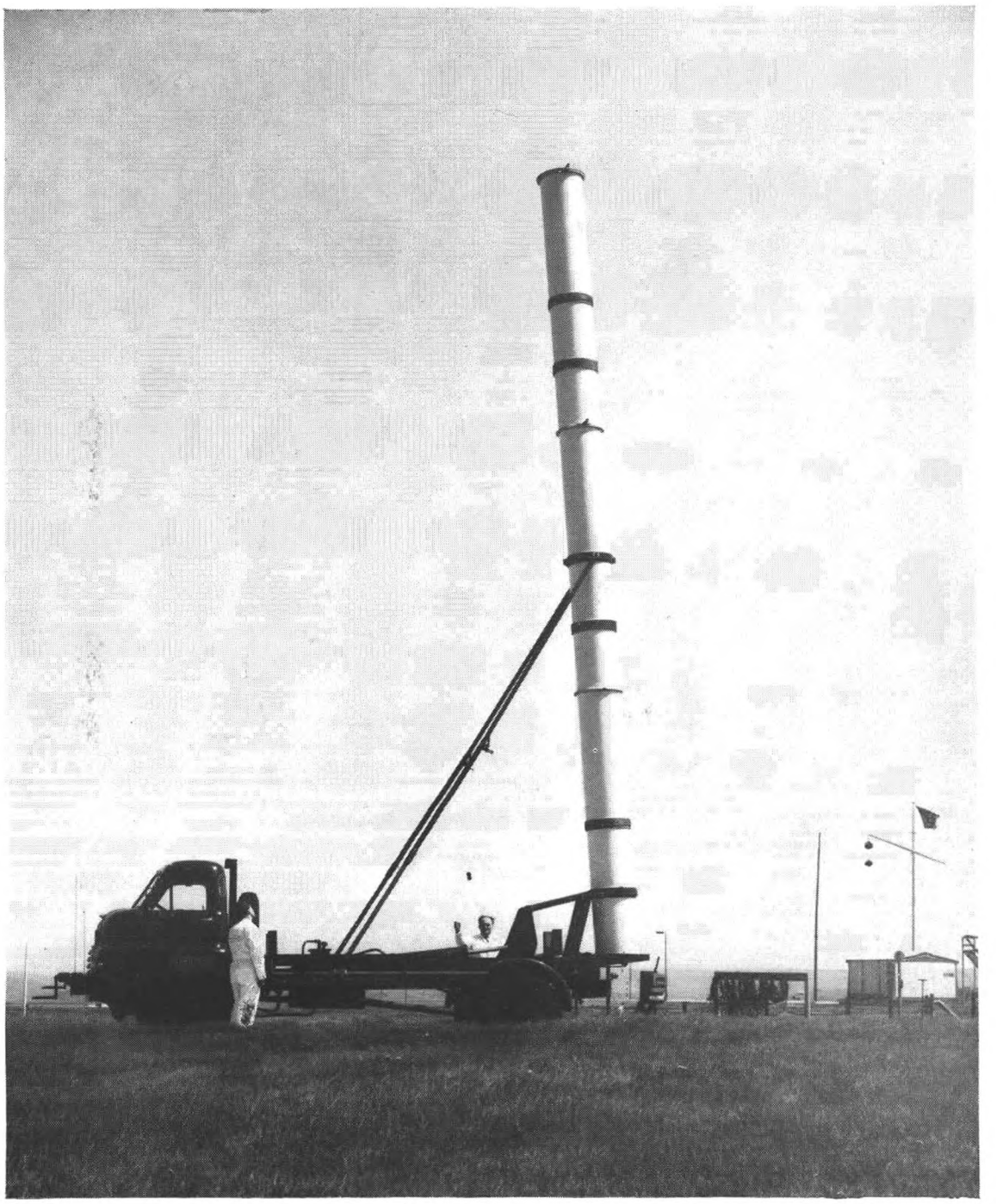
PLATE VI



Photograph by Bristol Aerojet Ltd

The Skua rocket with boost carriage and sabot ready for insertion into the launcher.

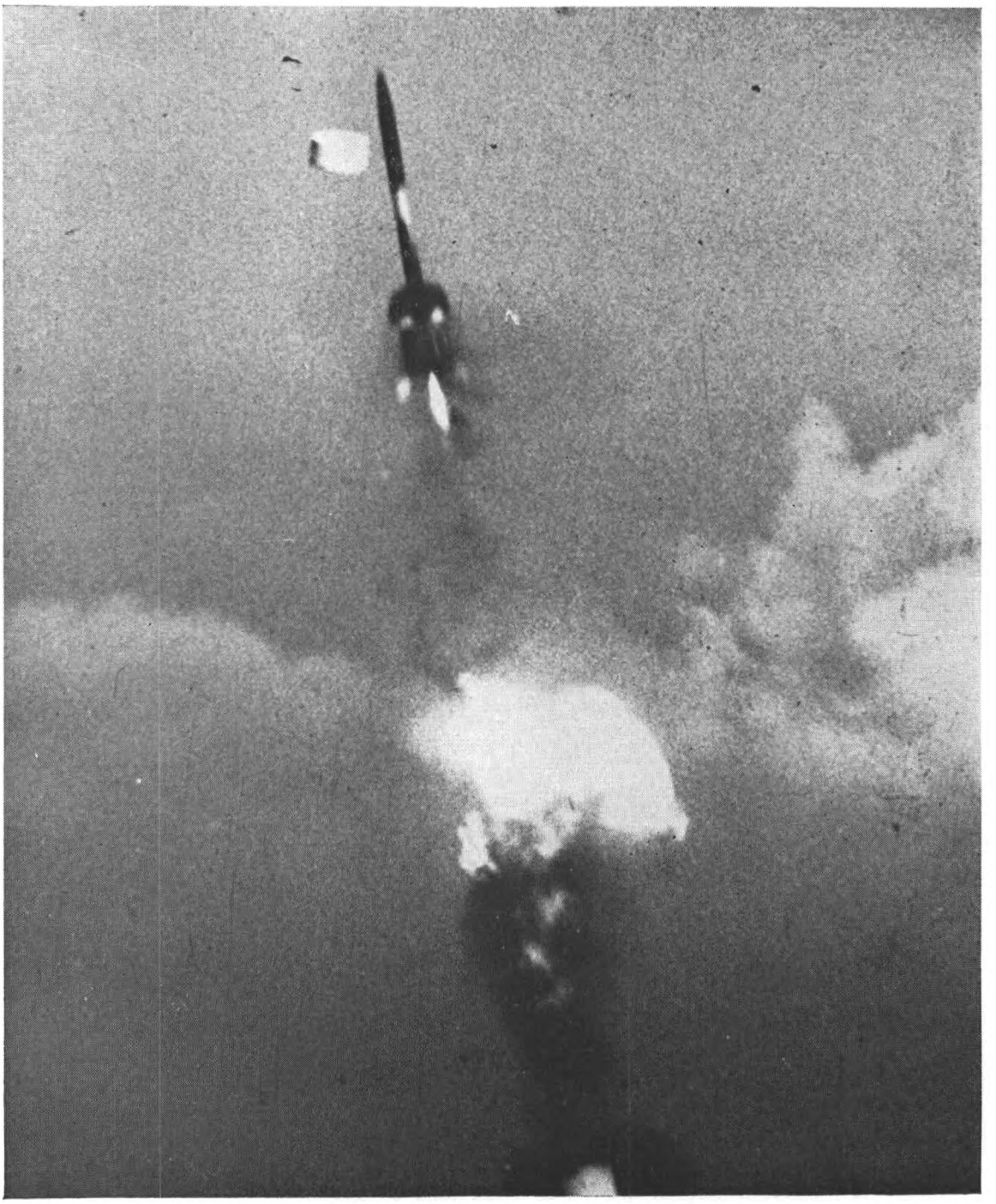
PLATE VII



Photograph by Bristol Aerojet Ltd

The launcher erected into firing position.

PLATE VIII



Photograph by Bristol Aerojet Ltd

Skua after launch at the instant of boost separation.

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 XIV

NUMBERS OF OFFICES OF VARIOUS TYPES STAFFED BY METEOROLOGICAL OFFICE STAFF AND OPERATING ON 31 DECEMBER 1963

	Within U.K.	Overseas
Principal forecast offices associated with the RAF	1	—
Main meteorological offices associated with the RAF	8	6
Subsidiary offices associated with the RAF	51	13
Observing offices associated with the RAF	4	7
Principal forecast offices associated with civil aviation	1	—
Main meteorological offices associated with civil aviation	2	1
Subsidiary meteorological offices associated with civil aviation	12	1
Observing offices associated with civil aviation	6	—
Upper air observing offices	8	9
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	22	6

Notes

A principal forecast office meets the needs of aircraft 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 XV

OCEAN WEATHER SHIPS

The United Kingdom, to meet its obligation under the ICAO North Atlantic Ocean Station Agreement, operates four ocean weather ships to serve, in rotation with two ships each from France, the Netherlands and Norway/Sweden, at five ocean weather stations in the Eastern North Atlantic. Each vessel makes on average eight voyages a year spending 24 days on station each voyage. The following are some statistics regarding the British ocean weather ships during 1963:

Total number of days on station	720
Total number of days on passage	210

	At Station			
	A	I	J	K
Average number of aircraft contacted per voyage of 24 days	326	521	1267	374
Average number of radar fixes to aircraft per voyage of 24 days	246	386	924	392
Average number of weather messages to aircraft per voyage of 24 days	52	118	237	8

Note

At station J, which is always the busiest station, the average number of aircraft contacted per voyage in 1953 was only 355.

TABLE XVI

MERCHANT NAVY SHIPS

A total of about 4000 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, 1963, the numbers of British ships reporting were:

Selected ships	480
Supplementary ships	48
Coasting ships	132
Lightships	13
Trawlers	14
Auxiliary ships	101
Total	788

The British voluntary observing fleet includes ships of over 100 shipping companies and they ply the routes shown below:

U.K. to Australia	102	U.K. to South America	39
U.K. to Far East	88	U.K. to Pacific Coast of North America	12
U.K. to Persian Gulf	27	U.K. to European Ports	43
U.K. to South Africa	36	U.K. to Falkland Island and Antarctica	2
U.K. to North America	80	World-wide 'tramping'	85
U.K. to West Indies	21		

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

		Reports June	Reports December
Direct reception from	British ships in Eastern North Atlantic	74	100
	Foreign ships in Eastern North Atlantic	39	25
	British trawlers in North Sea	6	4
	British merchant ships in North Sea	16	6
	Total (direct reception)	135	135
Via other European countries	Ships in Eastern North Atlantic	231	260
	Ships in Mediterranean	48	65
	Ships in North Sea	78	31
	Ships off North Russia	9	13
	Ships in other European waters	41	102
	Grand Total (Eastern North Atlantic and European waters)	542	606
Via U.S.A.	Ships in Western North Atlantic	342	268
	Ships in North Pacific	468	444

TABLE XVII

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 1963.

	Stations					Autographic Records		
	Observatories	Synoptic	Agro-meteorological	Climatological	Rainfall*	Sunshine	Rainfall	Wind
Scotland, north	1	8	0	26	323	23	9	7
Scotland, east	0	9	8	59	593	48	17	9
Scotland, west	1	9	4	42	522	32	22	10
England, north-east	0	12	4	27	437	28	14	3
England, east	0	13	11	16	468	23	18	9
England, Midlands...	0	12	19	50	1245	60	40	6
England, south-east (including London)	1	18	16	64	842	67	83	17
England, south-west	0	8	8	29	499	33	11	5
England, north-west	0	6	4	20	466	22	32	12
Wales, north	0	2	3	18	234	9	7	1
Wales, south	0	3	10	19	303	23	11	4
Isle of Man	0	2	0	1	17	3	1	2
Scilly and Channel Isles	0	3	0	3	22	6	1	2
Northern Ireland	0	10	2	36	241	15	7	3
Total... ...	3	115	89	410	6212	392	273	90

* Includes stations in earlier columns.

TABLE XVIII

HEIGHTS REACHED IN UPPER AIR ASCENTS

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

Observations of temperature, pressure and humidity

	Number of observations	Percentage reaching 100mb approx. height 53,000 ft	50mb approx. height 67,000 ft	30mb approx. height 78,000 ft
Eight stations in United Kingdom	5818	90·2	64·2	22·2
Eight stations overseas	4854	94·4	71·9	29·0
Four ocean weather vessels ...	1427	89·3	60·4	22·2

Observations of wind

	Number of observations	Percentage reaching 100mb approx. height 53,000 ft	50mb approx. height 67,000 ft	30mb approx. height 78,000 ft	10mb approx. height 100,000 ft
Eight stations in United Kingdom	11,477	87·9	60·5	18·1	2·1
Seven stations overseas	7757	88·3	65·6	25·7	2·0
Four ocean weather vessels ...	2660	88·3	62·4	19·3	0·0

TABLE XIX

THUNDERSTORM LOCATION

Number of thunderstorm positions reported by C.R.D.F. network 92,000

TABLE XX

METEOROLOGICAL COMMUNICATION TRAFFIC

Almost all the national and international exchange of meteorological data which are used in the construction of synoptic charts and the production of forecasts is effected by either coded messages or facsimile charts. The coded messages are composed of groups of five figures and there may be three to thirty such groups in one message. The messages are exchanged by radio and teleprinter. The following figures give an analysis of the traffic through the Meteorological Office Communications Centre for one typical day (24 hours) taken near the end of December 1963 and, for comparison, some corresponding figures for one day near the end of 1962.

Communication traffic for one day

Coded messages	Number of groups in one day			
	In	Out	Total	Total in 1962
Land-line teleprinter ...	333,330	386,242	719,572	799,113
Radio	109,878	197,075	306,953	317,533
Facsimile charts	**Number of charts in one day**			
Land-line	0	68	68	104
Radio	87*	48	135	73

*Received at Bampton by radio and passed to Met. O. by land-line.

TABLE XXI

SPECIAL SEASONAL FORECASTS

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

	Year	No. of customers	Year	No. of customers
Fine spell notifications (a summer service)	1962	808	1963	723
Weekend temperature forecasts (a winter service)	1962–63	56	1963–64	49
Snow and icy road warnings	1962–63	252	1963–64	251
Smith period notifications (1 March–31 May)	1962	19	1963	2
Beaumont period notifications (15 May–15 August)	1962	24	1963	8

TABLE XXII

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 works shows little variation from year to year. Forecasts for aviation constitute the primary function of many of the offices. The following figures indicate the numbers of forecasts issued for aviation and the numbers of meteorological 'briefings' which took place during 1962 and 1963. They do not include warnings and routine general forecasts.

	1962	1963
Number of meteorological briefings for		
aviation in United Kingdom	349,697	372,764
aviation at overseas stations	58,790	55,190
Number of aviation forecasts issued for		
aviation in United Kingdom	831,524	877,948
aviation at overseas stations	174,842	180,896

TABLE XXIII

NON-AVIATION INQUIRIES

Non-aviation inquiries are handled by four weather centres established at London, Manchester, Glasgow and Southampton to meet the needs of the general public for forecasts for special purposes and by many of the forecast offices established primarily to meet aviation requirements but which also answer telephone requests for forecasts and other weather information from the general public, public corporations, Press, commercial firms etc. (the 'Post Office Guide' lists the telephone numbers of 40 such offices). All but an insignificant proportion of these inquiries refer to current or future weather and are categorized according to the purpose of the inquiry in the figures below. Climatological inquiries are dealt with in Table XXV.

	1962	1963
Grand total of inquiries	794,195	912,751
Percentage of inquiries connected with		
agriculture, etc.	10·4	12·1
holidays	14·8	15·2
public utilities	9·2	9·0
road transport...	12·6	10·3
Press	11·6	10·5
marine	20·1	19·3

TABLE XXIV

AUTOMATIC TELEPHONE WEATHER SERVICE FORECASTS

By the end of 1963 forecasts for thirteen different areas were available in sixteen GPO Information Service Centres. The number of calls made on this service during 1963, together with those of 1962 for comparison, is indicated by the following figures (supplied by courtesy of the Postmaster-General).

Information Service Centre	Forecast area	Number of calls 1962	1963	Remarks
London	London	3,174,972	4,060,454	
London	Essex Coast	142,624	173,365	
London	Kent Coast	119,934	144,651	
London	Sussex Coast	168,216	215,513	
Colchester	Essex Coast	65,604	93,915	
Brighton and Hove	Sussex Coast	88,759	110,475*	
Birmingham	Birmingham	256,704	389,228	
Liverpool	South Lancashire and North Cheshire	322,700	246,115	
Liverpool	Lancashire Coast	—	51,630	Started March 1963
Manchester	South Lancashire and North Cheshire	330,871	249,369	
Manchester	Lancashire Coast	—	39,470	Started March 1963
Cardiff	Cardiff	167,061	256,606	
Belfast	Belfast	169,784	272,689	

TABLE XXIV—*continued*

Information Service Centre	Forecast area	Number of calls 1962	1963	Remarks
Glasgow	Glasgow	426,544	393,657	
Edinburgh	Edinburgh	191,853	241,064	
Bristol	Bristol	152,261	233,067	
Portsmouth	Southern Hampshire	95,414	112,202	
Southampton	Southern Hampshire	185,486	292,031	
Canterbury	Kent Coast	32,167	116,351*	Started September 1962
Blackpool	Lancashire Coast	—	66,120	Started May 1963
Southport	Lancashire Coast	—	20,551	Started May 1963
	Total	6,090,954 (Total in 1961—5,546,479)	7,778,523	

* Estimated.

TABLE XXV

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

	1962	1963
Total number of climatological inquiries	8116	8616
Percentage relating to		
agriculture (farming, market gardening and forestry)		14·8
building and design (including siting)		8·5
commerce (sales, marketing and advertising) ...		7·2
education and literary		5·8
industrial and manufacturing activities		7·7
legal (damage, accidents, insurance)		14·9
medical and health		3·1
Press and information centres		4·4
research		4·9
water supply		9·5

TABLE XXVI

LIBRARY

The following figures indicate the distribution of work in the Library during 1963:

Library statistics

Publications received during 1963 (excluding daily weather reports) ...		8915
Individual books, pamphlets, articles, microfilms classified and catalogued		6311
Transparencies acquired		869
Publications lent (excluding daily weather reports and internal 48-hour loans)		10,486
New exchange of publications agreements		5
Total number of exchange agreements		408
Number of pages translated by Library translators		
Russian	1758	
German	141	
French	27	
Icelandic	9	
Total	1935	

Archives

Number of Loans	645

TABLE XXVII
EDITING STATISTICS

The following figures give the number of publications edited in Met.O.18 during 1963:

Publication	Number	Remarks
Geophysical Memoirs	2	Nos. 108 and 109
Scientific Papers	2	Nos. 18 and 19
Meteorological Magazine	12	March 1963 to February 1964 inc.
Observatories' Year Books	1	1961 (Varityped by Met.O.18)
Annual Report	1	1962
Occasional Publications	12	(includes some for internal use)
Reprints	4	

The following figures give the number of publications edited in Met.O.1 during 1963:

Publication	Number	Remarks
Marine Observer	4	April 1963–January 1964 Nos. 200–203 inclusive
Occasional Publications	2	This includes Replacement No. 2 for M.O. 477 The Marine Observer's Guide
Reprints	5	

TABLE XXVIII
DATA PROCESSING

Punched-card installation

Number of cards punched by the Meteorological Office installation ...	839,000
Number of cards punched outside for the Meteorological Office	316,500
Number of cards converted to paper tape	752,000
Number of non-routine investigations completed	214

Computer installation

The electronic computer METEOR was used for computing during 3900 hours.

TABLE XXIX
TRAINING

The following figures give some details of courses which were completed during 1963, at the Meteorological Office Training School at Stanmore, the Radiosonde Training School at Hemsby, and the Air Ministry Civil Training and Education Establishment in London.

	Number of courses	Length of course in weeks	Number of students
Scientific Officers	1	23	9
Senior Forecasters	3	3	33
Forecasters (Advanced)	6	4	37
Forecasters (Initial)	2	17	50
Assistants	15	9	209
Assistants (Short Course)	7	5	95
Climatology...	1	9	4
Mediterranean Meteorology ...	2	2	11
Tropical Meteorology	2	3	16
Voluntary Observers	2	1	37
Auxiliary Observers (coastguards)	2	1	39
Special Course for Antarctic Observers	1	9	16
Advanced Instrument Maintenance	4	2	25
Assistants (Background Course) ...	2	1	30
Radiosonde (Initial)	4	8	37
Radiosonde (Refresher)	3	4	4
Radiosonde (Advanced)	4	4	13
Special Course for Antarctic Observers (Radiosonde) ...	1	10	7
Course for officers-in-charge ...	2	1	28
		Total	700

Students from the following territories attended courses:

Country	Number of students
British Antarctica	16
Channel Islands	1
Cyprus	1
East Africa	1
Egypt	3
Ghana	4
Hong Kong	1
Indonesia	2
Iran	1
Jordan	4
Libya	1
Mauritius	2
Nigeria	3
Sierra Leone	1
South Georgia	1
Switzerland	6
Syria	6
Turkey	5
West Indies	2
Total	61

THE DIRECTORATE OF RESEARCH

1. Special Topic—Climatic Variation

The mention of climatic variation most likely brings to mind those periods during the thousands of millions of years of geological time when ice fields extended over large areas, and the much longer warm periods when probably there was no permanent ice on earth. In this sense we are still in an Ice Age, for the last extension of the glaciation cleared from the British Isles only about ten thousand years ago. The study of the climatic changes on these long time-scales has not been included in the research programme of the Meteorological Office. The evidence is geological or geophysical demanding little acquaintance with meteorological principles, and the results, however important and interesting, have little relationship with any other work of the Office.

For climatic changes on much shorter time-scales there is direct evidence. The range of variation is not everywhere small and can be of practical importance in connexion with planning problems confronting governments and industry. The short-period variations are evidently associated with variations in the general circulation of the atmosphere and are therefore usefully studied in association with related theoretical work and the development of long-range forecasting.

Climate is never constant. The differences, sometimes remarkably big, between one year and the next add up to appreciable differences between one decade and another. Even periods centuries long differ to an extent that must affect the human economy and the stability of social life over wide regions of the globe. The general distribution of world climates, as represented by the relative differences between Britain and the Mediterranean or central Europe, has remained broadly the same over the last two to three thousand years. The variations that matter have been in regions near the climatic limits of cultivation—at the high latitude and altitude limits, where summers are not always warm enough for crops to ripen, and in the arid lands of the desert margin, where vegetation cover may become insufficient even for grazing. Theories that primitive peoples may at times have had their livelihood so badly upset as to impel barbarian invasions of European and Chinese civilizations appear reasonable in the light of rainfall changes within the last hundred years. Percentage changes of rainfall over periods decades long are illustrated in Figure 3. At Barnaul in central Asia the average yearly rainfall was 19 inches (482 mm) between 1900 and 1940, which was double that around 1850, and the yearly average has decreased greatly since 1940. Big percentage changes are also seen at Alexandria on the edge of the Sahara, and in eastern Australia.

The first half of this century was a period of warmth—particularly marked in high northern latitudes but also noteworthy in this country—that may have been unequalled in the last 600 years. Figure 4 presents the temperatures prevailing in central England (according to Professor Manley's computations) as 10-year averages for each season, and for the year as a whole, since 1680. The sharp rise from the 1690's (when there were disastrous famines in Scotland) to a very short-lived peak of warmth in the 1730's and thereafter the more gradual recovery to what now appears as a culminating period of warmth somewhere between 1920 and 1950 are obvious features of the graphs. The length of the growing season was extended by three weeks or so in most years in this period, and the worst years in the 1930's and 40's had a 3 to 5 weeks longer

growing season than the worst years of the last century. Symptoms of deterioration, particularly of our winter climate since this recent peak (the latest 10-year average winter temperature 1954–63 is 3·7°C compared with 4·6°C for the warmest decade 1920-29) make clear the need for deeper understanding, for investigation of previous deteriorations and ultimately (if it could be achieved) for a scientific basis for forecasting the climatic trend.

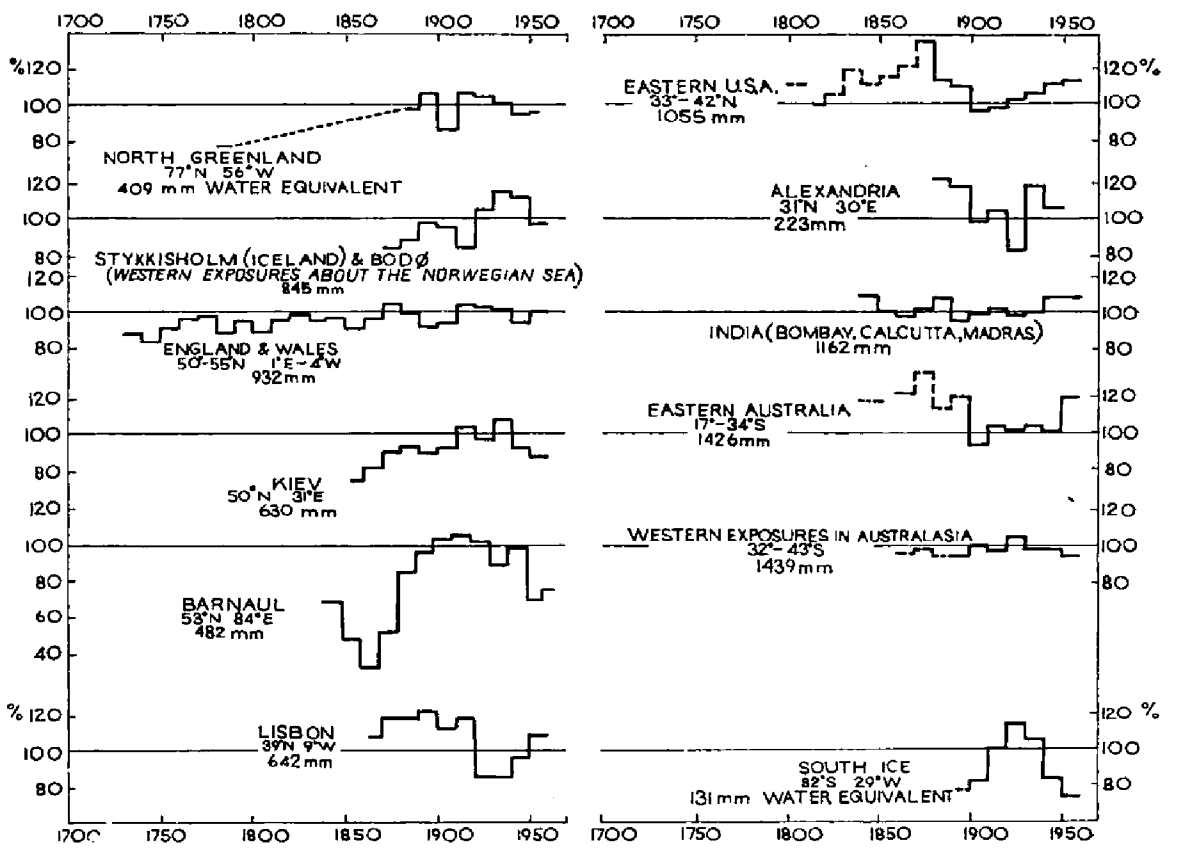


FIGURE 3—Rainfall: decade averages as percentage of 1900–39 average. Figures given in millimetres are the average yearly precipitation totals between 1900 and 1939.

Computations by Mitchell of the U.S. Weather Bureau indicate that these changes are by no means peculiar to Britain. Average temperature over the world, which had risen by 0·4°C since 1880, has been falling since the early 1940's and by the late 1950's had fallen 0·1°C or rather more. The change has been greatest in the Arctic and in northern Siberia, Alaska and northern Canada. The ice on the Arctic seas is believed to have become more extensive than at any time since 1888. In England the two years 1962 and 1963 stand out as the coldest since 1892.

Climatic changes, such as those that have occurred in the present century, from time to time appear to hold out the hope of exploitation of new crops and marginal land. Investigation of the matter soon reveals the standing threat of climatic reverse that hangs over projects for cultivation of 'virgin

lands' beyond the limit of previous cultivation. Within historical times, only 500–600 years ago, a lowering of prevailing temperature levels (for which there is much evidence) compelled the abandonment of grain growing in Iceland and, probably, of wheat in Scotland. Vine growing in England and parts of northern France, and at higher levels than now on the hillsides in Germany, was given up for the same reason. By the 1930's the climatic recovery

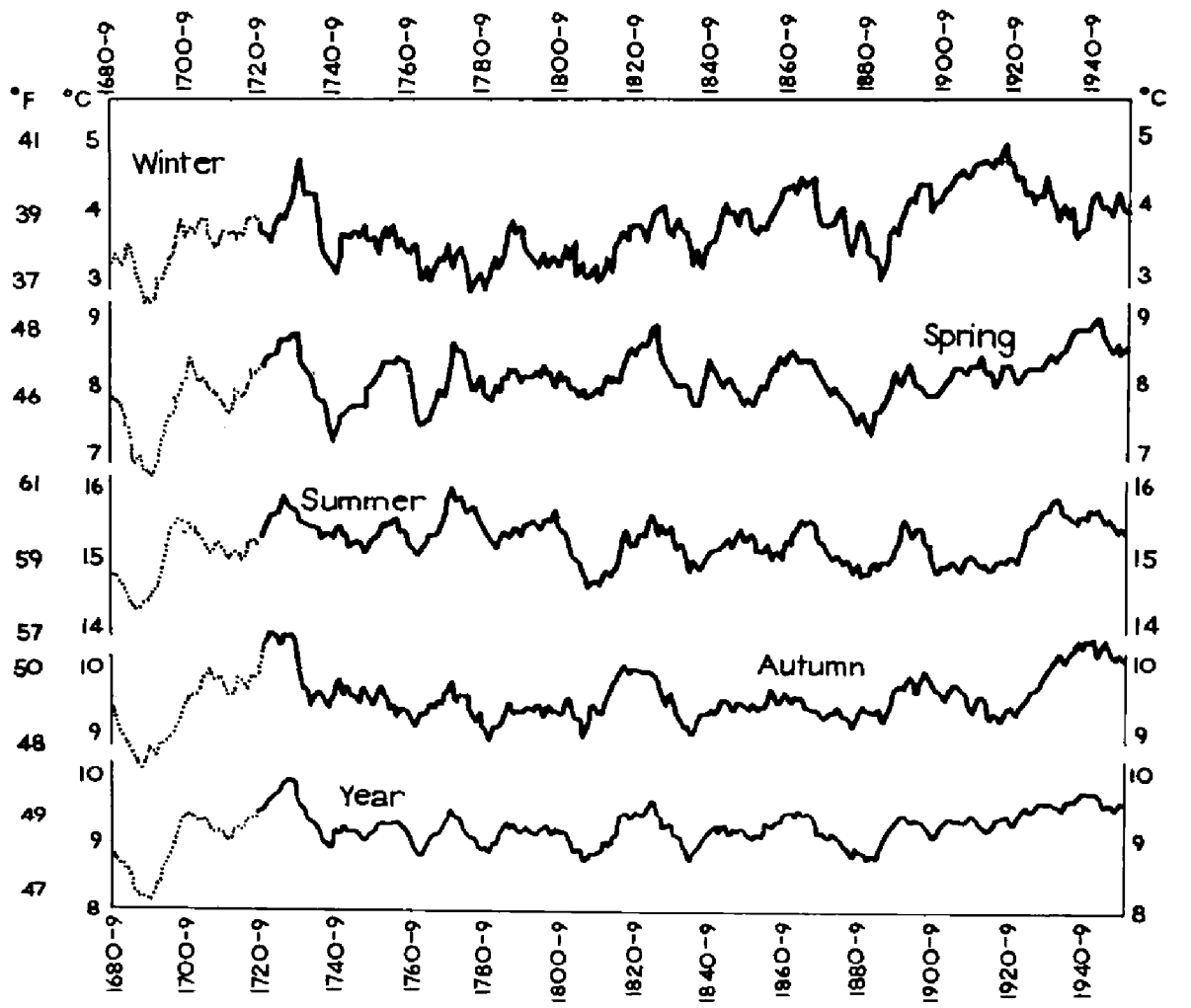


FIGURE 4—Average temperatures in central England 1680–1960 (after Professor Manley).

had induced a good deal of optimism in certain quarters in England about trying southern crops again; but lower summer temperatures since 1950 have adversely affected luxury crops like apricots, peaches and sweet corn grown in the open. Much more important to the economy, however, was the reliance that came to be placed upon a longer open grazing season and need for less winter fodder. These expectations, and many other easy-going habits (affecting fuel, transport and other things) have had to be modified since 1950. In some parts of the world, rainfall changes may have even greater effects, as in the

famous 'dust-bowl' erosion of soil in the 1930's in the Middle West of the United States. In the 1950's drought appears to have become more troublesome than for some decades before both in Kazakhstan and in parts of China (and since 1960 in Israel also).

Meteorologists over several generations have collected and published ancient weather diaries and have compiled miscellaneous records of weather and seasons found in various State, monastic and personal papers from the distant past. By now there is abundant information for temperate Europe from Ireland to Russia, and probably every extreme season since A.D. 1100 is known. (Historians have for the most part strangely ignored this information, except in Scandinavia where the effects of climatic change were obvious. Their lack of interest may be connected with the fact that in the deteriorating climate of the 14th to 16th centuries the economies of England and more southerly countries showed gains as well as losses—partly through the weakening of northern trading rivals and partly through such factors as migration of the herring and other fisheries. The climatic change may well have been the main factor in the cessation of European expansion 50–60 years before the Black Death, as well as in the increasing troubles in the Scottish Highlands, from 1300 onwards.) Other meteorologists have painstakingly examined the records of early barometers, thermometers and rain-gauges and have produced long series of observed values fit for comparative study. Professor Manley, under contract from the Meteorological Office, has been working on a compilation of daily weather observations and instrument readings in the London area which may eventually be continuous from 1669 to the present date.

The next step has been to submit the mass of observations to meteorological analysis. The approach adopted in the Meteorological Office has been to examine the wind circulation patterns that produced the weather reported in different years and epochs. This amounts to investigating the mechanism of climatic variation (the general circulation of the atmosphere and, so far as possible, of the oceans) in the hope of finding clues to the physical nature of the phenomenon. Using observations of barometric pressure and wind, maps of the average state of the atmospheric circulation have been constructed, covering as much of the world as possible, for each January and each July back to 1750. The reliability of the maps has been assessed by specially devised tests, and on this basis the limits of the area that can be effectively analysed are determined. (A more sketchy analysis, based on wind and weather observations only, is being produced for each year back to 1550. This may be important because it provides a glimpse of the period of climatic decline which led to the privations of the harshest periods in the 17th century.) The map series bring to light a number of interesting features, notably:

(1) During the 200-years-long period of climatic warming the main currents of the average wind circulation in most parts of the world became stronger. The trend parallels rather closely that of the winter temperatures in Britain and, like the latter, has reversed since 1930. The frequency of westerly winds over the British Isles appears to have undergone similar changes (see Figure 5). The abrupt fall in the frequency of westerly type since the 1930's has been accompanied chiefly by a rise in frequency of northerly type (average frequency almost doubled to about 33 days a year over the last 25 years) and lesser rises in southerly, easterly and north-westerly types. In all these respects the latest figures are comparable to the period before about 1895.

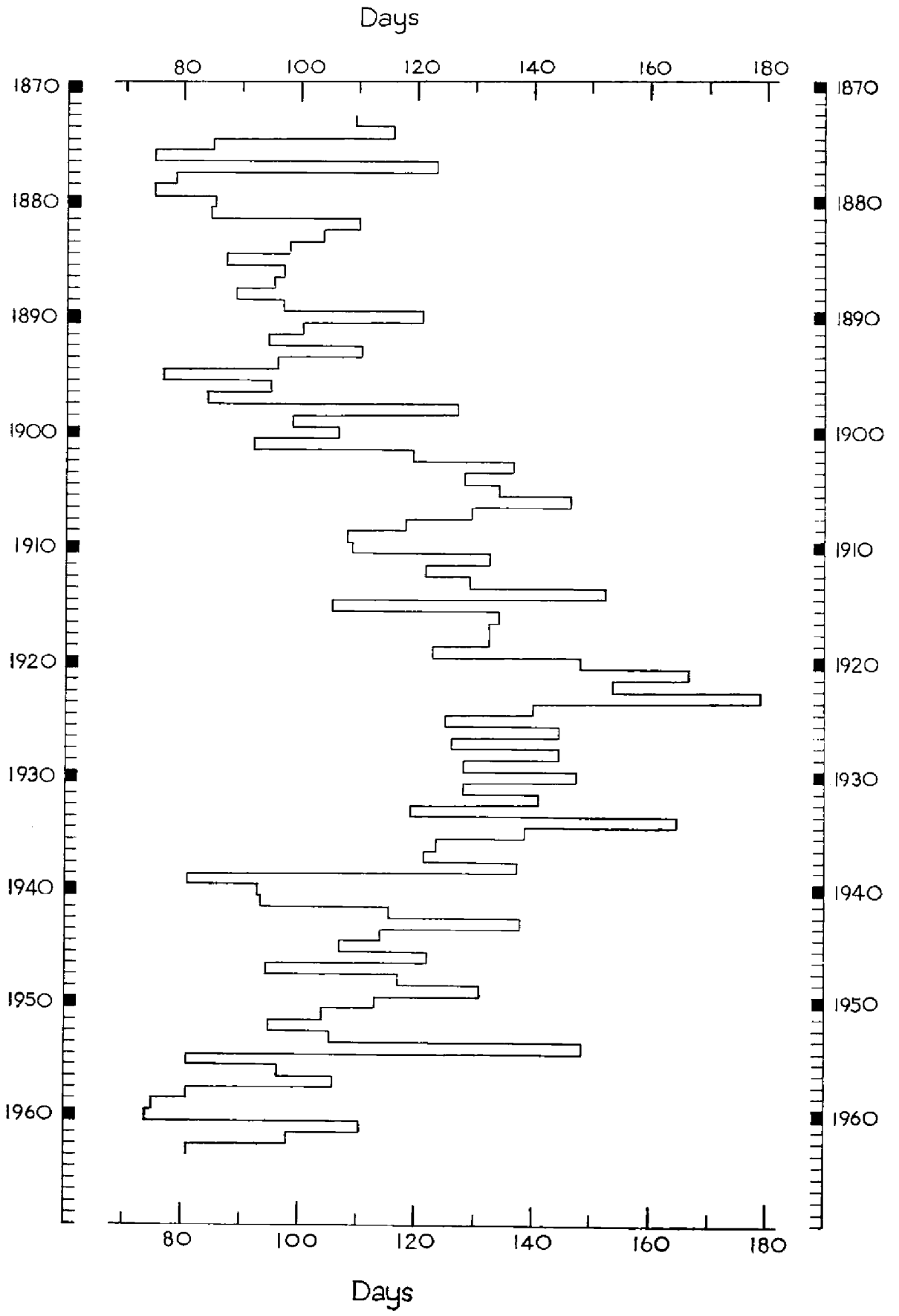


FIGURE 5—The number of days each year since 1873 classified as westerly type in the British Isles (approx. 50–60°N, 0–10°W).

(2) The paths most frequently followed by depressions across the Atlantic appear to have shifted north by several degrees of latitude, penetrating the Arctic further and in summer becoming generally more remote from this country, as the warmest epoch of this century was approached and the Arctic ice receded. Since about 1940, however, there has been a movement in the reverse direction. This has meant that circulation patterns in recent years have been more similar to those occurring in the latter part of the nineteenth century than in the period 1900–1939; since 1962 the closest parallels have sometimes been in the years between 1780 and 1840. The increased area of ice on the East Greenland and Barents Seas appears to be a consequence rather than a cause of these circulation changes, since it did not become evident until the years since 1958.

These discoveries raise the question whether climatic tables for the nineteenth century may in some ways be more relevant for planning ahead in the present situation than the statistics of any period between 1900 and 1950.

Analysis of the earliest surveys of sea surface temperatures in the Atlantic Ocean indicates changes in the Gulf Stream and in the cold East Greenland Current and Labrador Stream corresponding to those in the winds in the atmosphere. Both for 1780–1820 and for the 1840's there is evidence that the warm water of the Gulf Stream was diverted onto a more southerly course across the ocean (giving positive anomalies of sea temperature of up to 2 to 3°C along an axis from Florida to Portugal) compared to the period about 1890–1938, whilst the whole northern part of the ocean from New England to the coasts of Britain was 1 to 3°C colder than in recent times.

More vigorous heat transport in atmosphere and ocean would be expected to warm the higher latitudes, as was indeed observed, but it is interesting to discover that there was no counterbalancing cooling of the tropics. This suggests that the supply of energy was increasing, whether as a result of increased output from the sun (so far not demonstrated), greater transparency of the atmosphere (the frequency of great volcanic eruptions decreased, but cannot be said to have increased in time to be invoked as a cause of the recent decline of circulation vigour) or merely because of some change in the distribution of heat stored in the sea (such as might conceivably be brought about by the very slow net vertical circulation of the oceans).

These studies promise to assist the Meteorological Office experiments in longer-range weather forecasting, both by throwing light on at least some of the physical mechanisms and environmental controls involved in the slower and longer-lasting changes of weather and by providing many additional reference charts from which analogous situations in the past may be identified.

If we are to be able to identify relevant physical controls in the environment, it is essential to build up information also about solar activity, volcanic dust in the atmosphere, sea temperatures and extent of ice, over many years. By marshalling all available evidence under these heads for past years it is hoped that comparisons with the circulation maps will eventually be illuminating. The only available index of solar activity going back far into the past is the sunspot number. It is doubtful, however, whether this is really related to significant changes of energy output from the sun, and comparisons of sunspot activity with weather and atmospheric behaviour have not so far been encouraging. The question of solar variability is likely to be better understood as a result of solar beam measurements from satellites over the next 20 to 40 years. As yet the instrumentation problems have not been fully solved.

Changes in the longitude of the prevailing positions of key features of the circulation also look interesting, and have provided a means of interpreting the manuscript records of character of the seasons in Europe from the early Middle Ages. Airstreams controlling weather in the temperate zone appear to undergo an eastward shift of their whole configuration and penetrate farther into the continent of Eurasia in the main warm epochs (of vigorous circulation) than in the cold ones. Rather uncertain evidence from central Asia suggests that lands near 50°N in that region became relatively moist in both the 12th and 20th century warm epochs; the Caspian region however became drier and the level of the Caspian Sea was lower by several metres than in the cold climate between 1800 and 1850, when central Asia was much more arid (*cf.* Figure 3, Barnaul). A tendency for reversion since 1950 in those regions must be of concern to Soviet agriculture and irrigation control schemes, just as the cooling in the last decade concerns forestry in Finland or hill farms in Britain. Other regions, perhaps especially in Africa and in eastern North America, may be expected to gain in moisture from this latest change of the circulation picture, if the lessons of previous cooler climates—e.g. in the nineteenth century—have been rightly understood.

Studies of past climates are thus far from being of purely academic interest. Moreover, such physical principles and processes as can be recognized, and the patterns of past epochs when the environment was different, may throw light on the probable effects of proposals for artificial modification of climate.

2. Organization of the Research Directorate

An important development in the organization of the research directorate was the division of the branch for Climatological Research, Met.O.13, into two branches. The branch retaining the old number took as its title 'Synoptic Climatology', the first head, ADMet.O(SC), being Mr. M. H. Freeman, while a new branch, Met.O.20, with the title 'Dynamical Climatology' was headed by Mr. G. A. Corby, ADMet.O(DC). This increased provision for research reflected the conviction that the very large-scale problems of the general circulation of the atmosphere, and the associated practical problems of long-range forecasting and climatic variations, are opening up and becoming ready for attack on a broader front. With six staff of the scientific officer class in each of the two branches, suitably supported by ancillary staff, good progress may be expected.

For some years experiments have been made in long-range (30-day) forecasting and in the autumn of 1963 the decision was taken, on the advice of the Meteorological Committee, to make forecasts for a month ahead available to the public. More information on this new service is given elsewhere in this report (p.56) and it is sufficient to record here that the technical task of preparing the forecasts is carried by the research branch Met.O.13.

This decision illustrates the advantage of combining services and research within the one Meteorological Office. While it is broadly desirable to separate the various functions into different branches, of which nine are in the research directorate, it is unnecessary to sacrifice technical efficiency to organizational tidiness and these branches therefore carry such operational and advisory functions as fall naturally to their expertise. In the present state of knowledge

it would be unwise to establish a unit for the preparation of long-range forecasts independently of the associated research and, accordingly, the task is assigned to Met.O.13 although the issue of the new monthly report is a responsibility of the Director of Services.

In all other respects the organization of research remained as described in recent annual reports. Of the scientific staff in the nine headquarters research branches, 29 are allotted to dynamical and synoptic research (including some special investigations for immediate operational ends) and 19 to physical research and instrument development. In addition the directorate has eight outstations—including the three geophysical observatories, Kew, Eskdalemuir and Lerwick—with a total of 14 scientific officers. The overall strength of the directorate approaches 350.

The research continues to benefit from the interest, advice, and occasional direct co-operation of the outside members (from the Universities and other Government departments) of the Meteorological Research Committee and its sub-committees. This assistance is, it is hoped, to some extent reciprocated by the many visits which the Office research staff pay to the Universities, to deliver lectures and to join in discussion meetings, and by the service of the staff on various committees set up by other Government departments.

3. Physical Research

High atmosphere. It is a matter for congratulation to all concerned that the meteorological 5-inch Rocket, now to be known by the proper name 'Skua', came through its trials successfully and was ready for regular use at the beginning of the International Year of the Quiet Sun (IQSY) 1964–65. On this occasion it is permissible in a report for 1963 to encroach on the future to record that a height of more than 200,000 feet was reached in the early launchings in January 1964 with the lucky bracketing of the remarkable phenomenon known as a 'stratospheric warming'. These rapid increases of temperature, amounting to 20°C or more, are believed to be caused by some kind of large-scale dynamical disturbance. They occur from time to time during the early months of most years and are to be the subject of co-operative international study during IQSY.

The new rocket is 8 feet in length and weighs a little over 80 lb. The scientific instrumentation will usually consist of a radiosonde fitted with a large parachute. At a height of about 40 miles the sonde is ejected and thereafter falls, rather quickly at first and then more slowly, drifting in the wind as it does so. The sonde is tracked by a high performance radar, the CR 353 developed by Cossor Electronics Ltd. In this way the winds are determined, as well as the temperature as obtained from the radio transmissions of the sonde. The rocket has been developed for this project by Bristol Aerojet Ltd and the Rocket Propulsion Establishment, Westcott. The preparation and launch of the rocket are shown in Plates I–VIII.

The work in connexion with the ozone observations to be made from the artificial satellite UK-2 (Anglo-American research satellite of the Scout series) was very demanding as it was necessary to keep a member of the staff in the United States for long periods and it was therefore disappointing that the launching had to be postponed until 'the first quarter of 1964'. Progress was

made in further work for the succeeding satellite of the series, UK-3, this time to measure the proportion of oxygen in the high atmosphere.

There was delay in delivery of the new ozone-sondes but they will certainly be flown early in 1964. Some will go to locations overseas including Gan in the Maldives.

Radiation. There was a notable increase in the number of successful measurements of 'radiation balance' on ocean weather ships. Solarimeters were installed on four 'selected ships'. The equipment has been further developed for the routine recording of the intensity of solar radiation in 15 bands, isolated by interference filters. Observations should begin in a few months' time. Automatic data-logging equipment was brought into routine use for radiation data.

Turbulence and diffusion. The main effort in this field continues at Porton, within the organization of the Chemical Defence Experimental Establishment of the War Office, where the application of data logging and high speed electronic computing methods to turbulence problems has become a major interest. A significant conclusion from a number of calculations of dispersion is that the shear of wind with height is an important factor in the process. It is self-evident that vertical mixing combined with shear makes a contribution to horizontal diffusion but the importance of the effect for fairly short distances has only recently become manifest. A new departure which may throw much-needed light on the nature of turbulence is an attempt to study the structure over a small area (not more than 200 metres square) using a network of anemometers feeding into an oscilloscope or to digital recording equipment for later processing by electronic computer. The prospect of preparing 'synoptic charts' of small-scale turbulence is intriguing.

A computer technique has also been developed to obtain geostrophic trajectories separated by short intervals of time. Trajectories have been computed for periods of 60 hours starting at two-hour intervals through four days. It is not however yet clear that the results reflect true 'turbulence' on the synoptic scale.

The practical problem of the dispersal of pollution emitted from chimneys continues to present new difficulties as chimney heights increase. New data are being obtained from captive balloons, and the tower at Cardington will, it is hoped, help in supplying advice requested by the Central Electricity Generating Board.

The Rock of Gibraltar. By arrangement with the Royal Aircraft Establishment an instrumented research aircraft was used to obtain information in the approach zone to the lee of the Rock of Gibraltar. The results are not yet fully analysed but they seem to confirm the findings from wind-tunnel experiments reported last year and some change in the approach flying procedure for Gibraltar is a likely outcome.

Supersonic aircraft. The prospect of the regular operation of supersonic aircraft has brought a new urgency into some old problems. Matters of concern include the frequency with which cumulonimbus clouds with associated hail

may penetrate the stratosphere, horizontal gradients of wind and temperature, and clear air turbulence. A further report on the last item broadly confirmed previous results, but there is little hope of obtaining suitable data on cloud and hail in the stratosphere without an aircraft to fly at those heights.

Meteorological Research Flight. There was a long delay in obtaining an aircraft to replace the Canberra which crashed in February 1962 and the replacement will not be flying until the spring of 1964. Much of the delay was due to the time taken for the aircraft to be modified and equipped with the special instrumentation but some months were lost in attempting, without success, to obtain an aircraft of notably better performance. The supply and maintenance of a special type of aircraft would raise considerable difficulties but the matter is still being pursued.

Study of frontal rain clouds. Data collected by the Meteorological Research Flight on the rainfall rate in frontal cloud led to results that are difficult to explain. It appears that the rainfall rate near the cloud base greatly exceeds that recorded at the ground below.

Radar meteorology. Work continued at Malvern in co-operation with the staff of the Royal Radar Establishment (RRE) on lines which were discussed as the special topic in last year's Annual Report. Progress was made towards testing the feasibility of measuring rainfall by radar but conclusions of practical value are not yet available. A successful trip was made to Switzerland with personnel and equipment of RRE to test the performance of a mobile pulsed Doppler radar in thunderstorm conditions. The co-operation of the Swiss Meteorological Institute was much appreciated.

Instrument development. Tenders were received for the initial manufacture of the Mark 3 radiosonde to be based on a prototype made in the Office laboratory. Essential discussions with contractors on the many technical points which arose in this and other contracts took up a lot of time. It may be recalled that this will be the first completely redesigned Meteorological Office radiosonde for 25 years and its introduction will mark a definite advance in upper air sounding.

The first of the new Cossor wind-finding radars was installed at South Uist and performed extremely satisfactorily for the first few rocket launchings.

A complete 'automatic weather station' was constructed and operated over GPO lines between the experimental site and the main headquarters at Bracknell, a distance of three miles. If a permanent 'private line' is used continuous records may be transmitted and displayed. Alternatively, an ordinary telephone connexion will allow special reports to be obtained as required on interrogation. It now remains for operational needs to be further explored.

According to the latest information, the United States Weather Bureau plans to make earth satellites a permanent part of meteorological observing. A major feature will be 'automatic picture transmission' (A.P.T.) making photographs of the clouds below the satellite directly available to any station having the necessary receiving equipment. Hitherto signals from the satellite

could be received only at the one or two read-out stations set up by the United States and there has been long delay in making the information available elsewhere with a considerable loss in its value for forecasting; indeed, the value so far to the Meteorological Office has not been significant. Although it cannot confidently be expected that the satellite pictures will ever bring a radical improvement in forecasting for the British Isles there are obvious potentialities and, in co-operation with Royal Radar Establishment, Malvern, plans were made to receive A.P.T. with radio equipment designed and built in this country: some tests were made on A.P.T. from satellite TIROS VIII and reception was successful.

4. Dynamical and Synoptic Research

Research related to short-range weather forecasting. For a number of years the development of forecasting by basic dynamical methods has been a major research activity and the work during the year may be said to mark the end of an important phase. An extended trial, continued through the first ten months of the year, produced predicted upper air and surface pressure charts of great interest to the Central Forecasting Office (C.F.O.). The calculated upper air predictions were on the whole superior to those made by expert forecasters using the conventional procedures based on extrapolation and professional judgement. The calculated surface charts were less definitely superior but were still helpful. This experience has led to the decision to introduce numerical weather prediction into the routine procedures of C.F.O. as soon as a computer of sufficient capacity is available.

Research will of course continue. The calculations are at present based on a three-level model atmosphere using a stream function at the mid-level, a mesh size of 300 kilometres, and an area of 24 $\times$ 20 grid points. The adaptation of the computations, using the same model but a much larger area, to the KDF9 English Electric computer now on order will itself be a major technical task on which considerable progress has already been made. Automatic data extraction from the punched paper-tapes obtained from the routine international weather messages is an essential feature which presents computer programming problems in some ways more troublesome than the mathematical problems of solving the dynamical equations.

Other mathematical methods of treating the problems are under study including one which proceeds directly from the basic dynamical equations—the so-called 'primitive equations'—without the specific introduction of the vorticity equation which has been an important control in most of the mathematical formulations used so far.

Work has begun on the dynamics of fronts, one of the major outstanding problems of synoptic meteorology. The idea of fronts entered synoptic meteorology and forecasting some 45 years ago and has been of the greatest value in the analysis of weather but theoretical understanding of the dynamical and thermodynamical processes remains incomplete with the result that there is no satisfactory way of judging, for example, whether a front will give a large amount of rain or only a little. The analysis of the problem will lead to very heavy computations for which the most advanced high-speed computer yet available, the ATLAS, is to be used, by arrangement with the National Institute for Research in Nuclear Science.

Complementary research continued based primarily on the analysis of synoptic charts and the use of statistics or descriptive generalizations. This led to useful empirical rules for forecasting dry spells and cold spells of weather and to interesting papers on jet streams, ageostrophic wind components, subsidence and other technical aspects of synoptic meteorology. In some ways studies of this kind are more valuable in formulating problems than in solving them but succinct descriptive accounts of atmospheric processes and phenomena will always be an essential part of meteorological literature.

Research related to long-range weather forecasting. The preparation, as a research experiment, of monthly forecasts for the United Kingdom continued throughout the year and culminated in their issue to the public from December onwards. The technique rests largely on a search of past records for previous years in which weather conditions were in important respects similar to those in the current year. The sequels of weather of the analogous years provide the basis for a forecast. Nothing would seem in principle to be more simple, less sophisticated, than this approach but when it is applied in practice it leads to a great deal of effort (including high-speed computing) in the collecting and presentation of the historical information and calls for the exercise of wide knowledge of the atmosphere. The weather occurring over a period of a month and over a given region is a complicated concept which is defined amongst other things by the statistics of temperature, rainfall, etc. and by the sequence of daily weather maps for the surface and the upper air. The question arises as to what factors are most significant in defining the degree of similarity between one season and another. Simple averages of temperature or rainfall have often been examined but it is not surprising that they have led to no worthwhile system of forecasting; for two months, both of which are wet or dry or cold or warm, may be found to have virtually nothing else in common when the synoptic charts are studied. The analogous years are picked out at present primarily on three criteria. The first is the monthly mean surface pressure pattern for a large part of the hemisphere; the second is the mean pattern of temperature of the air mass in the lower half of the troposphere (the 1000–500 mb thickness pattern), again for a large area; the third is the sequence of synoptic weather situations during an extended period of time, some weeks at least. Using both expert judgement and computer-aided objective comparisons it is generally possible to find a small number, two or three, of previous years which ran similarly to the current year and so to provide the basis for a prediction for a month ahead. Techniques remain flexible. Recently, rather less emphasis has been given to the averages for the month and more to the sequence of conditions through the month, taking the short-range forecast as a jumping-off point, but it will be some time before the success can be judged satisfactorily. In the trial period something like two forecasts out of three have been on the right lines but it is reasonable to expect some improvement.

Physical ideas are discussed in relation to every forecast and plausible arguments are put forward based on features such as sea-temperature anomalies and the extent of the polar ice and continental snow fields. It would however be wrong to claim that these ideas have yet proved useful in forecasting: the relationships are evidently very complicated. Studies of circulation changes of various kinds likewise failed to establish consistent relationships of prediction value although interesting possibilities are continually suggested. It was found, for example, that in some cases changes in the location of the principal troughs

in the tropospheric flow pattern over America preceded by some six days the end of anticyclonic conditions over the British Isles, a rule which, if upheld, could be useful.

General circulation of the atmosphere. The new branch, Met.O.20, set up for research in dynamical climatology, to which reference has already been made, has the general circulation as its principal challenge. Briefly, the general circulation may be defined as the mean pattern of air motion in three dimensions over the whole earth and on the broadest scale, the theory of which leads into the most comprehensive problems of physics and dynamics to be met with in meteorology. In the United States ambitious attempts are being made to solve the problem, that is to compute the actual state of motion, by a frontal attack using elaborate models of the earth's atmosphere and the most advanced high-speed computers. It has not seemed desirable to embark on a similar project at this stage. Rather it has seemed more profitable to probe the problem simultaneously from different directions in the hope that more productive ideas will emerge as experience is gained. It is too early to expect significant results and it must suffice on this occasion to mention the following studies.

Attempts were made to determine the circulation in the stratosphere which, combining meridional mean motions and turbulent exchange, can explain the observed annual variations in the distributions of zonal wind, temperature and ozone in the stratosphere. Serious mathematical complications were encountered and it is difficult to disentangle the effects of dubious data from those of inadequate theory but the problem begins to take shape. The curious 26-month period in the stratospheric winds in equatorial latitudes was further analysed up to a height of 30 km. It was shown on theoretical grounds and confirmed from the data that the variations in zonal wind are accounted for by the transport of momentum in large-scale horizontal eddies. A kinematical model was inferred but the basic cause of the phenomenon remains unknown.

The stratosphere of middle and northern latitudes also presents extremely interesting problems. As is well known there is a complete reversal in the circumpolar circulation from easterlies of summer to westerlies of winter. In high summer the easterlies are remarkably steady but the winter westerlies have large amplitude oscillations and rapid changes, of which the sudden stratospheric warmings of late winter and early spring are the most striking. The circulation at the pressure levels 50, 30 and 10 mb (roughly 20, 24 and 30 km) was regularly studied from day to day and some attention was given to the dynamical theory of the distortions.

The interactions between the oceans and the atmosphere are of far-reaching importance for both meteorology and oceanography but so far it has not been practicable to devote much effort to the problems. Some preliminary studies of the relationship between anomalies of air and sea temperature were however made and suggest that serial correlations in air temperature anomaly arise primarily by virtue of the air–sea temperature relation. It would be important if it could be definitely shown that *anomalous* sea temperatures have a significant long-term effect on air temperatures: a connexion in the reverse sense is often obvious.

Climatic trends. Steady progress was made in the collection and co-ordination of data on climatic trends especially in the period of the instrumental

record although with some regard to earlier evidence. The subject forms the Special Topic for this year's report (see p. 45).

Following upon the exceptionally severe winter of 1962–63 speculations on changes of climate aroused much public interest and some anxiety. The careful assessment of the evidence led to the conclusion that the first part of the century, up to about 1940, had had exceptionally mild winters on the whole and that there was no reason to expect that this state of affairs would continue. In the absence of other evidence something more like the long-term average climate of the nineteenth century could reasonably be looked for.

Special investigations. All the research branches may be required to give attention to special inquiries which are received by the Office and for which they have the expert knowledge. The variety of *ad hoc* problems dealt with in this way is remarkable but does not lend itself to summarizing. A few items dealt with by the Special Investigations Branch are listed below by way of illustration.

Atmospheric pollution at the upper levels of a proposed tower block of flats. (London County Council)

Cross-wind gusts at United Kingdom airfields. (Air Registration Board)

Length of path of electromagnetic waves through precipitation in the Singapore area. Television relay by satellite. (General Post Office)

Trajectories on the hemisphere scale of radio-active contaminant following nuclear explosions. (Atomic Energy Research Establishment)

An empirical rule was developed for estimating from meteorological parameters the sulphur dioxide pollution in London.

Seismology, Geomagnetism and Gassiot Fellows. The Gassiot Fellow for Seismology, Dr. Iyer, unfortunately returned to his own country to take up an appointment in the Seismology Division in the Indian Government Atomic Energy Authority. Since his resignation on 30 June the post has been vacant. The opportunity was taken to re-examine the conditions of the Fellowships but a new appointment will, it is hoped, be made without too long a delay. While with us, Dr. Iyer was active in research, the interest being mainly in 'earth noise'.

The development of Eskdalemuir as the main seismological station for the United Kingdom went ahead. The new vault was completed and prepared for the installation of new standard equipment provided without charge by the United States but work on the new laboratory and other constructional work has been delayed.

The Gassiot Fellow for Geomagnetism, Dr. Stacey, has been very active in research and publication. His ideas on the possibility of forecasting earthquakes from the seismo-magnetic effect attracted much attention. Work on geomagnetic space-gradients and geomagnetic deep-sounding with the magnetometers placed at arranged sites at the three airfields Cardington, Oakington and Mildenhall, each some 20 miles apart, will begin as soon as the instruments (digitally recording proton vector magnetometers) are delivered and working satisfactorily.

5. International Research Activity

The interest of international organizations in the furtherance of the earth sciences, which took a big leap forward with the International Geophysical

Year of 1957–58, continues to develop and the Meteorological Office as a major centre of research is looked to for support wherever meteorology is concerned whether the main organizing body is inter-Governmental, such as the World Meteorological Organization or UNESCO, or non-Governmental within the broad field of the International Council of Scientific Unions (ICSU).

One consequence is an inevitable load of committee work on directing staff but there can be no doubt that up to the present at least the stimulation obtained from international collaboration has been beneficial to the science.

There are a number of activities in which the Office is not much involved except in an advisory capacity or by way of scientific liaison but they are of some interest as indicating the world background against which geophysical research is now carried out. Two of these are Antarctic Research, organized internationally by the Scientific Committee on Antarctic Research, and Oceanic Research, organized by the Scientific Committee on Oceanic Research, for both of which British National Committees (with Meteorological Office representation) have been set up by the Royal Society. In the past year there has also been further movement arising from the recent resolutions of the General Assemblies of the United Nations on the expansion of the atmospheric sciences, to which reference was made in last year's report. Responding to the pressure from the United Nations, WMO has now set up an Advisory Committee (of which the Director of Research is a member) and a WMO Research Programme is likely to emerge. At the same time ICSU is initiating complementary action on the non-Governmental side and, working down through the International Union of Geodesy and Geophysics and the International Association of Meteorology and Atmospheric Physics, the British National Committees (set up by the Royal Society) have now become actively concerned and no doubt further world plans and projects will be brought forward during the coming year.

The following notes refer to the main activities additional to those which arise from the normal workings of the World Meteorological Organization and which are listed in another part of this report (see p. 61).

International Year of the Quiet Sun (*IQSY*) 1964–65. This is a co-ordinated programme of observations in a wide range of geophysical disciplines during a period of minimum solar activity (complementing that of the International Geophysical Year, 1957–58, at the epoch of sunspot maximum). The Meteorological Office contribution to IQSY was set out in last year's report and came into operation substantially as planned. The launch of the satellite UK-2 was postponed and there were delays in the supply of ozone-sondes, but these projects are not expected to be held up for long. One of the aims of the IQSY is investigation of the phenomenon known as sudden stratospheric warming; as mentioned elsewhere in this report, the first rocket soundings made from the South Uist range made an important contribution to this problem.

International Indian Ocean Expedition (*IIOE*). The special radiosonde and radar-wind station set up in the Seychelles as a contribution to the IIOE began operation in September 1963. A number of radiosondes were supplied to R.R.S. *Discovery* but on the first cruise no successful ascents were made. The attempt will be repeated in the light of experience gained. Solar and terrestrial radiation records from the *Discovery* will be measured and studied by Meteorological Office staff.

Programme of the Committee on Space Research (COSPAR). The Assistant Director (High Atmosphere) was active in the Working Groups of this organization and is Chairman of the Working Group of the European Preparatory Commission for Space Research (COPERS) which examines proposals for rocket and satellite experiments in the field of meteorology and atmospheric structure. Co-ordination of the national space research effort, mainly by committees of the Royal Society, made calls on the services of several members of the Meteorological Office staff.

International Hydrological Decade. The proposal that hydrology should have its ten-year plan of development and research has yet to be accepted by UNESCO but provisional planning has gone quite a long way and the Meteorological Office, as the national body responsible for the co-ordination of measurements of rain and snow, has been closely concerned. Hydrology in the Office is the responsibility of Climatological Services and a representative of the Director of Services has been concerned in the planning but the Research side of the Office is also interested in some aspects, as for example the energy balance over catchment areas. It was convenient, therefore, that the Director of Research was nominated by the Royal Society, in a personal capacity, to serve on the British Committee for the International Hydrological Decade.

R. C. SUTCLIFFE
Director of Research

INTERNATIONAL CO-OPERATION

1. World Meteorological Organization

The highlight of World Meteorological Organization (WMO) activities during 1963 was the occasion of Fourth Congress of the Organization which took place in the Palais des Nations, Geneva from 1 to 27 April. The Congress was attended by delegations from 102 Member States or Territories and by observers from 3 non-member countries. The United Kingdom delegation was led by the Director-General who was assisted by the Director of the Naval Weather Service, Admiralty, a member of a Finance Division of the Air Ministry, a representative of the Legal Adviser of the Foreign Office and the Assistant Director (Defence and International).

Considerable time was devoted to proposals for a revision of the Convention of the Organization. The most important matters dealt with on the technical side concerned Meteorological Satellites and the associated subjects of World Weather Watch and Networks Development. It was decided to establish a Fund for development purposes not provided for under the Expanded Programme of Technical Assistance and the Special Fund of the United Nations. An amount of 1·5 million U.S. dollars was agreed on the understanding that a plan for the use of the Fund including procedures for its management and operation should be prepared by WMO and submitted to Members for their approval.

The Director-General, in a personal capacity, was re-elected to the Executive Committee of the Organization for a further four years. There was a short session of this Committee immediately following Fourth Congress.

There were no sessions of Technical Commissions during the year but the activities of Working Groups and Panels continued undiminished and several members of the staff attended meetings of these bodies most of which were held in Geneva (see Section 9).

A joint WMO/IUGG Symposium on Numerical Weather Forecasting was held in Oslo in March and was attended by Mr. E. Knighting, Assistant Director (Dynamical Research), Mr. G. A. Corby, Assistant Director (Dynamical Climatology) and Mr. P. Graystone (Met.O.11).

A symposium on Tropical Meteorology took place in New Zealand in November. Messrs R. Frost, Chief Meteorological Officer, Far East Air Force and D. H. Johnson, (Met.O.13) participated in the symposium. Mr. Johnson read papers dealing with weather systems in East and West Africa.

A Training Seminar on the relation between meteorology and the desert locust was held in Tehran in November–December, on the recommendation of the Food and Agricultural Organization Technical Advisory Committee on Desert Locust Control. Mr. D. H. Johnson (Met.O.13) was invited as a consultant instructor and Mr. J. C. Gordon (Nicosia) attended as one of the representatives of the United Kingdom. Other representatives were nominated by the Anti-Locust Research Centre, London.

The 8th International Meteorological Organization Prize was awarded by the Executive Committee of WMO at its 15th Session to Dr. R. C. Sutcliffe, Director of Research. The prize is awarded annually to a meteorologist of scientific eminence who has also worked for the furtherance of international collaboration. The presentation of the 1963 Prize by the President of WMO, Dr. Alf Nyberg, took place on Tuesday, 16 July at the Headquarters of the

Meteorological Office in the presence of His Excellency the Swedish Ambassador, the Lord Hurcomb, Chairman of the Meteorological Committee, Mr. Julian Ridsdale, Under Secretary of State for Air, Mr. D. A. Davies, Secretary-General of the WMO and many members of the Meteorological Office. Dr. Sutcliffe is the second British meteorologist to be honoured in this way, Mr. E. Gold (formerly a Deputy Director) having received the 3rd IMO Prize in 1958.

2. International Council of Scientific Unions

The Director-General attended a session of the General Assembly of ICSU which was held in Vienna from 22 to 29 November.

3. International Union of Geodesy and Geophysics

The General Assembly of the Union met in Berkeley, California during the latter half of August. Representatives of the Office were the Director-General, Dr. G. D. Robinson, Deputy Director (Physical Research), Mr. E. Knighting, Assistant Director (Dynamical Research) and Dr. R. J. Murgatroyd (Met.O.20). The Director-General, in his capacity as Chairman of the National Committee on Geodesy and Geophysics, led the United Kingdom delegation and participated in the meetings of the Council.

4. Central Treaty Organization (CENTO)

At the invitation of the United Kingdom Permanent Military Deputy of the Combined Military Planning Staff (CMPS), Mr. L. S. Clarkson, Chief Meteorological Officer, Near East Air Force visited Ankara from 8 to 10 September, to discuss various matters regarding United Kingdom meteorological policy.

A session of the Regional Meteorological Advisory Group was held in Ankara from 18 to 19 November, to discuss meteorological matters with the CMPS and to obtain agreement on certain procedural matters. The United Kingdom was represented by Mr. P. J. Meade, Deputy Director (Outstation Services), Inst. Capt. G. P. Britton, R.N., Director, Naval Weather Service, Admiralty, and Mr. L. S. Clarkson.

A conference of Civil Aviation Experts called by the Economics Committee of CENTO was held in Tehran from 8 to 11 April. Mr. A. A. Worthington (Met.O.17) attended as a member of the United Kingdom delegation.

5. North Atlantic Treaty Organization (NATO)

Dr. R. C. Sutcliffe, Director of Research, attended a meeting of the NATO Science Committee's *ad hoc* Advisory Group on Meteorology in Rome on 28 January. He also attended two meetings of a NATO International Consultative Group for Research on 'Cyclogenesis to lee of the Alps—North Italy and the Gulf of Genoa', in Rome from 6 to 8 March and on 22 October.

Dr. A. C. Best, Director of Services, United Kingdom member of the Standing Group Meteorological Committee, attended the 20th meeting of the Committee in Washington D.C. from 18 to 20 June. Mr. L. H. Starr, Assistant Director (Observations and Communications), and Mr. R. A. Buchanan, Met.O.17, were also present.

The two working groups of the Standing Group Meteorological Committee met in Washington D.C. from 12 to 21 March and in Paris from 22 to 30 October. Mr. L. H. Starr and Mr. R. A. Buchanan represented the United Kingdom.

The Supreme Headquarters Allied Powers in Europe Meteorological Committee met from 15 to 17 May near Paris, with Mr. L. H. Starr and Mr. R. A. Buchanan representing the Meteorological Office.

Mr. J. Crabtree and Mr. L. G. Hemens, Met.O.7, were members of the United Kingdom delegation at meetings of the Meteorological Sub-Group of the External Ballistics Group of the Armaments Committee in Rome from 25 February to 1 March. Mr. Crabtree also attended a meeting of the External Ballistics Group in Paris from 10 to 14 June.

6. South East Asia Treaty Organization (SEATO)

The Meteorological Committee of SEATO met in Bangkok from 22 to 26 January. Mr. R. Frost, Chief Meteorological Officer, Far East Air Force, was the chief United Kingdom delegate. He was assisted by Inst. Cdr. M. A. Waller, R.N., Fleet Meteorological Officer, Far East.

7. International Civil Aviation Organization (ICAO)

Mr. A. A. Worthington (Met.O.17) acted as Adviser to the United Kingdom Panel Member (Ministry of Aviation) at the first meeting of the ICAO North Atlantic Cable System Panel, held in Paris from 18 February to 8 March.

The fifth meeting of the ICAO Meteorological Operational Telecommunications Network (Europe) Development/Implementation Panel was held in Paris from 17 to 28 June. Mr. A. A. Worthington (Met.O.17) attended from 17 to 25 June as Adviser to the United Kingdom Panel Member (Ministry of Aviation).

Mr. Worthington (Met.O.17) attended, as a member of the United Kingdom Delegation, the first and second informal meetings of the Aviation Authorities of the North Atlantic Air Traffic Control Provider States. The first meeting was held in London during the last week of June and the second in Miami, U.S.A., during the first two weeks of November.

8. Commonwealth Conferences

The Seventh Conference of Directors of Meteorological Services of the Commonwealth took place at Bracknell from 7 to 10 May. The Conference was opened by the Secretary of State for Air, The Rt. Hon. Hugh Fraser, M.B.E., M.P. A feature of this Conference was the informality which was introduced for the first time and which met with general approval. Contributions were made by members of the Office and by visiting Directors, covering such subjects as Numerical Weather Prediction, Organization of Research,

Meteorological Satellites, Agricultural Meteorology and Long-Range Forecasting. A report of the Conference has been published and distributed (M.O.752).

9. Other International Meetings

Members of the Office attended other international meetings on meteorology and allied sciences during the year as follows. The list is not necessarily complete but read in conjunction with Sections 1–7 illustrates the extent to which the Meteorological Office participates in international activities connected with the atmospheric sciences.

(*a*) Dr. R. C. Sutcliffe, Director of Research, a member of the WMO Executive Committee Working Group on Research Aspects of Meteorological Satellites attended a session of the group in Geneva from 25 February to 1 March to prepare proposals for Fourth Congress regarding international research in meteorology.

(*b*) Dr. G. D. Robinson, Deputy Director (Physical Research) attended a session in Geneva from 25 February to 1 March of the WMO Executive Committee Panel on Artificial Satellites to consider operational and co-ordination aspects of plans to implement programmes under the WMO First Report on the Advancement of Atmospheric Sciences and their application in the light of developments in outer space.

(*c*) Mr. E. Knighting, Assistant Director (Dynamical Research) took part in a meeting of a joint Commission for Aerology and Commission for Synoptic Meteorology (CSM) Working Group in Oslo from 18 to 23 March to monitor and facilitate the exchange of research information and computation procedures, and to formulate requirements regarding codes and communications.

(*d*) Mr. C. J. M. Aanensen (Met.O.6) as U.K. member of the CSM Working Group on Codes attended a meeting of the group in Geneva from 25 to 30 March.

(*e*) Mr. A. A. Worthington (Met.O.17) attended the second session of the Working Group on Meteorological Aspects of Area Forecast Systems to prepare a report for the Third Session of the WMO Technical Commission for Aeronautical Meteorology. The meeting was held in Geneva from 12 to 23 November.

(*f*) Mr. E. Knighting, Assistant Director (Dynamical Research) and Dr. R. J. Murgatroyd (Met.O.20) participated in the International Symposium on the dynamics of large-scale atmospheric processes at Boulder, Colorado, from 3 to 7 September.

(*g*) Dr. F. Pasquill (Met.O.14) attended a seminar organized by the World Health Organization, the Food and Agriculture Organization and the International Atomic Energy Agency at Geneva from 18 to 22 November on the protection of the public in the event of radiation accidents. He presented a paper on 'The spread of windborne contaminants'.

(*h*) Dr. G. D. Robinson, Deputy Director (Physical Research) attended a symposium at Los Angeles, California on the results of the International Geophysical Year sponsored by the U.S. National Academy of Sciences and the Comité International de Géophysique from 12 to 16 August.

(*i*) Mr. J. B. Stewart (Met.O.15) attended the 5th International Symposium on Condensation Nuclei at Clermont-Ferrand and Toulouse from 13 to 18 May.

(*j*) Dr. F. D. Stacey (Met.O.14) attended the IUGG Assembly at Berkeley, California from 19 to 31 August and read a paper on 'The seismomagnetic effect and earthquake forewarning' to a Committee of IAGA.

(*k*) Mr. D. H. Johnson (Met.O.13) attended a conference on tropical meteorology organized by the U.S. Army Electronic Division, Research and Development Laboratory, Asbury Park, New Jersey from 9 to 10 May, and opened a colloquium on Contour Analysis in Low Latitudes at the Meteorological Institute, Bonn University on 11 July.

(*l*) Dr. R. Frith, Assistant Director (High Atmosphere) attended meetings of *ad hoc* Groups of the European Preparatory Commission for Space Research in January at Munich and in March at Stockholm. At the latter meeting Dr. Frith was accompanied by Dr. K. H. Stewart and Dr. P. L. J. Wildman (Met.O.19). Dr. Frith also attended the IGC/IQSY Assembly in Rome from 18 to 22 March and a meeting of the Committee for Space Research of ICSU in Warsaw from 3 to 7 June.

(*m*) Mr. P. J. Meade, Deputy Director (Outstation Services) was in Nigeria from 27 July to 8 August at the invitation of the Nigerian Government, to advise the Director of the Nigeria Meteorological Service on the reorganization of his forecasting organization with particular reference to the establishment of a Central Forecast Office.

(*n*) Mr. D. G. Harley (Met.O.6) attended the 15th Technical Conference organized by the International Air Transport Association at Lucerne from 25 April to 4 May on problems of all-weather landings and take-offs. He also attended, as WMO observer, the International Federation of Air Line Pilots Associations symposium on supersonic aircraft held in London from 12 to 14 November.

(*o*) Cdr. C. E. N. Frankcom, Marine Superintendent, attended meetings of the Assembly and Committees of the International Maritime Consultative Organization in London, as WMO observer in January, February, July, September and October, and as Chairman, a meeting of members of the Advisory Committee of European Operating States on the North Atlantic Ocean Stations, at The Hague in May.

(*p*) Mr. H. H. Lamb (Met.O.13) attended a conference on palaeoclimatology organized by the NATO Institute for Advanced Studies which was held at Newcastle-on-Tyne from 7 to 12 January, and a symposium on long-range forecasting held at Bad Homburg, Germany from 28 to 29 September.

(*q*) Mr. A. A. Worthington (Met.O.17) participated in the Informal Meeting on Snow and Slush Problems at International Aerodromes in Europe held in Paris from 16 to 21 September.

Two members of the staff were released during the year to take up appointments overseas under United Nations Technical Co-operation programmes. Mr. A. F. Jenkinson, Principal Scientific Officer, was appointed to the Chair of Meteorology at the Royal College, Nairobi and Mr. A. H. Gordon, Principal Scientific Officer, as WMO Adviser to the Meteorological Service of Iran. Mr. D. D. Clark, Principal Scientific Officer, was released for service in Paris with the European Preparatory Commission for Space Research.

STAFF

The Meteorological Office Headquarters organization is shown in the diagram on p. 68 and the names of the principal officers are listed on p. iv.

At the end of the year 1963, the total number of posts of all grades was 3628. The strength was made up as follows:

Scientific Officer Class	
Chief Scientific Officer	3
Deputy Chief Scientific Officer	4
Senior Principal Scientific Officer...	26
Principal Scientific Officer	78
Senior Scientific Officer	26
Scientific Officer	18
Administrative Class	
Assistant Secretary	1
Experimental Officer Class	
Chief Experimental Officer	20
Senior Experimental Officer	224
Experimental Officer	379
Assistant Experimental Officer	196
Scientific Assistant Class	
Senior Scientific Assistant	259
Scientific Assistant	1317
Marine Staff	
Nautical Officer Class	8
Ocean Weather Ships and Base	
Officers	50
Crew	123
Technical and Signals grades	307
Executive and Clerical grades	153
Typing and miscellaneous non-industrial grades ...	125
Industrial employees	92
Locally entered staff and employees overseas ...	195

On the whole the staff situation in 1963 was static. The greatest change was in the Scientific Officer class where a normally adequate intake was not sufficient to cope with a modest increase in posts. The satisfactory staff position in the Experimental Officer class and the excellent state in the Assistant grade were maintained.

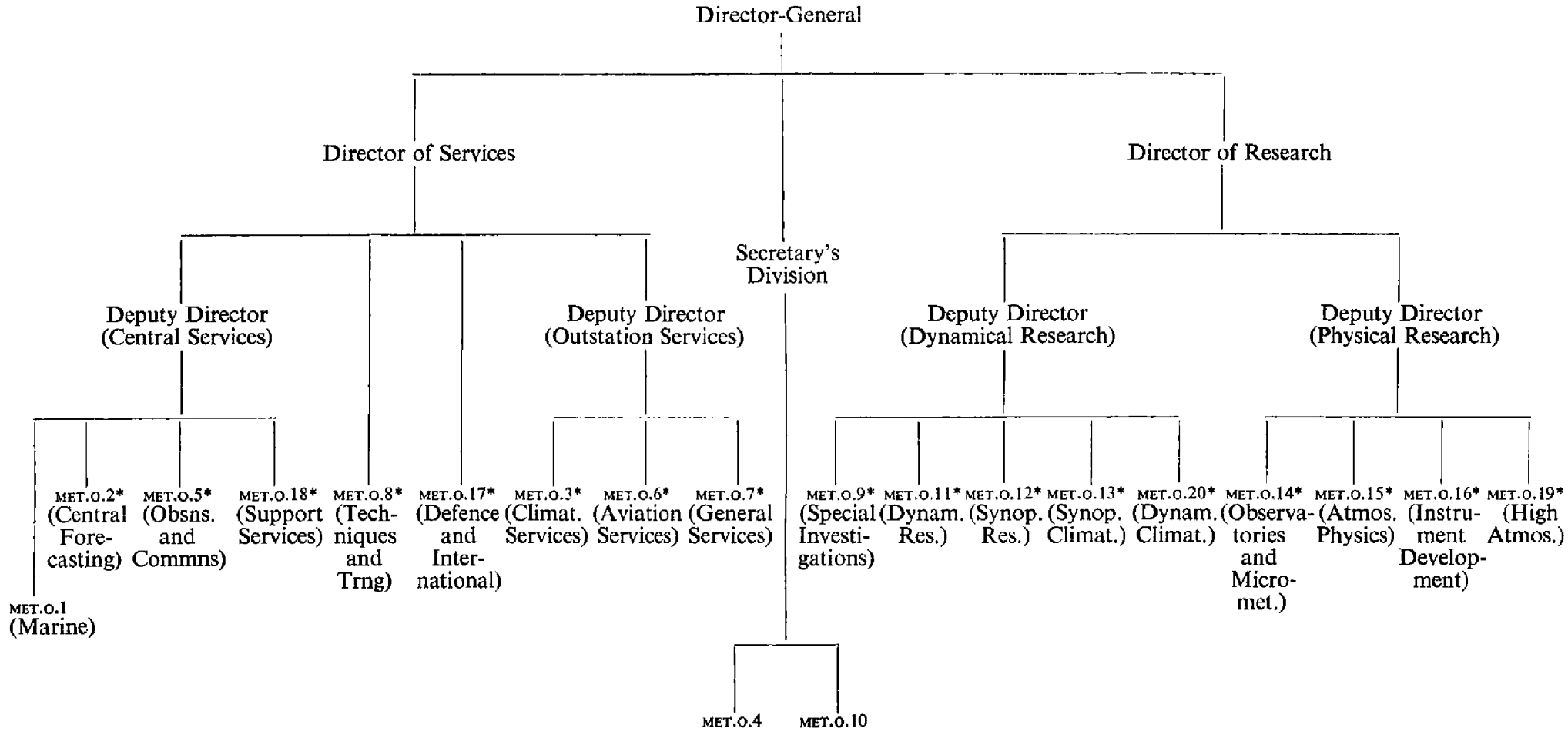
Seven Assistant Experimental Officers shared the year between the Office and the College of Advanced Technology where they were taking Sandwich Courses. Study concessions were granted to 329 members of the staff, an increase of 28 over the year. From many applicants 13 University undergraduates were chosen to work in the Office as Vacation Students. Two college-based Sandwich Course students spent their outside periods with the Meteorological Office.

In the Birthday Honours List R. J. Murgatroyd, B.Sc., Ph.D., was appointed an Officer of the Most Excellent Order of the British Empire.

On the recommendation of the Interdepartmental Scientific Panel, the Treasury granted 'special merit' promotion into the grade of Senior Principal Scientific Officer for two more members of staff, raising the total within the Meteorological Office to six. They are Dr. F. Pasquill (micrometeorology), Dr. R. J. Murgatroyd (general circulation of the atmosphere), Mr. J. M. Craddock (statistics of long-period weather changes), Mr. L. P. Smith (agrometeorology), Mr. T. H. Kirk (operational research on forecasting) and Mr. H. H. Lamb (climatic change).

APPENDIX I

METEOROLOGICAL OFFICE HEADQUARTERS ORGANIZATION



*Assistant Directorates

APPENDIX II

PUBLICATIONS

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

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

PERIODICAL

Daily Aerological Record, containing information respecting meteorological conditions in the upper air over the British Isles (to 19 December, 1963).

Daily Weather Report, containing weather maps for the northern hemisphere, British Isles, etc., and surface data (to 31 December 1963).

Daily Weather Report, Overseas Supplement, containing surface and upper air data (to 15 September 1963).

Meteorological Magazine, (to December 1963).

Monthly Weather Report, (to August 1963).

Seismological Bulletin. A diary of seismological disturbances recorded on the Galitzin aperiodic seismographs at Kew Observatory, Richmond (to June 1963).

Marine Observer (quarterly) (to October 1963).

The Observatories' Year Book, comprising the geophysical results obtained from autographic records and eye observations at Lerwick, Eskdalemuir and Kew Observatories, 1961.

Monthly Weather Survey and Prospects, a new monthly publication containing climatological data for Britain, the weather of the past month, a general survey and inference, and weather prospects for the coming month in Britain; a supplementary document, containing survey, inference and prospects only, is published in mid-month (December 1963).

British Rainfall, 1958.

SERIAL

Geophysical Memoirs: Vol. XIV

107. Report on a tornado at Malta, 14 October 1960, by T. H. Kirk, B.Sc. and D. T. J. Dean.

Scientific Papers:

17. Extremes of Wind Shear, by A. F. Crossley, M.A.
18. Airflow around a Model of the Rock of Gibraltar, by J. Briggs, B.A.

OCCASIONAL

Weather in the Black Sea.

Pictorial Guide for the Maintenance of Meteorological Instruments.

Averages of Temperature for Great Britain and Northern Ireland, 1931–60. (In degrees Celsius).

Averages of Bright Sunshine for Great Britain and Northern Ireland, 1931–60.

Handbook of Weather Messages, Parts II and III (4th Edition).

Marine Observer's Handbook (8th Edition).

Meteorological Office Headquarters Brochure.

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.

1951–1955. Part 10, Habbaniya; Part 11, Bahrain; Part 12, Aden.

APPENDIX III

BOOKS OR PAPERS BY MEMBERS OF THE STAFF

The following books or papers by members of the staff were published during the year ending 31 December 1963:

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J. S. SAWYER, M.A., F.R.S.; Next month's weather: can it be forecast? *Times Sci. Rev.* No. 48, *London*, 1963, pp. 3–4.

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